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DESIGN PRINCIPLES AND PRACTICES FOR IMPLEMENTATION OF MIL-STD-1760 IN AIRCRAFT AND STORES

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This technical report has been reviewed and is approved for publication.

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FOR THE COMMANDER

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The report provides supplemental information to: (1) enhance the understanding of MIL-STD-1760 requirements; (2) identify design issues that could contribute to interface incompatibility; and (3) present design techniques, components, and design practices for implementing MIL-STD-1760 compliant interfaces in aircraft and stores. To this end, implementation examples are presented from both the aircraft designer and store designer perspectives. The report provides:

(a) An overview of MIL-STD-1760 requirements, exclusions and future growth provisions;

(b) Detail design considerations applicable to the Aircraft Station Interface (ASI)

(c) Detail design considerations applicable to the Mission Store Interface (MSI);
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(d) Aircraft/Store physical design considerations applicable to the electrical interface; and

(e) A commentary on the requirements in MIL-STD-1760A.

Preface

This document was prepared by the LTV Missiles and Electronics Group under a joint Navy/Air Force contract. The contract, for the coordination, development and evaluation of Aircraft/Store Electrical Interconnection System (AEIS) technologies, consisted of seven tasks. This document was developed under Task 2, MIL-STD-1760A Design Handbook.

This document was not intended to address the logical element aspects of MIL-STD-1760A recently added to the standard by Notices 2 and 3. It is being published and distributed as a technical report in order to have the information it contains regarding the electrical and physical elements of MIL-STD-1760A reach as many users as quickly as possible.

As a joint service contract, many people and organizations were involved in the process of providing direction and review that led to the successful completion of this task of the contract. These organizations and personnel included: the Naval Weapons Center at China Lake CA, the contracting office for the contract, and Mr. Carl Stoddard, the contracting officer technical representative (Code 3144); the Engineering Standardization Division of the USAF Armament Division (AD/ENSM) at Eglin Air Force Base FL; the Aircraft and Crew Systems Technology Directorate at the Naval Air Development Center (Code 6012), Warminster PA; Naval Air Systems Command (AIR-540) at Washington, DC; and the Systems Engineering Avionics Facility of the USAF Aeronautical Systems Division (ASD/ENASF) at Wright-Patterson Air Force Base OH.

This document was originally prepared as a draft military handbook. Minor editorial changes were made to delete handbook references and make the document read as a technical report. Minor editorial changes were also made to clarify references to Notices 2 and 3 to MIL-STD-1760A.

The views, opinions, and/or findings contained in this report are those of the contractor and should not be construed as an offical Department of the Air Force position, policy or decision.

FOREWORD

The trends in weapon system designs (aircraft and stores) has resulted in a growing concern over the general proliferation of aircraft-to-store electrical interfacing requirements and the resulting high cost to achieve interoperability between aircraft and stores. MIL-STD-1760 was prepared to reduce the aircraft/store electrical integration problem by specifying a standard electrical interface between aircraft and stores. The standard electrical interface is based on recognized trends in store management systems which use serial digital transmission for control, monitor, and release of stores. This report deals with the interoperability requirements as described in MIL-STD-1760 and is intended to be an aid to understanding and meeting the requirements for both current and future weapon systems. In general, this report provides the following:

(a) An overview of MIL-STD-1760 requirements, exclusions and future growth provisions.

(b) Detail design considerations applicable to the Aircraft Station Interface (ASI).

(c) Detail design considerations applicable to the Mission Store Interface (MSI).

(d) Aircraft/Store Physical Design Considerations.

(e) A commentary on the requirements in MIL-STD-1760.

CONTENTS

CONTENTS - Continued

CONTENTS - Continued

CONTENTS - Continued

CONTENTS - Continued

CONTENTS - Continued

CONTENTS - Continued

CONTENTS - Continued

TABLES

1. SCOPE

1.1 Purpose. This report was prepared to increase aircraft and store designers' awareness of available methods for improving aircraft/store interoperability, to recommend specific design and fabrication practices, and to provide aircraft and store designers with sufficient engineering data to implement MIL-STD-1760 requirements. Additionally, it is the purpose of this report to emphasize to the aircraft and store designer the importance of the complete weapon systems approach to the solution of the interoperability problem. The systems approach is one that recognizes the interrelationships of components and parts within the system (aircraft and store) and the interactions between aircraft and store in the system.

While it is recognized that each weapon system is somewhat unique, an effort has been made to present recommended design practices in a manner that will assist the designer to adapt various recommendations to his particular situation. It should be recognized, however, that any given design practice may not be equally effective in all weapon systems. This use of this report must be complimented, therefore, by sound engineering judgement.

1.2 Scope. The material contained in this report is intended to provide the weapon system designer with three basic types of information. These are:

1. A thorough understanding of the requirements imposed by MIL-STD-1760A.

2. An identification of design problem areas that could contribute to an interface incompatability, and

3. A presentation of design techniques, components and design practices that offer suggestions for implementing MIL-STD-1760.

For most weapon systems, a low level of interoperability is inevitable unless the designer recognizes the design risks, is aware of their causes and available means for minimizing the risks, and organizes all phases of the weapon system development in the original design to enhance interoperability. Retrofitting after an interoperability problem is discovered is expensive and seldom contributes to weapon system reliability.

The complete Aircraft/Store Electrical Interconnection System (AEIS) is comprised of three elements: Electrical, Physical and Logical. The electrical element specifies the aircraft-to-store interface signal set and associated electrical characteristics including interrelationships between the various interfaces. The physical element specifies the mechanical

aspects necessary for achieving intermateable electrical connections within the system. The logical element (when incorporated into MIL-STD-1760) will define interconnection system aspects such as the communication protocol, formatting rules for messages and standard data words.

The electrical interface is comprised of two signal sets, a Primary Signal Set and an Auxiliary Power Signal Set. Both signal sets are applicable to the ASI and MSI.

1.3 Limitations. Areas of MIL-STD-1760A discussion not thoroughly covered in this report are as follows:

1. Aircraft and stores compatibility relating to mechanical, aerodynamic, logistic and operational factors. Size, shape, loads, clearances and functional limitations are not specified in MIL-STD-1760.

2. The rail launch MSI connector intermateability characteristics.

3. The simple store MSI signal set and connector intermateability characteristics.

2. REFERENCED DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. Unless otherwise specified, the following specifications, standards, and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this report to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-B-5087	Bonding, Electrical and Lightning Protection for Aerospace Systems
MIL-E-6051	Electromagnetic Compatibility Requirements, Systems
MIL-A-8591	Airborne Stores, Suspension Equipment and Aircraft-Store Interface (Carriage Phase), General Design Criteria for
MIL-C-38999	Connectors, Electrical, Circular, General Specification for
MIL-C-39029	Contacts, Electrical Connector, General Specification for

STANDARDS

MILITARY

MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462	Electromagnetic Emission and Susceptibility, Test Methods for
MIL-STD-704	Aircraft Electric Power Characteristics
MIL-STD-1498	Circuit Breakers, Selection and Use of
MIL-STD-1512	Electroexplosive Subsystem, Electrically Initiated, Design Requirements and Test Methods
MIL-STD-1553	Aircraft Internal Time Division Command/Response Multiplex Data Bus
MIL-STD-1560	Insert Arrangements for MIL-C-38999 and MIL-C-27599 Electrical, Circular Connectors

HANDBOOKS

MIL-HDBK-235	Electromagnetic (Radiated) Environmental Considerations for Design and Procurement of Electrical and Electronic Equipment
MIL-HDBK-1553	Mulitplex Applications Handbook

NATO STANDARDIZATION AGREEMENT

STANAG 3350AVS	Monochrome Video Standard for Aircraft System Applications

2.2 Other publications. The following document(s) form a part of this report to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted shall be those listed in the issue of the DoDISS specified in the solicitation. The issues of documents which have not been adopted shall be those in effect on the date of the cited DoDISS.

EIA-STD-RS-170	Electrical Performance Standards - Monochrome Television Studio Facilities
EIA-STD-RS-343A	Electrical Performance Standards - High Resolution Monochrome Closed Circuit Television Camera
EIA-STD-RS-485	Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems

(Application for copies should be addressed to the Electronics Industries Association, 2001 Eye Street NW, Washington, DC 20006.)

3. DEFINITIONS

3.1 Aircraft. Any vehicle designed to be supported by air, being borne up either by the dynamic action of the air upon the surfaces of the vehicle, or by its own buoyancy. The term includes fixed and movable wing airplanes, helicopters, gliders, and airships, but excludes air-launched missiles, target drones, and flying bombs.

3.2 Aircraft/Store Electrical Interconnection System (AEIS). The AEIS is a system composed of electrical (and fiber optic) interfaces on aircraft and stores through which aircraft energize, control and employ stores. The AEIS consists of electrical interfaces necessary for the transfer of electrical power and data between aircraft and stores and from one store to another store via the aircraft.

3.3 Electrical interface types. The AEIS consists of four electrical interface types as follows:

3.3.1 Aircraft Station Interface (ASI). The Aircraft Station Interface is on the aircraft structure where the mission or carriage store(s) is electrically connected. This interface is usually on the aircraft side of an aircraft-to-store umbilical cable. (Some carriage configurations may not use an "umbilical cable"-e.g. rail launchers.)

The Aircraft Station Interface locations include pylons, conformal and fuselage hard points, internal weapon bays, and wing tips.

3.3.2 Carriage Store Interface (CSI). The Carriage Store Interface is on the carriage store structure to which the aircraft is electrically connected. This interface is on the store side of an aircraft-to-store umbilical cable.

3.3.3 Carriage Store Station Interface (CSSI). The Carriage Store Station Interface is on the carriage store structure to which the mission store is electrically connected. This interface is usually on the carriage store side of the carriage store-to-mission store umbilical cable. (Some carriage stores, such as rail launchers, may not use an "umbilical cable" but use some other cable/connector mechanism.)

3.3.4 Mission Store Interface (MSI). The Mission Store Interface is on the mission store structure to which the aircraft or carriage store is electrically connected. This interface is on the mission store side of an aircraft-to-store umbilical cable, a carriage store-to-mission store umbilical cable, or a rail launcher cable/connector mechanism.

3.4 Store. Any device intended for internal or external carriage and mounted on an aircraft suspension and release equipment, whether or not the device is intended to be separated in flight from the aircraft. Stores are classified in two categories as follows:

3.4.1 Carriage store. A carriage store is a suspension and release equipment that is mounted on aircraft on a non-permanent basis. Pylons and primary racks (such as a MAU-12 and BRU-32) are not considered carriage stores. Examples of (non-AKTS) carriage stores include (but are not limited to) the LAU-88 and LAU-117 Maverick launchers, and BRU-33 Vertical Ejector Rack.

3.4.2 Mission store. A mission store directly supports a specific mission and excludes suspension and release equipment (carriage stores). Examples of mission stores include (but are not limited to) missiles, bombs and electronic pods.

3.5 Stores Management System (SMS). The stores management system is the aircraft avionic subsystem that controls and monitors the operational status of aircraft installed stores and provides and manages the communications between aircraft mounted stores and other aircraft subsystems.

3.6 Suspension and Release Equipment (S&RE). The suspension and release equipment includes all airborne devices used for carriage, suspension, employment, and jettison of stores, such as racks, adapters, launchers, pylons, etc. The S&RE includes "permanently mounted" equipment such as parent bomb racks (e.g. BRU-32) and removable carriage stores (see 3.4.1).

3.7 Provisions. Provisions are needed materials and space provided in advance to allow incorporation of added functions in the aircraft or store without modification other that the addition or changes to connectors, cables and hardware/software necessary to control the added functions.

4. GENERAL

4.1 Overview of MIL-STD-1760.

4.1.1 Scope. MIL-STD-1760 covers the 'electrical' portions of the interactions between the aircraft and the store. MIL-STD-1760 defines a standard interface for the transfer of electrical power from the aircraft to the store and transfer of information between aircraft and store. In addition, MIL-STD-1760 provides design requirements for the management of networks used to transfer electrical power and information between the aircraft and the store. Non-electrical interactions such as transfer of fuel, hydraulic power, coolant, pneumatic power, etc., are not covered by MIL-STD-1760.

The intent behind MIL-STD-1760 is to support achievement of interoperability between independently designed stores and aircraft by imposing specific interface design requirements applicable to each. The overall goal of the standard is to remove the non-standard electrical interface as an obstruction to interoperability. Modification of aircraft and store hardware to allow new individual combinations to operate together is to be minimized. The use of adapter modules is to be discouraged. In this way, the effort and cost necessary to integrate aircraft and stores will be minimized.

MIL-STD-1760 is designed to be flexible enough to accomodate individual system peculiarities. In particular, implementation may change with technology advances as long as the interface characteristics are maintained. The MIL-STD addresses only the electrical interface between aircraft and stores. Compatibility parameters such as size, weight, aerodynamics, avionics capabilities, etc., must be satisfied in addition to the electrical interface in order to realize interoperability. The electrical, or MIL-STD-1760, portion of the aircraft/store integration effort will ultimately be limited to developing software modifications necessary to accomodate new stores.

The electrical interface between the aircraft and a store, or between a carriage store and a mission store, is represented physically by the surface at which the two sides of the interface make or break electrical contact. This occurs at the contacts in a mated electrical connector set, one half of which is considered to be the aircraft side and one half of which is considered to be the store side. All electrical power and information is transferred between units (e.g., aircraft, mission stores, etc.) across these contacts. Ideally, a functionally equivalent unit can be substituted at the interface with no change in the operational characteristics of the unit on the other side of the interface. MIL-STD-1760 controls the electrical characteristics of aircraft and stores as seen at the interface, so that aircraft and stores may be interchangeable at that interface to the

maximum degree possible. As stated in the previous paragraph, total interoperability is achieved only after other aircraft-store compatibility issues (i.e., other than MIL-STD-1760) have been addressed and resolved. Aircraft and store compliance solely with MIL-STD-1760 will not directly result in interoperability but will remove electrical interfacing obstacles to achieving interoperability.

An aircraft achieves interoperability by containing one or more interoperable store stations. In the most general sense, an aircraft can contain other store stations which are not interoperable; for example, a station designed for carrying external fuel tanks only. For a store station to be an interoperable candidate, two criteria must be met. First, the store station must contain suspension and release equipment such as a MAU-12 or BRU-32 parent ejector unit or a rail launcher. Second, the store station must be capable of carrying more than one store type (at different times). The intent of these criteria is to exclude dedicated "store stations" (such as internal guns and internal chaff dispensers) and to exclude locations such as equipment bays with replaceable ECM modules or stations for conformal fuel tanks.

The MIL-STD-1760 functional interfaces are illustrated in figure 1. The specific implementation of a particular subsystem, i.e., mission store, carriage store, aircraft electronics, is the responsibility of that subsystem designer and is independent of the other subsystems from the perspective of the AEIS. The interface characteristics, however, are controlled by MIL-STD-1760 so that any subsystem may be interchanged with any functionally equivalent subsystem and still maintain circuit compatibility at the interface.

MIL-STD-1760 defines electrical characteristics at two major interfaces, i.e., the Aircraft Station Interface (ASI) and Mission Store Interface (MSI) as shown in figure 2a. Two additional interfaces, the Carriage Store Interface (CSI) and the Carriage Store Station Interface (CSSI) shown in figure 2b also comprise the electrical interconnection system. The physical locations shown in the figure are typical locations. Whether the ASI connector is at the bottom of a pylon, in an access "well" in the pylon or on some other structure for non-pylon carriage modes (e.g. conformal carriage) does not change the underlying interface definitions and requirements.

Interface characteristics for the CSI and CSSI are not specified in MIL-STD-1760. However, the characteristics defined for the ASI and MSI include allocations for the design of a carriage store and the two associated umbilicals from the carriage store to the ASI and to the MSI. Following are definitions of each interface segment:

> Aircraft Station Interface (ASI). An aircraft station that complies with MIL-STD-1760 is defined as an ASI. The "aircraft station" is taken to be at the lowest point of electrical equipment that is designed exclusively for the aircraft type and

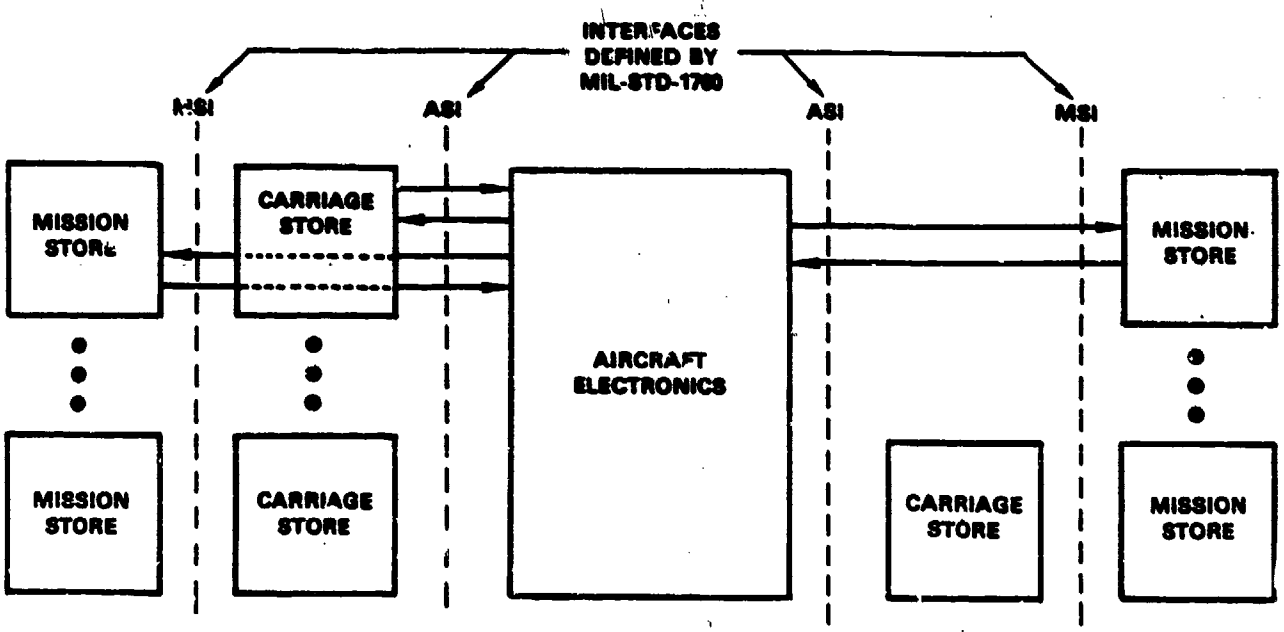


FIGURE 1. MIL-STD-1760 functional interfaces.

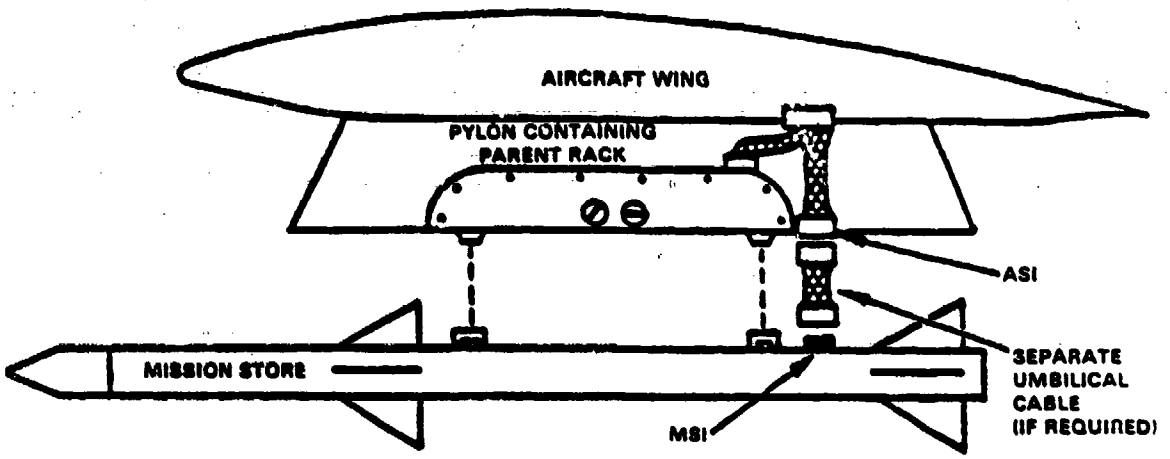


FIGURE 2a. Example of mission store connected directly to aircraft.

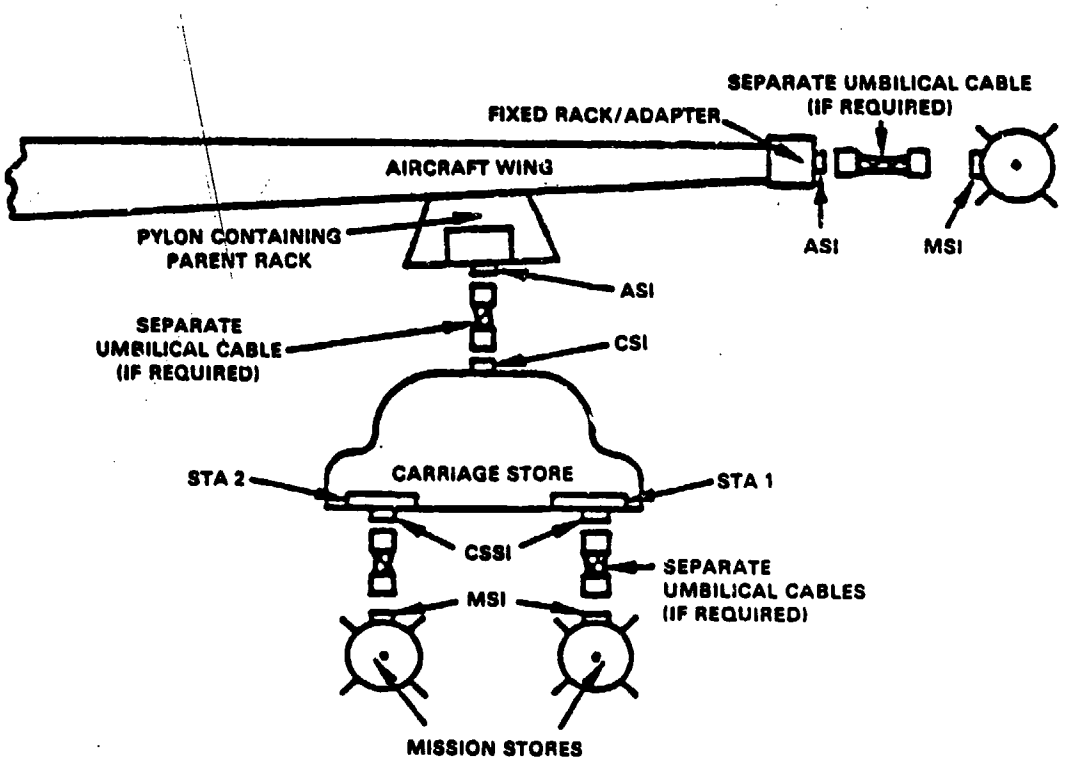


FIGURE 2b. Example of mission stores connected to carriage stores.

FIGURE 2. Typical AEIS interoperable interface locations.

model, whether or not the particular piece of equipment is permanently attached to the basic airframe. For example, an underwing or underfuselage pylon is considered to be part of the airplane even though it may be installed or removed depending on the requirements at the time. The interoperable interface location on a pylon is at the connection point which is considered as the lowest point of the aircraft. Typically, an umbilical cable is mated to this connector to allow electrical connection with the installed store. In effect, this umbilical cable acts as an "extension cord" from the ASI to the store's electrical connector.

Carriage Store Interface (CSI). Carriage stores that are capable of being carried on aircraft stations that comply with MIL-STD-1760 are defined as MIL-STD-1760 compatible carriage stores. The interconnection point at the carriage store for interfacing with the aircraft is defined as the CSI. The performance characteristics of the ASI to CSI umbilical must be considered in establishing the characteristics of the CSI. Specific electrical characteristics for the CSI are not included in the standard. The CSI is physically the electrical connector which is permanently part of the carriage store and through which the carriage store is electrically connected to the aircraft.

Carriage Store Station Interface (CSSI). A carriage store station that is capable of carrying mission stores which comply with MIL-STD-1760 is defined as a MIL-STD-1760 compatible carriage store. The interconnection point at the carriage store for interfacing with the mission store is defined as the CSI. The performance characteristics of the CSSI to MSI umbilical must be considered in establishing the characteristics at the CSSI. Specific electrical characteristics for the CSSI are not included in the standard. The CSSI is physically the electrical connector which is permanently part of the carriage store and through which the carriage store is electrically connected to a mission store.

Mission Store Interface (MSI). The electrical interface on mission stores which comply with MIL-STD-1760 is defined as the MSI. The MSI is the physical connector which is a permanent part of the mission store through which the store is electrically connected to the carrying aircraft (or carriage store).

Each ASI and MSI may be implemented with two separate signal sets identified as the primary interface signal set and the auxiliary power signal set. The signals contained in each set are shown in figure 3 for the primary signal set and figure 4 for the auxiliary power signal set. Separate connectors

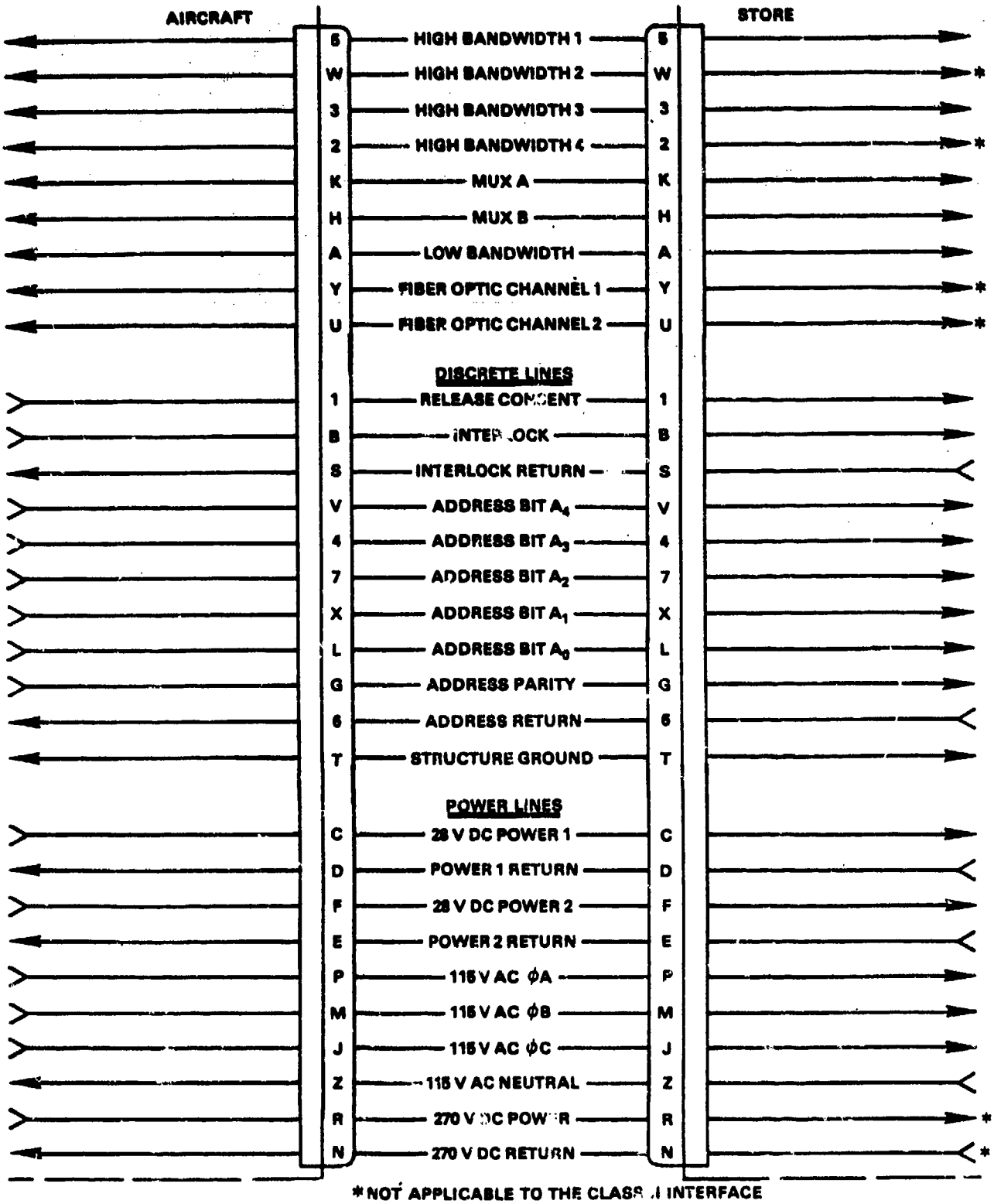


FIGURE 3. Primary interface signal set.

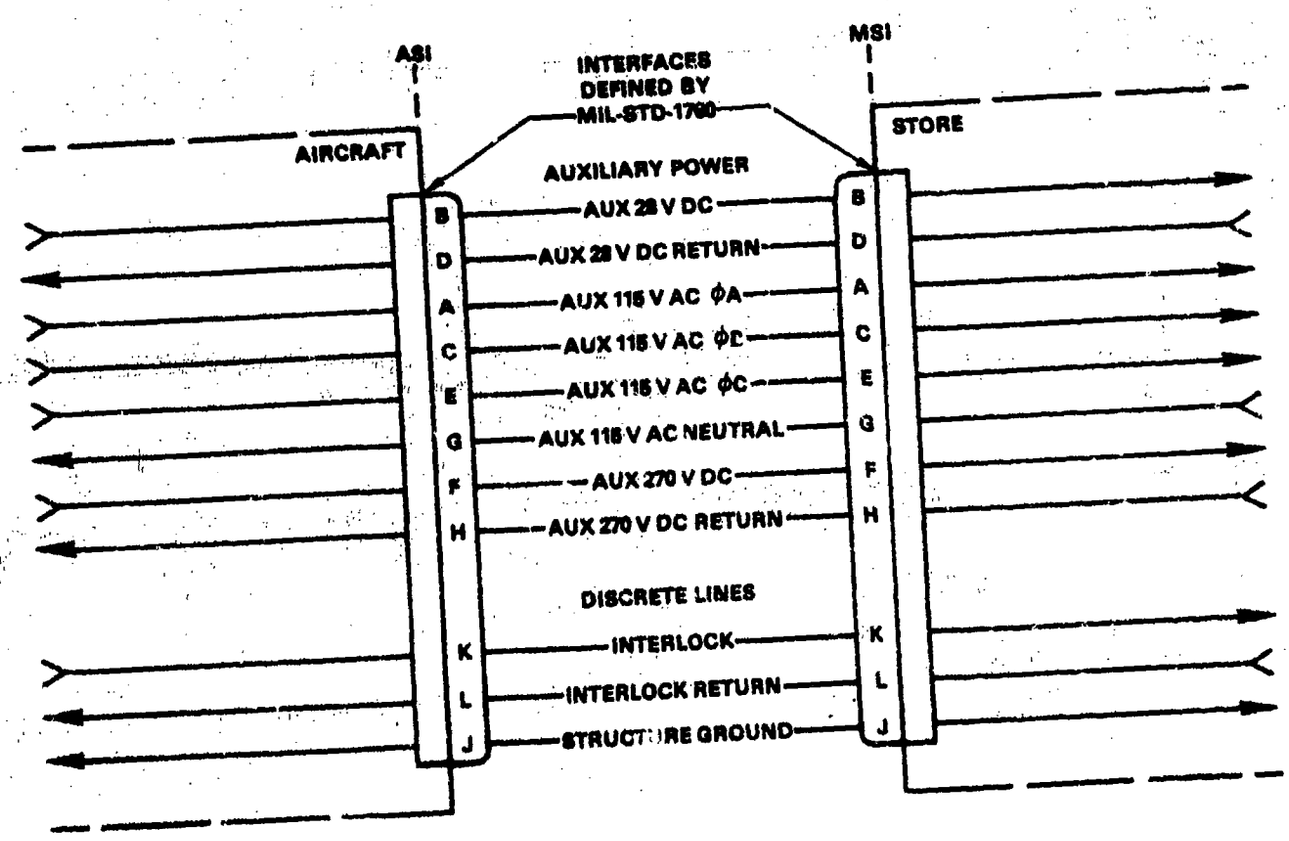


FIGURE 4. Auxiliary power signal set.

are used for each set. The aircraft is defined to have specific interface capability when identified by the following classes:

Class I - Full Primary Signal Set
Class IA - Full Primary and Auxiliary Signal Sets
Class II - Primary Signal Set excluding High Bandwidth 2 and 4, Fiber Optic Channels 1 and 2, 270 VDC Power and Power Return
Class IIA - Class II plus Auxiliary Signal Set

Mission stores are defined as being compatible with the applicable class above. This compatibility is achieved by complying with defined requirements (in the standard) applicable to those signals used by the store. If the signals required by a store are all contained within a class II signal set, then the store is considered as a class II (compatible) store. However, the store is not required to use all class II signals. (By definition, a class II (compatible) store is also compatible with class IIA, class I and class IA interfaces.)

4.1.2 Requirements. MIL-STD-1760 defines the electrical interface requirements for supporting high bandwidth signals, mulitplex data bus signals, low bandwidth signals, discrete signals and power. The electrical characteristics for supporting each of these signals are defined in the standard at the ASI and MSI interconnection points. (In the discussion which follows, the electrical connection within an ASI or MSI for each signal is referred as a signal port or simply a port.) Except as specifically noted below, these signals are provided through the primary signal set interface shown in figure 3.

4.1.2.1 High bandwidth signals. Four high bandwidth ports, identified as HB1, HB2, HB3, and HB4 are available for transferring two types of high bandwidth signals distinguished by the signal's frequency content. Type A signals are contained within a passband bounded by 20 Hertz and 20 MegaHertz. Type A signals include composite video and time synchronization signals. Type B signals are contained within a passband bounded by 20 MegaHertz and 1.6 GigaHertz, and include low power radio frequency signals such as Global Positioning System (GPS) RF. Signal assignment for each high bandwidth port is as follows:

a. Radio frequency signals (Type B) are transferred on HB1.

b. Time correlation (synchronization, clocking and blanking) signals (Type A) are transferred on HB1 and HB2.

c. Composite video signals (Type A) are transferred on HB3 and HB4.

The HB1 and HB2 ports are specified as 50 ohm (nominal) impedance circuits while the HB3 and HB4 ports are defined as 75 ohm (nominal) impedance circuits.

The extent that these signals are actually transferred between stores and aircraft subsystems or between stores via the aircraft varies with the mission requirements for each aircraft. As a result, the standard does not impose a specific network topology or capacity on the airplane.

4.1.2.2 Digital multiplex data signals. The digital multiplex data ports provide signal interconnections so that MIL-STD-1553 remote terminals installed in the stores can exchange serially encoded data with similar terminals in other stores or in the carrying aircraft. Redundant channels (Mux A and Mux B) are provided for transferring information, store control and store status data between aircraft and stores connected to a common data bus. The store's remote terminal is assigned a communications address via a set of address discretes (see 4.1.2.4.3) when connected to a specific aircraft station interface.

4.1.2.3 Low bandwidth signals. One low bandwidth port is available for transferring bi-directional signals (DC to 50 kiloHertz) between the aircraft and stores. The signals assigned to this port include tones and voice grade audio. The port characteristics are also specified to allow potential future applications as a low cost, low speed serial digital data link alternative to the Mux A and Mux B ports of 4.1.2.2.

4.1.2.4 Discrete signals.

4.1.2.4.1 Release consent signal. One port identified as release consent, is used by the aircraft to transfer an enable/inhibit signal to the store for the purpose of granting consent to the store to act on safety critical commands received over the digital multiplex data bus. The return line for release consent is the 28V DC power 2 return line. The actual store release, however, is commanded by the aircraft over the digital multiplex bus or through other media interconnecting the aircraft stores management system with the station's parent rack. The release consent signal is not a firing signal.

While release consent was orginally established (and named) as an enable/inhibit safety interlock on the release of certain types of stores, the signal function has been broadened somewhat. The release consent is now viewed as a reversable enable/inhibit interlock for any safety critical function commanded of the store over the digital multiplex data port.

4.1.2.4.2 Interlock interface. One port, identified as interlock (and its associated interlock return), is available to the aircraft for monitoring the mated status of the primary interface connector. Similarly, an additional port is available to the aircraft for monitoring the mated status of the auxiliary interface connector. This monitoring feature is provided by a continuity loop between interlock and interlock return in the store such that as long as the store connector is mated, continuity exists.

While release of a store from the aircraft will break the electrical interconnection and thereby lose continuity, simple loss of continuity must not be used as the sole criteria to establish a store "not present" condition since the store could be mechanically attached to the aircraft with the connector not mated. The operating sequence for rail launching some types of missiles (e.g., AIM-120) provides a good example of the differences between electrical separation and mechanical separation.

4.1.2.4.3 Address signals. Another type of discrete signal in the primary interface is the address signal. Five binary weighted address lines, one parity line and one common return line are provided by the aircraft to assign the store's MIL-STD-1553 terminal an address (between 0 and 30) for data bus communication. This discrete set can also be used by the store to determine the mated status of the primary interface connector (i.e., the store's equivalent to the interlock discrete described in 4.1.2.4.2).

4.1.2.5 Structure ground. One line is used to connect the aircraft structure to the store structure for the purpose of minimizing electric shock hazards. The line must not be used specifically as a power or signal return line. (See 5.4.4 for comments on MIL-STD-1760 paragraph 4.3.1.8.) The structure ground circuit is contained in both the primary and auxiliary interfaces.

4.1.2.6 Power. Two power lines and two return lines are contained in the primary interface to transfer 28V DC power 1 and 28V DC power 2 to the store. Four lines are used to transfer 115/200V AC power (three phases and neutral) through the primary interface to the store. The auxiliary interface contains two lines for 28V DC power and return, and four lines for 115/200V AC (three phases and neutral).

4.1.2.7 Growth provisions. Provisions (two 16 gage contact locations) for adding two fiber optic communication channels to the primary signal set are contained in the class I primary interface connector. Provisions (two 16 gage contacts) for adding one channel of 270V DC (power and return) to the primary signal set and auxiliary set are contained in the class I primary and auxiliary interface connectors.

4.1.2.8 Connectors. The primary interface connector required by the standard must comply with the intermateability dimensions of MIL-C-38999, Series III, Shell Size 25, with a polarization key at location N and MIL-STD-1560 Insert Arrangement 25-20. The auxiliary interface connector is identical to the primary interface connector except the polarization key location is A and the MIL-STD-1560 Insert Arrangement is 25-11. These connector requirements apply to all ASIs. The requirements also apply to all MSIs except rail launched stores and possible high volume, low cost "simple" stores (see 4.3.3).

4.1.3 Exclusions. Aircraft/Store Electrical Interconnection System (AEIS) refers to standardized weapon interfaces and certain interrelationships between those interfaces. Performance requirements at this interface are specified in MIL-STD-1760. AEIS does not specifically refer to an assembly or software embedded in an aircraft or store, with the implication that this assembly could be removed from the aircraft or store and be regarded as an "AEIS system". AEIS does, however, impact several aircraft systems such as the stores management system and power distribution system. It is expected that implementations of the AEIS in different aircraft and stores will use different design technologies. However, the interface characteristics between the aircraft and store are standardized at each interface (ASI and MSI) by MIL-STD-1760.

4.1.3.1 Stores management system (SMS). Aircraft equipments assigned to the Stores Management System (SMS) implement the aircraft portion of the AEIS. In recent generation tactical aircraft, a "disbributed" SMS has been selected. This SMS is typically composed of a central processor, dedicated and/or shared controls and displays, Store Station Equipments (SSE) and miscellaneous aircraft interface equipment. The SSEs are generally located close to the Aircraft Station Interface. These SSEs are referred to as Remote Interface Units, Station Decoders, Missile Interface Units, etc., on various aircraft and provide a common function - control of interface inputs and outputs required to operate a specific store or set of stores. For an SMS with these store station equipments, the aircraft's MIL-STD-1760 interface (i.e., ASI) is implemented in this equipment - at least as long as operation of other non-AEIS stores is required. The AEIS standard, therefore, impacts these SSEs just as interface requirements of non-AEIS stores impact the SSEs. However, the SSE is only one part of the SMS. Other major functions of an SMS include the processing of information, control and monitoring store states, interfacing with the flight and ground crew, and interfacing with other aircraft avionics. The AEIS standard has minimal impact on these other SMS functions. As examples, MIL-STD-1760 does not define control/display requirements for the man-machine interface or specify the allocation of processor memory between volatile and non-volatile types. Therefore, although the AEIS impacts the SMS by imposing requirements on the SMS, MIL-STD-1760 is not a Stores Management System specification or standard and allows a high degree of SMS implementation flexibility.

4.1.3.2 Jettison. At least two catagories of jettison are defined by armament system specifications: Emergency jettison and selective jettison. Other names are used for these functions in various documents but they can generally be classified into one of two categories.

(1) Jettison (i.e., unarmed release) of "all" stores in response to an emergency such as being attacked by an enemy fighter. The word "all" is qualified because in most cases air-air missiles are not jettisoned. For air-ground store stations, the aircraft is generally cleaned at the highest point. For

example, if an aircraft is carrying six 500 pound bombs on a Multiple Ejector Rack (MER) at a station, the MER may be jettisoned with the six bombs attached.

(2) Jettison of only those stores selected by the flight crew. For this case, the individual bombs on the MER (in the above example) can be jettisoned without releasing the MER or stores at selected stations can be jettisoned while other stores are retained.

As a general case, the jettison function is achieved by the SMS and the Suspension and Release Equipment (S&RE) at a store station. The S&RE provides a mechanical interface between aircraft and store analogous to the electrical interface provided by the AEIS. The power and information for achieving this jettison function does not normally cross AEIS interfaces and is not, therefore, addressed by the AEIS standard. The only cases where this doesn't apply are: (1) for selective jettison of mission stores (e.g., bombs) from a carriage store (e.g., MER); and (2) for unarmed firing of a self-firing rail launched missile. Both of these exceptions are actually unarmed releases and can, therefore, be provided through the capabilities in the AEIS interfaces.

4.1.3.3 Internal store functions. Similar to the SMS functions discussed in 4.1.3.1, most internal store functions are not impacted by MIL-STD-1760.

While the AEIS standard defines characteristics of the mission store interface, design and operating requirements on internal store functions are not covered by MIL-STD-1760. As examples, the AEIS standard does not define the power supply voltage levels for internal store circuitry, for the information transfer mechanism between subsystems within a missile, or for the performance required for mid-course guidance.

4.1.3.4 Carriage stores. Carriage stores (and interconnecting umbilicals) can be inserted between the ASI and MSI (see figure 2b). Since MIL-STD-1760 specifies the requirements at the ASI and MSI, the interface requirements on the carriage store are bounded at each end (i.e., ASI and MSI), thereby minimizing the need to define detail requirements for the carriage store interfaces (i.e., CSI and CSSI). Designs of carriage stores can, therefore, extract needed CSI and CSSI characteristics from the ASI and MSI requirements. In extracting these characteristics, the performance degradation from the two umbilicals (ASI-CSI and CSSI-MSI) must be considered during the design of the carriage store.

4.1.3.5 Ground Support Equipment (GSE). MIL-STD-1760 impacts the design of GSE since GSE connects to the aircraft and store at the interfaces. However, the procedures and fault isolation algorithms will vary between different aircraft and stores. Therefore, MIL-STD-1760 does not address specific GSE design requirements. It is not the MIL-STD-1760 interface

that is tested, but rather specific SMS or store implementations of that interface that is tested.

4.2 Basic design areas. The system design section herein provides an explanation of the design requirements as delineated in MIL-STD-1760 and provides application guidelines with examples for meeting the requirements. Also provided are results of tests performed on representative ABIS networks, specifically in the areas of EMI and electrical performance characteristics. The system design section is divided into four areas:

1. Aircraft station electrical design
2. Mission store electrical design
3. Aircraft and mission store physical design
4. A commentary on MIL-STD-1760

4.2.1 Aircraft station electrical interface. Specific areas discussed include the interrelationship of MIL-STD-1760 to avionic systems and design aspects pertaining to digital data transfer, discrete lines, high bandwidth distribution, power distribution and EMI.

4.2.2 Mission store electrical interface. Specific areas discussed include design aspects pertaining to digital data transfer, discrete lines, arming and motor ignition safety, jettison safety, high bandwidth signal usage, power usage, electromagnetic compatibility, signal subsets and growth provisions.

4.2.3 Aircraft and mission store interface physical design. Specific areas discussed include the commonality of umbilicals, environmental considerations, and connector and cable assembly considerations.

4.2.4 Commentary on MIL-STD-1760. The commentary on MIL-STD-1760 provides background information on the requirements in MIL-STD-1760. Basically, the requirements are discussed from the following perspectives:

- o An explanation of the requirement
- o Rationale for the requirement
- o Subtleties of the requirement and
- o Reference to appropriate sections in this report which expand on the rationale and design considerations for complying with the requirement

4.3 Future expansion of MIL-STD-1760. MIL-STD-1760 is structured to allow future update to include advanced technologies presently in the development phase. Four technologies in various stages of development

which may be applicable are: High Voltage DC electric power systems, fiber optics information distribution, low cost store interface subset, and High Bandwidth digital communications.

4.3.1 High Voltage DC electric systems. The high voltage DC (270V DC) electric system under development offers several potential advantages over the existing standard 115/200 volt AC system. These advantages include the following:

1. HVDC eliminates the need for a constant speed drive, thereby reducing weight and maintenance associated with generator drives.

2. HVDC allows the use of a wild frequency generator which is light in weight because operation can be at very high and varying speeds.

3. DC/DC converters are lighter in weight than AC/DC converters because high frequency transformers can be used.

4. HVDC allows a reduction in wire weight.

5. Bus power dropout during power source switching can be eliminated because parallel operation is easier to accomplish with DC systems than with AC systems.

Although MIL-STD-704 includes 270V DC as a "legal" standard power system voltage, the availability of a HVDC electric system for aircraft has been slow in developing. This is primarily due to the time and cost required for developing and fielding new hardware (generating systems, power controllers, converters, ground power carts, etc.). Also, changing to a new voltage standard (270V DC is intended to replace 115/200V AC) results in a short term penalty since immediate conversion would make 115/200V AC equipment in inventory obsolete and gradual conversion would have a negative impact on system complexity and logistics. Consequently, MIL-STD-1760 retains the standard 115/200V AC and 28V DC power voltages - while reserving connector provisions for 270V DC in the event that 270V DC systems are introduced into aircraft systems. This reserved status is intended to restrict implementations to some degree. For example, a store can not be designed to require 270V DC. For a store to require 270V DC would result in an immediate obstruction to interoperability since aircraft will not provide 270V DC at an ASI at this time.

4.3.2 Fiber optics. Similar to the HVDC case, fiber optic communication techniques can offer significant advantages to future aircraft-store interface performance if higher data rates or higher electromagnetic environmental requirements are needed. While near-term projections indicate that MIL-STD-1553 communication links provide an adequate service capability

for the weapon, growth provisions are included in the interface for fiber optics. These provisions are limited to two 16 gauge contact cavities in the primary connector for two reasons. First, studies to date have not shown conclusively that an optical path through an aircraft-store interface can provide adequate control of signal losses when operating in the typical ASI/MSI environment. Second, efforts are currently underway to evolve a multi-Megabit per second fiber optic communication standard (other than MIL-STD-1773) for military applications. The intent of the Air Force and Navy developers of MIL-STD-1760 is that the AEIS will adopt the fiber optic standard once it is available and an application to stores is needed. Since design requirements such as operating wavelength(s), optical waveguide core size, optical contact performance, etc., can be significantly affected by the requirements in the fiber optic communication standard, the prudent approach at this time is to specify only the contact cavities. This cavity requirement is included in MIL-STD-1760.

4.3.3 Low cost stores. An alternative serial digital interface is being considered for "low cost stores" such as unguided bombs, dispensers, etc. Alternatives under investigation include: (1) Using the Low Bandwidth interface in an EIA-RS-485, Manchester encoded, point-to-point data link mode, (2) using a non-redundant, reduced capability MIL-STD-1553 data link, or (3) using a MIL-STD-1553 data link with low power transceivers.

These alternatives are being studied for the following reason. The installation of MIL-STD-1553 terminals in stores would be a significant cost impact on present high volume low cost stores such as unguided bombs. Based on present electronics cost, the cost delta to a store for this interface could be two orders of magnitude less if non-MIL-STD-1553 terminal hardware were used. This difference in cost, however, is narrowing rapidly and may be insignificant in the near future. Alternative serial digital techniques are being studied for use if the cost reductions expected do not materialize.

4.3.4 High Bandwidth. The high bandwidth transfer media requirements specified in MIL-STD-1760 include provisions for accommodating future weapon requirements. As such, no changes to the standard are expected for adding capacity in the form of additional bandwidth, higher signal levels, etc. As an example, HB3 and HB4 ports are defined with a 20 MHz upper frequency limit for video applications. Typical video signals in current stores have an approximate 6 MHz upper frequency limit. However, high resolution video systems are being considered and are being included in military video standards (re: STANAG 3350). As a result, MIL-STD-1760 includes the higher bandwidth specification for encompassing the high resolution video.

4.3.5 Initialization requirements. Notice 2 to MIL-STD-1760 revision A was released (24 October 1986) to define aircraft and store requirements for a standardized store initialization procedure. This procedure defines: (1) Permitted states of interface signals during initialization; (2) the power lines to be activated at initialization; (3) the MIL-STD-1553 message

(and its format) to be requested from the store for determining the time of store "wake-up" and the identity of the connected store; and (4) minimum level of communication protocol to support the identity message.

4.3.6 Logical element. A Notice 3 to the standard is scheduled to be released to add the remainder of the standardized logical element of the AEIS. This proposed notice is still in a review process and as such it's content and scope are subject to change. The proposed notice is expected to define additional communication requirements oriented primarily at the MIL-STD-1553 portion of the AEIS. These requirements are expected to include: (1) identification of MIL-STD-1553 options which will be required or disallowed for AEIS applications; (2) specific message assignments for certain command subaddresses; (3) control of certain MIL-STD-1553 mode command and status function interpretations and uses; (4) definition of messages for safety critical store functions; (5) selection of a common set of coordinate systems for data; and (6) specification of some data word formats for specific types of data.

5. SYSTEM DESIGN

This section provides background information and design considerations for use during the application (i.e., design) of MIL-STD-1760 to aircraft, stores and interconnecting umbilical cables. The information is presented in subsections divided by design responsibility. That is, Section 5.1 covers design issues of interest primarily to the aircraft or stores management system design staff while Section 5.2 is oriented primarily toward the mission store design staff. Section 5.3 addresses physical design issues related to electrical connectors and cable assemblies and is applicable to both aircraft and store designers.

While the material in this report is segregated by interface responsibility (i.e., the aircraft designer is responsible for compliance with ASI requirements of MIL-STD-1760, etc.), readers are encouraged to understand both aircraft and store design issues, options and implications. A more thorough understanding will enhance the application of AEIS to weapon systems.

Finally, the reader is reminded that this report covers interfacing and integration issues related to MIL-STD-1760A. This report is not a missile or SMS design guide. As such, this report does not address: (1) Logical interface aspects (e.g., communication protocol, etc.) to be covered by a future notice to MIL-STD-1760A, or (2) internal missile subsystems and stores management system design considerations which extend beyond AEIS interface requirements.

5.1 Aircraft station electrical interface. This section provides supplementary explanations of MIL-STD-1760 requirements and design considerations applicable to the Aircraft Station Interface. The information is applicable primarily to the aircraft system designer.

5.1.1 Stores management system versus AEIS. The AEIS influences the design of systems within aircraft and stores due to reliance on these systems to implement the AEIS interfaces. The overlap of AEIS into these systems is shown in figure 5.

The primary aircraft system affected by MIL-STD-1760 is the Stores Management System (SMS). The aircraft SMS contains several major functions such as information processing, interfacing with flight and ground crew and interfacing with various aircraft avionics in addition to interfacing with the store for control and monitoring of store functions. Of these functions, only the store interface portion of the SMS is directly impacted by MIL-STD-1760. The SMS function can be implemented with a number of different architectures and equipment mixes. Specific SMS functions may be implemented by electronic boxes assigned to systems which typically are not considered as SMS. As an example, one aircraft design might switch power to an ASI via the aircraft's power distribution system based on inputs from a Stores Management Processor (SMP). Even under this condition, power

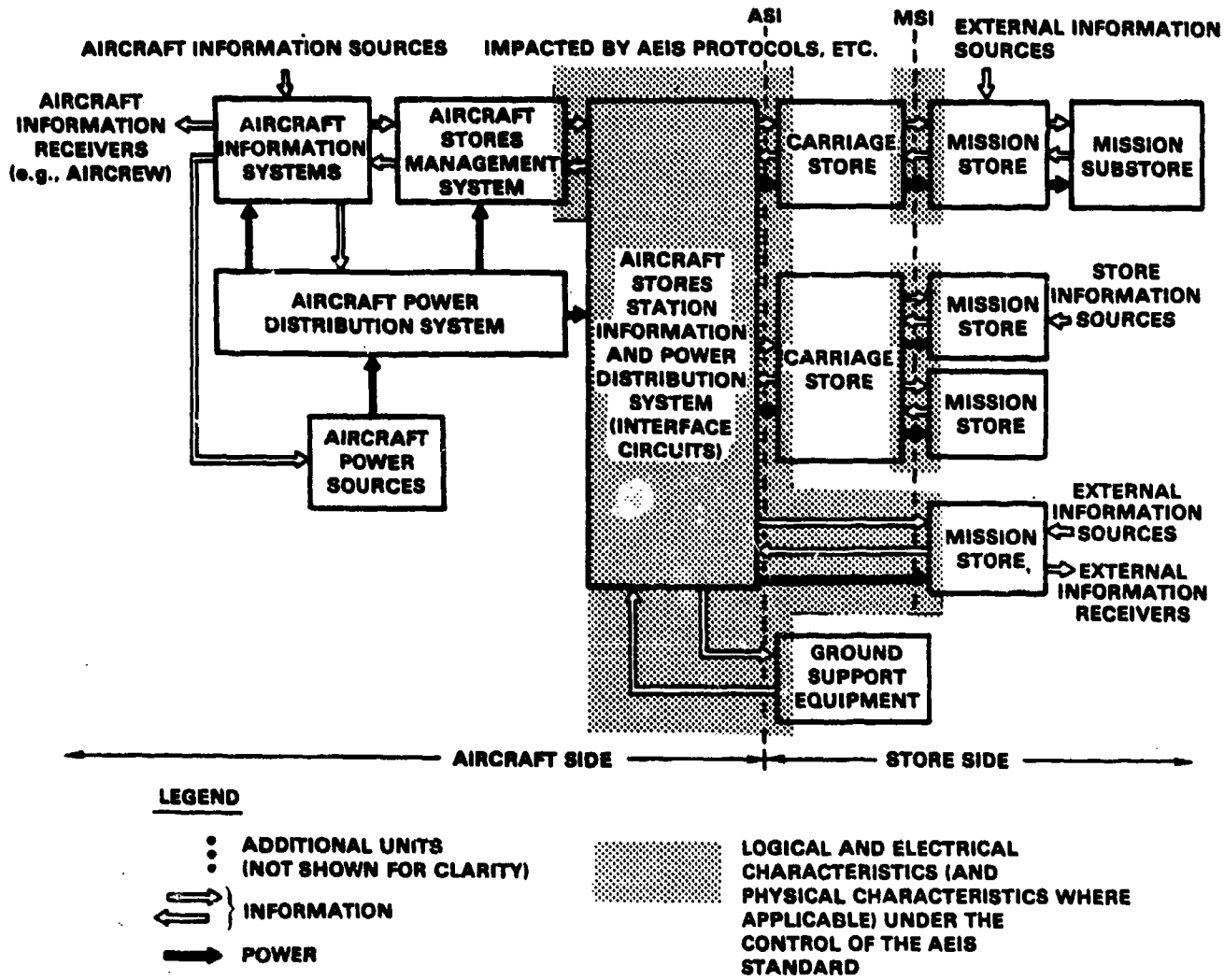


FIGURE 5. AEIS relationships and boundaries.

swtiching is a SMS function even though the switching is performed by other system equipment. In this context then, the SMS is the primary aircraft system impacted by MIL-STD-1760. Once the Logical Element requirements are added into MIL-STD-1760 (via notice, revision, etc.), other aircraft systems could be indirectly affected. These indirect influences would result primarily from data word standardization by the Logical Element and the possible roll-over of these data word formatting requirements into the aircraft's avionic data buses. However, even these potential impact areas could be decoupled from the aircraft avionics by the SMS. Similar decoupling exists on F-16 and F-18 aircraft between the aircraft's avionics data buses and the data buses servicing the store interfaces. Not only are the data word formats changed in these cases but, the electrical characteristics of the data bus signals may also be different.

By presenting an overview of potential SMS architectures and SMS equipment descriptions, the clarity of AEIS design issues and possible impact areas can be enhanced. To help achieve this clarity, figure 6 illustrates two representative SMS architectures and the equipment which could be used to form the systems. It is emphasized that this figure is presented to aid in the discussion of follow-on report sections and is not intended to represent all possible architectures or to provide recommendations on SMS architectures.

Figure 6a illustrates a generic centralized SMS architecture. From a general perspective, this architecture is representative of a number of current inventory aircraft such as A-6D, F-14A, F-15A, F-4, A-7D/E and A-10A. This architecture is represented by (essentially) one central box which implements the SMS logic processing and power and analog switching functions necessary to control stores as well as the Suspension and Release Equipment (S&RE) such as BRU-12 parent bomb racks at each station. This one central unit is usually supported by ancillary control/display panels and peculiar interface equipments such as the Navy's AWW4 electrical fuzing power supplies or specialized missile controllers. This central unit is referred to as the Stores Management Control Unit (SMCU) in this report. The SMCU interfaces to other avionic equipment through a mix of discretes, analog and serial interfaces or through an Avionics Multiplex Data Bus (AMUX) as shown in the figure. The SMCU then connects to the MIL-STD-1760 ASI via the aircraft wiring. It should be noted that the SMCU will connect to the existing (non-MIL-STD-1760) station interfaces also shown in the figure.

The second SMS architecture configuration (figure 6b) splits the centralized SMCU into separate units and distributes these units into different aircraft areas. These distributed units are interconnected with a Stores Management Multiplex Bus (SMUX), with a wideband signal network (for video, audio, RF and pulse signals) and with a limited power distribution network. (This architecture is comparable to the current SMS in the F-16 and F-18.) The information and logic processing functions are centralized in a Stores Management Processor (SMP). This SMP provides centralized control of the

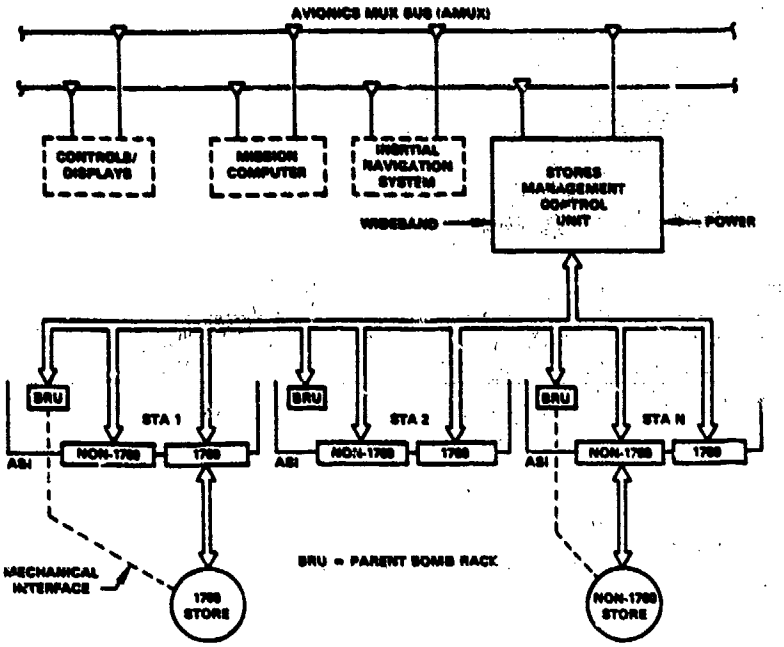


FIGURE 6a. Centralized system.

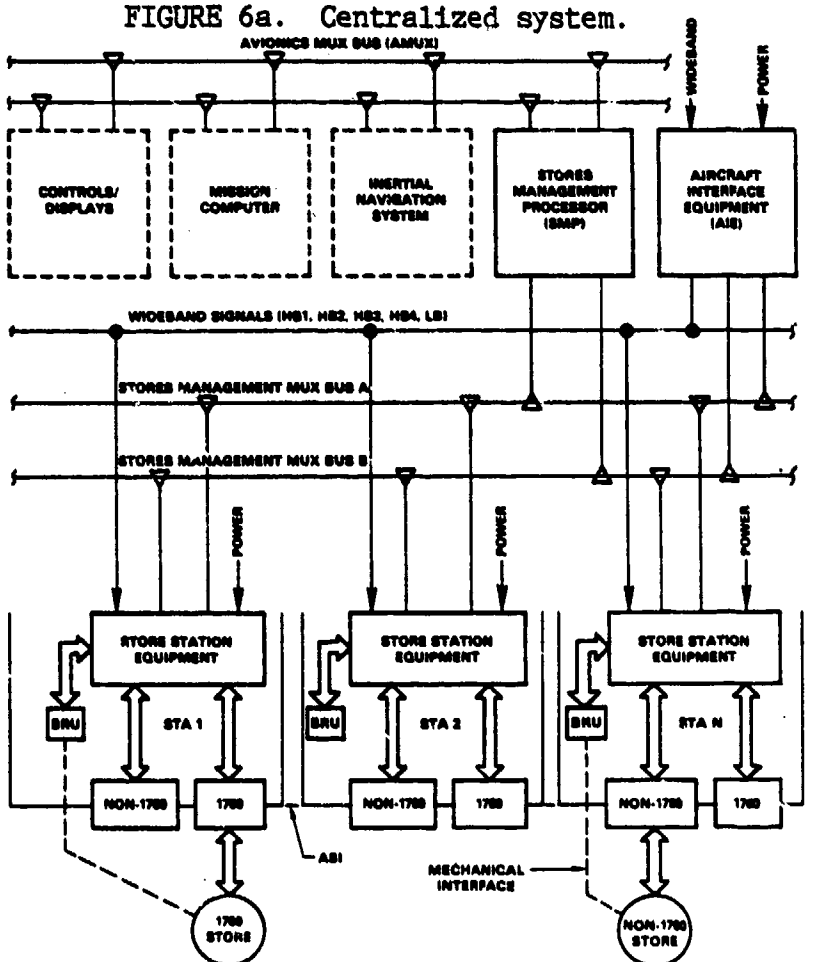


FIGURE 6b. Distributed system.

FIGURE 6. Stores management system architecture.

SMS and all loaded stores. The SMP also provides a centralized interface into the aircraft avionic system (shown in the figure by the connection to the AMUX data bus).

An ancillary box (Aircraft Interface Equipment or AIE) is also shown in figure 6b. The AIE function is to interconnect the wideband signals between aircraft stations and avionic equipments such as cockpit CRT displays. This routing is controlled by the SMP via the SMUX interface to the AIE. The AIE also provides power switching from the aircraft power bus to the store station under SMP/SMUX control.

The last components of the distributed SMS are the Store Station Equipment (SSE) units. (This SSE is referred to as remote interface units on the F-16 and as decoders on the F-18.) The SSE extracts information and control data from the SMUX and converts this data to signals passed to stores through the non-MIL-STD-1760 station interface or through the MIL-STD-1760 ASI as appropriate. As is covered in later sections, the multiplex ports in MIL-STD-1760 ASIs can be connected directly to the SMUX without SSE conversion. The SSE also interfaces with the S&RE (such as a BRU-32 parent bomb rack) to control the mechanical interface. The control of this S&RE interface is a SMS function that is not part of MIL-STD-1760.

As stated previously, other combinations of equipments and SMS function allocations can be derived to implement a SMS in any specific aircraft. The specific equipments described here provide a common reference for technical discussions in the follow-on report sections. Once again, it is emphasized that the above overview of possible architectures is presented not as SMS design recommendations but as an aid to clarifying technical discussions which follow.

For the centralized SMS concept (figure 6a), MIL-STD-1760 can have a significant impact on SMCU design requirements. The AEIS may also increase the number of wires and cables in the wire bundle between the SMCU and station interfaces. This increase, in large part however, is not necessary if shared conductor concepts are used.

For the distributed SMS concept (figure 6b), only secondary impacts are expected on the SMP and AIE units. The extent that the SMP and AIE are affected depends on specific technologies and concepts used in the SSE. The primary impact of the AEIS is on these SSE units. This occurs since the SSE provides the input/output interfaces to the MIL-STD-1760 ASI.

As a point of reference for discussions in later portions of this report, figure 7 illustrates a functional division of a typical SSE. The primary purpose of this figure is to relate the impact of MIL-STD-1760 on the SMS by using the SSE as an example. As a result, the figure emphasizes the AEIs portions of the SSE with only cursory references to other SSE functions such as control of the parent bomb rack and interfaces to non-1760 stores.

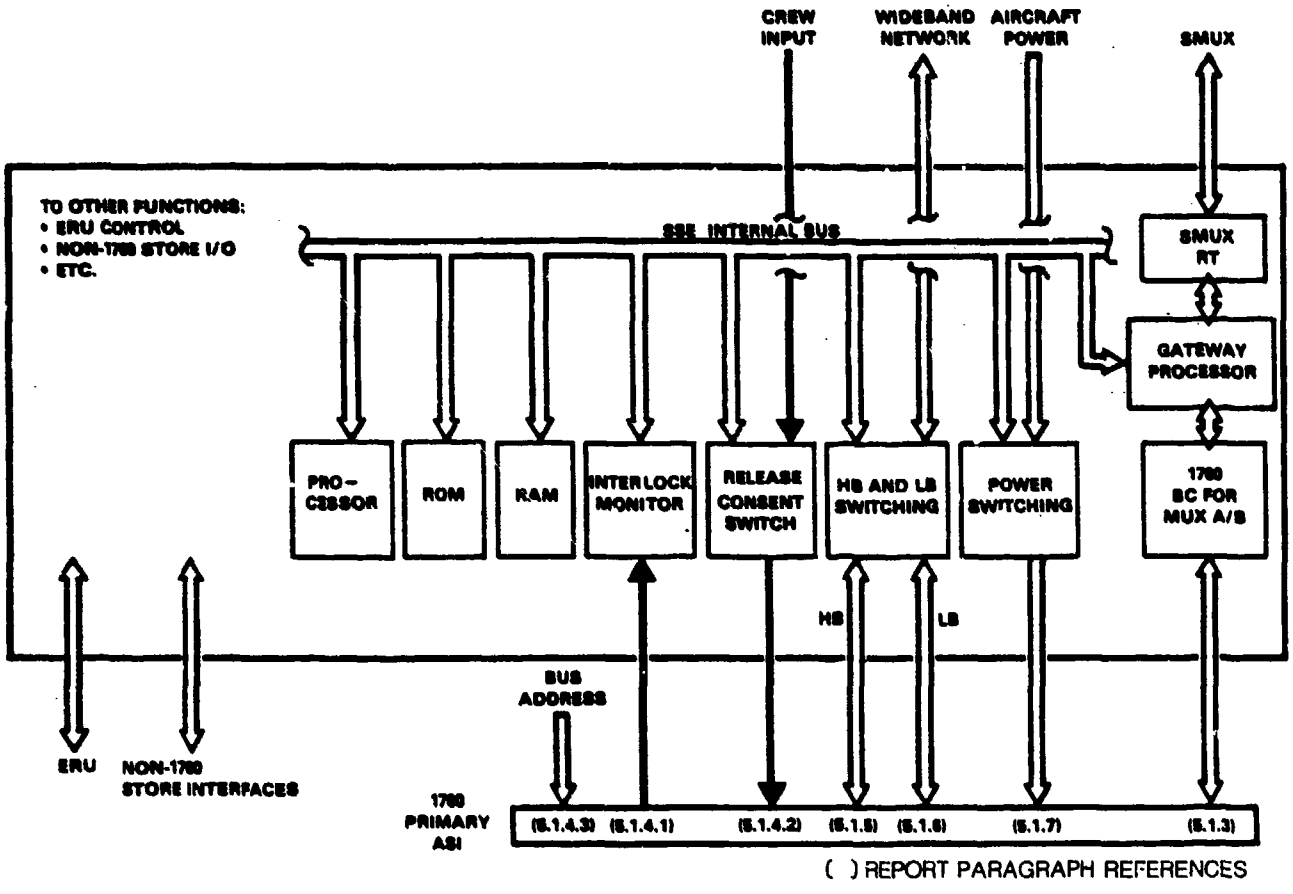


FIGURE 7. Representative SSE configuration.

References to specific sections of this report are shown at the 1760 ASI connector in the figure. As an example, the ASI ports for Mux A and Mux B interfaces are referenced to section 5.1.3 of this report. Details of multiplex data interface considerations for the aircraft are covered in this referenced section. (It is not intended that figure 7 imply tht SSEs should use a gateway or bridge type interconnect between the Stores Management System bus and the Mux A and B ports in the ASI. Such an interconnect is simply shown as an example.) Similarly, the associated bus address interface function is discussed in detail in section 5.1.4.3. This bus address interface may be provided by a hardwired connection at the ASI (as implied in figure 7), by an electronically controlled address interface inside the SSE, or by other means.

Details of considerations for implementing the interlock function are covered in section 5.1.4.1 while release consent requirements are presented in 5.1.4.2. Section 5.1.5 addresses issues and concepts for implementing the High Bandwidth ports of the ASI along with aircraft networking options and technologies. In a similar manner, section 5.1.6 covers networking considerations for the Low Bandwidth interface. (As discussed in these two sections, HB and LB switching functions are not required in the SSE with certain network concepts or may be replaced with electronic multiplexing techniques if other network concepts are selected for the aircraft.) Those issues affecting the power (28V DC, 115/200V AC and 270V DC) interfaces are described in section 5.1.7.

5.1.2 Selection of interface classes for aircraft stations. Several interface classes are defined in MIL-STD-1760 which apply to the ASI. These classes are shown in table I along with the applicable signals. The standard requires the aircraft to provide the full signal capability identified by the designated class. By providing this full capability, a minimum level of service at the ASI is assured for store applications.

As an example, the class II interface listed in table I includes Mux A and Mux B serial digital interfaces; High Bandwidth 1, High Bandwidth 3 and Low Bandwidth signal ports; address, interlock and release consent discretes; and 28V DC power 1, 28V DC power 2, 115/200V AC and structure ground power interfaces. While a mission store is only required to implement those signals of the class II interface needed for store operation, the aircraft is required to implement all of the class II signals to provide this minimum service utility.

Since class IA represents maximum ASI capability, it is desirable for the aircraft to install class IA ASIs at all aircraft stations. From a practical viewpoint, however, this level of capability is not considered as necessary at all stations.

The following comments are presented to provide guidance on the types of applications envisioned for the various interface classes. It must be realized, however, that the services required by certain types of stores discussed below may change in the future.

TABLE I. Interface classes.

SIGNAL TYPE	INTERFACE CLASS			
	I	IA	II	IIA
PRIMARY				
Mux A	E	E	E	E
Mux B	E	E	E	E
High Bandwidth 1	X	X	X	X
High Bandwidth 2	X	X	-	-
High Bandwidth 3	X	X	X	X
High Bandwidth 4	X	X	-	-
Low Bandwidth	X	X	X	X
Fiber Optic Channel 1	X	X	-	-
Fiber Optic Channel 2	X	X	-	-
Release Consent	X	X	X	X
Interlock	M	M	M	M
Address	C	C	C	C
28V DC Power 1	X	X	X	X
28V DC Power 2	X	X	X	X
115/200V AC Power	X	X	X	X
270V DC Power	X	X	-	-
Stucture ground	A	A	A	A
AUXILIARY				
Auxiliary 28V DC	-	X	-	X
Auxiliary 115/200V AC	-	X	-	X
Auxiliary 270V DC	-	X	-	X
Auxiliary Structure Ground	-	A	-	A
Auxiliary Interlock	-	M	-	M

LEGEND

E Aircraft is required to provide capability and except for very special cases, mission store is required to use interface.

X Aircraft is required to provide capability but mission store has option of using or not using signal.

M Mission store is required to provide interface but aircraft has option of monitoring or not monitoring interface.

C Aircraft is required to provide capability and mission store must use interface if the store uses Mux A/B.

A Aircraft and mission store must implement interface.

The class IA interface provides the full primary signal set plus the additional power capacity of the auxiliary power interface. This interface class is primarily envisioned for operating electronic pods with high power and multiple high bandwidth signal requirements. Self-cooled, forward looking infrared pods and Electronic Countermeasure (ECM) pods are representative of this type of store. These pods are expected to be installed on fuselage stations (centerline or cheeks) or on heavy wing stations.

The class IIA interface is applicable to similar stores and aircraft stations. The major difference between class IA and IIA interfaces is that class IIA does not contain HB2 and HB4 ports. As a result, the primary impact of installing class IIA instead of IA is that support for some of the multiple high bandwidth requirements is not available. Typical high power level pods which might require the multiple HB support include ECM pods and target acquisition pods.

A second category of store installations which could require class IA or IIA interfaces is the multiple carriage of "smart" stores on a multiple station ejector rack or multiple station launcher. These multiple carriage installations will, like the electronic pods, tend to be located at the heavy-store stations. The major advantage of providing the auxiliary power interface to these multiple station S&RE is to allow simultaneous powering of all stores on the common S&RE. The simultaneous powering could be needed for environmentally conditioning the stores prior to release. Without the auxiliary power capacity, operational restrictions would likely be imposed on the release sequence of the multiplely loaded mission stores for accommodating sequencial environmental conditioning.

The class I interface provides full primary signal support without the additional power capacity of the auxiliary interface. Use of this class is primarily projected for fuselage or heavy wing stations on those aircraft which lack the power system capacity for supporting class IA. (The power capacity of the auxiliary interface will, in many instances, exceed the unused generator power capacity of many current inventory aircraft.) The class I interface is directed at supporting stores such as low power (less than 4KW) electronic pods, self-powered EMC pods, multiple sensor missiles, or some classes of anti-radiation missiles.

The class II interface covers the minimum primary signal set capability required of the aircraft. This class is directed at air-air stations and the non-heavy air-ground stations. For the near-term, it appears that the majority of aircraft stations will select the class II interface.

Table II summarizes the projected interface capabilities of several current aircraft. As noted in the table, interface classes are identified that most closely match the interface capability projected for different store stations on some models of the aircraft. The table, therefore, only provides a general overview of aircraft interface capabilities and must not be used as design data.

TABLE II. ASI interface classes for representative aircraft*.

AIRCRAFT	CLASS AT STATION NUMBER			
	I	IA	II	IIA
A-6			L,R,1,2,3,4,5	
F-14			1,3,4,5,6,3	
F-15	2,LCFT,5,		2A,2B,3,4,	
	RCFT,8		6,7,8A,8B	
F-16	4,6	3,7	1,2,3A,5,7A,	
			8,9	
F-18			2,3,4,5,6,7,8	
B-52	LWWR RWWR BB			

* This table designates the interface class that most closely matches the projected implementation of MIL-STD-1760 for some models of the identified aircraft. Various models of these current aircraft may not fully implement all aspects of the listed interface class due to retrofit considerations. For example, the high bandwidth networking capability available at an ASI may be less than the standard requires due to limitations of currently designed aircraft. For detail interface capabilities on specific aircraft, contact the cognizant organization such as the appropriate Air Force System Program Office, Navy Class Desk or weapons integration/systems engineering office (e.g., AD/ENSI, ASD/ENASF, NWC Code 3144, NADC Code 6012, etc.).

Abbreviations

LCFT - Left conformal fuel tank
RCFT - Right conformal fuel tank
LWWR - Left wing weapons rail
RWWR - Right wing weapons rail
BB - Interface in bomb bay rotary launcher. (Launcher not 1760.)

The various aircraft station interface classes have specific compatibility relationships to potential MSIs. These relationships are shown in table III. As covered in Section 5.2.1 of this report, MSIs are defined as class X compatible, where X can be IA, II, or IIA. While the ASI is not permitted to implement a subset of an interface class, the MSI is permitted to subset. This occurs because the MSI (as a service user) may incorporate only those interface signals needed. The MSI is not required to use all available interface services. As a result, the MSI can select a "subset" from any of the interface classes. (See Section 5.2.1 and 5.2.10 for MSI subsetting guidelines.)

Section 5.3 covers the aircraft interconnection for various ABIS class compatible stores to a common store station interface set. This interconnection is normally achieved with an umbilical cable.

TABLE III. MSI class compatibility.

MSI CLASS	IS COMPATIBLE WITH ASI CLASS:			
	IA	I	IIA	II
IA	X			
I	X	X		
IIA	X		X	
II	X	X	X	X

5.1.3 MIL-STD-1553 digital data bus. The application of MIL-STD-1553 to the electrical interface between aircraft and stores results in several peculiar design issues not directly addressed by the MIL-HDBK-1553 Multiplex Applications Handbook. These issues include the reconfiguration of the multiplex data bus in the aircraft (see figure 8). This reconfiguration results from different store loadouts for different missions and from periodic removal of remote terminals from the network as a direct result of store release during a mission. Other issues include: (1) Concerns about "open data bus stubs" and how these unterminated stubs affect waveform quality from both reflections and electromagnetic interference susceptability perspectives; (2) uncertainties on the impact of harsh store station environments on multiplex data link performance; and (3) unfamiliarity with the need to impose data link electrical characteristic requirements at an interface breakpoint (i.e. ASI and MSI) that is different than the control point (i.e. remote terminal interface) defined in MIL-STD-1553. The purpose of this section of this report is to supplement

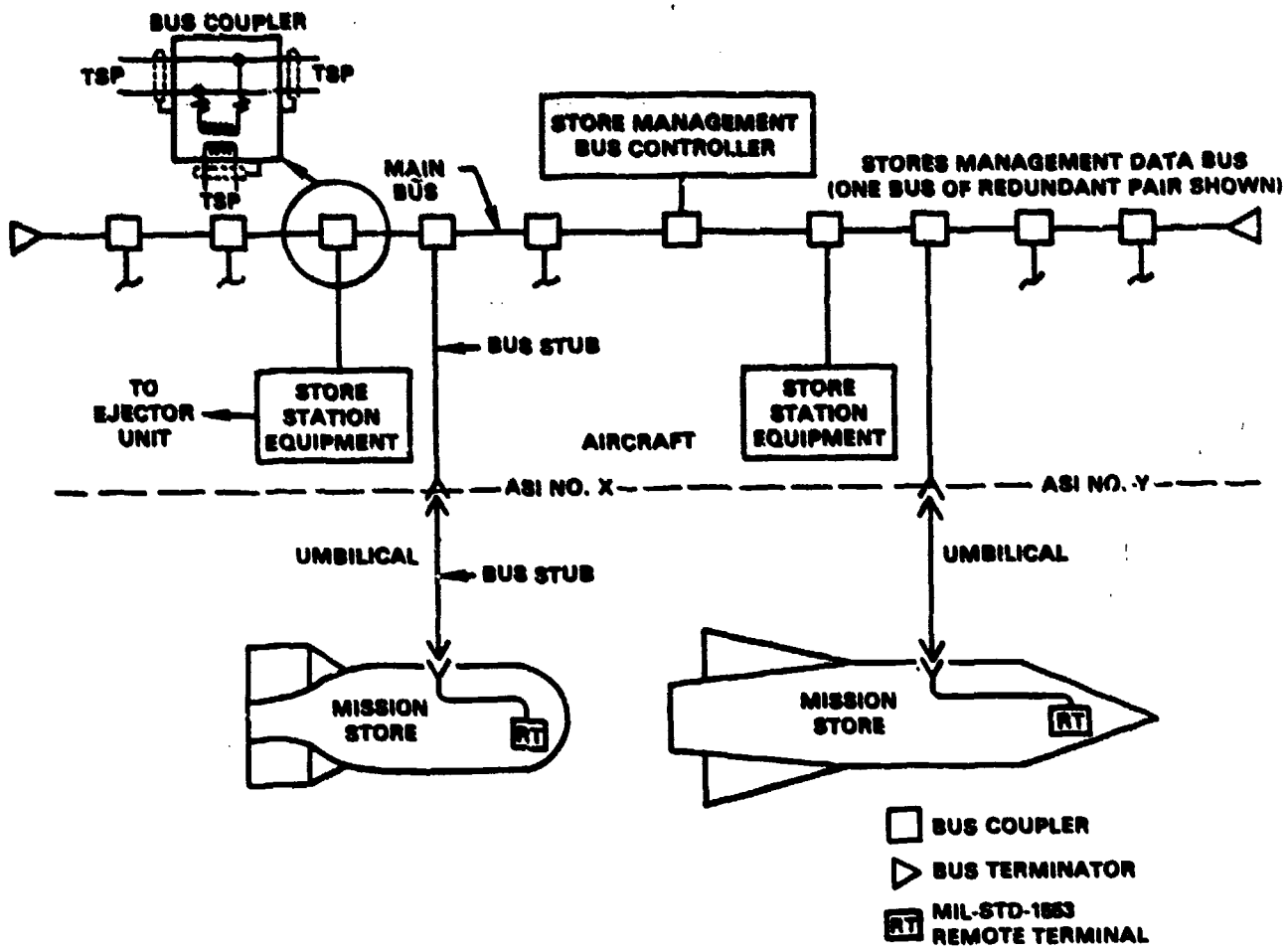


FIGURE 8. Basic network configuration.

information in MIL-HDBK-1553 for those aircraft design issues which are unique to MIL-STD-1760. This section is not intended to replace or conflict with design issue discussions contained in MIL-HDBK-1553.

5.1.3.1 Overview of digital serial multiplex data bus applications to AEIS. Prior to MIL-STD-1760, the application of MIL-STD-1553 in avionics systems has been primarily in fixed network configurations. These applications include a fixed number of terminals, each connected to the main bus through fixed length stubs. As shown in table IV, the AEIS application of MIL-STD-1553 implies a variable data bus network. The impact of these bus variations are discussed in paragraphs which follow.

All classes of ASIs are required by MIL-STD-1760 to include a set of redundant MIL-STD-1553B (1553) data bus stubs (Mux A and Mux B). The type of 1553 stubs required are transformer coupled stubs as opposed to direct coupled stubs also allowed by MIL-STD-1553. These redundant stubs provide interconnection paths between the aircraft Stores Management System (SMS) and the store electronics for the transfer of serial digital data between these equipments. Except for some additional requirements, (which are discussed in this report), the Mux A and Mux B ports are defined around the terminal requirements of MIL-STD-1553.

The stores management bus network is defined (for purposes of this report) as that collection of hardware which allows MIL-STD-1553 formatted messages to be transferred between aircraft equipment and stores and from one store to another store via the aircraft. There are numerous arrangements of equipments and components which are practical network configurations. Figure 8 represents the most basic network configuration. This configuration allows most of the bus components to be located within the aircraft. In the general case, only a MIL-STD-1553 transformer coupled stub from the main bus penetrates the skin of the aircraft for interconnection to a remote terminal in a mission store. The only case where larger portions of the bus network are external to the aircraft is when a hierarchical architectured carriage store is inserted between the aircraft and mission store(s). (See figure 9.) However, even in the figure 9 configuration, it can be argued that the second level bus in the carriage store - while functionally part of the stores management bus - is an electrically isolated "independent" bus and not an extension or part of the bus in the aircraft. This position of electrical isolation is used in this report since the primary issues being discussed are the impact of ASI loading and environmental conditions on the interface electrical characteristics. The fact that other equipments may be functionally interconnected (but electrically isolated) does not change this discussion.

To further refine term definitions, a distinction is made between stores management bus network, main bus and bus stub. As defined above, the stores management bus network includes all components and equipment which form the multiplexed data link "network". The term "main bus" or "bus" is used to refer to the components and equipment on the "aircraft side" of the MIL-STD-1553 bus coupler (including the coupler). The term "bus stub' or

TABLE IV. Application comparison table.

NETWORK CHARACTERISTICS	AVIONIC APPLICATIONS	MIL-STD-1760 APPLICATIONS
Number and placement of stubs, length of main bus	Fixed by design	Fixed by design
Number of terminals	Generally fixed	Function of mission loadout and release
Stub length	Fixed by design	Function of store mated at ASI
Open stubs	Limited	Normal operation: o Loadout variations o Store release

"stub" refers to the portion of the network which crosses the MIL-STD-1760 interfaces (ASI, MSI, CSI and CSSI). In the general case, the stub consists of those components between the MIL-STD-1553 bus coupler (in the aircraft) and the MIL-STD-1553 remote terminal (in the store).

Since MIL-STD-1760 only defines MIL-STD-1553 stub characteristics as measured at the ASI and MSI, a number of bus architectures is permitted to supply these characteristics. Figure 8 illustrates one architecture that represents a basic bus design. Figure 10 and 11 show two additional architectures that are also permitted. The important aspect that must be understood is that MIL-STD-1760 does not require any specific stores management system or avionics bus network configuration in the aircraft. Any conventional or inovative design for the circuitry on the aircraft side of the ASI is allowed provided that the multiplex bus stub signal characteristics measurable at the ASI (and defined in MIL-STD-1760) are provided.

With that disclaimer, a few points on the basic network configuration of figure 8 are presented. First, for aircraft with removable pylons and other types of S&RE adapters, the data bus couplers shown in figure 8 should be installed on the aircraft side of the pylon-to-main aircraft structure interface. If the coupler is installed in the pylon, then the Main Bus must loop into and then back out of the pylon in order to connect to the

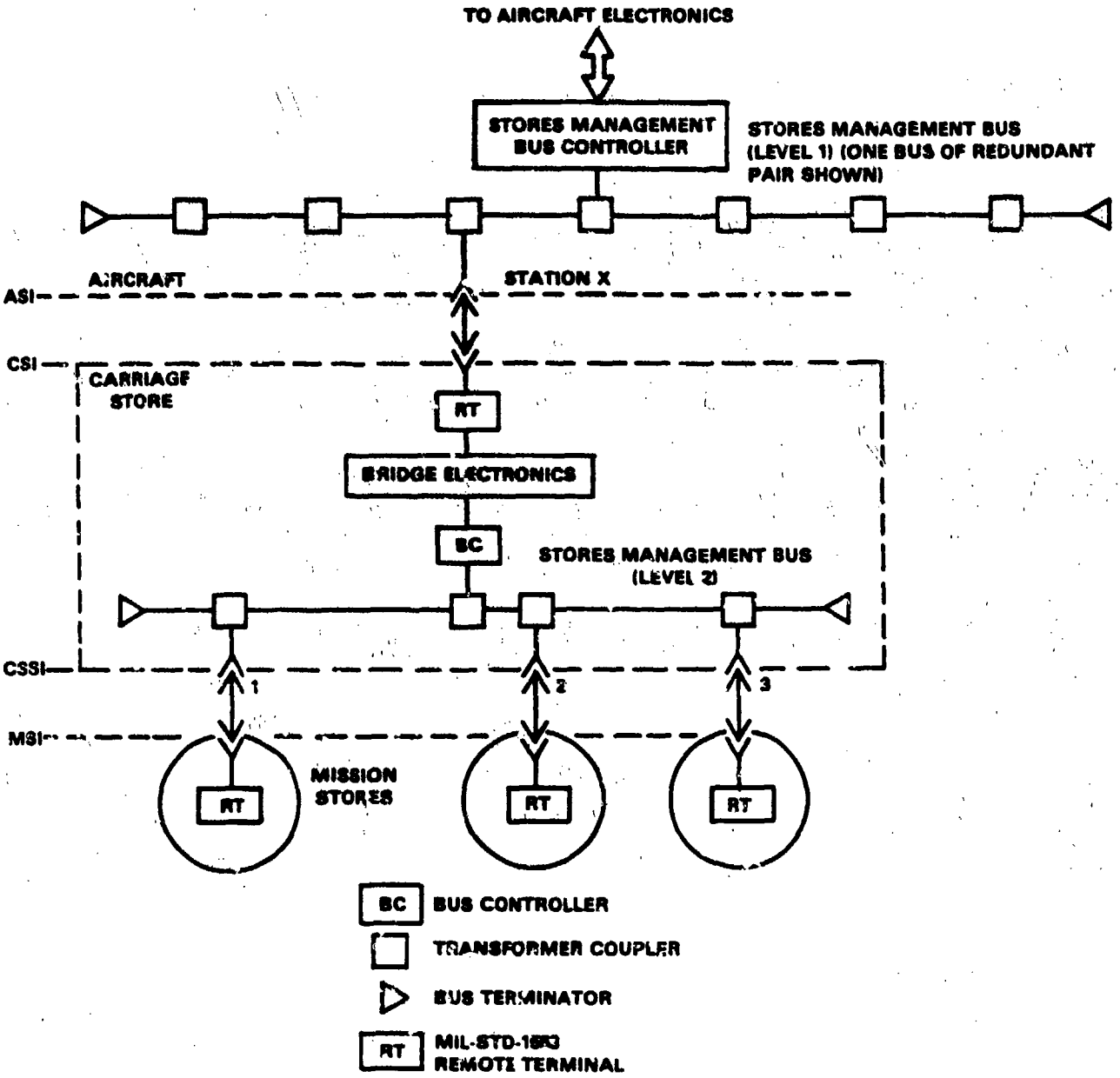


FIGURE 9. Hierarchical carriage store bus configuration.

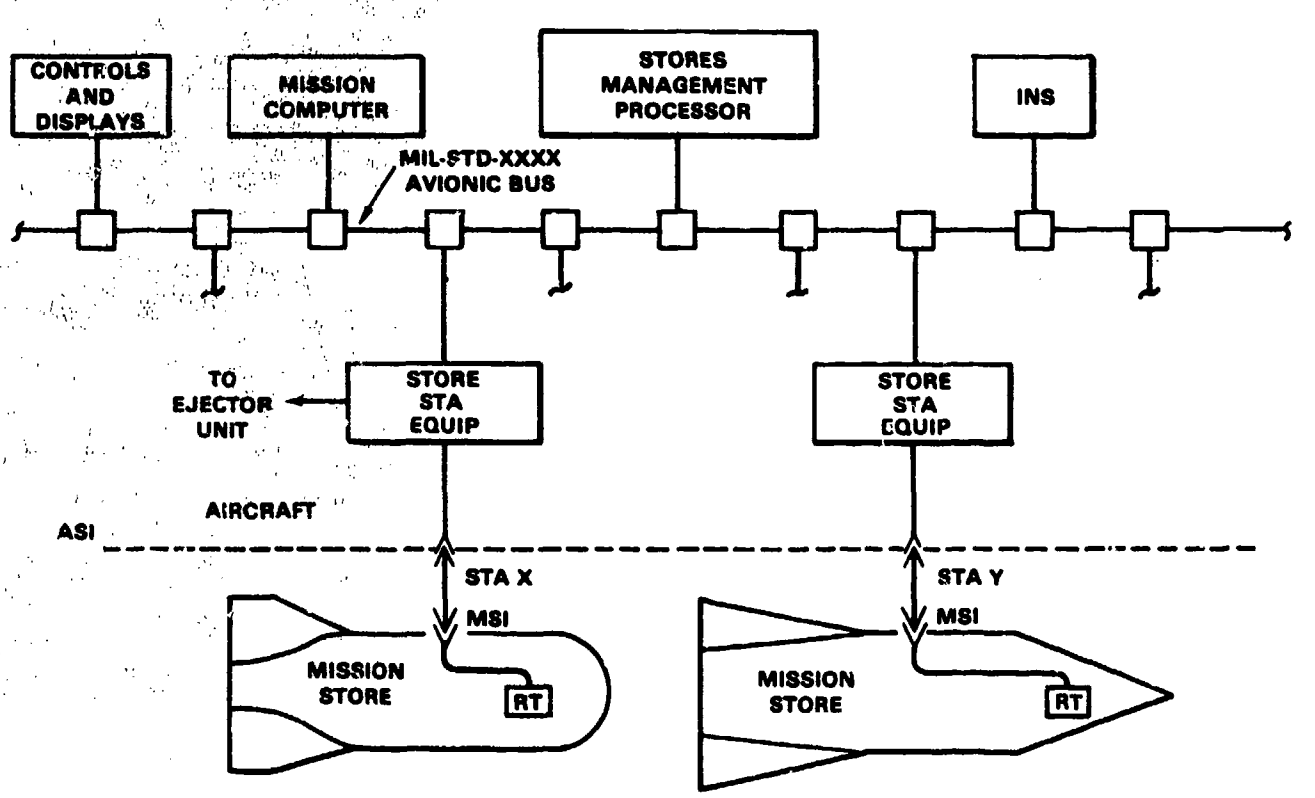


FIGURE 10. Multiplex network configuration - alternate 1.

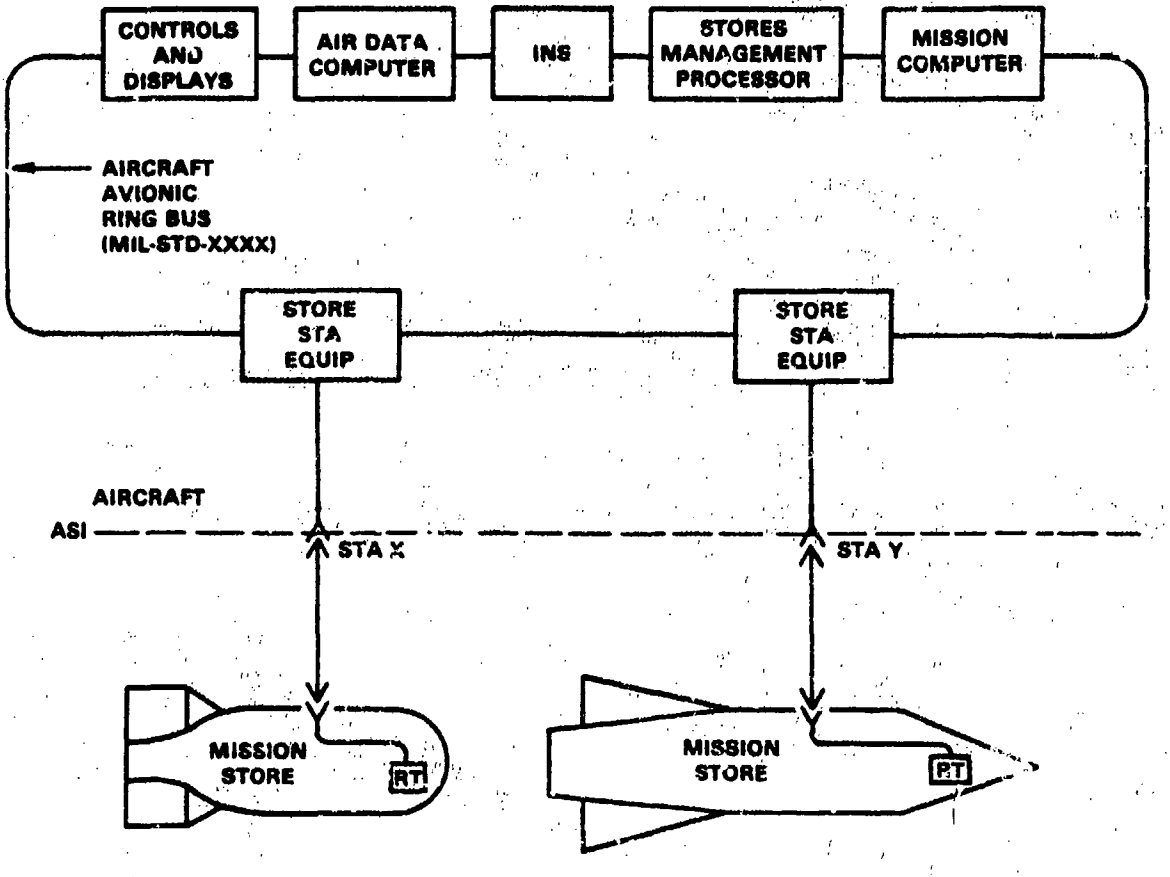


FIGURE 11. Multiplex network configuration - alternate 2.

coupler. If the pylon is removed, the Main Bus is "broken" or "cut" at the pylon-main aircraft structure interface and communication with any terminals downstream of the break is no longer possible. Potential alternatives around looping the bus through the pylon are discussed in 5.1.3.5.4. In addition to eliminating the "cut" bus problem, locating the bus coupler on the aircraft side of the pylon-aircraft structure interface increases the bus reliability, reduces main bus exposure to external EMR fields and improves bus survivability. The disadvantages with this coupler location are primarily twofold. First, the "aircraft side of the pylon" is generally the wing and wings on current tactical aircraft are not noted for excessive space for coupler installations. Second, locating the coupler deeper into the aircraft results in longer bus stubs. The impact of stub length is discussed in 5.1.3.3.

The second point to note on the basic network configuration of figure 8 is that a portion of the bus stub along with the AEIS interfaces which the stub passes through are exposed to external environments. The primary stub exposure is in the section of the bus stub contained in any umbilical cable used to connect the ASI to MSI. This cable should contain a good quality gross shield to maintain total 360 degree shield coverage of the AEIS cabling once it leaves the protective shield of the aircraft. Without this gross shielding on the umbilical, it is very difficult for the aircraft and store to operate successfully in the expected high EMR environments. A second advantage of the umbilical gross shield is that the metallic shield tends to provide additional mechanical protection to the cable. This protection improves the odds that the cable will not be damaged (such as line-line short circuits) as a result of store separation. (The shield, however, provides no protection to the connector mating surface from damage due to rocket motor blasts, salt fog, moisture, etc.) (See 5.1.3.3, 5.1.3.4 and 5.1.3.5 for additional details.)

5.1.3.2 Data communications and system control. The intent of the AEIS standard is to rely on the MIL-STD-1553 network as the basic communication media between aircraft and store. In time, this reliance may transition from 1553 to some other high(er) speed data bus communication standard (such as a fiber optic based system). For the immediate future, however, a need for a higher data rate communication support is not expected for store applications. In addition, some concerns already exist in the store community that the cost for a 1553 based store interface may be too high relative to the total store cost or to the cost of the store electronics. (See 4.3.3.) Requiring installation of a higher cost high speed data bus terminal in the store would reinforce this concern - particularly if the store does not require the higher data rate support.

A second and significant advantage for using the 1553 interface as a common communication and control interface is to simplify establishing initial store communication. By providing one common communication interface, the aircraft system avoids having to "search" through various possible communication channels in order to initialize the store. The aircraft instead only needs to power-up the store and then send interrogation

commands to the store via the serial 1553 port. This "initialization" procedure is covered in Notice 2 (24 October 1986) to MIL-STD-1760A.

5.1.3.2.1 Communication roles. The AEIS standard identifies the baseline roles for the aircraft and store in the digital communication network. The standard requires that the aircraft "be responsible for the bus controller function" of 1553. The intent here is to remove any implication that might exist through 1553 or through available terminal hardware that the store is expected to provide a bus controller capability. As a general case, the AEIS standard is interpreted to require that the bus controller of the AEIS data bus be a permanent equipment of the aircraft. There are Stores Management System configuration possibilities (that are periodically considered by aircraft system houses) in which the SMS bus controller can be in a detachable electronic pod connected to a store station. However, this pod is generally considered to be a unique electronic system designed for that specific aircraft. The complications resulting from trying to integrate a multi-aircraft compatible electronic pod into an SMS when the electronic pod is expected to continuously (or even for short time windows) take over the aircraft's SMS bus control is expected to preclude any general purpose store from being a bus controller.

As a result, the general system configuration expected calls for the aircraft to supply the bus controller (BC) terminal functions defined by MIL-STD-1553. In addition to this BC function, the aircraft will generally also contain a number of equipments connected to the data bus which contain 1553 remote terminals (RT). Examples of some of these RT based equipments are shown in figure 8. (The Store Station Equipment shown in the figure typically includes RT functions.) As a result, the assignment of bus controller function to the aircraft also allows RT functions on the aircraft side of the ASI in addition to the BC function.

In its responsibility as a bus controller, the aircraft is required to control all communications through the ASI interfaces. This communication includes information transfer between a store and the aircraft and between stores connected to the aircraft. The mode used for store-store communication can be dependent on the aircraft SMS architecture. The most obvious store-store communication mode is the remote terminal-to-remote terminal (RT-RT) information transfer format of MIL-STD-1553. However, aircraft architectures similier to those shown in figures 10 and 11 do not directly support the RT-RT transfer mode. To achieve the effect of a store-store data transfer in one of these system architectures essentially requires a two step transfer. An RT-BC transfer is required through one ASI followed by a BC-RT transfer at the second ASI. While this two step process has several disadvantages such as increased data latency and additional data "handling" by the bus controller, it does offer two advantages. First, as implied above, the two step process allows a higher level of architecture design flexibility. Second, the two step data transfer allows "decoupling" the message formatting, data word formatting and message rate requirements of the two stores. Unless the two stores are designed as an operating pair

(or one store designed specifically to operate with the second store), the probability that the data in a transmit message of one store is compatible with the data in a receive message of the second store is very small. Decoupling these two stores by a RT-BC, reformat, BC-RT transaction simplifies integration provided that the increased data latency is still acceptable.

5.1.3.2.2 Addressing modes. MIL-STD-1553 identifies two basic modes for addressing information and commands to a remote terminal. The first addressing mode relies on each remote terminal connected to a data bus being assigned a unique five bit binary address. The command word transmitted by the bus controller contains a five bit address field to designate the specific RT to which the message is directed. To support this addressing mode, MIL-STD-1760 interfaces include a set of address discretes (see 5.1.4.3) for assigning addresses to each store connected to the aircraft. This assigned address is referred to as "bus unique" address. This term is used because all that is required is for the combination of SMS architecture and ASI address assignments be such that stores connected to the different ASIs on the aircraft can distinguish between commands directed to them versus commands directed to other stores. This means, for example, that the addresses at the two ASIs shown in figure 10 can have the same RT address provided the SSE between the ASI and the avionics bus blocks out messages directed to other ASIs. In this way, the store connected to ASI No. X would not see commands directed to ASI No. Y even if X and Y are assigned the same RT address.

The second mode defined by MIL-STD-1553 is the "broadcast" mode. The RT address of 31 is designated by MIL-STD-1553 as a broadcast command indicator. The multiplex standard does not specifically require remote terminals to accept "broadcasted" messages. In fact, Notice 1 to MIL-STD-1553B disallows the use of broadcast for Air Force applications. This broadcast prohibition is loosened some by Notice 2 to MIL-STD-1553B. The second notice allows the broadcast of mode commands to terminals but disallows other receive messages. This second notice applies to equipment for all military services. Since the debate on broadcast continues and since the implementation of broadcast is an RT option, MIL-STD-1760 remains neutral on the subject. The forthcoming notice to MIL-STD-1760 to add the communication protocol requirements will resolve the broadcast issue - at least as it applies to MIL-STD-1760 equipment.

5.1.3.2.3 Subaddress restrictions. The AEIS standard includes a limitation that a specific subaddress can only be used for nuclear weapon applications. MIL-STD-1760A assigns subaddress 7 for this nuclear application. Notice 2 against Revision A, changes this reserved subaddress from 7 to 19 to minimize the impact on existing aircraft bus systems. (In addition, subaddress 27 was also assigned to nuclear weapons by Notice 2.) The need for this subaddress change was generated after industry recognized the impact of the restriction.

This restriction is included in MIL-STD-1760A to provide "protected" subaddresses for MIL-STD-1553 messages used to control nuclear warheads. Given that multiple RTs can be connected to a common data bus along with a nuclear warheaded weapon, a safety concern arose in the nuclear community. In simple terms, this concern was that messages directed to non-nuclear equipment might corrupt into a misdirected message to a nuclear warhead. To increase the protection from misdirected messages (where destination is determined strictly by a 5 bit address field), two subaddresses are set aside for use only by nuclear warheads. (A nuclear warhead can also use other subaddresses.)

When this restriction is applied to aircraft, it could impact aircraft avionic equipments as well as non-nuclear stores. This avionic impact would occur if the bus architecture selected for a specific aircraft resulted in stores and non-SMS avionic subsystems (e.g. inertial navigation, mission computer, communication) being mixed onto a common bus. This mixing of avionics and stores on a common bus is most likely to occur in retrofitting MIL-STD-1760 into less sophisticated aircraft and helicopters. However, significant nuclear certification compliexities (particularly with software revisions) could result if nuclear stores are installed on avionic buses.

As a result of this AEIS restriction potentially rippling up into the aircraft avionics, the reserved subaddress was moved from 7 to 19. By moving the restricted subaddress to a higher subaddress, the impact on existing fielded systems can be minimized.

One further point is that this subaddress restriction is not an outright ban of subaddress 19 and 27 for all MIL-STD-1553 applications. The restriction only applies to non-nuclear equipments if its 1553 commands are detectable at an ASI. For example, the architecture of figure 10 allows equipment on the avionics bus to use subaddress 19 for non-nuclear functions since these avionic bus messages (and the associated subaddresses) are not "visible" at the ASIs. For this reason, the subaddress restriction, while significant for some architectures, is very minor for most SMS/AEIS applications.

5.1.3.2.4 Communication redundancy. MIL-STD-1553 defines multiplex terminal requirements for a single data port. However, the standard also identifies requirements for applications which need a redundant data port. (This redundancy is not mandated by 1553 on terminals.) For these redundant port applications, MIL-STD-1553 specifies that bus system operation will be in a dual standby mode as described in the standard. Since MIL-STD-1760 represents a specific application of 1553, the AEIS standard specifically requires this dual standby redundant operation. This redundancy is required at the ASIs to minimize the impact of single event failures. This redundancy was considered particularly prudent given the destructive capability of the RT based equipments (missiles, etc.) connected to the bus. The external exposure of the data bus stubs and potential stub damage following store release also contributed to the need for redundancy. As

with other requirements imposed by MIL-STD-1760, all that is being levied on the aircraft is that digital data multiplex functions "visible" at the ASIs meet the redundancy requirements i.e., Mux A and Mux B ports are supplied at each ASI and operate in the dual standby redundant mode. The level of redundancy and system operation internal of the aircraft is not directly specified by MIL-STD-1760. For example, the internal bus structure of figure 11 can be transparent to Mux A/B operations detectable at the ASI.

5.1.3.3 Network reconfiguration. One of the application issues introduced in an earlier section dealt with reconfiguration of the aircraft bus network as a function of store loadout. This reconfiguration occurs in three ways. First, when different stores are connected to the aircraft store stations, the total bus stub lengths vary. This variation is due primarily to the different lengths of cable internal to the different stores (between the MSI and the store remote terminal). A secondary contributor to the length variation results from the possibility that umbilical cables of different lengths are used to interconnect the ASI to the MSI for different stores. Variations in stub length can influence: (1) The effective bus loading, (2) the waveform distortion due to reflections and time-of-arrival of these reflections, and (3) the attenuation of signals traveling through the bus network.

An additional reconfiguration issue results when the stores are released from the aircraft. This release operation effectively results in an instantaneous shortening of the associated bus stub and loss of stub termination. The third contributor to bus network reconfiguration is a variation on the release operation. This results from the variations in the total store loadout selected for specific missions. With various mission loadouts, stores (i.e. loads) may be connected to some stations while other stations remain unloaded. The net result is that variations in stub lengths and variations in the number of stubs loaded with terminals must be considered by the aircraft bus network designer during initial design and during redesign (for adding more equipment to the bus).

The network variation considerations for both bus reflections and load changes are expanded in the paragraphs below.

5.1.3.3.1 Bus reflections. The component (cable, coupler and remote terminal) characteristics defined by MIL-STD-1553 result in a bus network which is a highly mismatched and lossy transmission line system. (For example, data bus stubs are required to use 77 ohm (nominal) twinaxial cable but are terminated into 1000 ohm (minimum) remote terminal input impedances.) This mismatched and lossy network was intentionally selected by MIL-STD-1553 to minimize, and to some extent stablize the loading of terminal transmitters.

The large mismatch at the RT-to-stub interface results in some of the signal energy being reflected back up the stub to recombine with the signal on the

main bus. The lossy transformer coupler reduces the load on the main bus by the connected terminal. As a result, very little of the bus signal energy is drained by each terminal and the load seen by a terminal can be maintained at a "relatively constant" level independent of the number of terminals connected to the bus. In addition to impedance mismatches at the terminal end of a stub, the connection of a coupler to the main bus also results in a mismatch. One disadvantage of this mismatched transmission line is that a large percentage of the power transmitted from a terminal (or reflected from the terminal interface) is dissippated in the transformer data bus coupler. A second disadvantage of the mismatched network is that the waveforms on the bus (and ultimately delivered to a terminal) are distorted by the reflections from the terminal and the coupler. One aspect then of the stub length variations is that the time-of-arrival of these reflections is dependent on stub length. Figure 12 shows the magnitude of typical bus reflections from a data bus coupler. For illustration purposes, the reflections in the figure were generated with a very fast (relative to MIL-STD-1553) rise time and short duration pulse. (By using these high speed, narrow pulses, the different components of the reflection can be seen.) The negative going reflection at point A is due to the data bus coupler itself with its connected 77 ohm twinaxial cable. The positive pulse at point B is a result of the reflection returning to the main bus from the remote terminal at the end of a stub. (In this particular test case, the cable between the coupler and remote terminal is approximately 17 feet long.) The magnitude of this return pulse is however smaller than the initial (negative) reflection. As a result, superimposing these reflections on a step input (see figure 13) yields loss of signal amplitude at point A and partial recovery at point B. The result however, is a net signal loss of 1.8 percent (nominal) by the coupler on a steady state basis.

Even though, on a steady state basis, the net signal loss is low, the difference in time distribution of the two reflections, (negative and positive) results in waveform distortion. The length of the data bus stub determines the time lapse between onset of the first negative reflection (which is nominally -12.5 percent of the incident wave) and the onset of the second positive reflection (nominally +10.7 percent of the incident wave). Based on a typical propagation delay for twinaxial cable (.67 feet per nanosecond) the time lapse between pulses is roughly 3 nanosecond per foot of stub length.

While the time lapse between the negative and positive pulses is dependent on stub length, the time of onset of the negative reflection relative to the original signal is dependent on the location on the main bus where the waveforms are measured. For this reason, the time that the reflection pair appears on the original signal is determined by the main bus cable length from point of measurement to the coupler and by the 3 nanoseconds per foot (round trip) propagation delay.

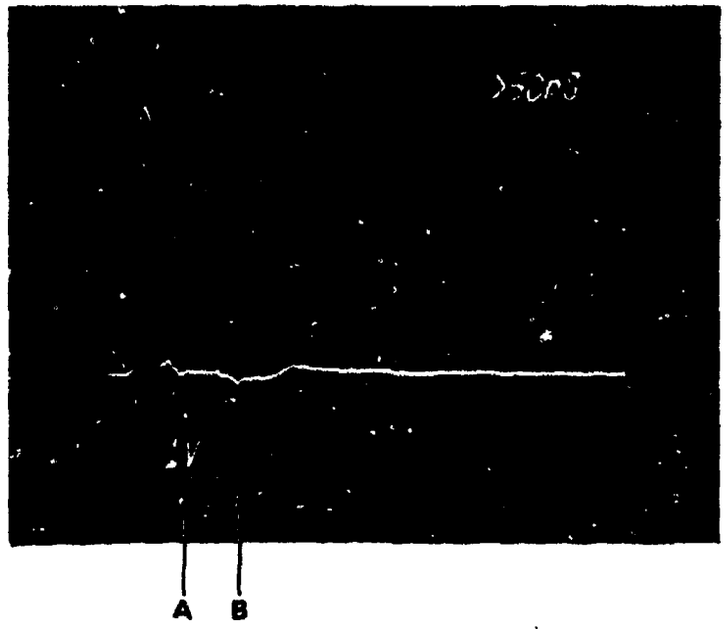


FIGURE 12. Reflections from pulsed coupler.

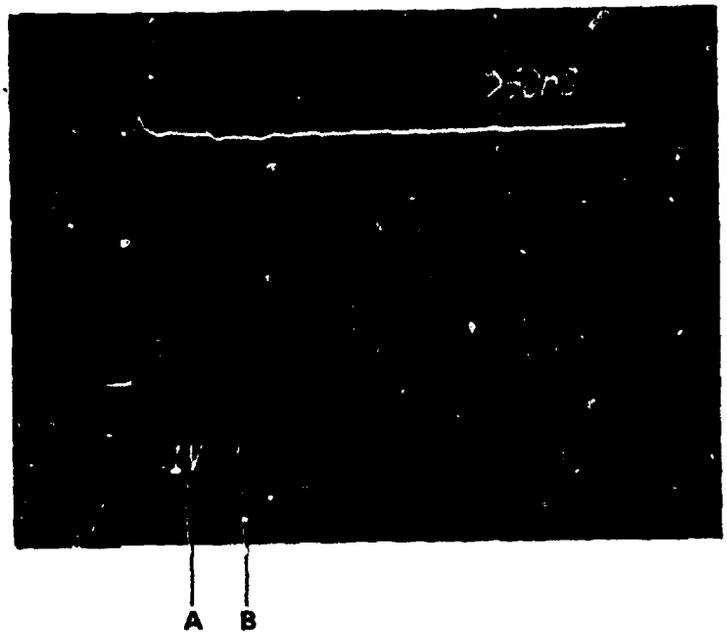


FIGURE 13. Superimposed reflections for coupler.

Figure 14 shows the top half of a (simulated) normalized trapezoidal waveform that is distorted by an ideal bus coupler terminated with a 20 foot stub. An undistorted trapezoidal signal is also superimposed in the plot. This figure illustrates the waveform as it appears 10 feet in front of the coupler. Note the three types of signal distortion. First, the leading edge is shifted relative to the trailing edge. This affects the perceived "zero crossing deviation" addressed by MIL-STD-1553. Second, a "dip" appears at the top of the waveform on the leading edge side resulting in a delay until the maximum signal amplitude is achieved. Third, the peak distorted signal does not reach the full magnitude of the original incident wave, i.e., part of the signal is lost on a steady-state basis.

Figure 15 depicts the same waveform 67 feet in front of the coupler. The difference between these two waveforms is that the negative "dip" in the trapezoidal waveform is moved out of the leading edge of the trapezoid. This results in a lower zero crossing distortion but a wider dip in the "flat" area of the trapezoidal signal. Figure 16 shows the same 67 foot measurement point but with the stub length increased to 40 feet. As can be seen in this figure, the long stub length has the effect of increasing the measured dip in the trapesoid. On a nominal basis, the largest magnitude of this negative dip is 12.5 percent of the incident wave. Based on component tolerances allowed by MIL-STD-1553, the worst case dip is approximately 15 percent of the incident wave. Unless the magnitude of the signal is approaching the receiver thresholds, this worst case dip in signal amplitude should be unnoticed by the RTs' transceiver. Figure 17 shows that by moving further away from the coupler, the reflection can be delayed to be 180 degrees out of phase. This results in a waveform overshoot rather than the negative dip. (In reality, due to cable losses at these long distances, the overshoot isn't as significant as shown in the figure. The point, however, is that at some distances an apparent overshoot can occur in the trapezoidal wave.)

To summarize the simple case of a single data bus coupler, the waveform distortions on the bus are influenced by the distance between the bus location of interest (e.g. where another coupler might be located) and the next data bus coupler. The waveform distortions are also affected by the stub length. The primary influence of the stub length is that length determines the time that the "re-enforcing" wave will return to the bus to increase the signal magnitude. This stub length in combination with the distance to the coupler also affects the reflection induced zero crossing deviation. The worst case deviation is dependent on the detection thresholds set in the RT receiver as well as the magnitude of the RT input signal. Figure 18 shows the waveform conditions which can lead to a worst case distortion. This waveform occurs very close to a coupler with an extremely long stub. (The 67 feet stub length shown is hopefully unrealistically long but, was selected to move the RT reflected wave away from the signal leading edge.)

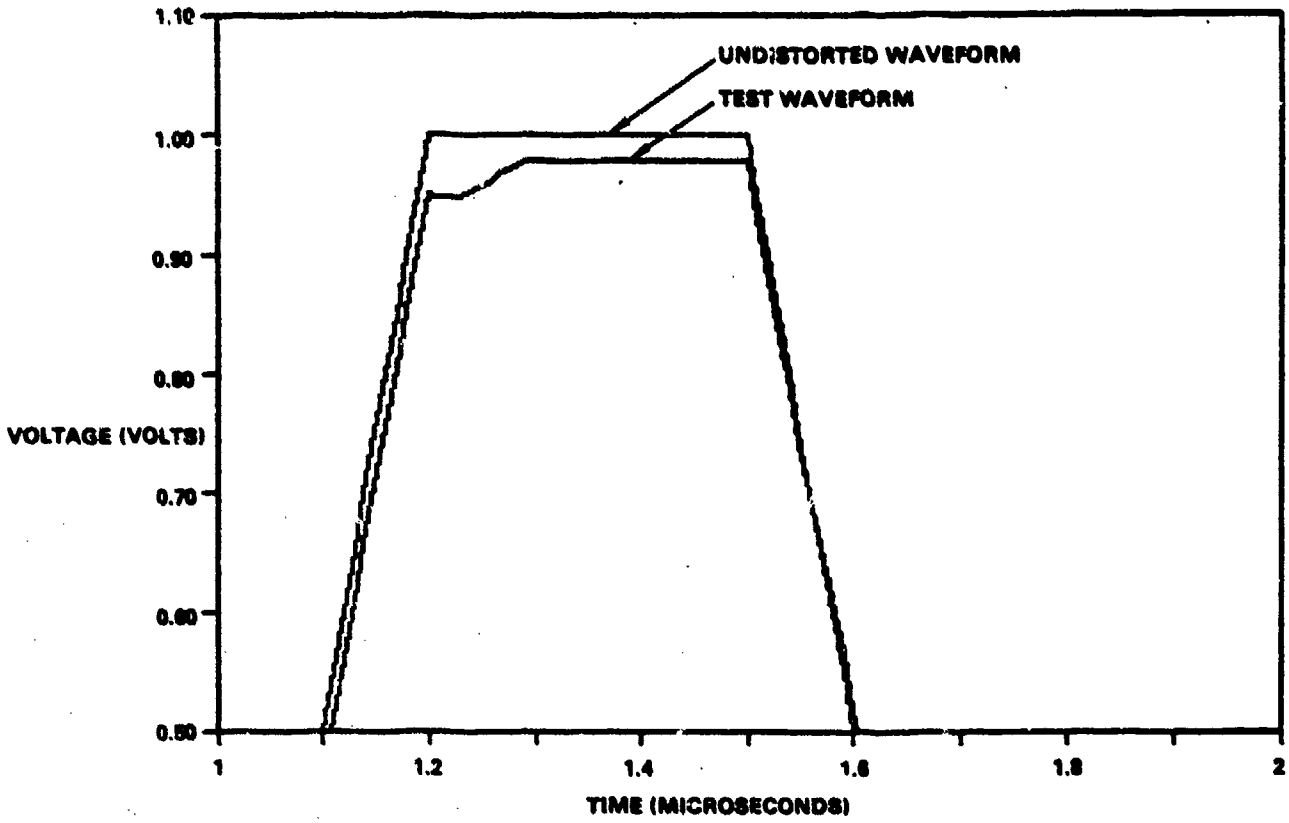


FIGURE 14a. Test waveform.

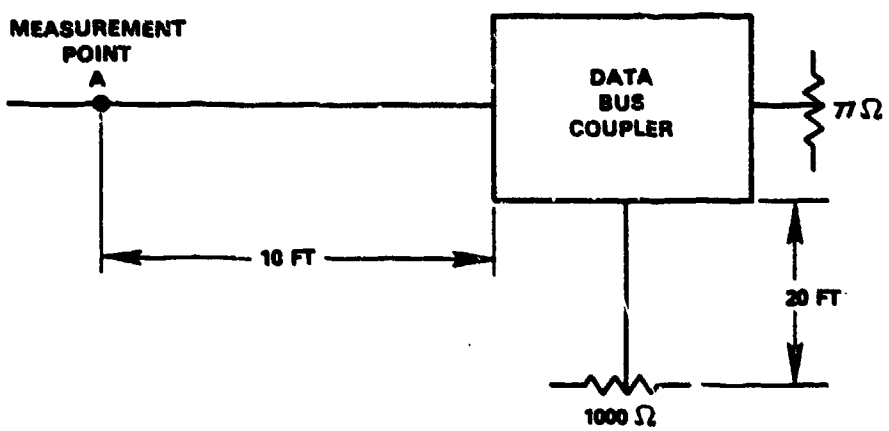


FIGURE 14b. Test set-up.

FIGURE 14. Waveform at 10 feet from data bus coupler.

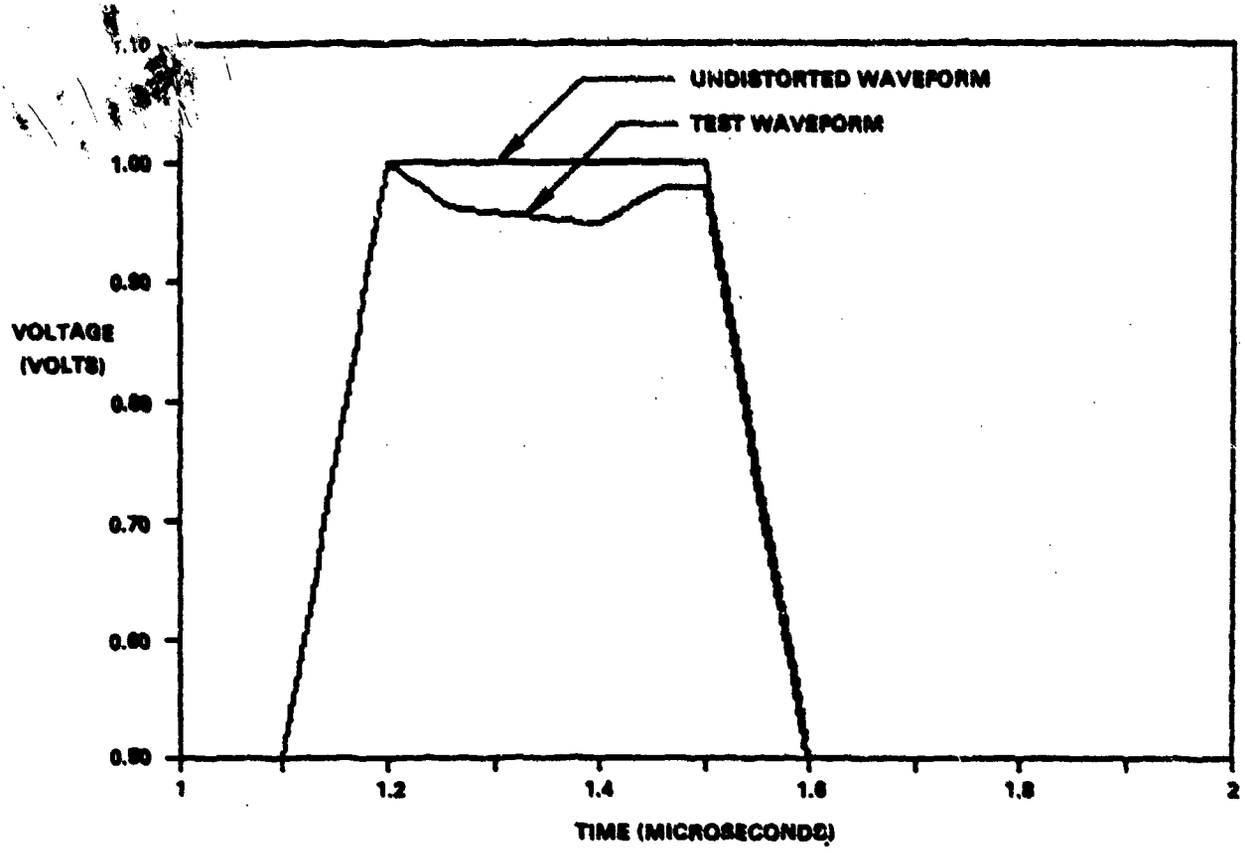


FIGURE 15a. Test waveform.

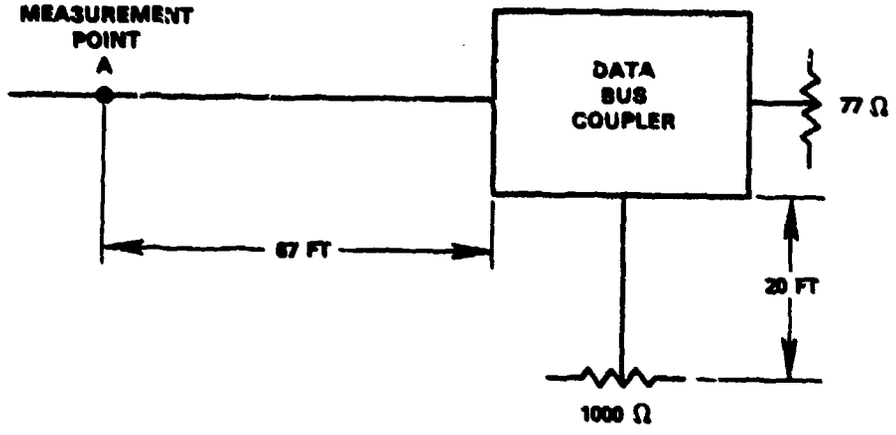


FIGURE 15b. Test set-up.

FIGURE 15. Waveform at 67 feet from data bus coupler - test.

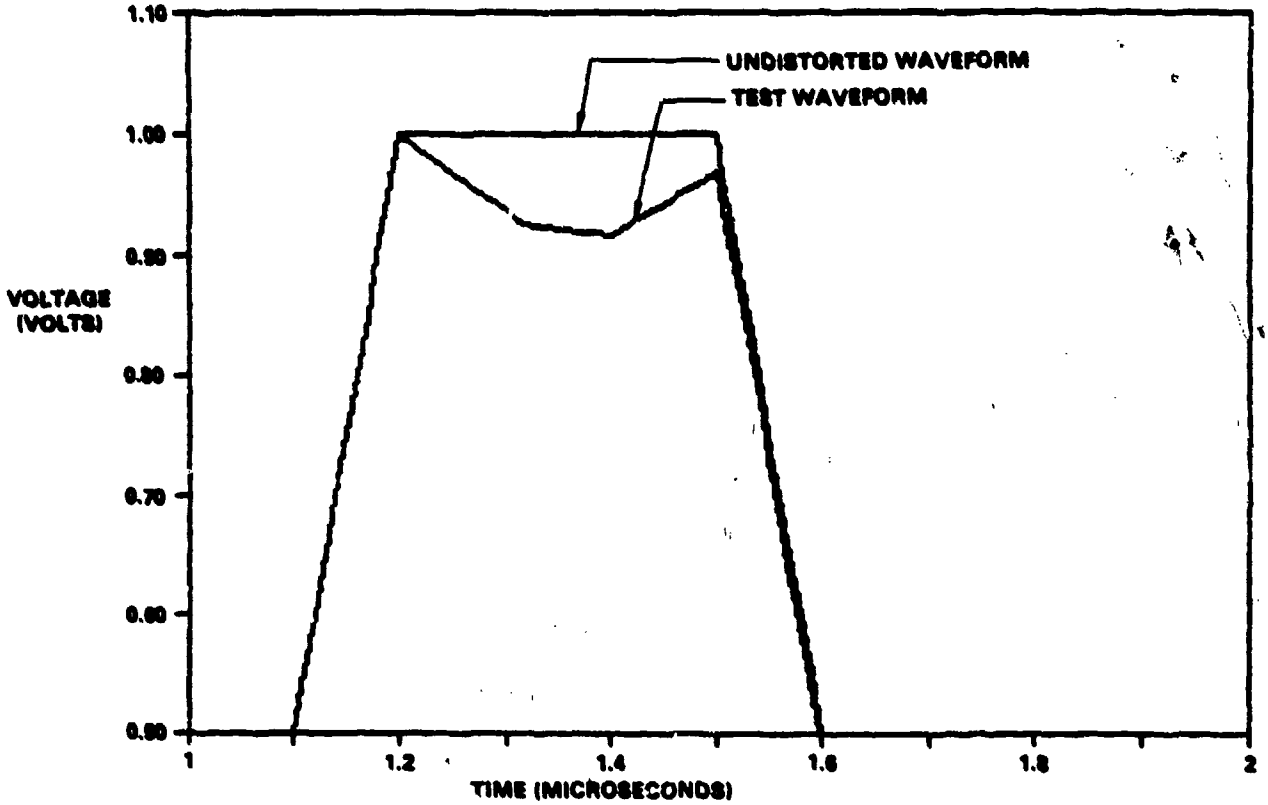


FIGURE 16a. Test waveform.

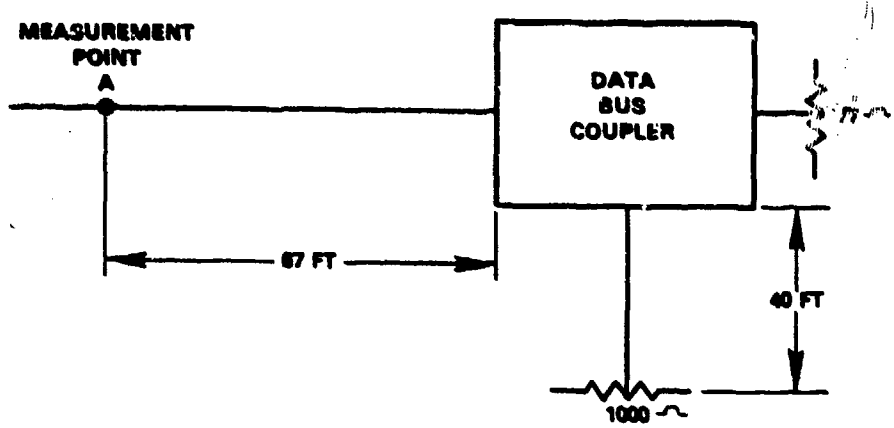


FIGURE 16b. Test set-up.

FIGURE 16. Waveform at 67 feet from data bus coupler - test 2.

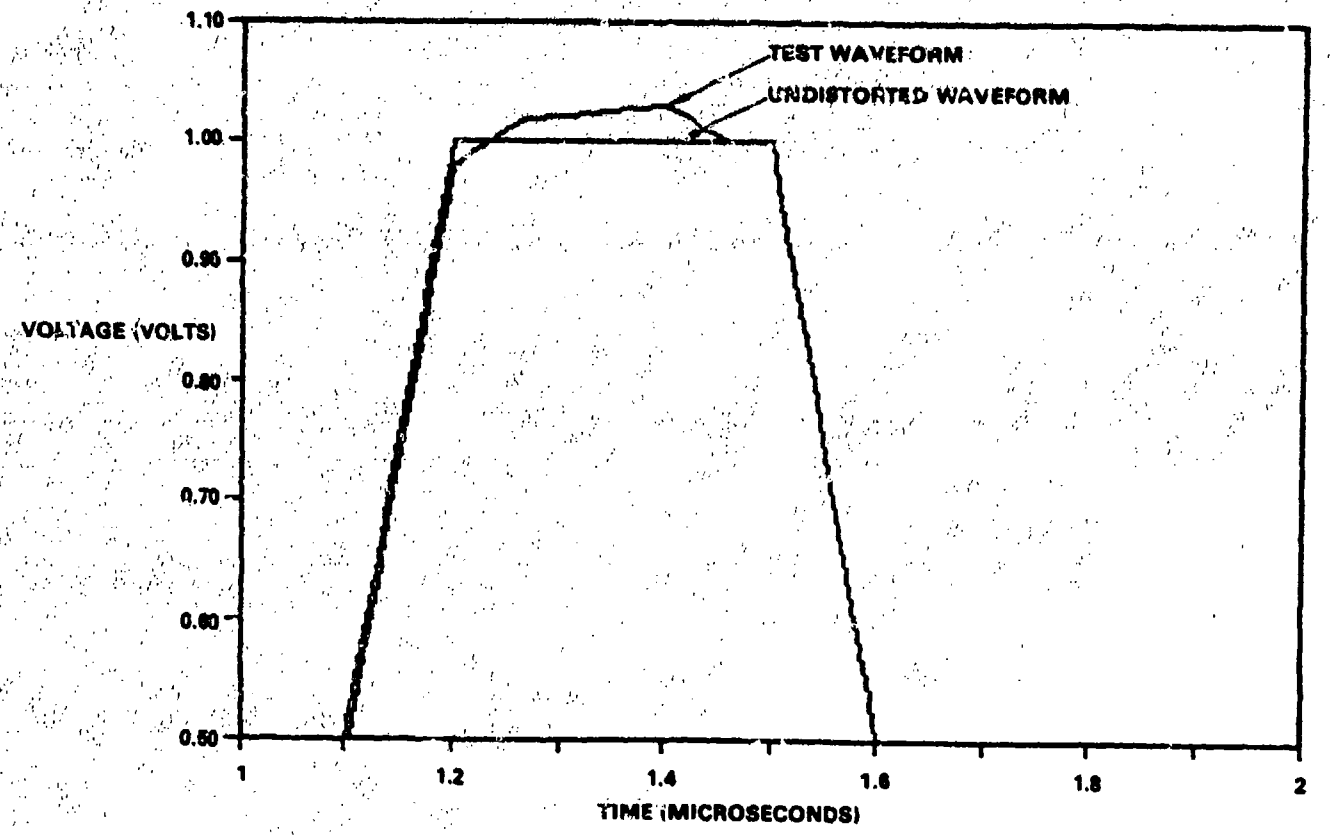


FIGURE 17a. Test waveform.

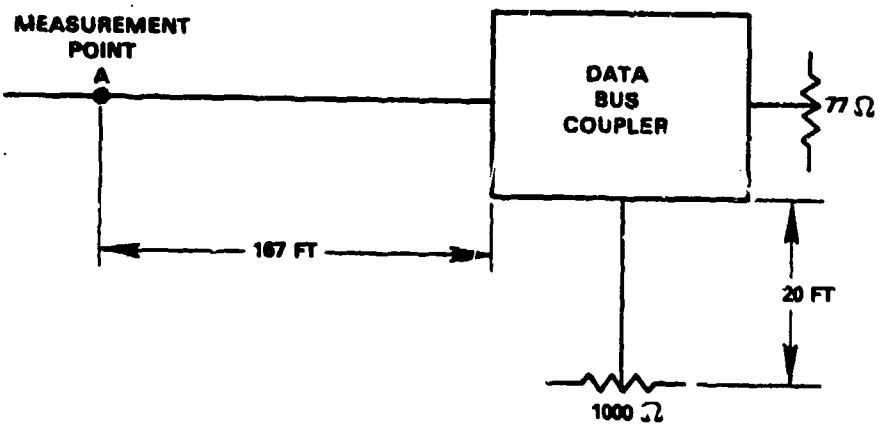


FIGURE 17b. Test set-up.

FIGURE 17. Waveform at 167 feet from data bus coupler.

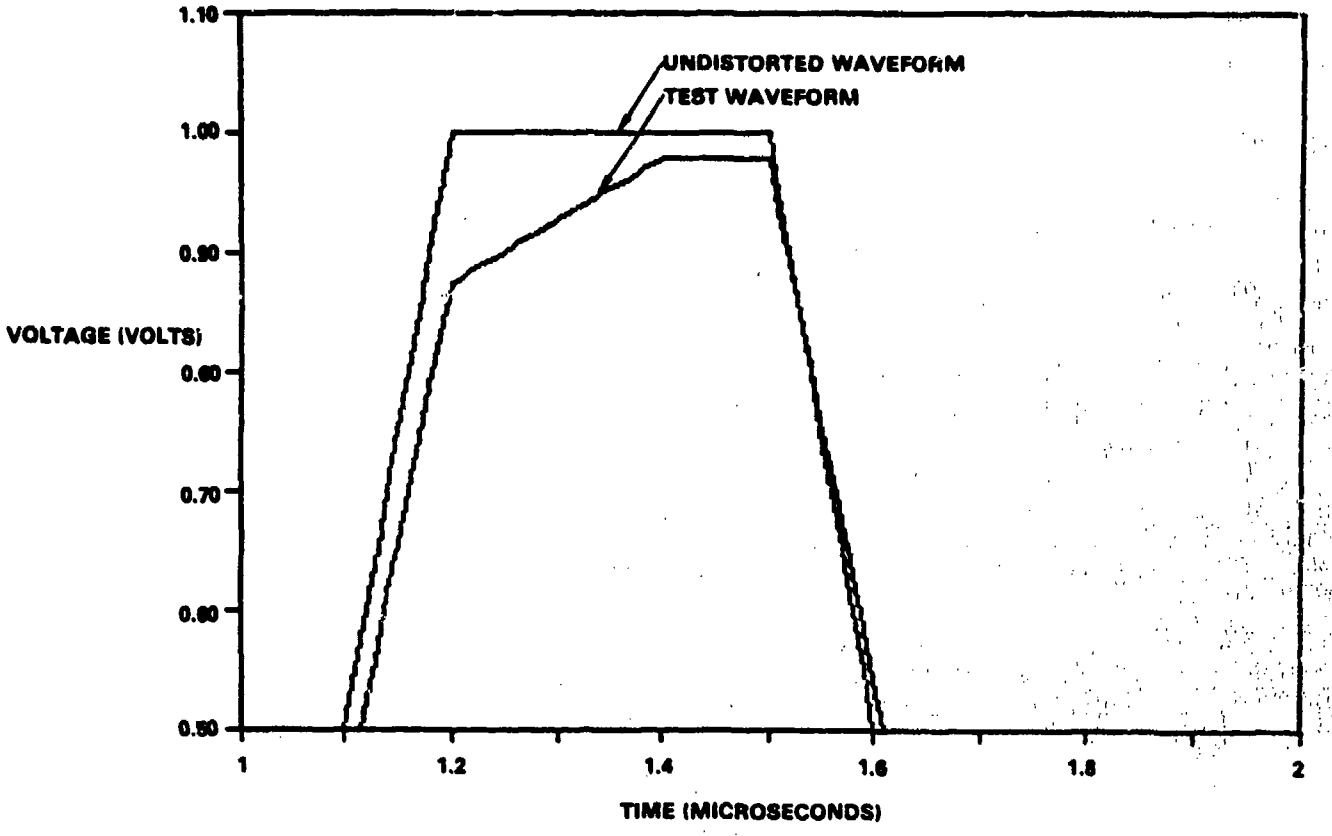


FIGURE 18a. Test waveform.

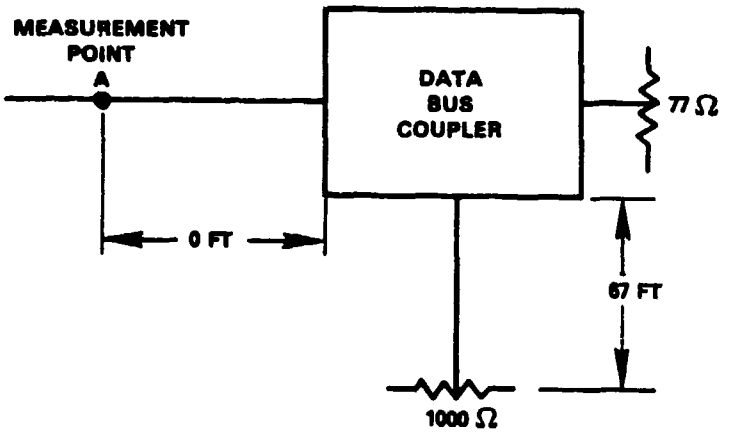


FIGURE 18b. Test set-up.

FIGURE 18. Waveform at 0 feet from data bus coupler.

The impact of multiple couplers on signal waveforms is more complex due to multiple reflections. Figure 19 illustrates the waveform seen at a distance of 10 feet from a pair of couplers. In this figure, the couplers are separated by 30 feet and each coupler is terminated with a 20 foot stub. Comparing this figure with figure 16 (single coupler at 10 feet) shows the impact of adding a second coupler. As seen in the comparison, the magnitude of the distortion increases with the addition of a second coupler. Due to the large separation distance between the two couplers, the waveform distortion from each coupler is readily visible in the figure.

In contrast, figure 20 illustrates the waveform distortion when the two couplers are installed immediately adjacent to each other. The magnitude of the signal dip is larger but the distortion is over quicker. For both two coupler configurations, the steady-state signal amplitude is also less than for the single coupler case.

To summarize the multiple coupler configuration, the installation of multiple couplers with a very small separation between couplers can result in a relatively large dip in the signal waveform. The magnitude of this dip is dependent on the stub length (longer stubs yield a larger dip). The location of the dip in the incident wave is dependent on the distance from the couplers where the measurement is taken. The location of the dip relative to the pulse leading edge is directly proportional to the distance from the coupler. As a worst case (based on MIL-STD-1553 tolerance extremes), the amplitude at point A of figure 20 can be as low as 74 percent of the peak-to-peak amplitude for the incident trapesoid. Figure 21 shows a worst case for nominal (not worst case tolerances) 1553 components. For a three coupler case, this point A amplitude drops to 66 percent. However, for more realistic stub lengths (i.e. 20 foot maximum stubs), the worst case point A amplitude is closer to 90 and 86 percent for two and three coupler configurations, respectively. (See figures 22 and 23 for amplitude variations.) As long as sufficient signal amplitude is available at an ASI to keep the distorted waveforms within the envelope defined by MIL-STD-1760 figure 6 (figure 24), the coupler and stub induced distortions should not cause receiver problems. Keeping stubs to realistic lengths will minimize the distortion in waveforms on the bus and hence on the stubs.

Analytical techniques can be used to model the waveform quality of a specific bus configuration but the model will be fairly complex for large bus networks. Due to this complexity, the model should be validated by comparing analytical results with laboratory tests of several network configurations. A validated model provides higher flexibility for design analysis by allowing various configurations and component tolerances to be quickly checked.

The level of accuracy required of the model can vary with different design requirements. For example, the simulation programs described in MIL-HDBK-1553 can provide useful first cut approximations.

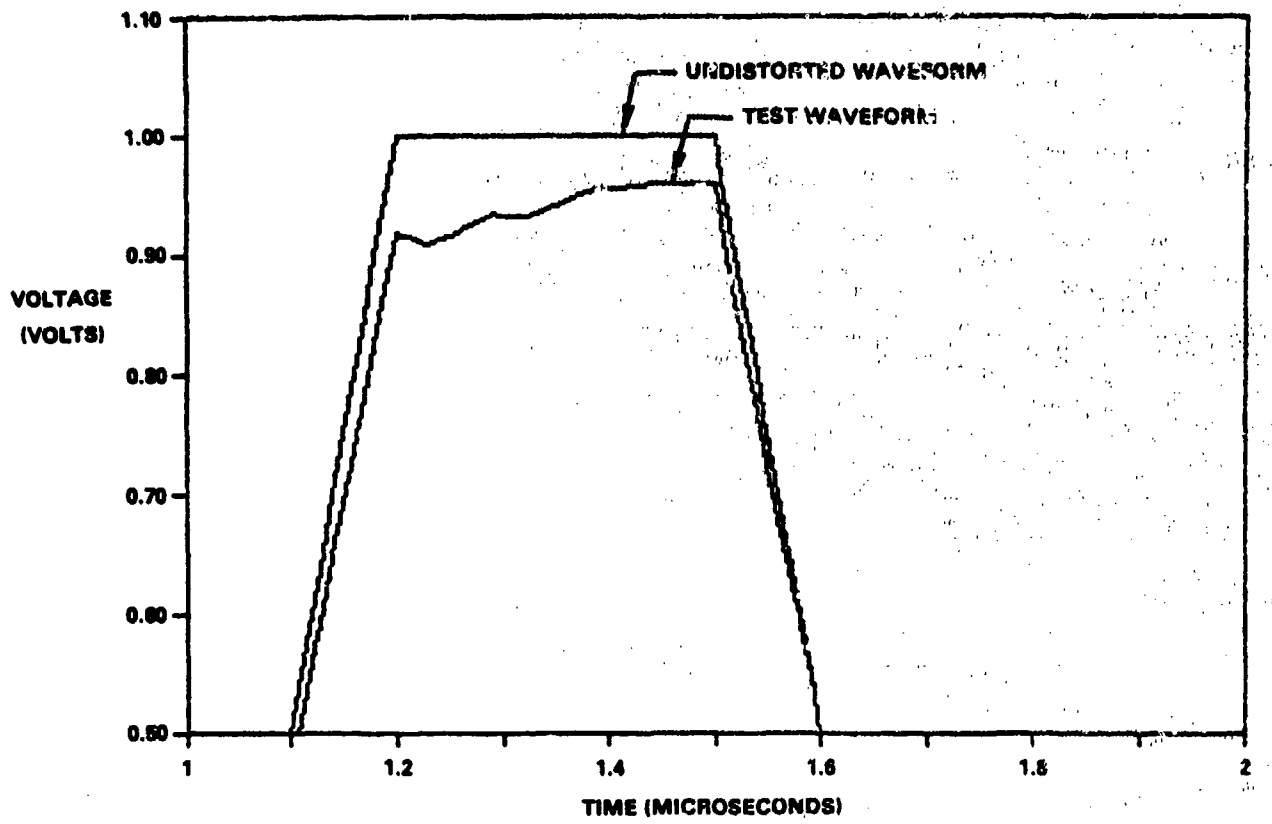


FIGURE 19a. Test waveform.

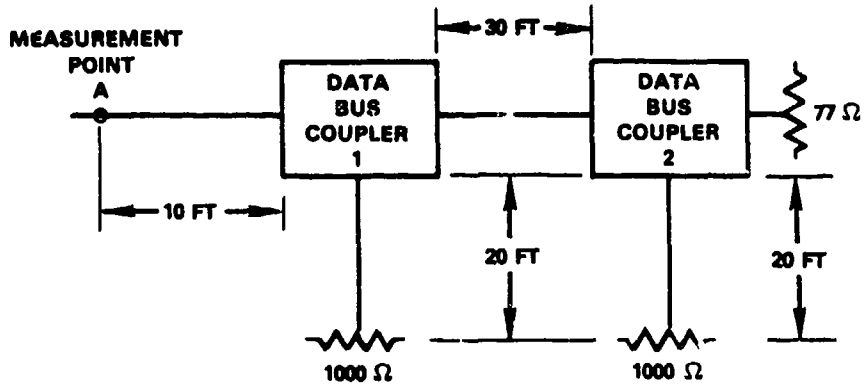


FIGURE 19b. Test set-up.

FIGURE 19. Waveform with two data bus couplers - test 1.

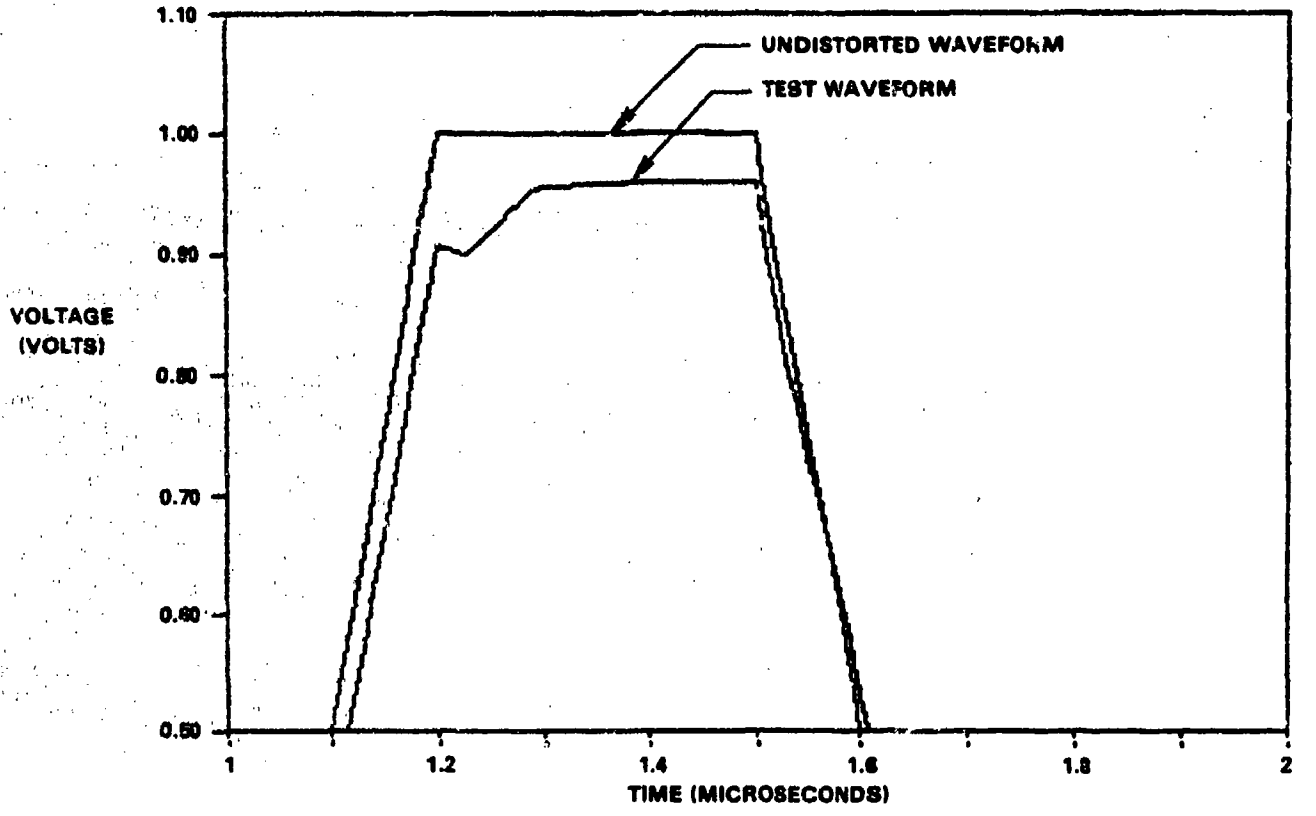


FIGURE 20a. Test waveform.

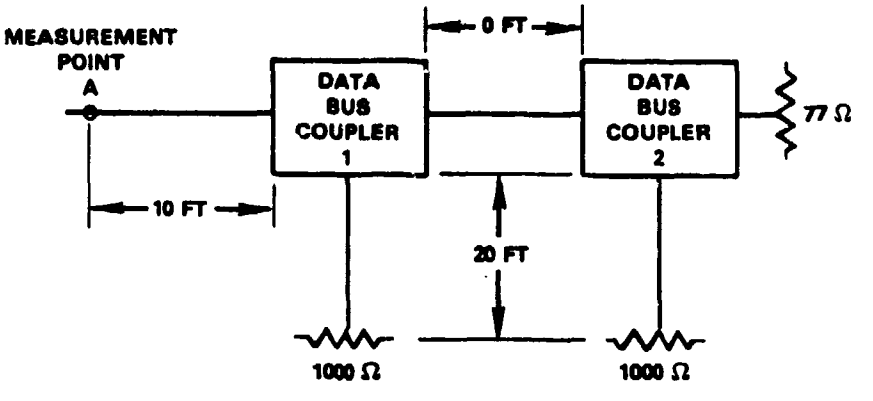


FIGURE 20b. Test set-up.

FIGURE Waveform with two data bus couplers - test 2.

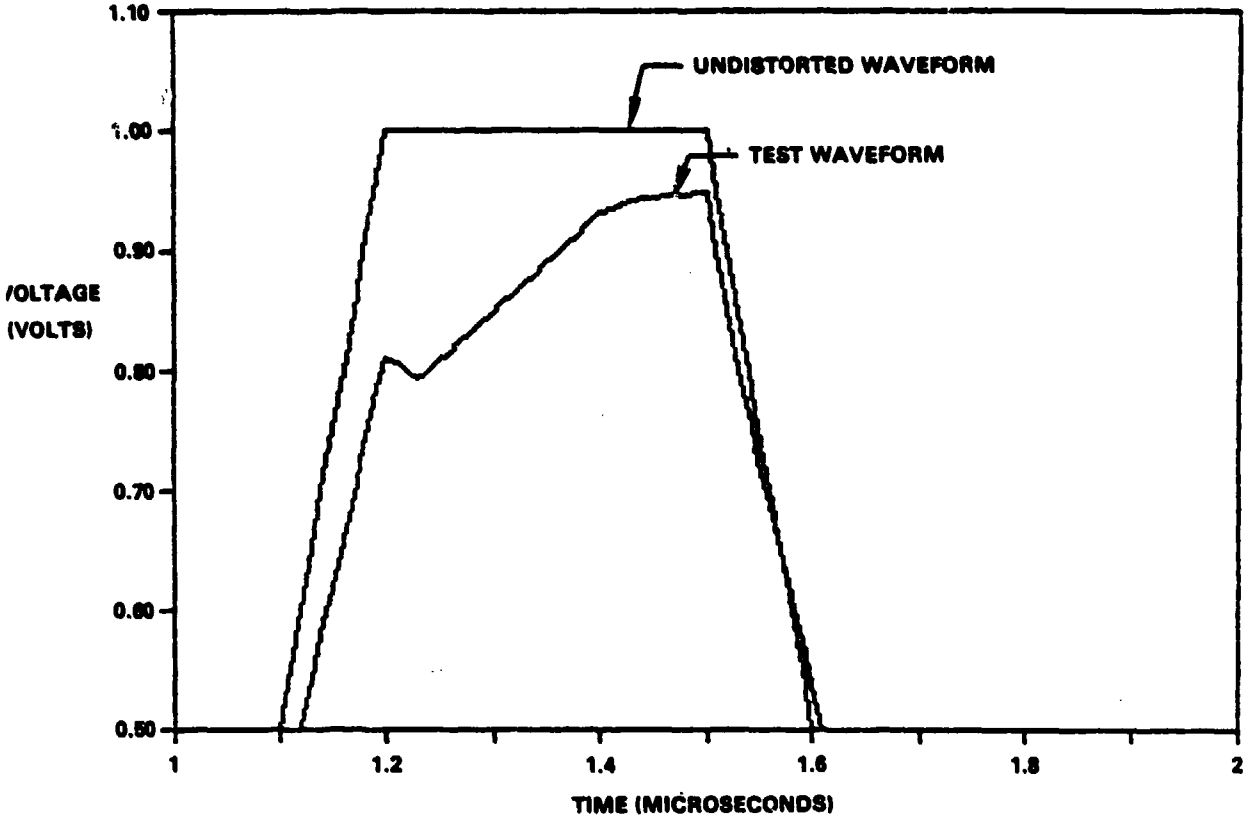


FIGURE 21a. Test waveform.

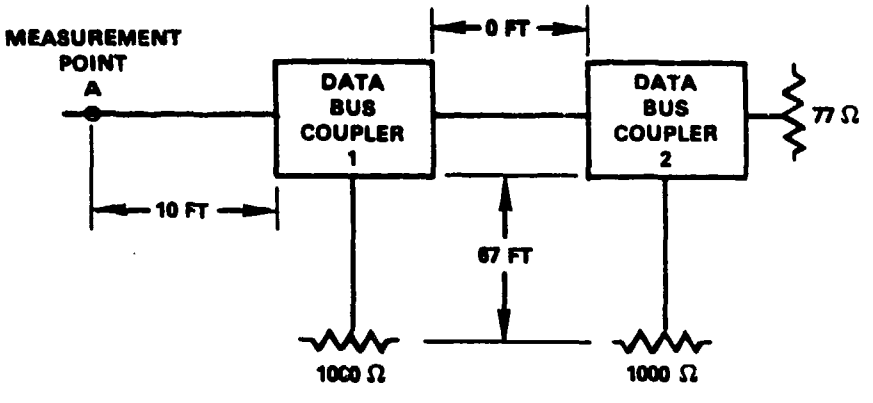


FIGURE 21b. Test set-up.

FIGURE 21. Waveform with two data bus couplers - test 3.

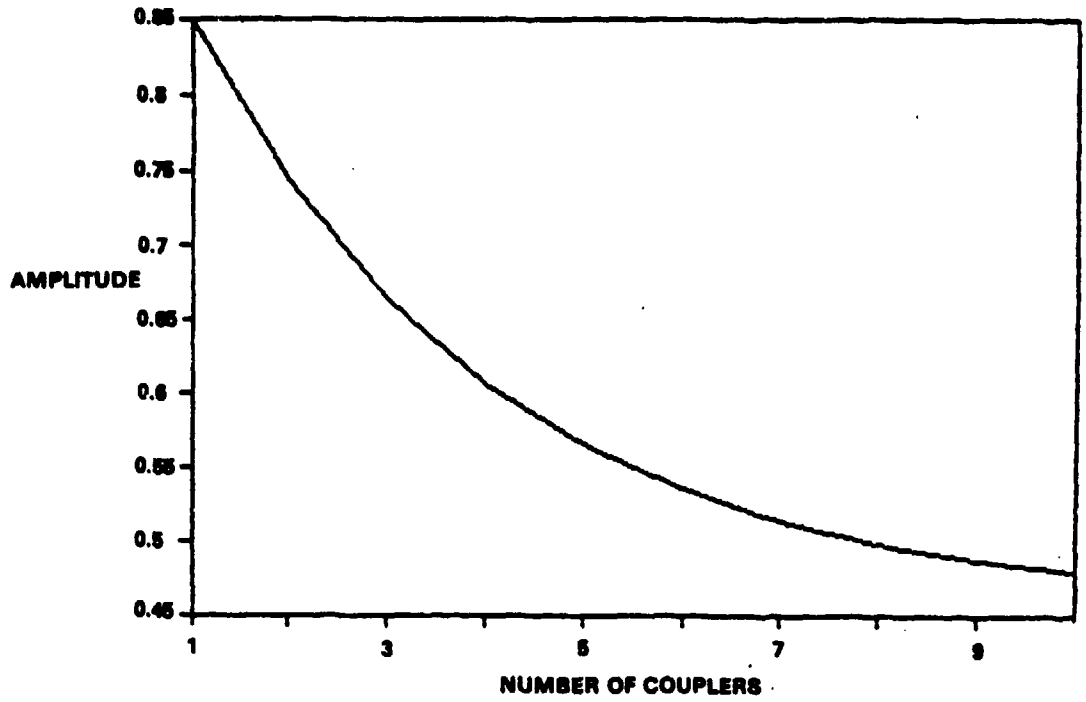


FIGURE 22. Amplitude variation for worst case stub length.

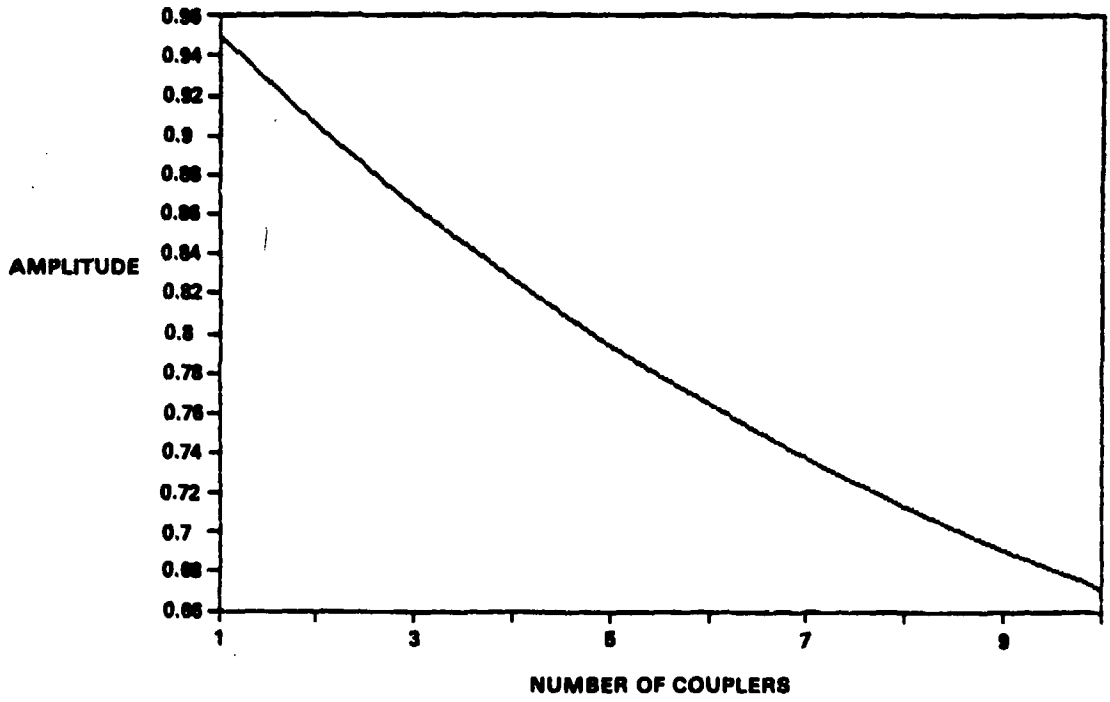


FIGURE 23. Amplitude variation for typical stub length.

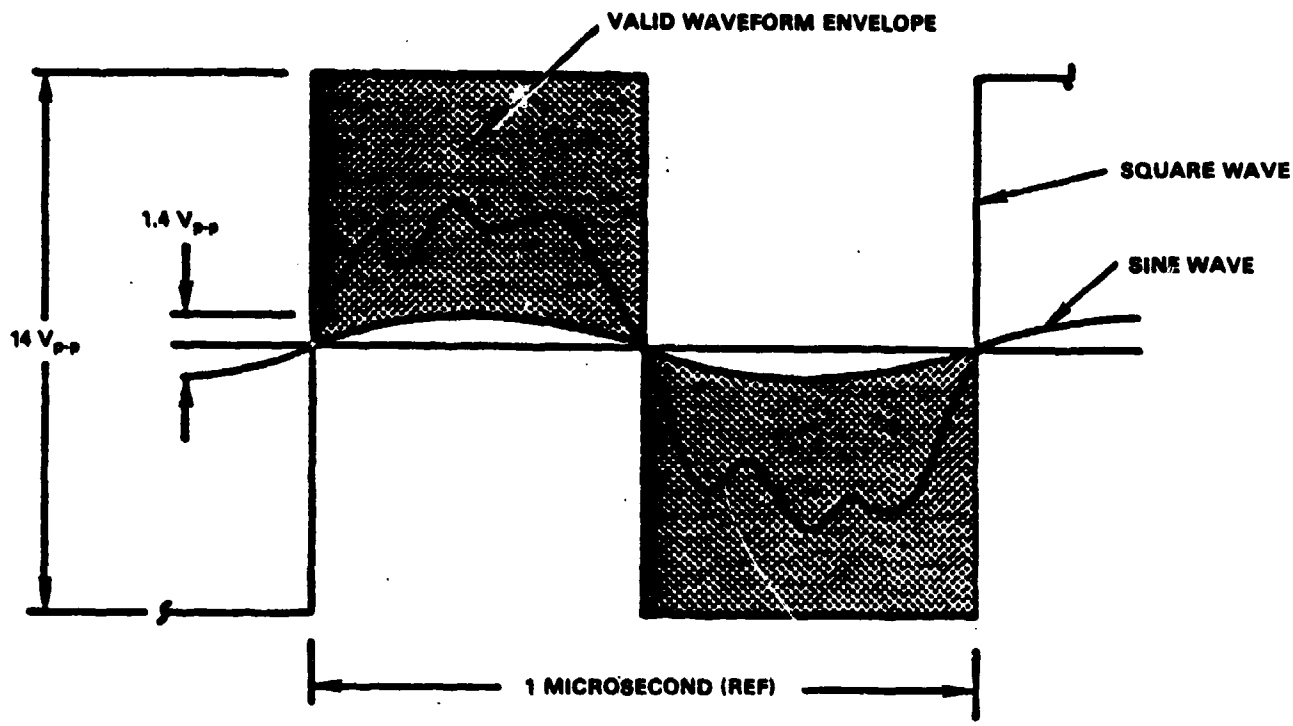


FIGURE 24. MIL-STD-1760 defined waveform envelope.

In conclusion, the bus configuration, including variations in stub lengths and termination conditions, can affect the waveform amplitude and quality delivered to an ASI. It is recommended that designers use analytical models to evaluate bus configuration variations during bus network design. It is also recommended that designers follow-up the modeling with tests of the selected configuration(s) since all models contain inaccuracies, assumptions and simplifications.

5.1.3.3.2 Loading effects. The electrical load seen by remote terminal transmitters can vary over a broader range than implied by MIL-STD-1553. (The military standard requires RTs to be tested into a 70 ohm ± 2 percent load.) This transmitter load is affected by the bus configuration, the components (tolerances) used in the bus and by the number, location and length of stubs connected to the bus. To complicate matters, the load seen on a bus or seen by a transmitter (i.e. on a stub) also varies with frequency.

To illustrate this impedance variation with frequency, figure 25 is an impedance plot for a 21 foot long twinaxial cable terminated with a 1000 ohm resistive load. By comparing figures 25 and 26, one can see that cable length also affects the impedance at various frequencies. In effect, the longer the cable, the lower the impedance at a given frequency. This relationship applies until the quarter wave length is reached (as can be seen in figures) at which point the impedance starts to increase. This impedance will cycle with minimums occuring at half wavelength intervals. The net result is that the load seen on the bus varies with frequency and with stub length. The effect of this loading can be measured by determining signal attenuation through the bus. As a simplified illustration, the bus side attenuation through a coupler directly terminated with a 1000 ohm load is shown in figure 27. The loss through the coupler (bus output/bus input) is basically flat over frequency with a net loss of approximately 0.2 dB.

In contrast, loading the coupler with a long stub (e.g. 30 feet) results in a marked increase in signal attenuation - particularly at high frequencies. (See figure 28.) The signal loss at 2 MHz has increased from 0.2 dB to over 1 dB. At the low frequency end (75 KHz) the signal loss is basically unchanged at 0.16 dB. A second extreme condition is shown in figure 29. This figure plots the attenuation through a coupler with a short circuited stub-side termination. Even though the 1553 transformer coupler contains fault isolation resistors, the coupler attenuation is still fairly large (2.7 dB). The addition of twinaxial cable between the coupler and the shorted termination will reduce the signal loss through the coupler.

Figure 30 defines typical signal attenuation versus frequency for two couplers located close together and each loaded with a fairly long stub.

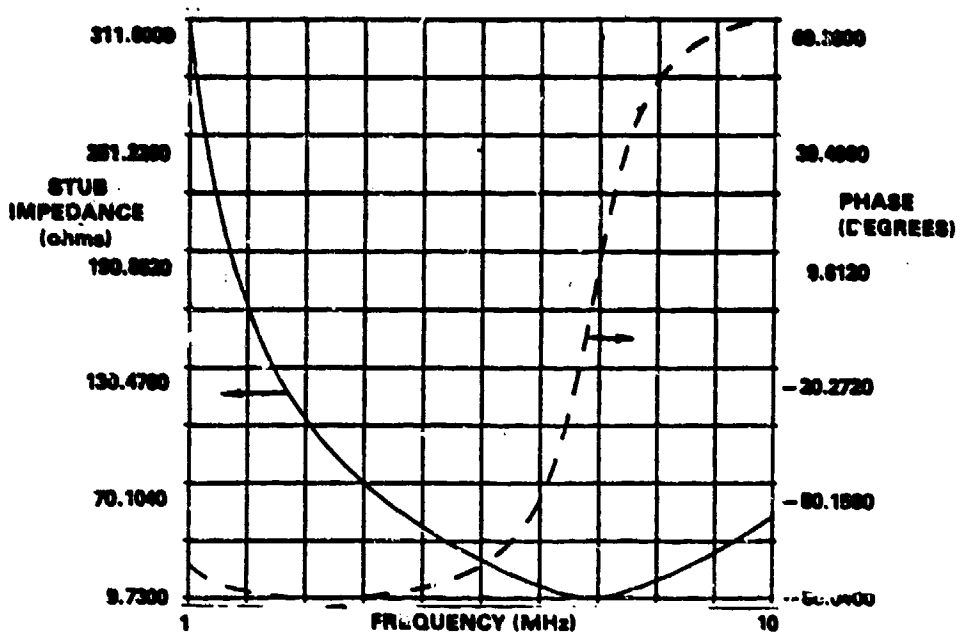


FIGURE 25. Stub impedance for 21 foot terminated cable.

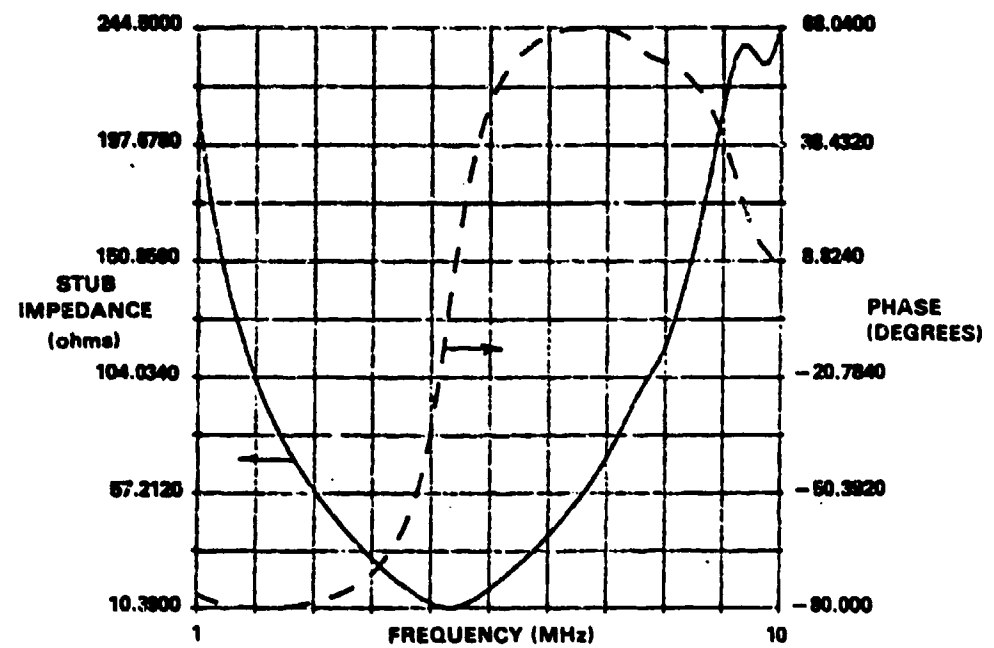


FIGURE 26. Stub impedance for 31.5 foot terminated cable.

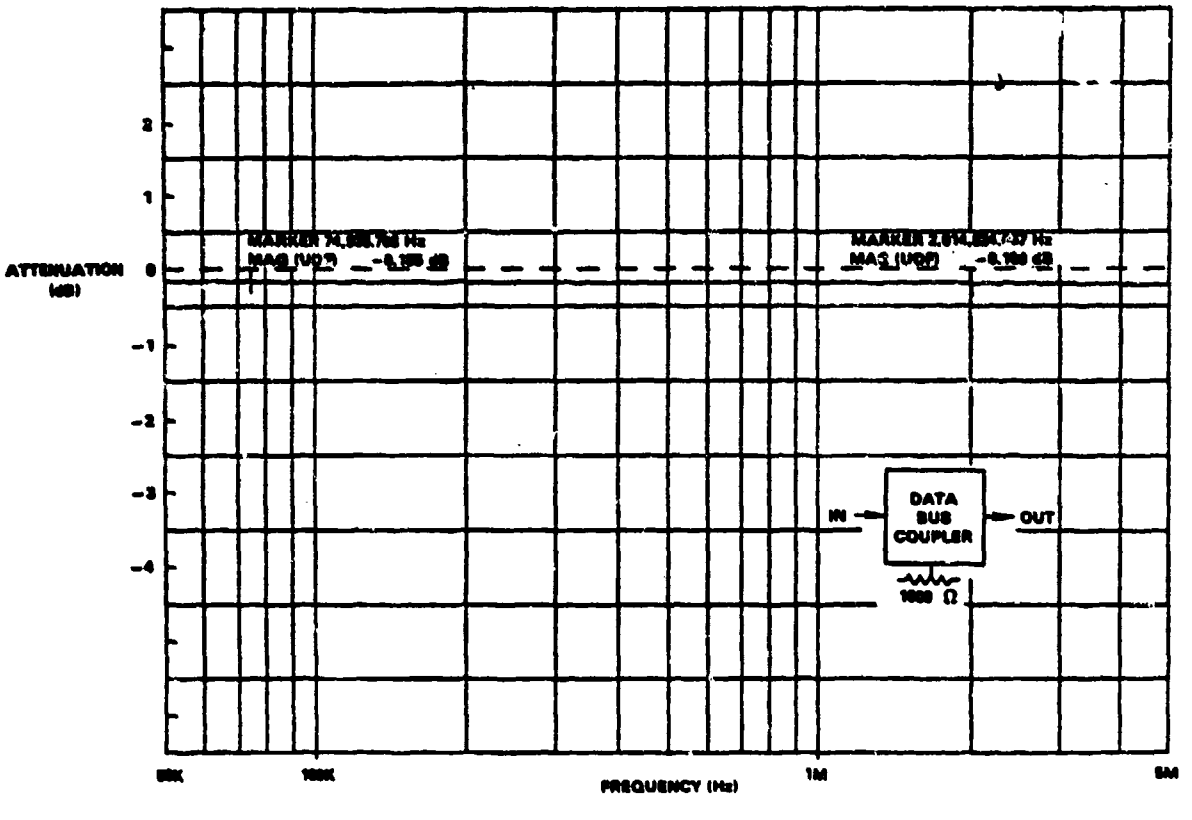


FIGURE 27. Data bus coupler loss - 1000 ohm termination.

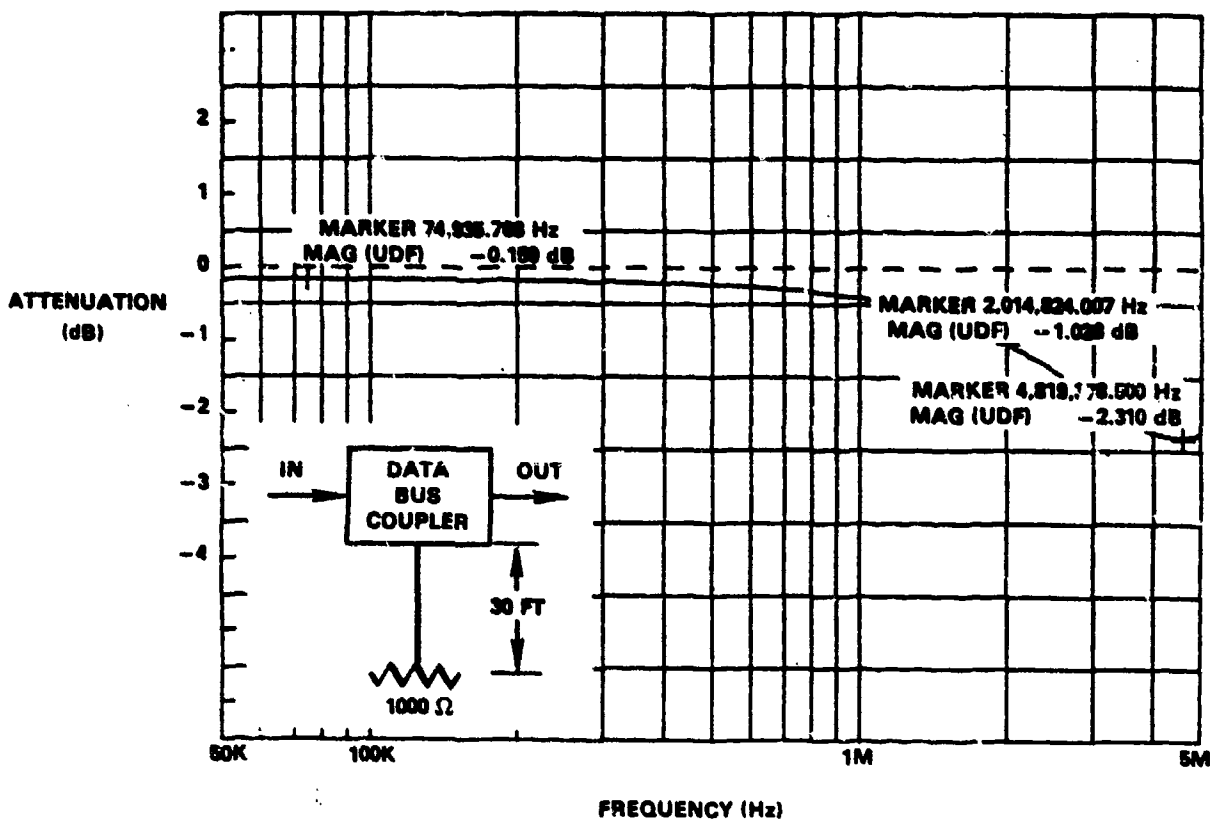


FIGURE 28. Data bus coupler loss - 30 foot terminated stub.

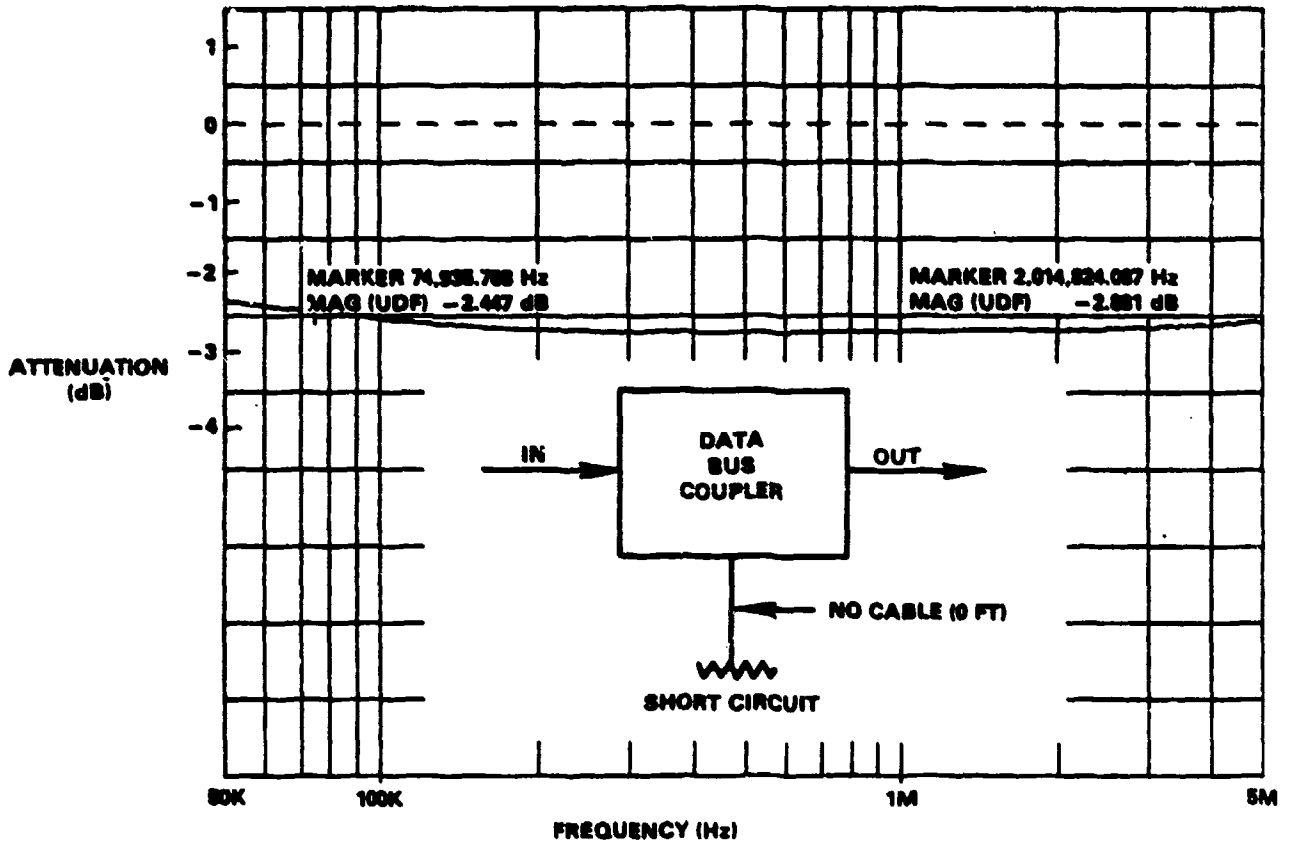


FIGURE 29. Data bus coupler loss with shorted stub.

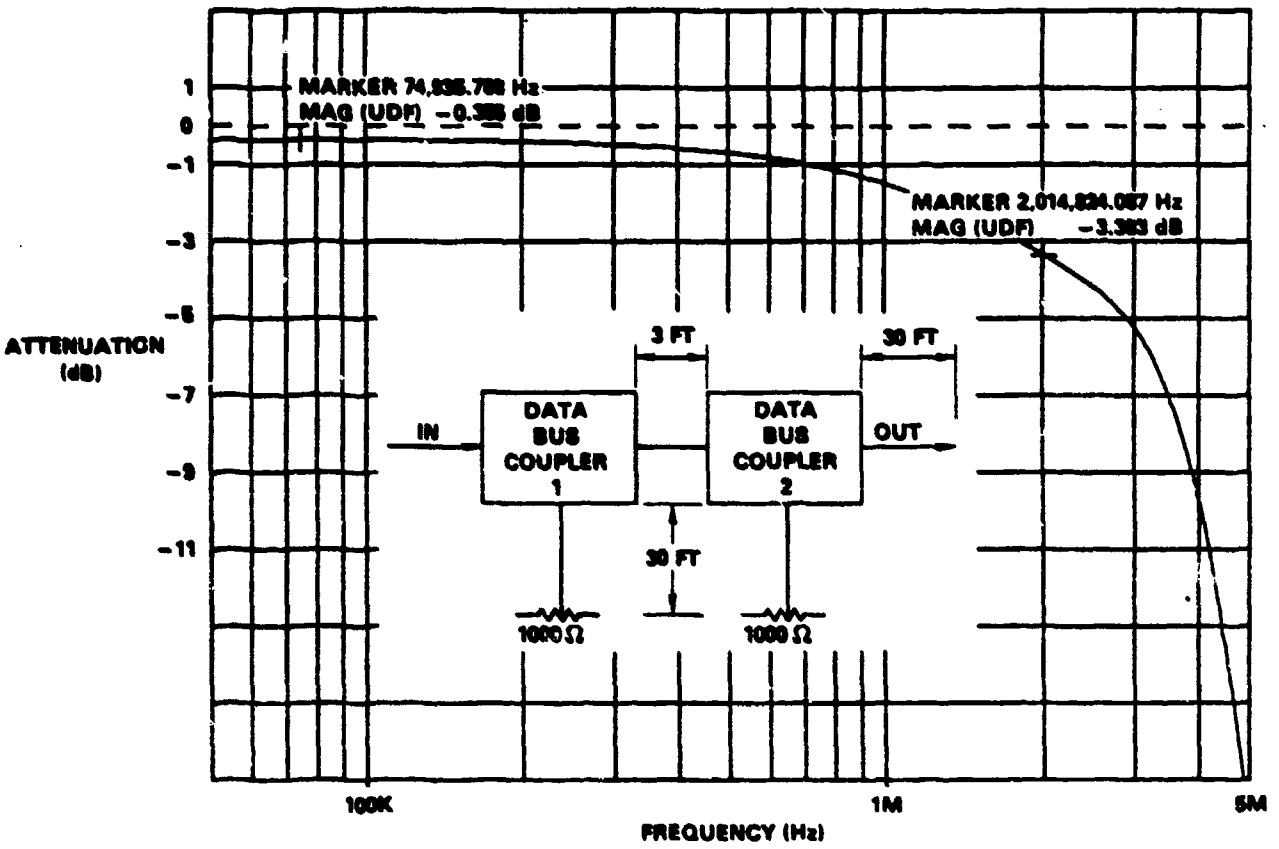


FIGURE 30. Co-located dual data bus coupler loss.

Since this t configuration also includes a 30 foot section of twinaxial cable in the main bus path, comparison with figure 28 requires consideration of the cable losses. This 30 foot section is included in order to compare losses of two co-located couplers versus couplers separated by a distance of 30 feet. The 30 foot separated coupler losses are plotted in figure 31. Comparison of figures 30 and 31 shows similar differences (at high frequencies) between the two configurations when measured in the frequency domain as are shown in figures 19 and 20 for the time domain (in short time windows). The main point is that stacking up couplers in one location results in higher losses (1.5 dB vs 0.8 dB at 1 MHz, for the example shown) than occurs if the couplers are distributed. However, physical installation limitations in many aircraft can require co-location of data bus couplers to service adjacent ASIs and associated Store Station Equipments. As long as the effects of a coupler co-location are considered during bus network design, suitable waveforms can be provided at the ASIs.

5.1.3.3.3 ASI output waveform. MIL-STD-1760 requires the aircraft to deliver output waveforms (measured at the ASI) which fall within the envelope defined by figure 6 of the standard (figure 24 of this report). This waveform envelope complies with the stub voltage requirements of MIL-STD-1553 but is also potentially more stringent in the minimum required voltage. MIL-STD-1553 defines the minimum stub voltage delivered by the bus as 1 volt p-p at the RT input (MIL-STD-1553 reference Point A). In contrast, MIL-STD-1760 requires the aircraft to deliver 1.4 volts p-p minimum (see figure 24) at the ASI. While this minimum voltage is higher, it is also measured at a different point. The 1553 measurement point is the RT input while the AEIS measurement point is the ASI. A number of feet of twinaxial cable can exist between the ASI and the RT buried inside a store. The higher required voltage increases the design margin as well as offsets for cable length differences. This higher voltage also raises the effective signal/noise ratio to help offset high noise levels expected from the data bus stubs exposed to the external electromagnetic environment.

5.1.3.4 Multiplex interface EMI considerations. This section addresses several EMI issues which, while not unique to MIL-STD-1760, are periodically raised in AEIS applications. (See 5.1.9 for additional EMC discussion.)

5.1.3.4.1 Shield grounding. The first of these issues concerns shield grounding. The mulitpley standard is vague on the grounding scheme for the data bus and stubs. While MIL-STD-1553 requires the use of twisted shielded pair (TSP) cable and 360 degree shield termination, it does not directly define at what location(s) the shield should be grounded or even if the shield should be grounded. (However, implications are given in the standard.) The AEIS standard specifically requires the shield to be grounded on the store side of the MSI and the aircraft side of the ASI. Since MIL-STD-1760 is an interface standard, it defines the shield grounding only as measurable at the interface (e.g., ASI and MSI). The AEIS standard

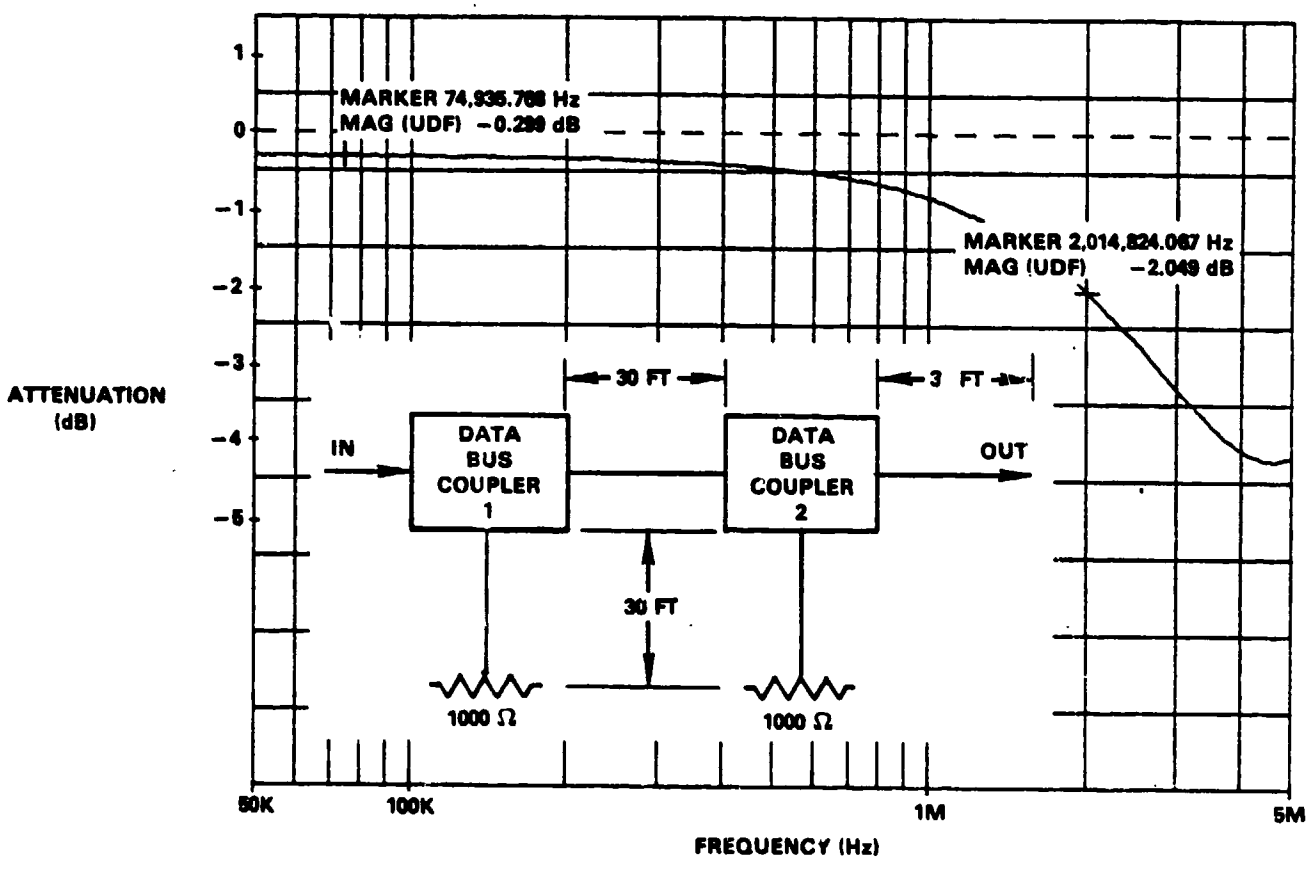


FIGURE 31. Separate dual data bus coupler loss.

does not define how many shield ground connections exist in the aircraft nor does it define the locations of these connections. MIL-STD-1760 only requires that the measurement of the shield connection at the ASI indicates that the shield is electrically connected to aircraft structure ground.

Since the multiplex bus and stubs use twisted shielded pair cable, multi-point grounding of the shield on the aircraft is recommended. This multi-point shield grounding in combination with the magnetic field rejection of the twisted wire pair results in good overall electrostatic and electromagnetic shielding. Multi-point shield grounding can be physically achieved if bus couplers are used with conductive base plates. By bonding the couplers to aircraft structure, a good quality shield ground can be achieved at each cable's connection to a coupler. This method avoids the use of pigtailed shield terminations and the resulting high impedance ground path of pigtails.

5.1.3.4.2 Twinaxial versus standard contacts. A variation of the shield grounding issue concerns the type of connector contacts used for the digital multiplex interfaces in the AEIS. The connector requirements of MIL-STD-1760 (5.1.2) specify the use of twinaxial contacts in the interfacing connectors. These contacts are defined by MIL-C-39029/90 and /91 specification sheets. The twinaxial contact contains three concentric connections: a center contact, an intermediate contact which axially surrounds the center contact and an outer contact which axially surrounds the intermediate contact. By connecting the shield to the outer contact, a 360 degree multiplex dedicated shield is provided through the AEIS interfaces.

An alternative connection method used in some MIL-STD-1553 equipment results in dividing the two conductors and the shield of the TSP cable among three standard (single connection) contacts of a connector. This method losses a dedicated 360 degree shield coverage and also results in pigtailing the shield through the connector. Radiated emission tests have shown significant emission increases with pigtailed connections for a standalone MIL-STD-1553 cable run. A different set of tests conducted for radiated emissions and susceptability of a multiplex cable bundled with other AEIS signals in a shielded umbilical still showed a degradation in shielding effectiveness but the degradation within the 1553 passband was not as severe (approximately 5 dB) due to the gross shield of the umbilical. At some frequencies tested, the standard 20 AWG contacts yielded over 20 dB of shielding degradation when compared to the twinaxial contact. Figure 32 plots the noise levels (at the ASI) induced by a 200 volt/meter field into a TSP cable constructed with twinaxial contacts and standard contacts . The cable assembly tested was a gross overbraided AEIS primary signal set cable.

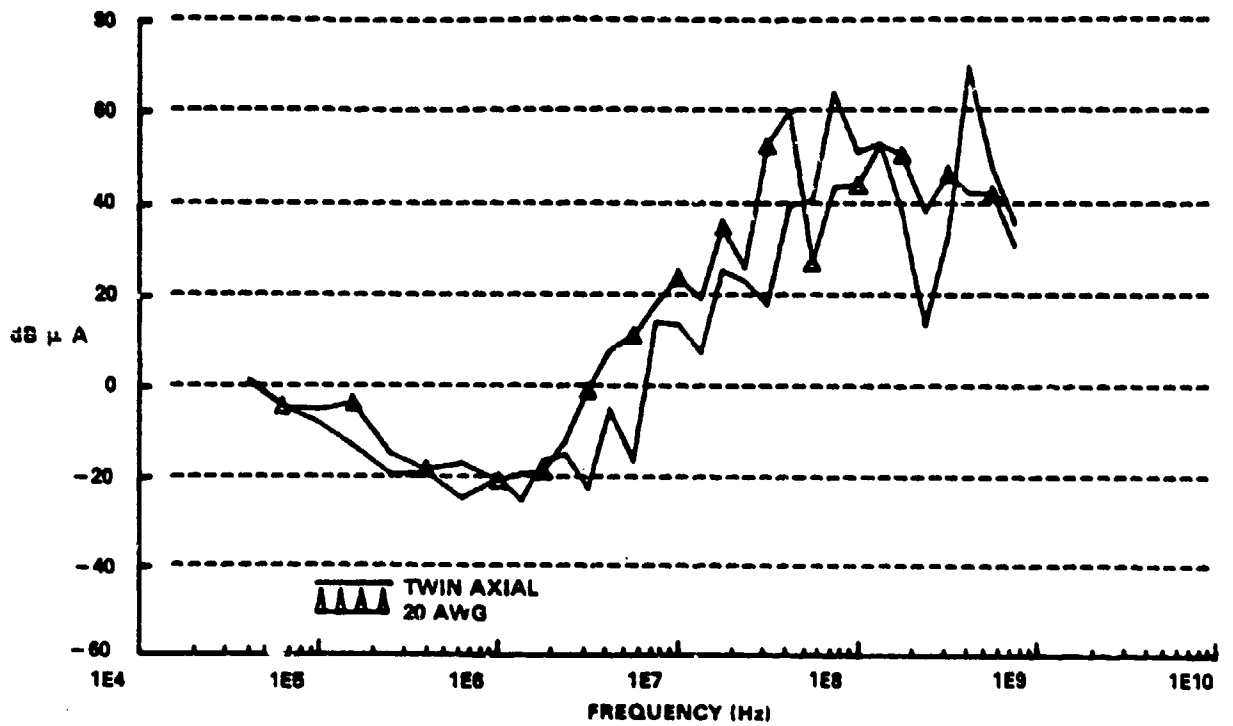


FIGURE 32. Multiplex data interface field induced noise levels.

While the induced noise levels are higher in the standard contact cable, the increase is relatively small (5db) within the 1553 frequencies. However, two factors need to be considered when interpreting this data. First, the cables tested had a total length of approximately 41 feet with six mated connector pairs. Of these six, only one connector pair was replaced to substitute standard contacts for twinaxial contacts. Second, the 41 foot cable assembly was constructed with a 360 degree coverage metal overbraid. Therefore, the pigtailed TSP connections were buried inside a shield overbraid. This reduces the measured degradations.

When a store is not loaded at a particular store station, the ASI connector contacts are left exposed to external radiation sources. The MIL-STD-1553 data bus stub contacts defined by MIL-STD-1760 are twinaxial contacts, hence a shield around the contacts is carried through the connector. These twinaxial contacts provide a relatively small aperture when unmated. The noise entering through the contact aperture can be approximated by the attenuation of a circular waveguide with the same dimensions. The low frequency cut-off (f_o) for a circular waveguide is approximated by:

$$f_o = 6920/D \text{ (MHz)}$$

Where D is the aperture diameter in inches

Since the worst case (largest aperture) will exist with the twinaxial socket contact (versus the twinaxial pin contact), the low frequency cut-off is:

$$f_o = 6920/0.218$$

$$f_o = 31.7 \text{ GHz}$$

For signals with maximum frequencies at least an order of magnitude lower than f_o (i.e., 3 GHz for the twinaxial socket), the attenuation down a circular waveguide is approximated by:

$$A = 32L/D \text{ (dB)}$$

Where L is the length and D the diameter

For the socket contact alone, therefore:

$$A = 32\ (1.2/0.218)$$

$$A = 176\ dB$$

This indicates that noise entering the unmated socket's shield aperture at frequencies below 3 GHz is significantly attenuated through the socket alone. In addition, noise at frequencies above 3 GHz is attenuated by the twisted wire pair transmission line and by the MIL-STD-1553 data bus coupling transformer. It is not expected, therefore, that the shield opening in unmated twinaxial contacts will lead to a radiated susceptibility problem on the MIL-STD-1553 stub interface.

When stores mated at the ASI are released, the umbilical cable is left attached at the ASI thus leaving the MSI contacts exposed. It is possible that twinax contacts will not be used for the data bus stubs on some simple mission stores. The frequencies coupled will then depend on the inside diameter of the connector shell and the length of the non-shielded contacts. Considering the connector shell (assume 25 shell size) and pin sizes, the frequencies coupled into the stub are still above 0.5 GHz and should again be filtered off the bus by the transformer and transmission line.

A second set of radiated susceptibility tests were conducted with the two connector (contact) configurations. The second set of tests was run with the umbilical cables disconnected from the store to simulate externally induced (200 volts/meter) noise at the ASI after store release. Figures 33 and 34 compare the results. Figure 33 compares 200 volt/meter external field induced noise into a cabling configuration representative of a mission store installed on a carriage store which in turn is installed on an aircraft. The cable configuration contains 9 sets of mated connector pairs in a series connection within a total cable length of 62 feet. All connector pairs use twinaxial contacts. The noise levels plotted by Curve A in the figure were measured at the ASI for this cable setup. Curve B plots the ASI measured noise when the umbilical at the MSI is disconnected and the open umbilical connector is exposed to the external field. This disconnected cable configuration is 8 feet shorter than the Curve A configuration. As a result, comparing Curves A and B result in comparing 62 foot mated cable noise levels versus 54 foot cable with open connector noise levels. The only real conclusion that can be made is that the noise levels didn't increase in the tested cable configuration when the mission store

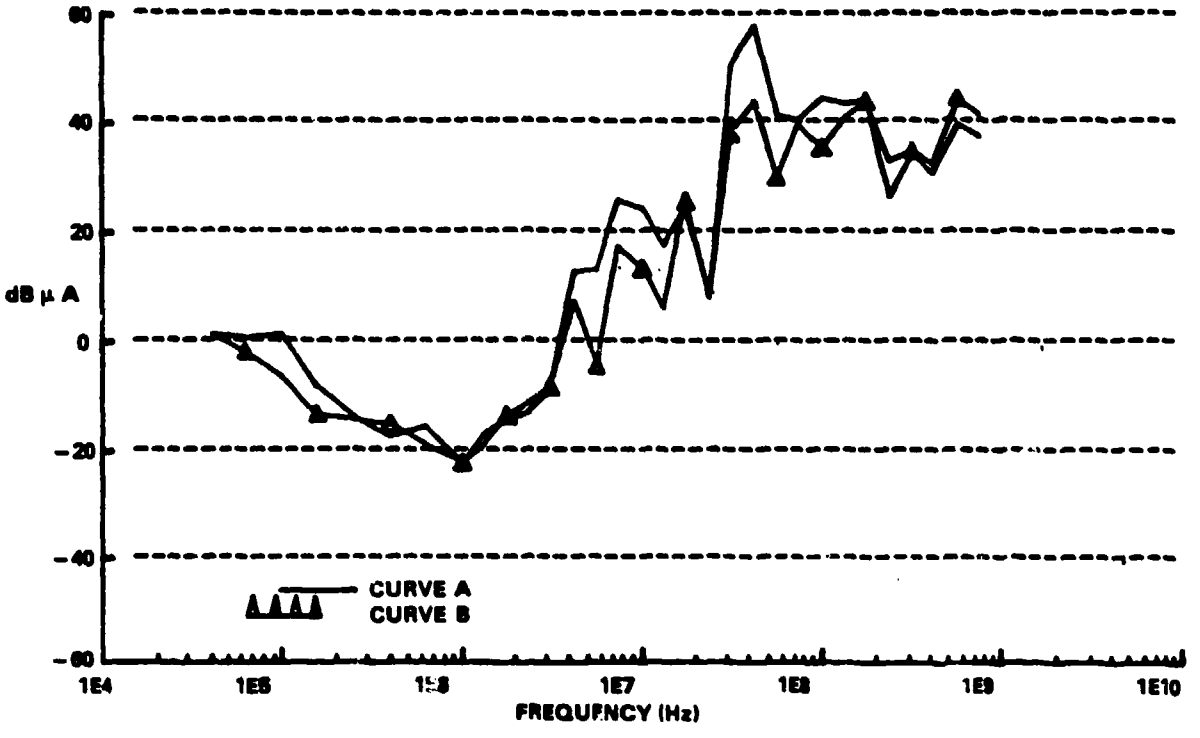


FIGURE 33. Twinaxial contact cable assembly noise levels.

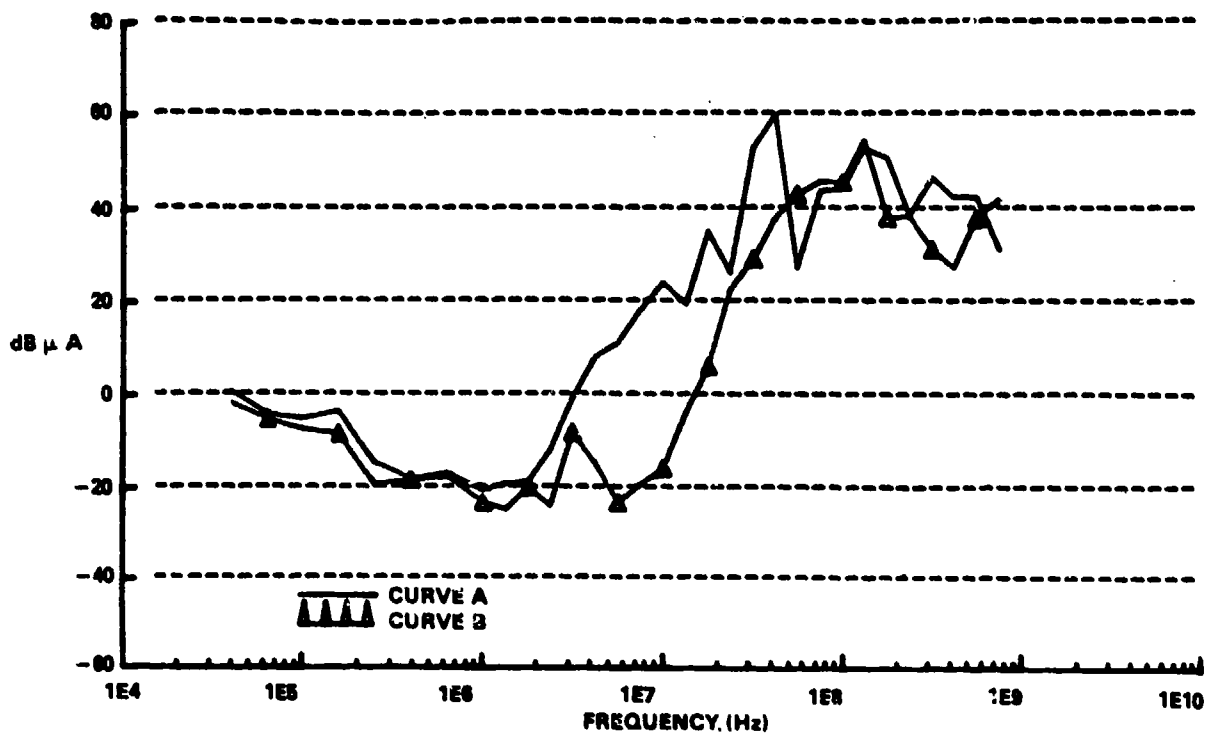


FIGURE 34. Standard 20 AWG contact cable assembly noise levels.

was disconnected from the aircraft. However, since the Curve B cable is shorter some degradation is apparent. Figure 34 likewise compares the 200 volt/meter external field induced noise into a second cabling configuration representative of a mission store carried directly on the aircraft (i.e. no carriage store installed). This cable configuration contains six mated connector pairs in a series connection within a 41 foot total cable length. The MSI connector used 20 AWG contacts for multiplex data bus stub while the remaining five connectors used twinaxial contacts. The noise levels of Curve A in the figure were measured at the ASI for this cable setup. Curve B plots the ASI noise when the umbilical connector is exposed to external fields. This disconnected configuration is 8 feet (20 percent) shorter than the Curve A configuration. Therefore, care needs to be exercised in comparing the two curves. Considering that the Curve B cable is 20 percent shorter, the essentially equal noise levels below 1 MHz and above 40 MHz implies significant shielding degradation. However, the total noise levels with the disconnected umbilical are generally no worse than the fully mated longer configuration through the frequency range tested.

The conclusion is that concentric twinaxial contacts should be used for all multiplex bus and stub cable runs to reduce the amount of noise pick-up. (MIL-STD-1760 mandates the use of twinaxial contacts in the class I and II ASI connectors. See 5.1.2 of MIL-STD-1760.) Where use of twinaxial contacts is not practical, a gross overbraid of the entire cable assembly should be considered with a 360 degree gross shield termination to the mating connectors. When using the gross overbraid technique, consideration should be given to cross-talk between a pigtailed 1553 line and other signal and power lines within the shielded cable assembly.

5.1.3.4.3 Center tapped transformers. Some aircraft multiplex bus networks use grounded center taps on the transformer couplers, or on the transformer output winding of the RT, or on both. The purpose for adding a grounded center tap is to improve the TSP common mode rejection by improving the impedance balance between each of the two lines and ground (shield).

Noise immunity can be improved or worsened when a center tap is grounded, depending upon the quality of the coupling transformer. The accuracy of the center tap electrical balance determines the level of rejection of noise voltages between two grounded center taps. Two well balanced center tapped transformers can improve the overall noise rejection. Another advantage is the grounded center tap transformer allows continued operation (in a degraded mode) when one side of the circuit fails open as shown in figure 35b. An open in a non-center tapped transformer coupler (figure 35a) will disrupt communication between the RT and the data bus.

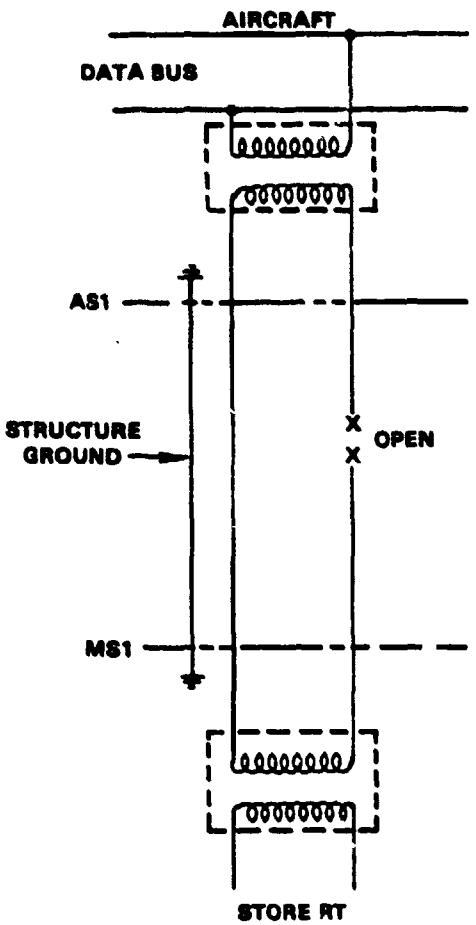


FIGURE 35a. Non-center tap.

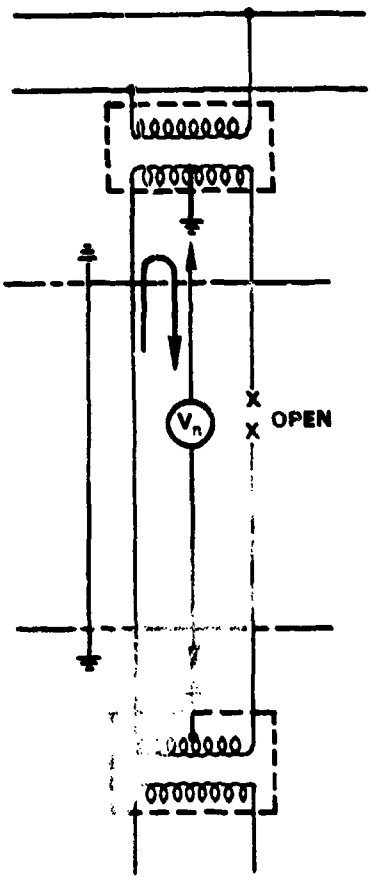


FIGURE 35b. Center tap.

FIGURE 35. Transformer coupler alternatives.

However, the center tapped grounded network can also inject a noise voltage into the data bus system. As long as the noise voltage between aircraft and store structures is low (good bonding between aircraft and store structures), bus operation can continue.

However, high structure ground noise or unbalanced center taps can degrade system performance by increasing the noise levels injected into the main bus. For data bus networks that are totally contained within an airplane, the aircraft designer generally has sufficient authority to control the quality of all center tapped RT transformers and coupler transformers if he chooses to use this balancing technique. The quality of this balance is not however, covered by MIL-STD-1553 and MIL-STD-1760. A center tap balancing requirement was not included in MIL-STD-1760 because EMI tests showed little performance improvement. It was also not addressed due to a concern that additional controls (over MIL-STD-1553) would be required on the transformers and interface impedance balance to preclude system degradation. As a result, MIL-STD-1760 neither requires nor disallows grounded center tap transformers. The aircraft designer lacks prior knowledge on whether a store uses a grounded center tap transformer and on the quality of the transformer balance. Therefore, the safest approach for the aircraft designer is to not use grounded center taps on the ASI side of the bus coupling transformer. The decision whether to use grounded taps on the bus side of the coupler can be made independent of stub grounding balance. (See figure 36.)

5.1.3.5 Architectural considerations. Section 5.1.3.1 addresses several architectural options for supplying MIL-STD-1553 interfaces at the ASI. This section is a follow-up on architecture considerations which may minimize the reflection, loading, etc. problems previously covered.

5.1.3.5.1 Carriage store functions. MIL-STD-1760 includes only a limited number of comments on carriage stores. However, provisions are included in the standard to allow future use of carriage stores. MIL-STD-1760 requires that the data bus network provide a medium for connecting the SMS to stores. Communication between the SMS and stores mated at the ASI (including carriage stores) is required. In addition, communication between the SMS and mission stores connected at a CSSI is also implied. The communication level from the SMS through the ASI interface points on the aircraft can be defined as Level 1.

A second level can also be defined to cover carriage stores. This level fans out the digital information received at the CSI, through the CSSI interface points down to mission store remote terminals. Also, if a hierarchical (or second tier) data bus is installed in the carriage store, the carriage store must terminate the data links (stubs) of Level 1, control traffic on the data link of the secondary level (Level 2), and retransmit (and reformat as necessary) all traffic between levels. Since MIL-STD-1760 requires electrical characteristics for the ASI and MSI to be consistent with MIL-STD-1553 transformer coupled stubs (and the additional requirements

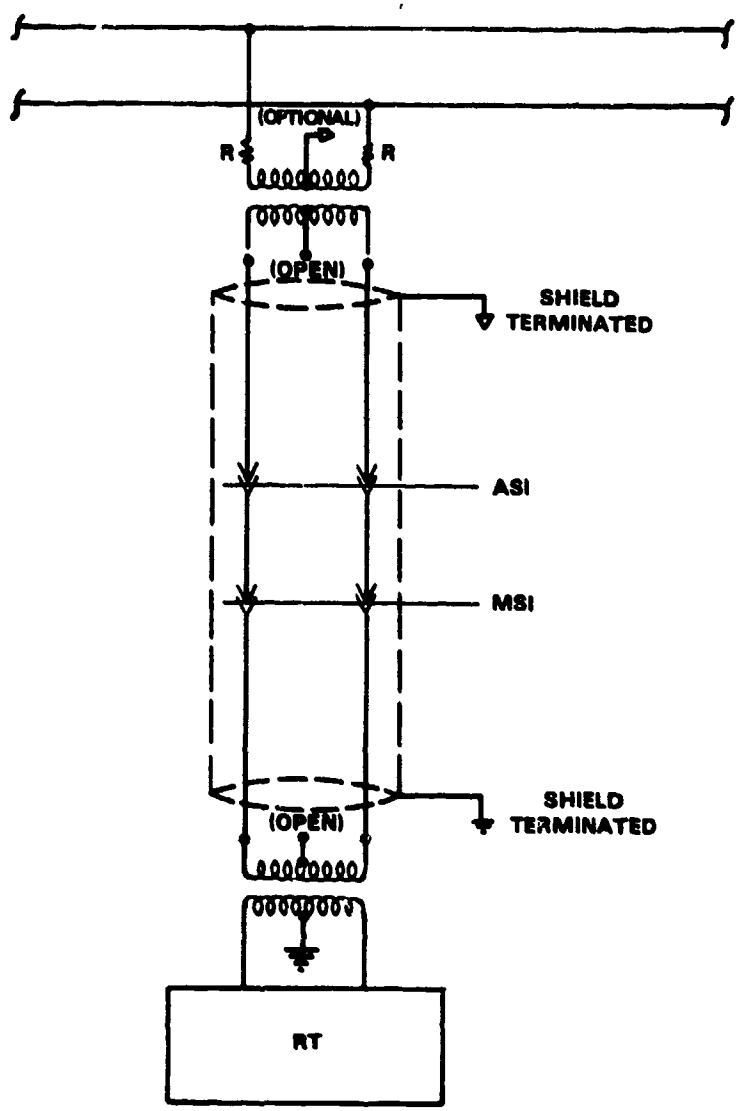


FIGURE 36. Transformer center taps.

of MIL-STD-1760), certain multiplex interface requirements are implied for the carriage store. When a carriage store is installed between the aircraft (ASI) and mission store (MSI), the MIL-STD-1553 stub must be functionally extended from the ASI to one or more CSSIs. In order to achieve interoperability, the carriage store must contain electronics to interconnect CSI stubs with CSSI stubs while maintaining MIL-STD-1553 characteristics. Electrically, this requires terminating the stub segment crossing the ASI and CSI interfaces and providing isolated data path(s) to remote terminals below the CSSI interface(s). The electrical requirements implied for the carriage store at the CSSI are identical to the requirements imposed on the aircraft at the ASI interface. Thus, electrically the carriage store electronics as seen from the CSI is equivalent to an MSI (i.e. a MIL-STD-1553 remote terminal). Likewise, the carriage store electronics as seen from the CSSI is equivalent to the ASI (i.e. a MIL-STD-1553 bus controller coupled to a stub). The bridging electronics within the carriage store could include bus controller and remote terminal hardware or could include special electronic repeater circuits. The CSI side of this repeater, however, would have remote terminal electrical characteristics while the CSSI side of the repeater would have data bus stub (or bus controller) characteristics.

5.1.3.5.2 Internal aircraft hierarchical bus. A variation on the heirarchical carriage store technique is also available for use inside the airplane. One version of this approach is shown in figure 37. This structure has specific disadvantages in terms of higher data latencies and more complex electronics. It also provides several advantages. First, it decouples the ASI's need for a MIL-STD-1553 bus interface from the aircraft's data bus structure (ring, tree, star, etc.) and communication method (1553 TDM, FDM, fiber optic, token passing ring, etc.). This decoupling has advantages for retrofitting non-1553B aircraft with MIL-STD-1760 and for integrating AEIS into future high speed data bus aircraft. A second advantage is that the internal hierarchical arrangement removes the impact of potential network variations due to different store loadouts from the main aircraft data bus. Also, it electronically isolates noise on the ASI stub from internal aircraft buses. A fourth advantage is that distributed processing techniques (if selected for the SMS) tend to lead to a tiered multiplex interface.

The main point is that designers should consider the trade-offs of complexity and latency disadvantages against the listed advantages during selection of the SMS architecture.

5.1.3.5.3 Bus repeaters. In this concept, a bi-directional electronic repeater is connected between the SMS bus and a lower level stub (or bus). (See figure 38 for example). When a transmission at point A (from the bus controller) is sensed, the repeater activates and retransmits the signal through the stub (point C) to a lower level RT. The RT response is received by the repeater and echoed back to the main bus. The primary benefit of

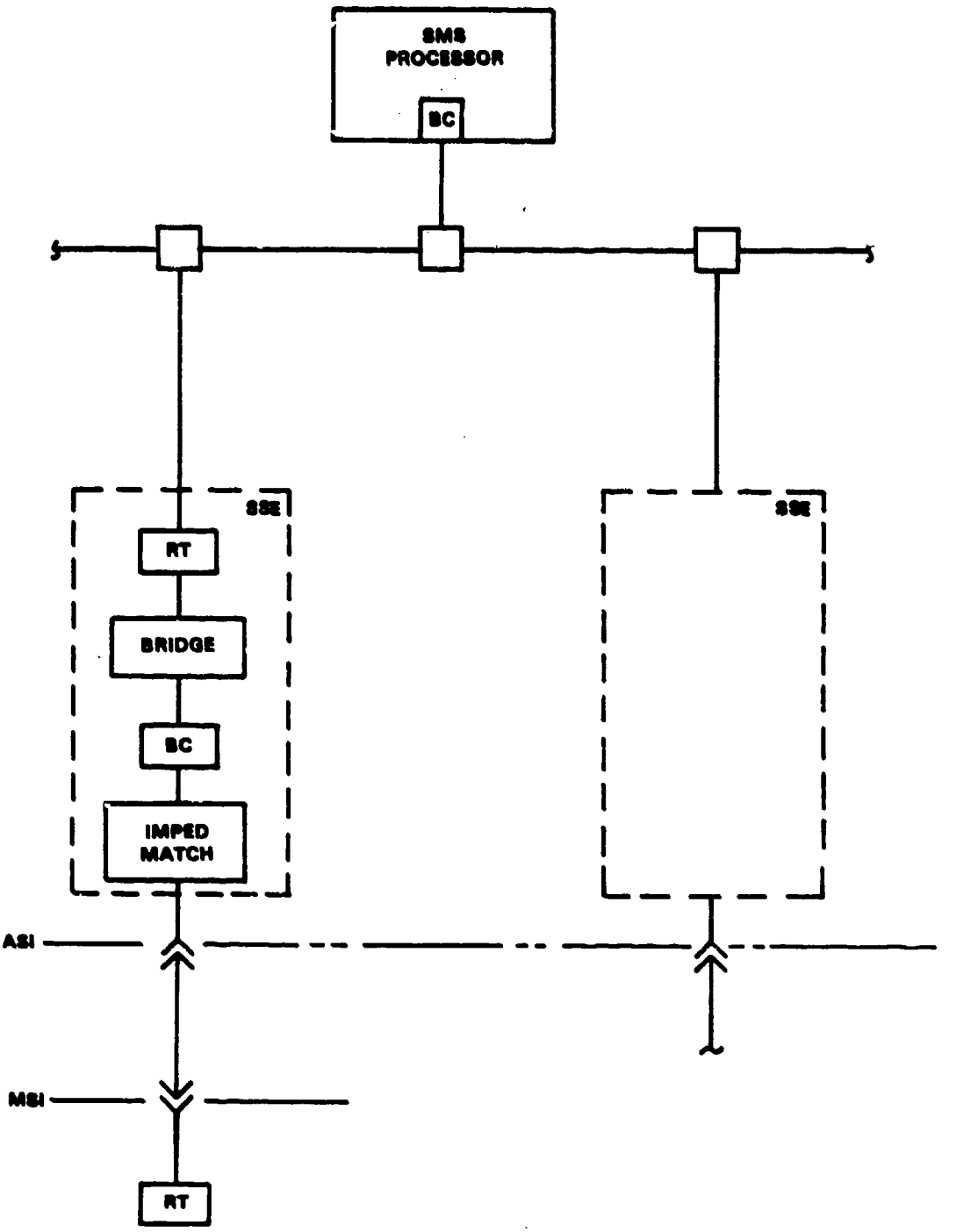


FIGURE 37. Aircraft hierarchical bus.

this approach is to buffer the main bus from stub generated reflections and stub variations by fixing the electrical length of the stub to the distance between the main bus and the repeater bus input. A secondary benefit is that data latencies are much lower with this "immediate repeat" concept when compared to the "store and forward" technique of a hierarchical bus. The primary disadvantage lies in the repeater design trade-off between round trip transmission delay and system noise immunity. As time available for repeater signal processing is increased, the repeater can conduct more checks on the received signal to reduce probability of repeating illegal or distorted signals. The primary deterent to high delays (several microseconds) is the "no response time out" feature of MIL-STD-1553 bus controllers. If the aircraft designer selects a bus controller with a "long" no response time out, the designer can then increase the repeater processing for improved signal quality.

5.1.3.5.4 Bus branch. One problem that is somewhat common in AEIS applications is the need to support multiple RTs below the wing-pylon disconnect. Even excluding pylons with multiple ASIs, a pylon containing an SSE and one ASI is expected to be a common configuration. To service these two RTs (one in the SSE and one in the store connected to the ASI) requires two couplers (actually two for Mux A and two for Mux B). (Note that use of hierarchical or repeater concepts in the SSE eliminates the need for these two couplers.) These couplers can be installed in the wing (see figure 39a) but wing space is severely restricted on most aircraft. Routing the main bus through the wing-pylon disconnect can be done (see figure 39b) but reliability is degraded and jumpers are required if the pylon is removed. A direct coupled stub can be spliced directly into the bus and run through the wing-pylon disconnect. The two transformer couplers can then be connected to this stub for feeding the ASI and SSE. This connection results in signal distortions similar to co-located couplers (see 5.1.3.3.1) as long as the cable between main bus and the coupler pair is kept short (e.g. 1 foot). As this short stub length increases, the bus loading and reflections will also increase. Performance tests must be run on the actual configuration prior to use since it is, at best, stretching the rules for acceptable bus design.

5.1.4 Discrete signals. Dedicated discrete signals in the Aircraft Station Interface (ASI) are provided for the interlock, address and release consent functions. Design issues on implementing these signals are discussed below.

5.1.4.1 Interlock. The purpose for the interlock circuit is to provide a means for the aircraft to determine if the store is "electrically" mated to the aircraft. This discrete signal is similar to the "ground interlock" or "store present" discrete signal in many existing aircraft and stores. The aircraft has the option of using this discrete signal or not using it. If, however, the aircraft uses the discrete signal then the requirements in the AEIS standard apply to the aircraft.

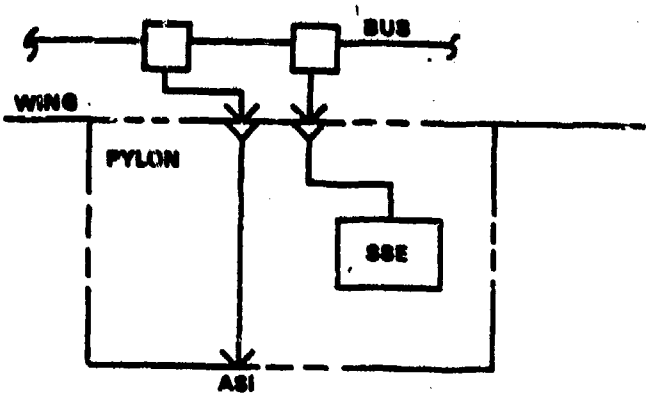


FIGURE 39a. Couplers in wing.

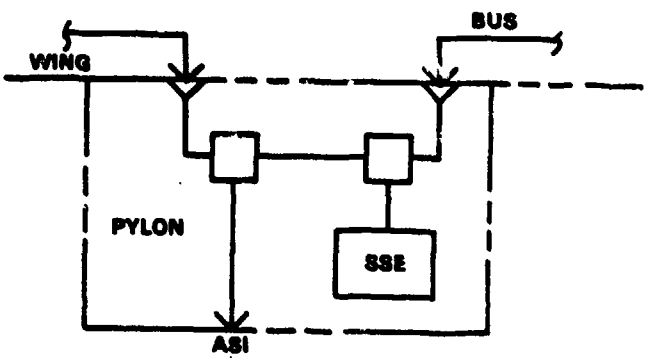


FIGURE 39b. Loop bus through pylon.

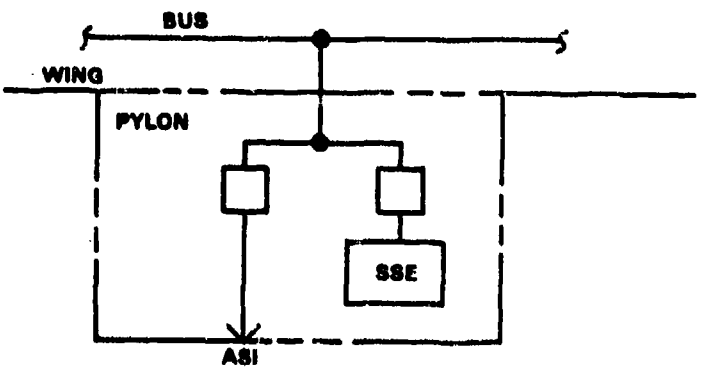


FIGURE 39c. Branch-off bus.

FIGURE 39. Multiple remote terminal coupling options.

The interlock circuit is equally applicable to the primary and auxiliary interfaces. The interlock circuit is not intended to be used as the sole indication of "store gone" since it cannot always determine the true status of the "mechanical" mating between the aircraft and store. Consequently, the following caution note is contained in MIL-STD-1760 and must be heeded:

CAUTION

The interlock interface shall not be used as the sole criteria for functions which could result in an unsafe condition if the interlock circuit fails open.

The primary concern addressed by this caution note is that several failure modes exist in the interface which could result in an indication of "interface not mated". Obvious examples are a broken wire or contaminated contacts anywhere in the circuit path from the aircraft's sensor circuitry (probably in some SMS black box) to the ground or return connection for that sensor circuitry. The existence of continuity could lead to a reasonably valid conclusion that the interfacing connectors are mated. It follows then that lack of continuity could be interpreted as "no assurance that the interface is mated". This latter condition, however, is not equivalent to an indication that the store has physically separated from the aircraft. It is this physical separation sensing function that is the specific concern of the caution note. Some designs in the past have used the "ground interlock" signal as an input to the aircraft's SMS in ways that could result in safety problems under certain combinations of events. If the SMS uses the interlock as an input to determine store separation, a second input should be used as a confirmation of physical separation. The form of this second input can vary with different aircraft and different separation modes and is not addressed by MIL-STD-1760. An example of a second input is a store presence switch (mechanical or proximity) in the suspension and release equipment. Further discussion of store separation sensing techniques available to the SMS is outside the scope of this report.

5.1.4.1.1 Design requirements. The aircraft is required to comply with a set of electrical characteristics (see 5.1.1.5.1 of MIL-STD-1760) measurable at the ASI if the aircraft uses (i.e. monitors) the interlock interface.

The electrical characteristics in the standard can best be understood if the aircraft circuitry is viewed as an input to a logic gate with a pull-up resistor on the input. The gate input pull-up resistor can be tied to an aircraft voltage source that can range from as low as 4 volts DC to as high as the 28V DC levels defined by MIL-STD-704. Given the actual voltage source selected by a specific aircraft, the pull-up resistor is then sized to limit the short circuit current (assume a short is applied at the ASI) to 100 milliamperes maximum and limit the current into a 2 ohm load at the ASI to 5.0 milliamperes minimum. The gate on/off thresholds can then be set to

level(s) that assures that:

(1) An interface connected condition is detected for any impedance between 0 and 2 ohms connected on the store side of the ASI, and

(2) An interface disconnected condition is detected for any impedance greater than 100 kilohms.

The actual impedance levels at which the aircraft circuit switches between connected and disconnected states can be at any point between these two values.

The two ohm and 100 kilohm impedance points are applicable for aircraft excitation voltages and currents over a frequency range from DC to 4 kiloHertz. The 4 kHz frequency establishes an upper frequency limit for any aircraft circuit that uses excitation pulses (e.g. sampling) instead of continuous excitation in an effort to reduce SMS power dissipation.

5.1.4.1.2 Circuit design. The interlock interface is simply a continuity jumper on the store side of the MSI that is available to be monitored by the aircraft. Figure 40 illustrates this interface. Figure 40a shows the actual circuit from ASI into the mission store. Figure 40b defines the equivalent impedance looking into the MSI while figure 40c shows the resulting equivalent impedance that the aircraft circuitry sees looking out the ASI toward the store.

The selection of equivalent impedance thresholds for the aircraft monitor circuit needs to consider the additional line losses between the monitor circuit and the ASI connector. These losses are dependent on the wire type and size selected, the wire length, cable bundling characteristics (such as twist rate) and on the excitation frequencies of interest to the monitor circuit.

Figure 41 shows three typical circuits for the interlock function. The Vcc for the solid state implementation (figure 41c) must be sufficiently high to provide a minimum voltage of 4.0V DC at the ASI connector contact B during an ASI unmated condition.

The circuits are current limited to 100 milliamperes maximum which is easily supported by 24 AWG or larger wire. The diode in the interlock line is used to protect the aircraft circuit against failure in the event power is applied at the interlock interface at the ASI connector as a result of a fault. In some applications, filters may also be installed on the input circuit to exclude EMI entry into the SMS electronic package. Static discharge protection from the outside environment may also be required on these inputs.

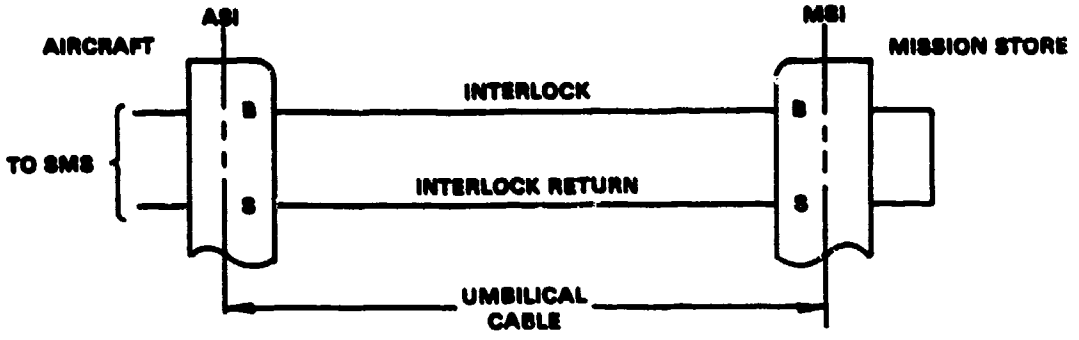


FIGURE 40a. Circuit

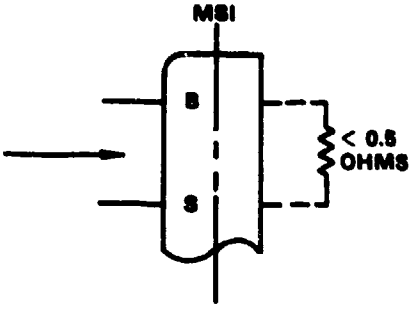


FIGURE 40b. MSI equivalent

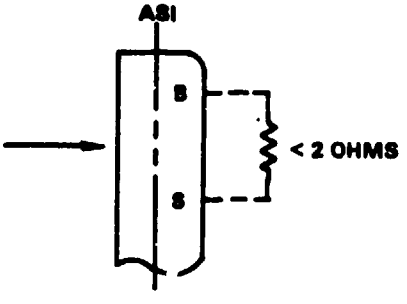


FIGURE 40c. ASI equivalent

FIGURE 40. Interlock interface requirements.

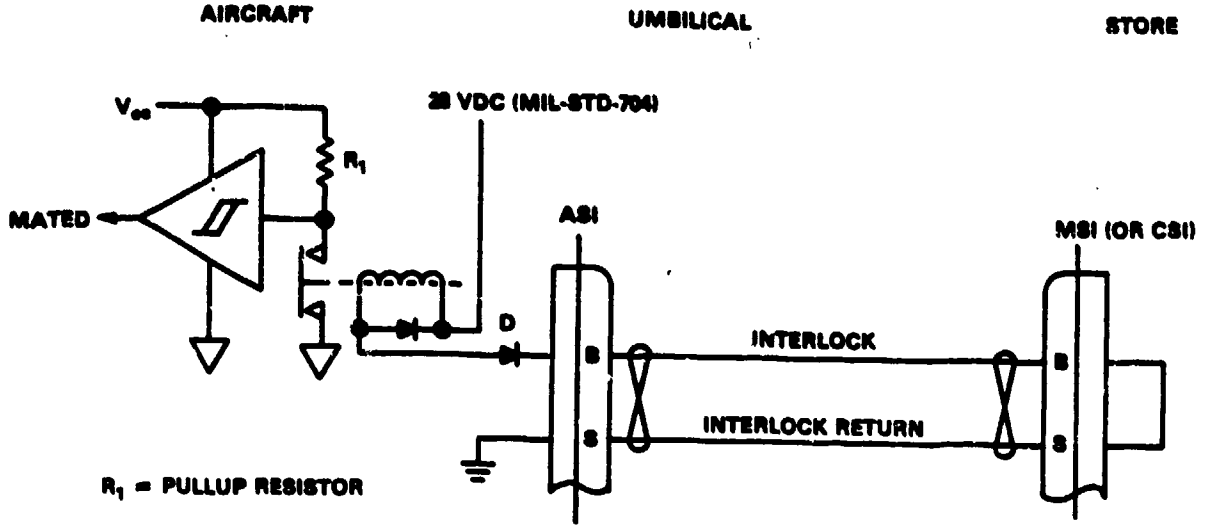


FIGURE 41a. Electromechanical relay.

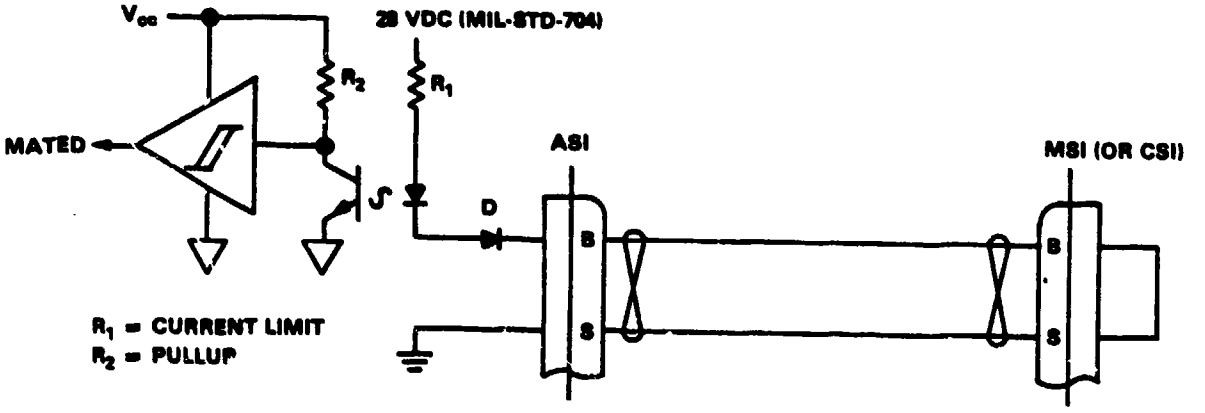


FIGURE 41b. Optical coupler.

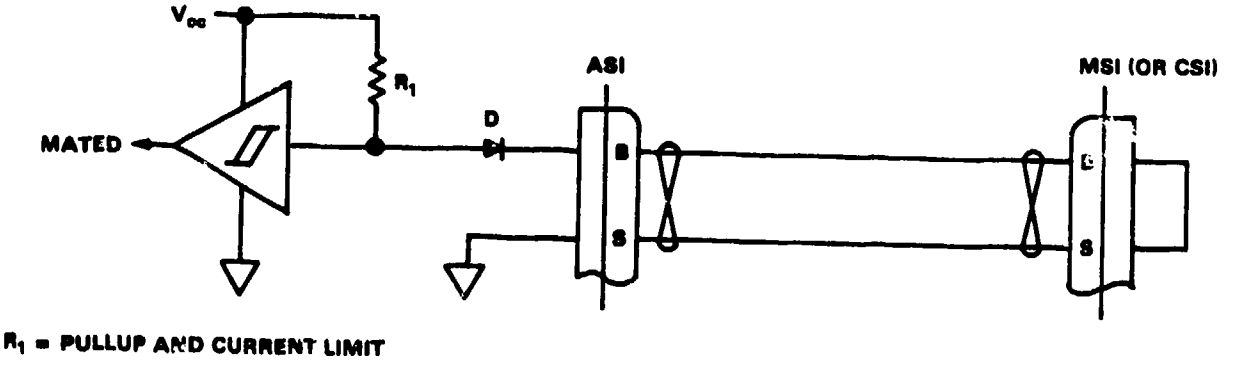


FIGURE 41c. Solid state.

FIGURE 41. Aircraft interlock circuit implementations.

5.1.4.1.3 Test data. Test data on the interlock and interlock return lines implemented with 22 gauge wire show a typical resistance of less than 600 milliohms from the ASI to the mission store in applications not requiring a carriage store and 1.4 ohms in applications requiring an "extension cord" style carriage store. (See Appendix A for test configurations.)

5.1.4.2 Release consent. The purpose for the release consent circuit is to provide the aircraft with a hardwired discrete control to the store for enabling and inhibiting the store from acting on safety critical commands received over the Mux A/Mux B interface. In theory, the aircraft can enable the release consent signal at any time. The only timing restrictions in MIL-STD-1760 are that: (1) The enable state must be provided at least 20 milliseconds before a "store release" or "safety critical" command is sent to the store over the MIL-STD-1553 bus, and (2) the inhibit state must be provided at least 20 milliseconds before the aircraft wants the store to be inhibited. The store is not allowed to use the transition to the enable state to activate any internal store function other than the internal store "functional state" which enables acting on safety critical commands from the multiplex interface.

The AEIS standard does not define which commands are safety critical nor does it require any specific commands to be interlocked with release consent. The standard is silent on this issue primarily because it is deemed too application dependent. The designation of specific release consent interlocked commands is therefore left to the aircraft-store Interface Control Document (ICD) or to the individual system specification. It is intended and expected however, that certain types of commands will be interlocked. Examples include: (1) Firing commands sent to rail launched missiles, (2) ejection commands sent to carriage stores, (3) commands that result in irreversible store actions such as commands to activate an internal thermal battery, and (4) commands that place Safe and Arm devices in the "Arm" position.

5.1.4.2.1 Design requirements. The release consent circuit is in the "enable" and "inhibit" states when the voltage levels at the ASI (contact 1 referenced to contact E) comply with figure 42. The voltage transition time between enable and inhibit states must not exceed 3 milliseconds under resistive load conditions.

When the signal is in the enable state, the aircraft must be capable of supplying 100 milliamperes through the ASI. The aircraft must also be capable of supplying the required enable voltage levels when store loads ranging between 5 and 100 milliamperes are attached to the ASI. Under conditions of a low impedance fault at the ASI, (release consent faulted to 28V DC power 2 return) the aircraft is required to limit the fault current to the maximum overcurrent curve defined in MIL-STD-1760 figure 7.

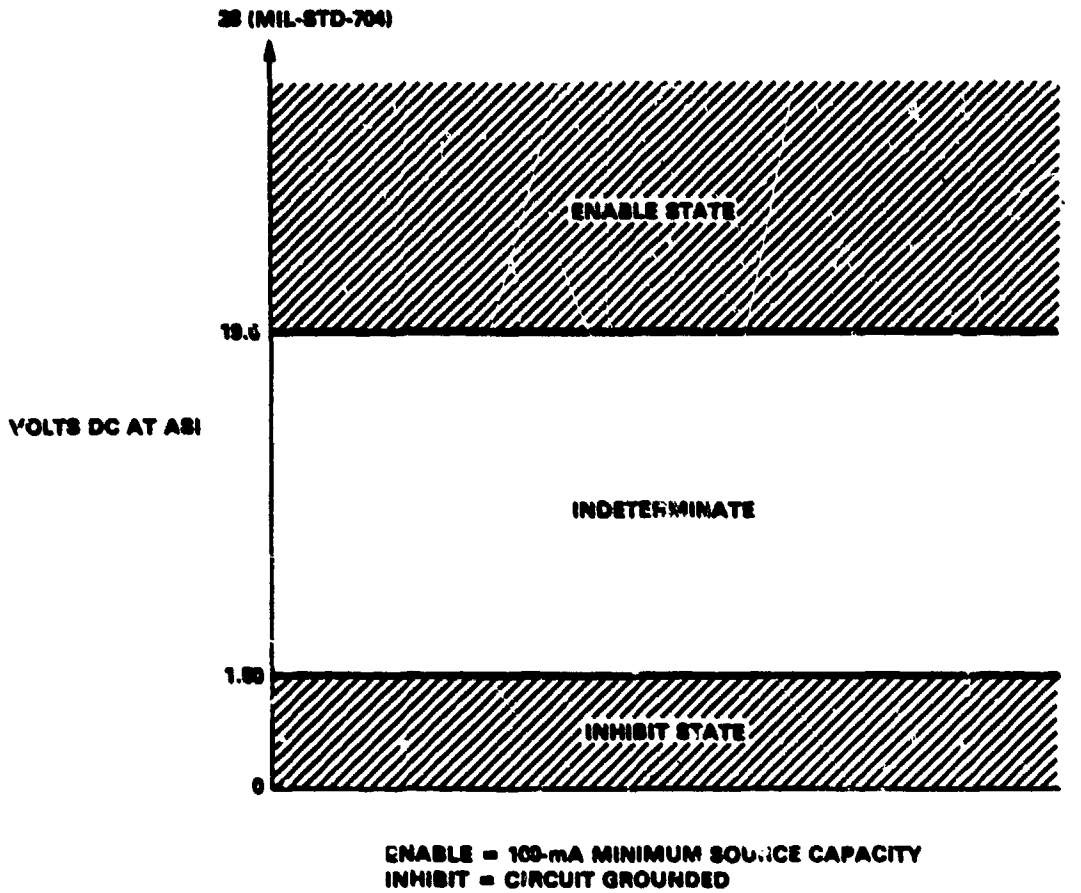


FIGURE 42. Aircraft release consent voltage requirements.

The final design requirement on release consent can be subject to misinterpretation. Paragraph 5.1.1.4.1 of MIL-STD-1760 states that when in the inhibit state, the release consent interface at an ASI must be electrically isolated (100 kilohms minimum at DC) from the release consent interface at all other ASIs. The intent behind this requirement is that a fault (e.g. 28V DC shorted to release consent) in the release consent circuit of one station must not result in the release consent signal at other station(s) going to the enable state. The way the requirement is worded, however, can lead to a misinterpretation for the condition when several stations' release consent signal are inhibited by being connected to ground (see figure 43). If several release consent signals are inhibited (grounded) then these lines are connected to a common point (ground). It is not intended that a common connection to ground potential be interpreted as lack of electrical isolation.

5.1.4.2.2 Circuit design. Figure 43 shows typical aircraft circuits for the release consent function. Figure 43a is an electromechanical relay implementation and figure 43b is a solid state design. The current level limits of 5.0 milliamperes to 100 milliamperes allow a high degree of reliability to be achieved with the use of electromechinical relays since significant contact arcing is avoided. The release consent circuit is connected to ground when operating in the inhibit state. This is required to ensure the 1.5 volt limit is not exceeded as a result of EMI pick-up.

The current level limits are also compatible with efficient solid state implementations. As shown in figure 43b, transistor Q_1 can operate in a current limit mode during a fault condition, thereby providing protection to the circuit wiring in addition to the drive transistor. Similar to the electromechanical implementation, the output circuit must be clamped to ground when in the inhibit state to ensure the voltage to the store does not exceed 1.5 volts. As a further precaution against EMI, the output circuit may require filters and static discharge protection. The need is dependent upon circuit design employed.

5.1.4.2.3 Circuit protection.

5.1.4.2.3.1 Aircraft circuit. MIL-STD-1760 specifies that the aircraft must ensure that the current at the ASI not exceed the current levels depicted by the "maximum overcurrent" curve of figure 44. This "maximum overcurrent" curve represents maximum current-time durations permitted under a fault condition at the ASI (or MSI). This abnormal condition may occur once during a flight or may never occur during the life of the airplane. Furthermore, the "maximum overcurrent" limit specified in MIL-STD-1760 and shown in figure 44 was established for circuits rated at 10.0 amperes. Since the release consent current demand is only 100 milliamperes, it is not necessary that the release consent circuit components (wire, relays,

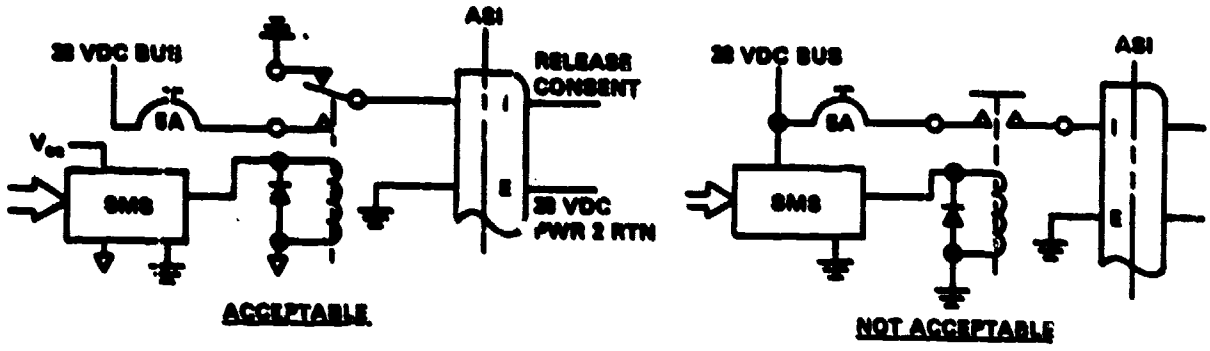


FIGURE 43a. Electromechanical relay.

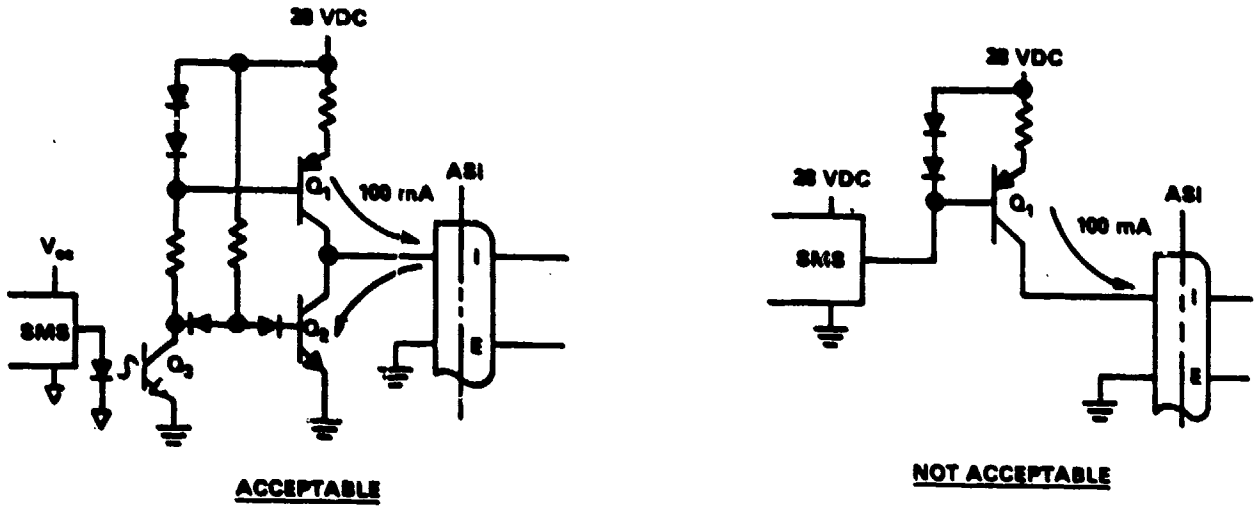


FIGURE 43b. Solid state.

FIGURE 43. Aircraft release consent implementation examples.

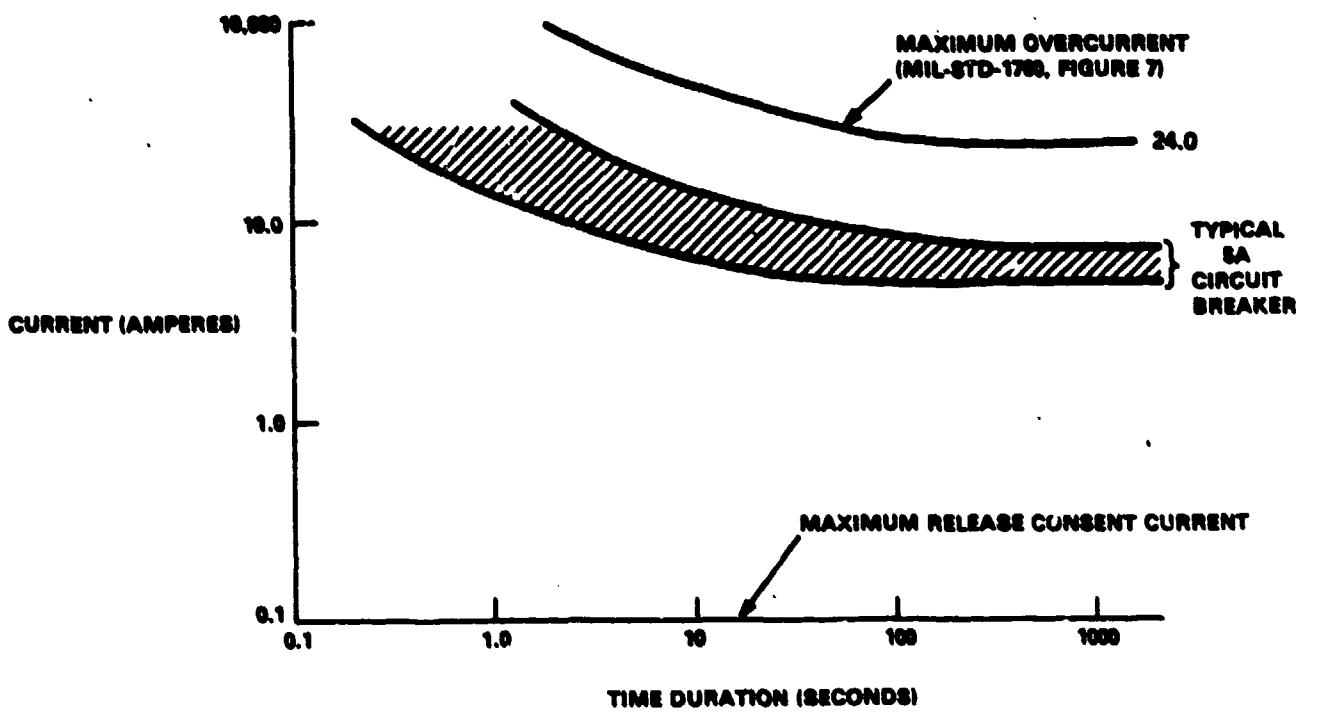


FIGURE 44. Typical release consent circuit protection.

connectors, etc.) in a specific aircraft be rated for 10.0 amperes if the aircraft limits the current to lower levels by design (e.g. figure 43b. In the interest of saving weight, the aircraft designer should select the smallest gauge wire (in compliance with MIL-W-5088) that will support the maximum load current expected for his design. A protective device should then be selected to protect this wire (and other components). As shown in figure 44, the circuit protective device trip characteristics must lie above the maximum release consent load current rating of 100 milliamperes and below the maximum overcurrent curve.

This overcurrent limit was imposed by MIL-STD-1760 for the benefit of the connected mission store. This establishes an upper limit on fault currents which could be sourced into a store and which the store should safely withstand. A complication is that the allowed fault levels were defined to allow the aircraft to use the protection afforded one of the primary 28V DC power lines (10 ampere rating) instead of installing an additional release consent circuit breaker or some other current limiter. This results in a very high "allowed" fault level compared to the 100 milliampere non-fault current capacity required of the release consent line. (Note that the July 1981 MIL-STD-1760 required a 1 ampere capacity for release consent.)

Due to this low current level, it is in the interest of all (aircraft, store and umbilical designers) that the current limiting on release consent be lowered considerably below the levels allowed by MIL-STD-1760 figure 7 and the associated reference in paragraph 5.1.1.4.2.2. Since the MIL-STD-1760 connector assigns a 20 gauge contact to the release consent function, an obvious implication exists that a 20 guage or smaller wire will be used in the circuit. (The required current level of 100 milliamperes can actually be provided through wire gauges smaller than can be installed in aerospace applications due to mechanical considerations.) If the aircraft installs a 20 gauge (or smaller) wire, then the requirements imposed by aircraft system specifications for compliance with MIL-W-5088 will require that the aircraft protect the 20 gauge (or smaller) wire. Umbilicals and stores which use a 20 gauge wire for this function would then also be protected.

5.1.4.2.3.2 Umbilical cables. In applications where an aircraft uses a unique umbilical cable for connecting stores to the aircraft, the umbilical release consent line can be sized to safely withstand the fault current levels as limited by that specific aircraft. If the umbilical is a design used on various aircraft, then an implication exists that the umbilical should safely withstand (no fire, melt down, etc.) the figure 7 overcurrent. Realistically, however, the umbilical is restricted by the 20 gauge contact size defined for the connector at each end of the umbilical.

A more realistic approach is to design the umbilical based on the design recommendations of 5.1.4.2.3.1 above - i.e. install a 20 gauge wire for the release consent circuit. The other alternative is to install a high temperature insulation 18 gauge wire and discard the umbilical after the umbilical is exposed to the overcurrent levels depicted by figure 7.

5.1.4.2.4 Carriage store. Carriage stores are required to release mission stores although the release command is under the control of the aircraft Stores Management System (SMS). Consequently, the carriage store must provide a release consent signal at each CSSI in response to a similar signal provided at the ASI (and CSI via the umbilical cable). MIL-STD-1760 requires the carriage store to be compatible with signal levels at the ASI and MSI as depicted in figure 45. It must be remembered that the carriage store design must make allowances for signal losses caused by the ASI-to-CSI and CSSI-to-MSI umbilical cables. That is, the maximum signal voltage drop allowed between the ASI and MSI is 4.0 volts. A minimum voltage drop of 0.5 volts should be allocated for the ASI-to-CSI and CSSI-to-MSI umbilical cables, leaving 3.0 volts to be dropped across the carriage store (CSI-to-CSSI).

Typical carriage store designs for the release consent circuit are shown in figure 46. Figure 46a shows a direct connection between the CSI and CSSI interfaces. This implementation is applicable only when a single mission store is carried. All carriage stores having multiple mission store capabilities will require the release consent signal supplied at the ASI (and CSI) to be used for control only as shown in figures 46b and c. This is true because each mission store is allowed to demand 100 milliamperes which is also the minimum that is guaranteed to be available from the ASI. Consequently, current amplification is required when more than one mission store on a carriage store is to be sourced a release consent signal simultaneously. Current amplification is obtained by using a separate power source (such as 28V DC power 2) as shown in figures 46b and c. Relays requiring less than 100 milliamperes of coil current can be driven directly by the release consent signal, otherwise a transistor drive circuit is required. Figure 46c is an implementation similar to figure 46b except individual control of release consent fanout is provided based on commands received over the MIL-STD-1553 interface and solid state switches with current limiting are provided.

MIL-STD-1760 intended for carriage store wiring to be protected by the aircraft fault protection system to avoid the addition of protective devices in the carriage store. In theory, the only guarantee (from MIL-STD-1760) is that the release consent line is protected to MIL-STD-1760 figure 7 limits. However, as discussed in 5.1.4.2.3.1 and 5.1.4.2.3.2 above, it is highly recommended that a lower overcurrent limit (sufficient to protect 20 gauge wire) be provided by the aircraft for release consent.

While this lower overcurrent will benefit the carriage store on its release consent input protection, it could be a disadvantage in the release consent output circuit. Specifically, the circuit concept of figure 46b requires the carriage store to include a series protective device between the 28V DC power (1 or 2) input at the CSI and the release consent output at the CSSI.

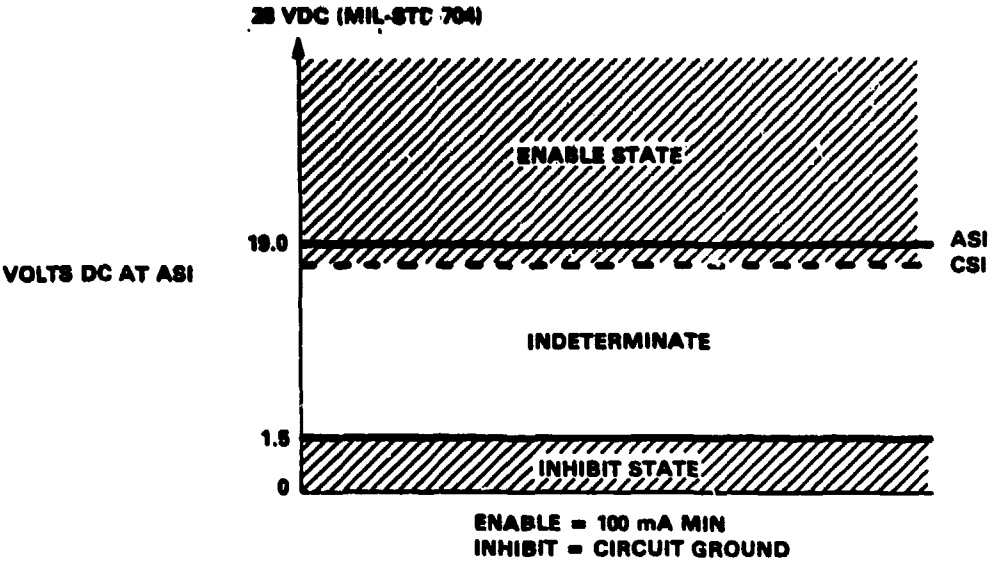


FIGURE 45a. Input to carriage store (measured at the ASI).

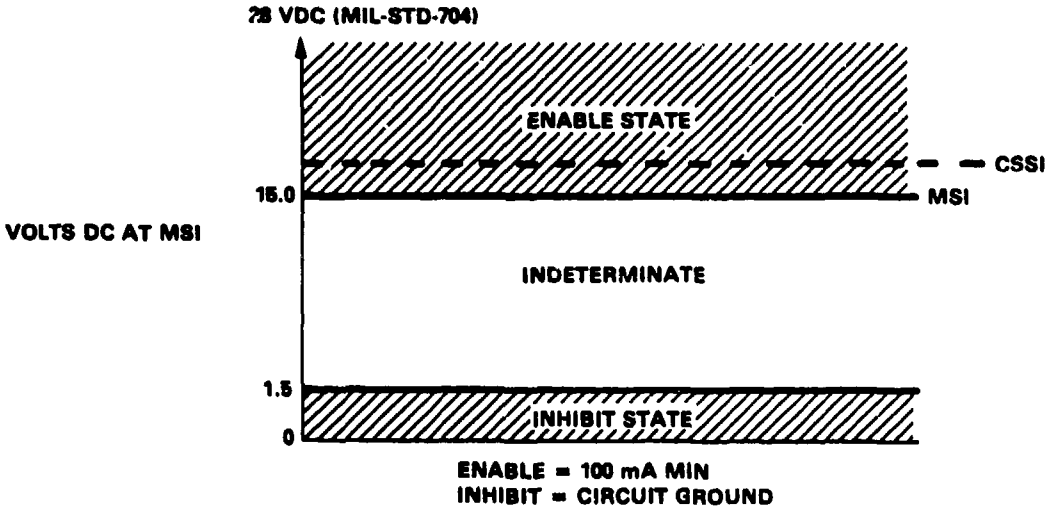


FIGURE 45b. Output from carriage store (measured at the MSI).

FIGURE 45. Carriage store release consent signal requirements.

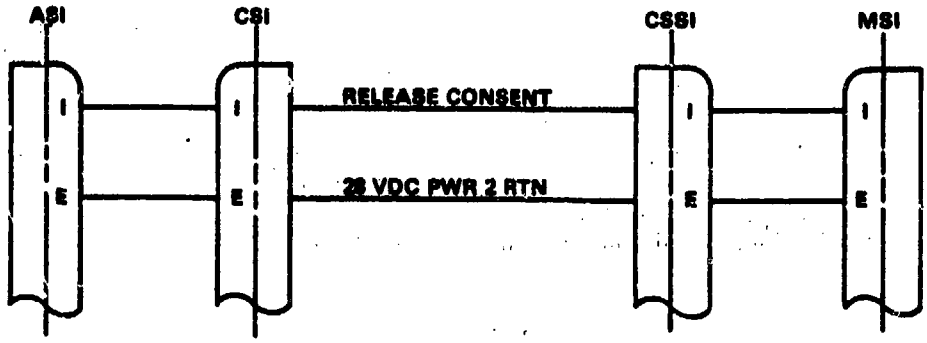


FIGURE 46a. Direct connection (one MSI only).

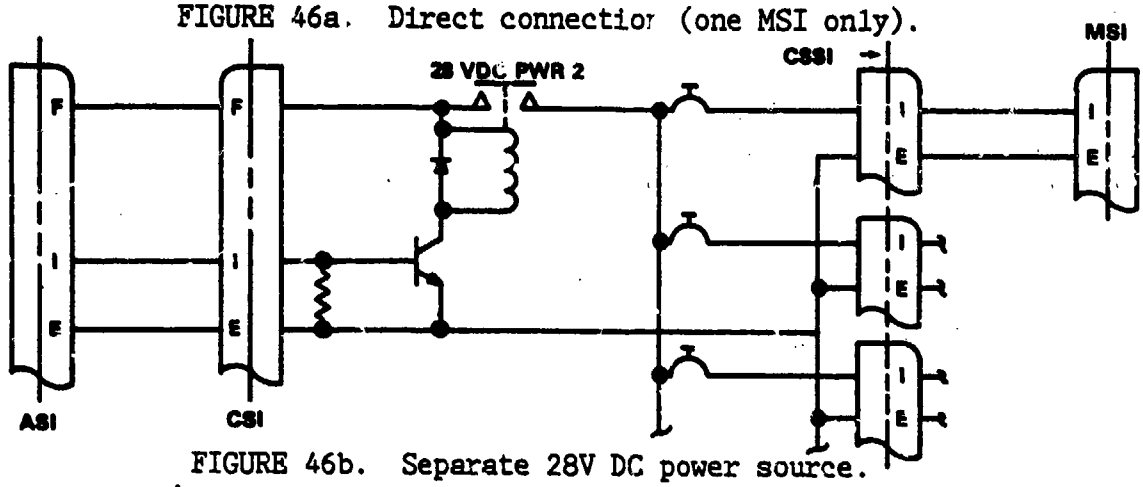


FIGURE 46b. Separate 28V DC power source.

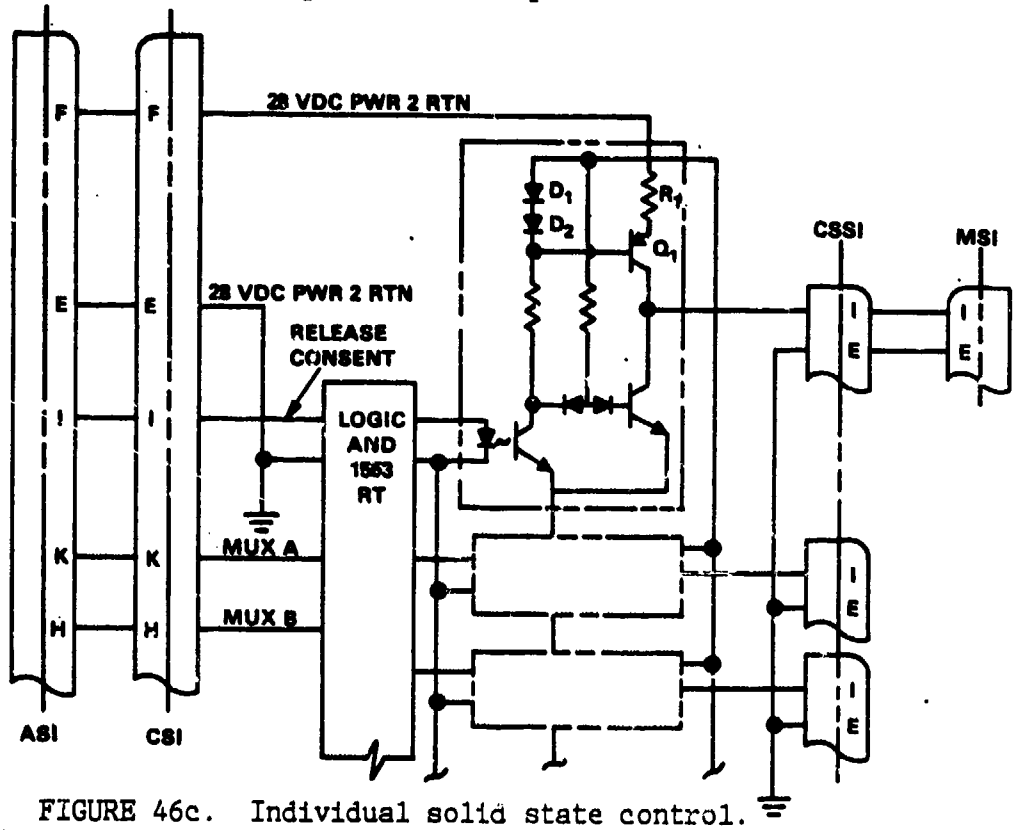


FIGURE 46c. Individual solid state control.

FIGURE 46. Carriage store release consent circuit examples.

This series protection is required to maintain the "protected 20 gauge wire" recommendation. In contrast, if the carriage store implements the concept of figure 46c, then the current limiting circuit composed of R_1, Q_1, D_1 and D_2, can be sized to significantly limit fault currents (typically 100 ma) out the CSSI while still delivering the required 15 volt minimum signal to the MSI under fault-free conditions. (Note that the fault-free load current is only 100 milliamperes maximum.)

5.1.4.2.5 Test data. The release consent circuit was implemented with 22 gauge wire in the test circuit. The worst case voltage drop (in environmentally fatigued harnesses) was less than 0.9 volts from ASI to MSI for applications not requiring a carriage store and 3.4 volts in applications requiring a carriage store. (See Appendix A for test configurations.)

5.1.4.3 Addressing. The purpose for the address interface is to provide a means for the aircraft to assign a digital multiplex data bus address to the MIL-STD-1553 compliant remote terminal in the mission store or carriage store as applicable. The address transfer mode consists of five address discrete lines with binary coded weighting, one address parity discrete line and one discrete line for a common return. The nominal operating modes for these lines are an open circuit for Logic 1 and a short circuit for Logic 0 for each address line. The five binary coded address discretes are identified as Address Bit 0 (A_0) through Address Bit 4 (A_4). The address assignment is determined by:

$$\text{ADDRESS} = (A_4) \times 2^4 + (A_3) \times 2^3 + (A_2) \times 2^2 + (A_1) \times 2^1 + (A_0) \times 2^0$$

where A_4 through A_0 are either 1 or 0

One additional discrete (defined as Address Parity) is set to the proper logic state at the ASI to produce an odd number of Logic 1 states on the five address discretes and the one parity discrete. If the circuit uses an active address circuit (see 5.1.4.3.1), some additional rules apply. The aircraft is required to provide a stable set of address discretes at an ASI prior to application of any interface power. Furthermore, the aircraft must not (intentionally) change the address assigned to any ASI after power has been applied to that interface. If power is later removed from the interface (e.g. due to internal store power change over), the aircraft must still maintain the same address at the interface until this connected store has been released from the aircraft.

5.1.4.3.1 Design requirements. In the simplistic form, the aircraft circuit is only a set of jumpers on the aircraft side of the ASI. These

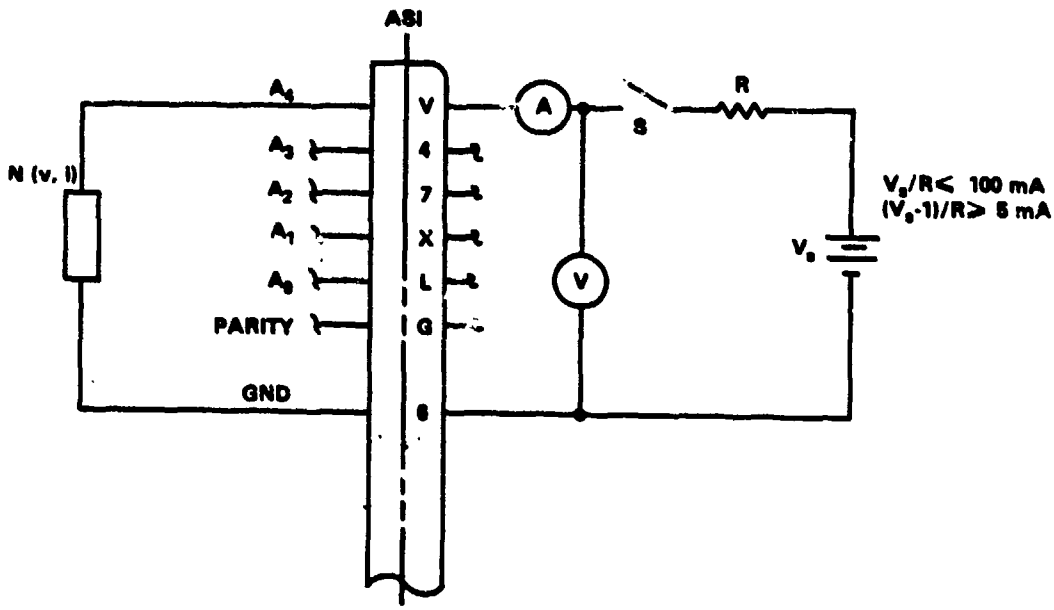
jumpers provide either a "short" or "open" circuit between each address and parity connection and the associated address return. However, the requirements in the standard were written to allow more complex implementations for cases where: (1) The address at a given ASI must be changed as a result of mission loadouts, or (2) the address is provided by an electronic box such as Store Station Equipment which is used at various stations and must therefore contain a programmable (changeable) address interface. The number of applications which will actually use such modifiable addresses is unknown but expected to be relatively small. In fact, some applications such as ASIs certified for nuclear store carriage may be prohibited from using software or electronic programmable addresses. (See the System 2 Specification on nuclear weapon interfaces.)

Figure 47 illustrates in a test circuit format, the electrical requirements imposed on the ASI. If a particular address line is in a Logic 1 state, then the aircraft circuit must be such that less than 300 microamperes flows into the ASI connection when voltages between 3.5 and 31.5 volts DC are applied. Similarily, the aircraft must provide circuits for a Logic 0 state such that less than 1 volt is measured between the address connection and address return when currents ranging from 5 to 100 milliamperes are sourced into the ASI. The aircraft designer must also consider the effect (i.e. additional voltage drop in address return) on measured voltage when currents up to 100 milliamperes are sourced simultaneously into all Logic 0 set address lines at an ASI.

Furthermore, the aircraft is required to reach these required voltage/current levels within 10 milliseconds of address excitation application (i.e. closure of switch S in figure 47). This 10 millisecond response imposes some limits (though nothing significant) on any filtering or other circuitry which might be included in the aircraft address interface.

Finally, paragraph 5.1.1.6.3.4 of MIL-STD-1760 requires that the aircraft isolate all address connections including the address return from all other aircraft circuits including grounds. This isolation level is specified at 100 kilohms minimum for frequencies up to 4 kiloHertz. This isolation requirement primarily affects aircraft which use some active address concept.

5.1.4.3.2 Circuit examples. Examples of circuit implementations to meet these requirements are given in figure 48. Figure 48a shows a hard-wired (uncontrolled) implementation. Figure 48b shows an optical coupler design. The solid state device must be capable of conducting 100 milliamperes with a voltage drop of 1.0 volts maximum when closed and be capable of blocking 31.5 volts DC minimum when open. Figure 48c shows an electromechanical relay approach. Implementations that electrically isolate the address lines (including address return) from the aircraft control electronics are



LOGIC STATE	NOMINAL DESCRIPTION	V (VOLTS)	A (AMPERES)
1	N = OPEN	3.5 TO 31.5 (APPLIED)	$<300 \times 10^{-6}$ (MEASURED)
0	N = CLOSED	<1.0 (MEASURED)	$5 - 100 \times 10^{-3}$ (APPLIED)

FIGURE 47. ASI address electrical characteristics.

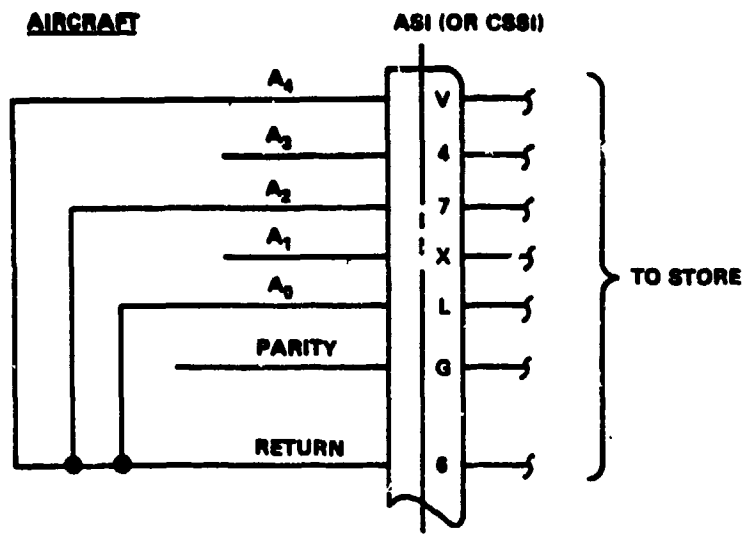


FIGURE 48a. Hardwired.

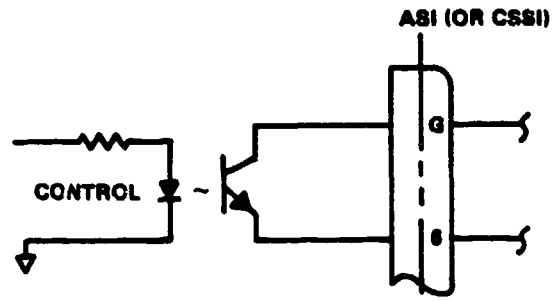


FIGURE 48b. Optional coupler.

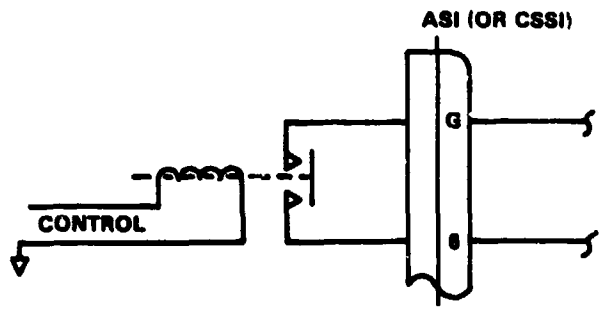


FIGURE 48c. Electromechanical relay.

FIGURE 48. Aircraft address circuit examples.

required. The implementations shown are compatible with both continuous and pulse type excitation signals from the store. The circuit design should accomodate a "worst case" excitation signal condition which is a continuous signal of 100 milliamperes on each address line. EMI filtering and static discharge protection may be required for those designs which feed the address lines from the ASI back into some aircraft black box.

5.1.4.3.3 Carriage store addressing. If a carriage store is provided, the carriage store must energize and monitor a set of six address discrete signal lines (plus a dedicated address return line) at the CSI in accordance with the requirements defined in paragraph 5.1.4.3.1. This set is used to assign the terminal address for the internal carriage store MIL-STD-1553 remote terminal. For conditions where the aircraft assigns terminal addresses to mission stores attached to the carriage store, the aircraft must accomplish this lower tier address assignment via the Mux bus. The carriage store would then need to contain circuitry (similar to figure 48b and c) to setup address discretes at each CSSI based on these assigned lower tier addresses. For configurations where the carriage store determines the assigned terminal address for attached mission stores any address except 31 may be assigned to any CSSI.

5.1.4.3.4 Test data. Test data taken on address and address return lines (22 Gauge Wire) show a typical voltage drop of 0.11 volts on the aircraft side of the ASI. The voltage drop between the ASI and MSI was 0.025 volts with no carriage store and 0.11 volts with a carriage store. Test current was 100 milliamperes. MIL-STD-1760 allows a 1.0 volt drop on the aircraft side of the ASI and a 0.5 volt drop between the ASI and MSI. (See Appendix A for test configurations.)

5.1.5 High bandwidth signals. The high bandwidth distribution system consists of four ports (circuits) at each ASI designated as HB1, HB2, HB3 and HB4 for transferring high bandwidth signals between the aircraft electronics equipment and the ASIs, and between ASIs. All four ports must be capable of transferring signals in the frequency range of 20 Hz to 20 MHz (Type A signals). One port (HB1) must also be capable of transferring signals in frequency range of 20 MHz to 1.6 GHz (Type B signals). The HB circuit design must provide for the simultaneous transfer of HB signals on all four HB lines at any given ASI. The design must provide for the transfer of four HB signals through class I ASIs and two HB signals through class II ASIs. Furthermore, the design should provide a capability for transferring Type A signals from one ASI to another ASI.

The transfer capacity requirement imposed by MIL-STD-1760, i.e., transfer of one Type B signal or one Type A signal on HB 1 simultaneously with the transfer of Type A signals on HB2, HB3 and HB4 through an ASI, is a minimum requirement. Essentially, all this requirement achieves is that all HB ports at an ASI are simultaneously available for store use. For an

aircraft to meet its mission requirements, it is expected that a higher level of HB network capacity may be needed. The actual network capacity required, i.e., the number of simultaneous HB signals flowing through the Stores Management System (SMS) will vary with each aircraft and with each store loadout. As a design goal, the aircraft should support the following minimum network capacity:

a. Simultaneous transfer of one Type B signal (on HB1) and two Type A signals (on HB1 and HB2) between the ASIs and aircraft equipment plus one Type A signal (on HB1 and HB2) between any two ASIs. The transfer network shall be a 50 ohm system as seen at the ASI.

b. Simultaneous transfer of two Type A signals (on HB3 and HB4) between ASIs and the aircraft equipment plus one Type A signal between any two ASIs. The transfer network shall be a 75 ohm system as seen at the ASI.

This recommended minimum network capacity is illustrated in figure 49. Signal assignment for each interface class is given in table V.

The purpose for this signal assignment is to direct specific signal types to/from stores onto specific HB lines to maximize compatibility between stores and the aircraft HB signal distribution system. This reduces the number of cross connecting paths required in the distribution network. As an example, the network can provide signal paths between the cockpit video displays and HB3 and HB4 at any one ASI but need not provide paths (switching) to interconnect the displays to HB1 and HB2 at all ASIs.

TABLE V. HB signal assignments.

ASI CLASS	SIGNAL		HB1	HB2	HB3	HB4
	TYPE	IDENT				
I	B	RF	X			
	A	TCP	X	X		
	A	VIDEO			X	X
II	B	RF	X			
	A	TCP	X			
	A	VIDEO			X	

HB1 and HB2 - 50 ohm networks
HB3 and HB4 - 75 ohm networks

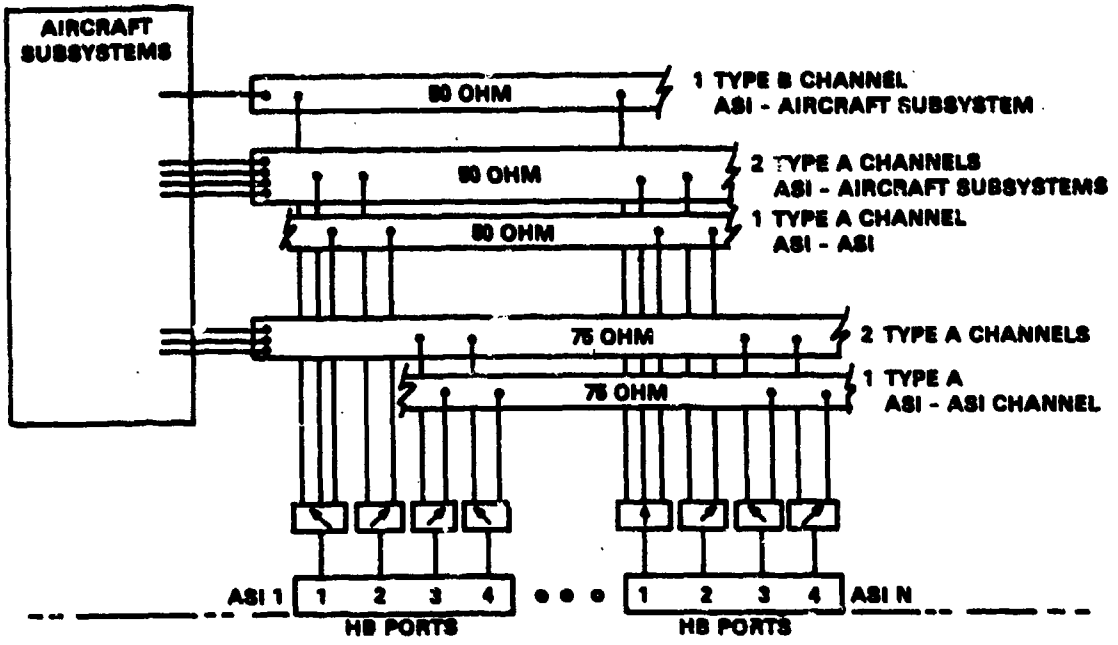


FIGURE 49a. Recommended channel capacity.

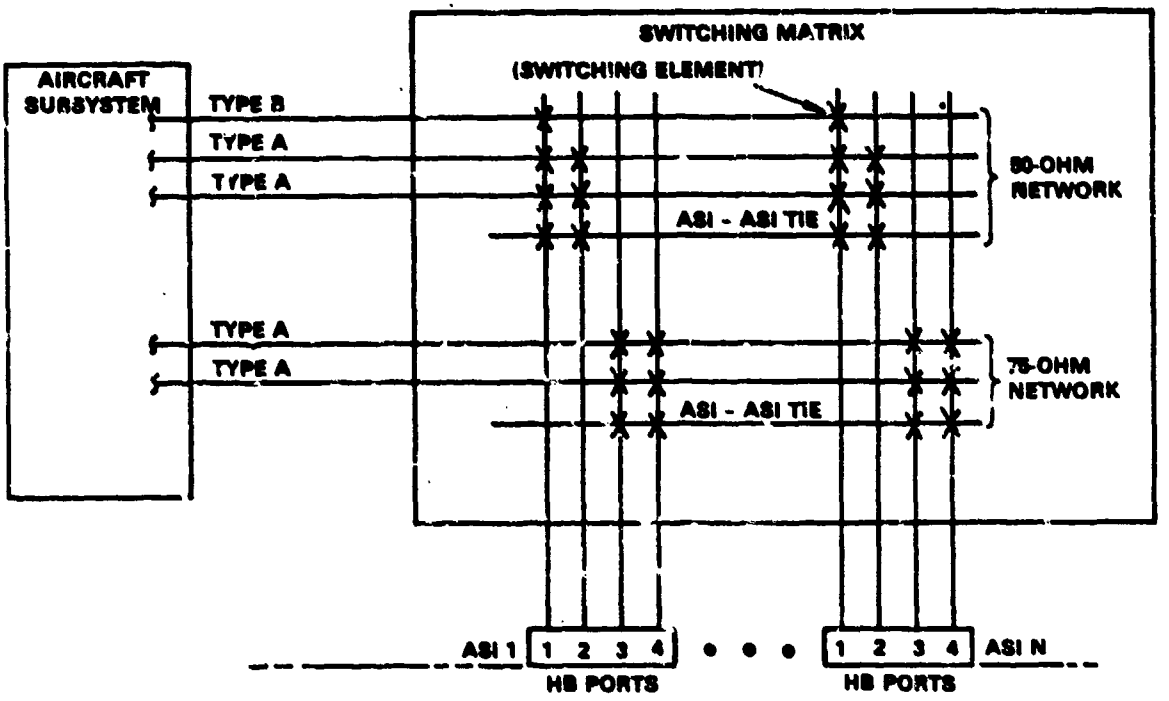


FIGURE 49b. Centralized switching matrix example.

FIGURE 49. Minimum recommended HB network capacity.

The aircraft VSWR requirements are illustrated in figure 50. Basically, two requirements are defined, i.e., maximum VSWR provided by the aircraft and minimum VSWR with which the aircraft must be compatible. The requirements are defined at the ASI and also at the MSI when umbilical design responsibility rests with the aircraft designer.

The attenuation and attenuation flatness requirements of 6.0 dB and 5.0dB respectively are specified for the ASI-ASI signal path only and apply to Type A signals only. The attenuation and flatness of the ASI-to-aircraft equipment signal path is difficult to specify in a standard due to lack of direct control of the interface requirements and interface location of "aircraft equipment". Consequently, attenuation and attenuation flatness requirements for this signal path are not specified.

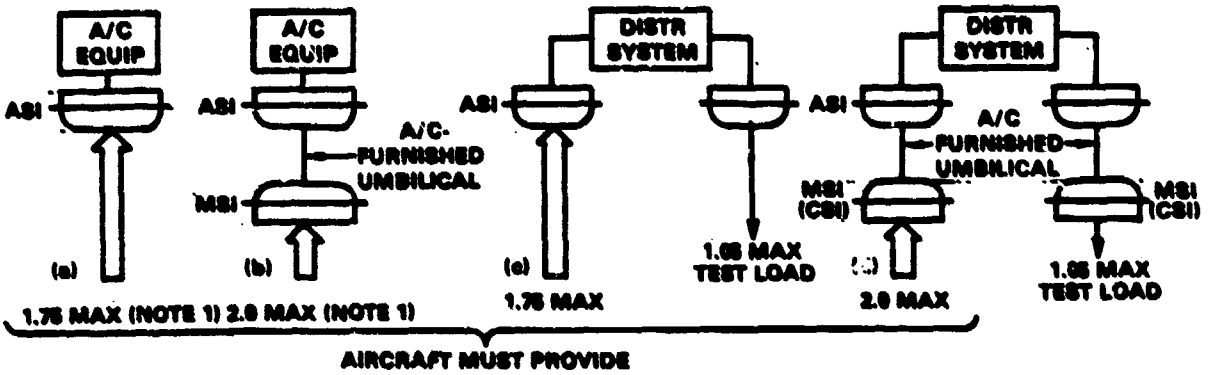
The AEIS standard also defines specific requirements on the aircraft distribution system's ASI-to-ASI transfer performance for propagation delay, signal dispersion and harmonic distortion. As with the attenuation requirements, ASI-to-aircraft equipment transfer path performance is not controlled in MIL-STD-1760.

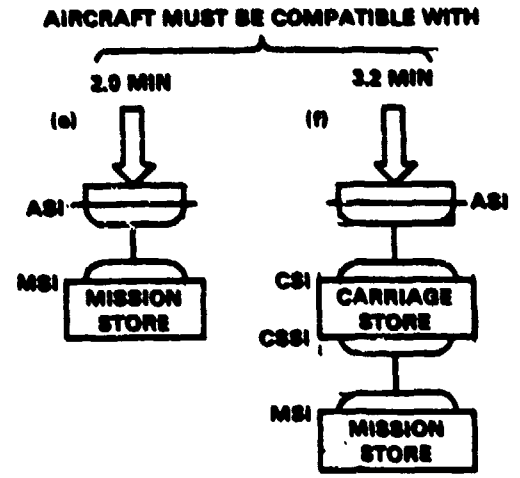
The AEIS standard also defines a set of general characteristics (see table VI) for the Type A and Type B signals. These general characteristics are intended to provide design requirements on the aircraft's HB distribution network - i.e., the distribution network must be capable of transferring signals which fall within the tabulated characteristics.
In addition to these general signal characteristics, specific requirements are defined for video signals transferred through the AEIS. These requirements are patterned around existing video standards with some modifications for accommodating store environment applications. These video requirements are listed in MIL-STD-1760 paragraph 5.1.1.1.2.1. (See 5.4.5.)

5.1.5.1 Networking techniques. The technologies available for providing HB signal distribution through the aircraft span a broad technology base from electromechanical relays to electronic multiplexing. The networking methods discussed below are divided into two broad catagories - Type A signal distribution and Type B signal distribution. Some of the techniques outlined for Type A distribution systems can also be used for Type B distribution with the qualification that components used in the Type B system will tend to have more stringent performance requirements.

5.1.5.1.1 Type A signal distribution. The Type A signals have a relatively small frequency range (20 Hz to 20 MHz). Also, since the upper frequency limit (20 MHz) is relatively low, a number of distribution networking methods are viable alternatives.

Table VII lists techniques currently available or expected to be availble in the near and intermediate term for distributing Type A signals. The





FREQUENCY RANGE	HB_1	HB_2	HB_3	HB_4
5 MHz TO 29 MHz	X	X	X	X
29 MHz TO 1.6 gHz	X			

NOTE:

1. THE FREQUENCY RANGE FOR (a) AND (b) TESTS IS SHOWN IN THIS TABLE, OR WHEN APPLICABLE, A SMALLER BAND WITHIN THE RANGE AS DETERMINED BY THE SPECIFIC AIRCRAFT EQUIPMENT LOAD.

FIGURE 50. Aircraft VSWR requirements.

TABLE VI. High bandwidth general signal characteristics.

CHARACTERISTIC	SIGNAL TYPE	
	TYPE A	TYPE B
Signal frequency		
Minimum	20 Hz	20 MHz
Maximum	20 MHz	1.60 GHz
Full scale signal voltage		
Minimum	1.0V pp	.01 microvolt pp
Maximum	12.0V pp	1.0V pp
Signal voltage dynamic range	30 dB	30 dB
Maximum power		
HB1	300 milliwatts 1/	10 dBm 2/
HB2	300 milliwatts 1/	(Not Applicable)
HB3, HB4	200 milliwatts 1/	(Not Applicable)

1/ The average power level shall not exceed the value specified when measured over any 1 second interval.
2/ The instantaneous power level shall not exceed the value specified.

TABLE VII. Type A distribution techniques.

TIME PERIOD	METHODS
NEAR TERM: (Present-Late 80s)	1. Switching matrix (centralized or distributed, crosspoint or tree) Challenges: Impedance matching (VSWR), reliability, size and weight. 2. Broadband Frequency Division Multiplexing (FDM) Challenges: Wide signal dynamic range, high SNR, number of channels with coaxial bus.
INTERMEDIATE TERM: (Late 80s-Mid 90s)	1. Switching matrix (same as above) except VSWR, size and weight may be improved by module miniaturization. 2. Broadband FDM Challenge: Channel quantity. 3. Wavelength Division Multiplexing (WDM) with fiber optics. Challenges: Fieldable system vs. bread/brassboard.

techniques basically are divided into two methods: (1) brute force baseband signal distribution through switched coaxial cables and (2) electronic methods where the baseband signal is modulated to a higher frequency for multiplexing through one of several channels on a common bus. If this bus is composed of coaxial transmission lines, this second technique is referred to as Frequency Division Multiplexing (FDM). The fiber optic bus equivalent is referred to as Wavelength Division Multiplexing (WDM). The section below summarizes design considerations for switching matrix and FDM methods. Further discussion of WDM methods is not included due to the current state of development. The near term trade-offs between switching matrix and FDM methods are listed in table VIII.

5.1.5.1.1.1 Switched matrix systems. The switched matrix systems can be catagorized in two aspects: matrix topology and matrix physical distribution. The topology options described below are crosspoint matrices and tree matrices. The physical options are centralized matrix and distributed matrix. In general, both physical options can apply to both topology options (i.e. four combinations). However, the distributed matrix is actually more applicable to the crosspoint topology since the advantages of a tree system tend to be lost when the matrix is split apart and distributed around the airplane.

The crosspoint matrix system is illustrated in figure 51 for the centralized and a distributed options. As is evident in the figure, one advantage of the distributed matrix is a reduction in coaxial transmission lines required through wing areas to service the aircraft ASIs. This cable reduction, however, is generally traded off against a reliability reduction due to: (1) Higher connector count to enter and exit each distributed switching unit, and (2) harsher environment for the matrix components in the vicinity of the ASI. In addition, the distributed matrix is restricted to a fixed number of simultaneous signal paths that are less than the total paths available in a centralized matrix. (This path reduction is the source of the lower wing cable count in the distributed system.) As a result, a later expansion in the number of simultaneous HB paths for the aircraft will result in a more extensive retrofit effort if a distributed system is selected.

The individual crosspoint switch element shown in figure 51b is generally composed of several sets of relays. Figure 52 identifies several design options for this element using standard switches (relays). The three options range from low to high in switch contact count. This low to high rating also correlates to some performance characteristics such as VSWR. The switch shown in figure 52a can only be used in small matrices operating at low frequencies because the "splice" at Point A can result in reflections from whichever end (L or R) that is left open circuited. (At 20 MHz, discontinuities on the order of 2 feet or more can be detected.)

TABLE VIII. Distribution method trade-offs.

	SWITCHING MATRIX	FDM
ADVANTAGES:	1. Low technical risk 2. Low development cost 3. Available components	1. Reduction in wing wiring in exchange for station electronics (modem) 2. Most discrete components are available (but may not be off-the-shelf) 3. Higher channel capacity
DISADVANTAGES:	1. Weight and size grows at high rate with increasing channel capacity 2. Potentially low reliability in aerospace environment 3. Centralized matrix requires "high" wing wiring count	1. Higher technical risk 2. Higher development cost 3. Modem required near ASI 4. Reliability uncertainty in aerospace (e.g. pylon) environment

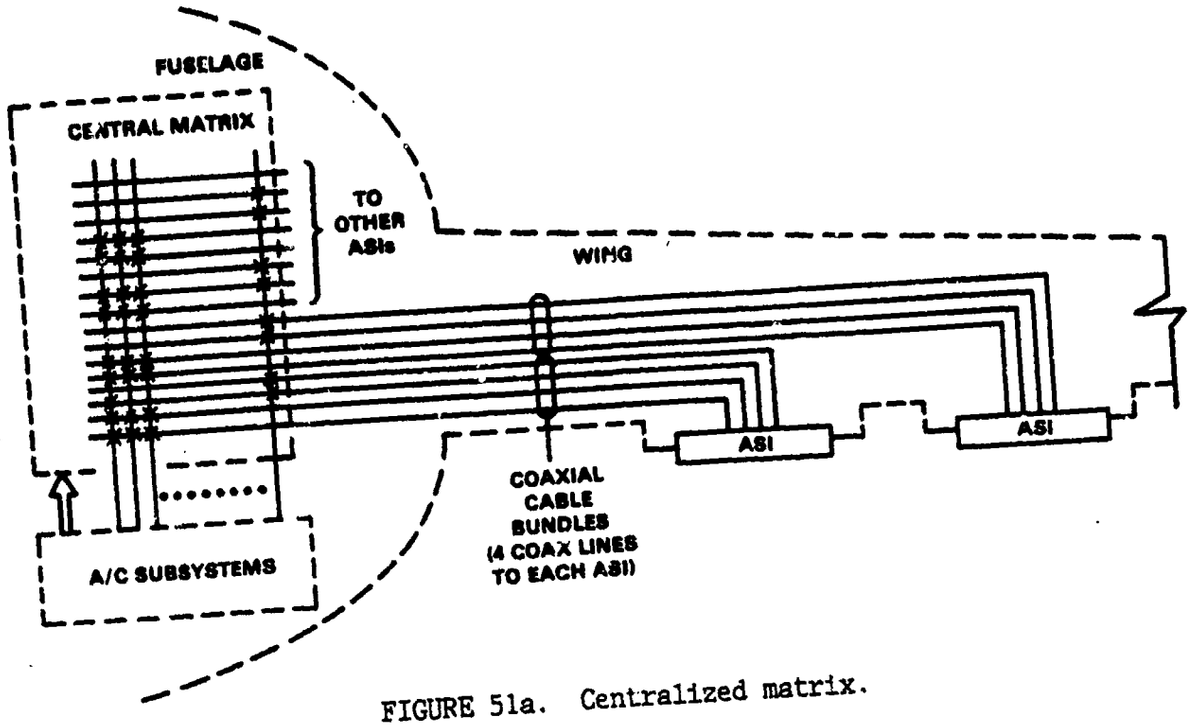


FIGURE 51a. Centralized matrix.

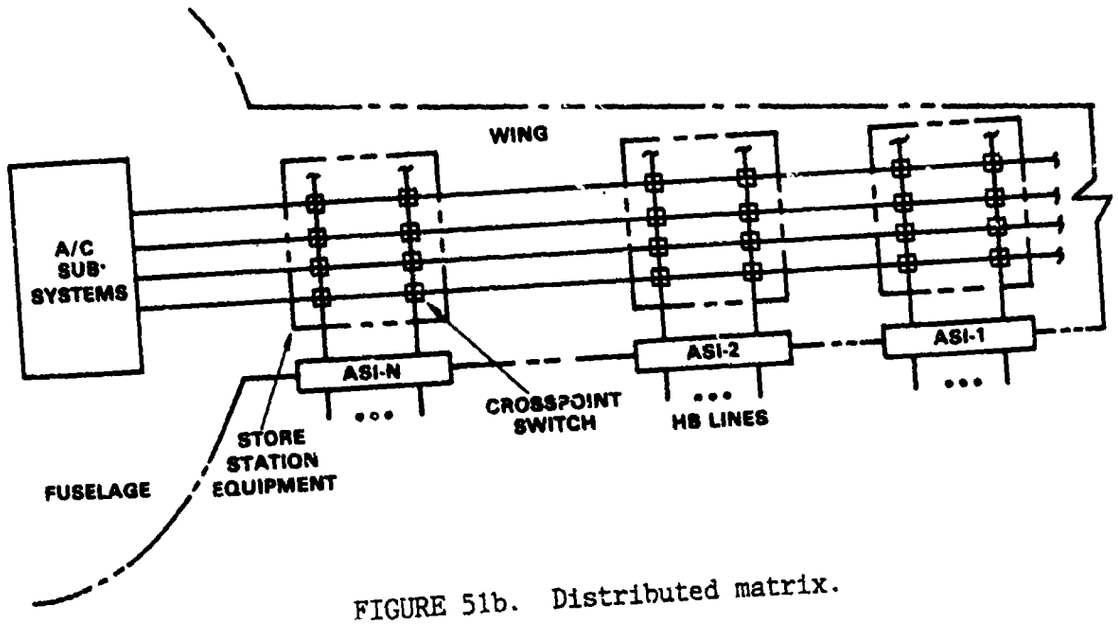


FIGURE 51b. Distributed matrix.

FIGURE 51. Crosspoint matrix signal distribution network.

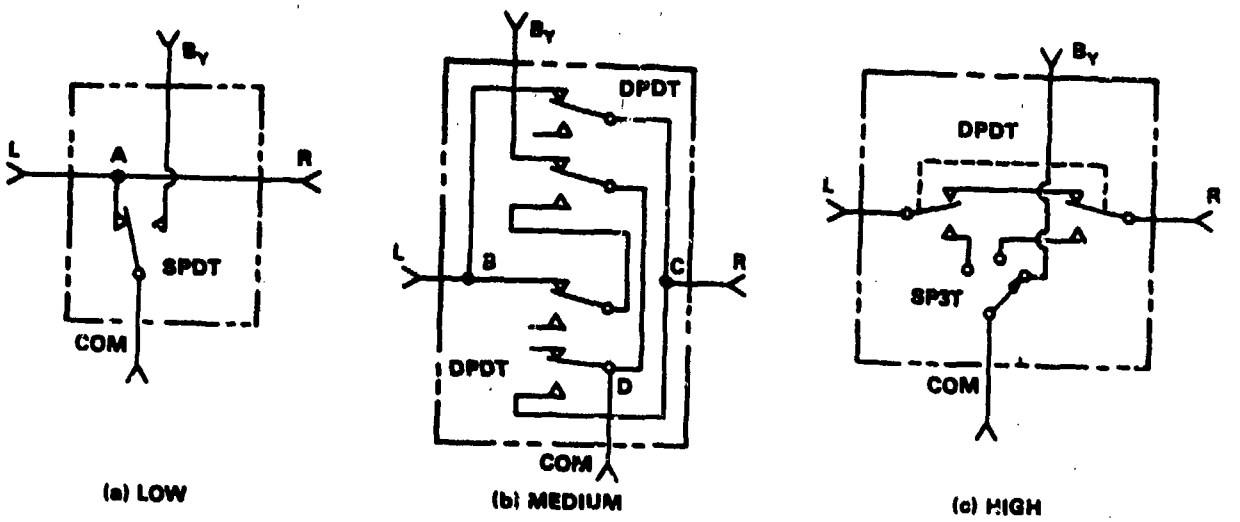


FIGURE 52. Crosspoint switch element.

The switch circuit shown in figure 52b also has discontinuities at Points B, C and D. However, these discontinuities are contained within the switching element and would generally not be noticed at the Type A frequencies (but would likely be detectable at the Type B frequencies). The primary disadvantage of this element is the high contact count. Figure 52c illustrates a switching element configuration that has no discontinuities (other than the relays themselves). This configuration has the highest contact count but also the best high frequency VSWR performance.

In contrast to the N x N switching capability of a centralized crosspoint matrix, a tree matrix provides less extensive input-to-output path combinations in exchange for reduction in hardware component count. Figure 53 illustrates a tree matrix which is designed to provide M simultaneous paths. The advantages of the tree matrix are not evident, however, until figures 54 and 55 are inspected. Figure 54 compares the number of switch positions in a matrix and the number of series switch contacts in a signal path for a crosspoint matrix and a tree matrix (four simultaneous paths) as a function of the number of stations. In both series contact count (affects insertion loss) and switch position count, the tree option is significantly less complex. Likewise, the same conclusion is reached when matrix complexity versus the number of simultaneous paths is considered. (See figure 55.) The conclusion from these figures is that conventional crosspoint switching matrices are easier to design but more complex (i.e. higher parts count) than an equivalent capability tree matrix. The only area where a crosspoint matrix has an advantage is where a distributed matrix is used. However, as pointed out above, distributed matrices have their own set of disadvantages and are not recommended as a general purpose solution.

5.1.5.1.1.2 FDM systems. FDM systems can be catagorized by a number of characteristics or design concepts such as: (1) Active or passive bus, (2) modulation method, (3) Automatic Gain Control (AGC) or no AGC, etc. Each of these choices (and others) must be made synergistically during design of the system. These trade-offs involve more technical detail than is appropriate for this report. However, a few points are presented here.

To begin, the basic concept of FDM in an AEIS application is shown in figure 56. This figure shows an active bus. (A passive bus is similar except the bus amplifiers are removed and the directional coupler is replaced with a bidirectional coupler.) As an example of operation, assume that a store at ASI 1 is sending a signal to a store at ASI 3. The store sources the signal up through the ASI into Modem 1A. (One modem is required for each HB port.) This baseband sourced signal is then modulated onto a higher frequency carrier (channel X) and sent out the Tx port to the FDM bus coupler. From here the modulated signal is propagated down the FDM bus and enters each modem receiver. Modem 3A is, however, tuned to the channel X frequency. This modem receives the signal, demodulates the FDM bus signal to extract the original store sourced signal and then routes the signal out

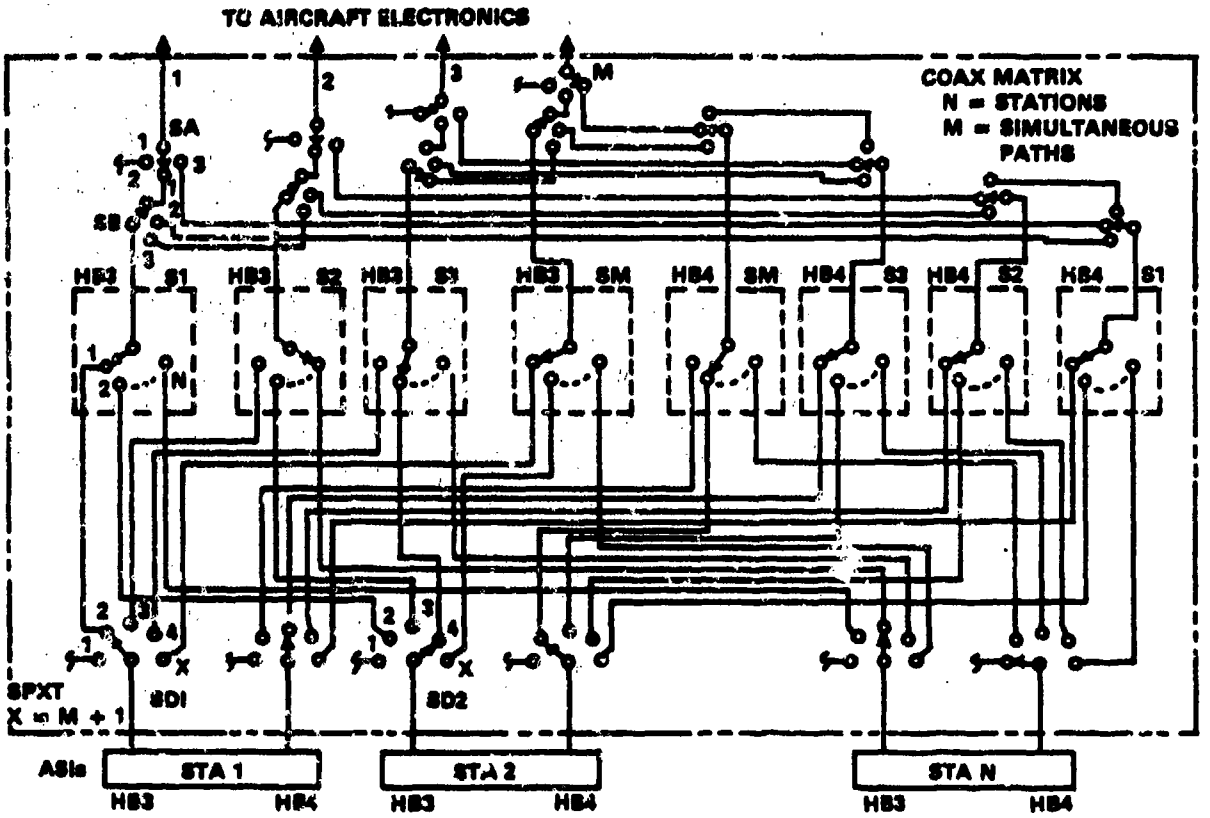


FIGURE 53. Tree switch matrix.

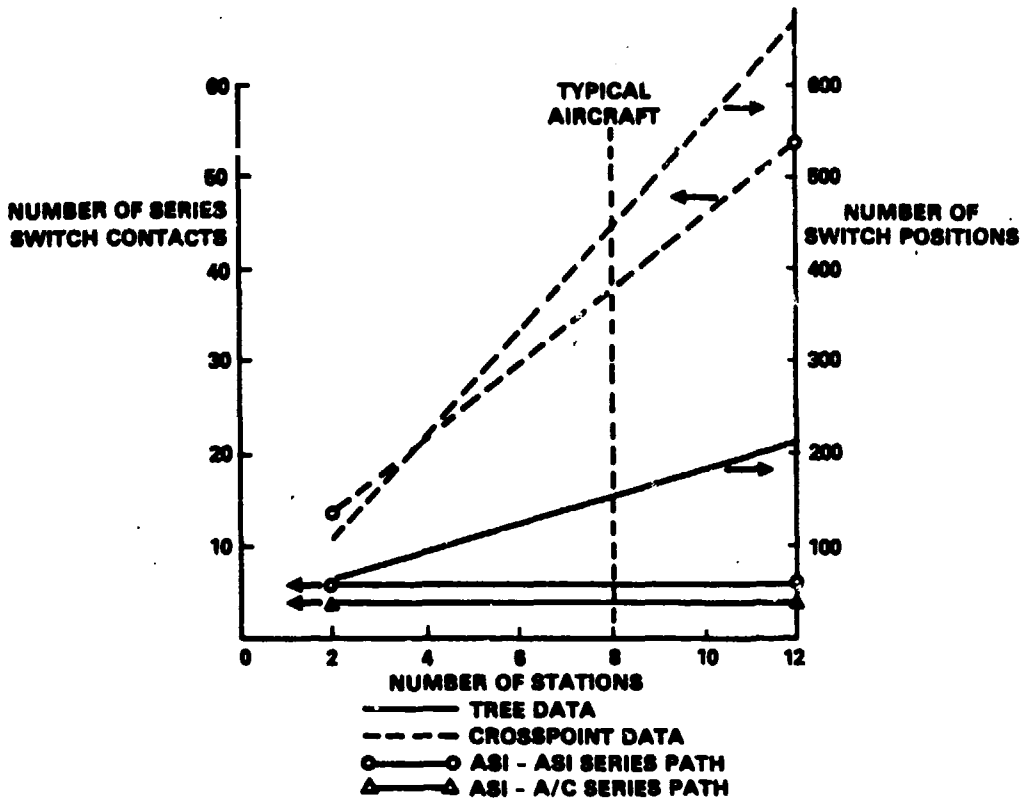


FIGURE 54. Matrix complexity - HB1 and HB2.

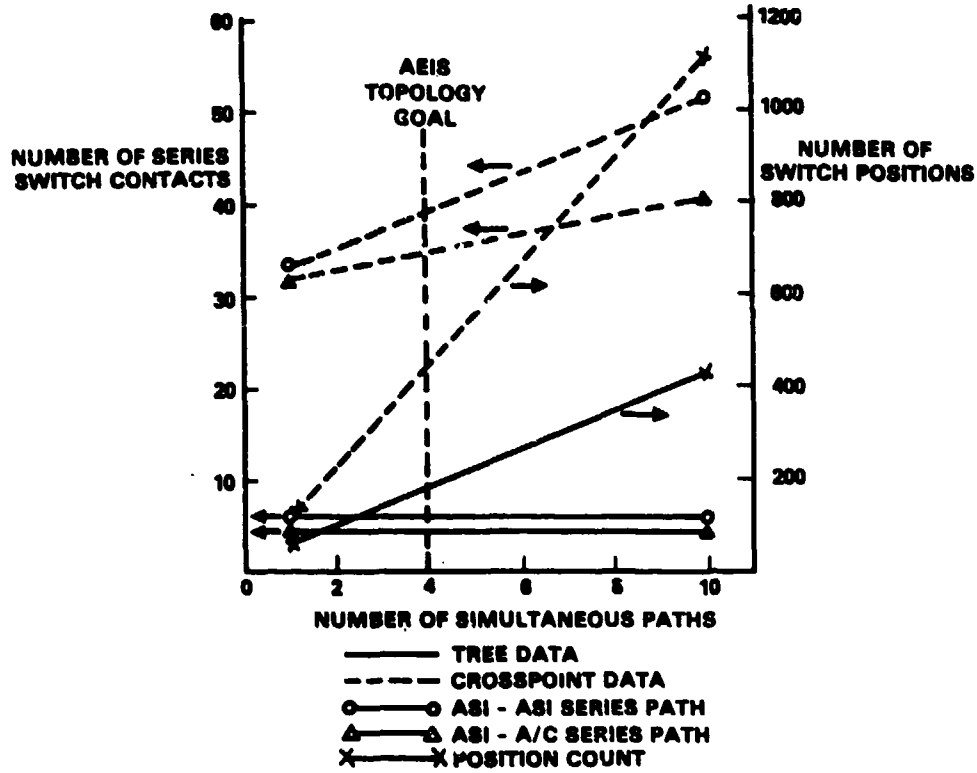


FIGURE 55. Matrix sensitivity to simultaneous paths.

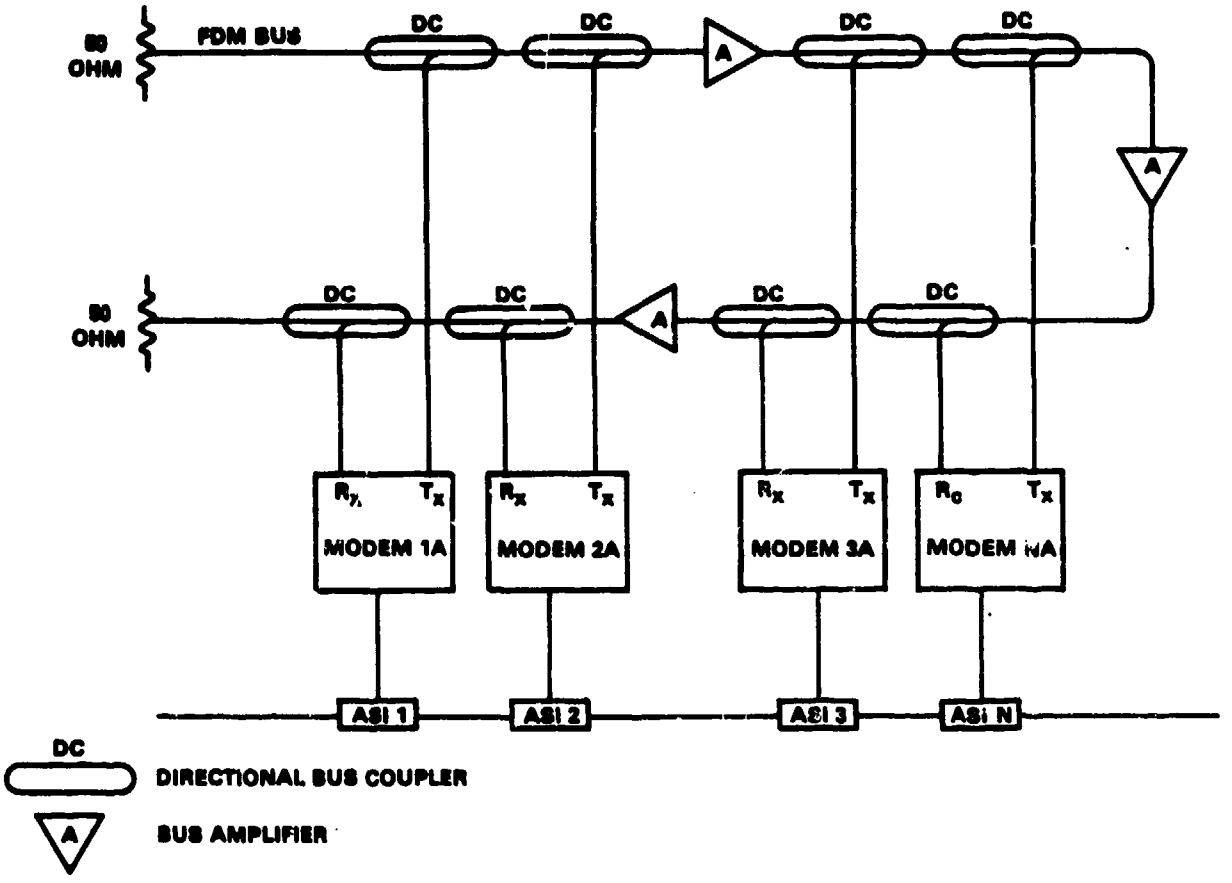


FIGURE 56. FDM signal distribution system - active bus.

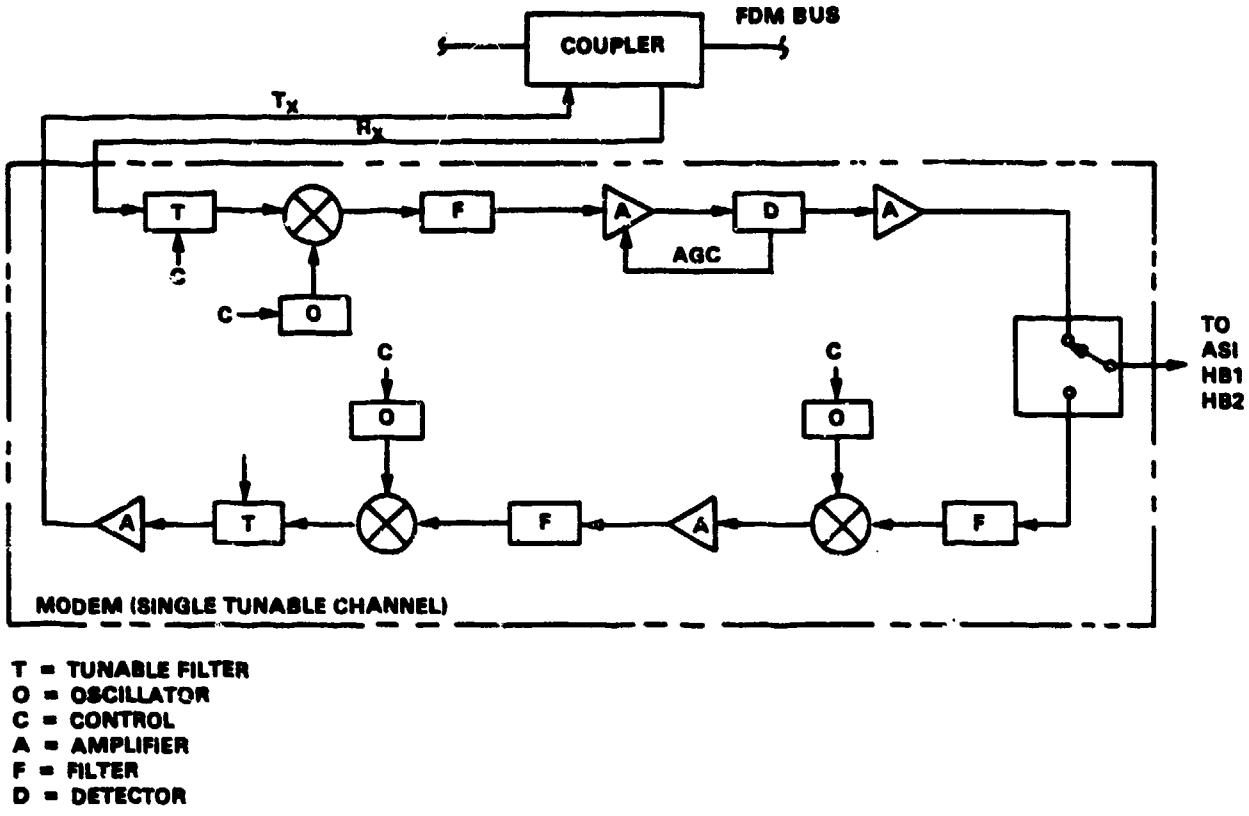
the modem through ASI 3 to the receiving store. In a similar manner, the original signal could be sourced or sinked by some aircraft avionic unit rather than by a store. (In addition, multiple receivers can receive and demodulate the same channel for a single source-to-multiple sink signal transfer.)

While the selection of passive or active bus does not directly affect MIL-STD-1760 interfaces (i.e., the intent is that the method of signal distribution is transparent to interface characteristics), the interface requirements can influence the selection. By its nature, a passive bus will deliver various FDM bus signal levels to the FDM receiver - i.e. the longer the cable distance between transmitter and receiver, the lower the received signal level. A passive bus must either control the FDM bus amplitude by limiting the bus attenuation to a small value or include an AGC function in the receivers. MIL-STD-1760 requires an effective 6 dB maximum ASI-ASI attenuation. The FDM system must provide this effective attenuation from ASI to ASI. Since the FDM bus is operating at a higher frequency then the baseband signal, bus cable attenuation will be higher (for the same size cable) than equivalent cable path in a switched matrix system. The net result is that passive bus systems generally require some form of amplitude adjustment (such as AGC) in the modem receivers. The specific AGC design in the modem receiver, however, can affect the ASI-ASI transfer performance for pulses such as Time Correlation Pulse (TCP).

A number of modulation schemes can be used by the modem to insert the baseband Type A signal onto the FDM bus. Details of these options are not discussed here. However, FDM signal distribution systems for AEIS applications have been demonstrated using vestigal sideband Amplitude Modulation (AM) and using conventional AM (double sideband with carrier). The trade-offs between these two methods generally involve the number of channels that can be packed into a given FDM bus passband versus the modem capacity. Figures 57 and 58 are block diagrams for one modem channel of vestigal sideband AM and conventional AM, respectively. Whichever modulation scheme is used in the modem, a four channel assembly similar to figure 59 required at a class I ASI. (Class II ASI would require a two channel assembly.)

In developing the FDM system, the designer needs to consider carefully the general signal characteristics of MIL-STD-1760 table I (table VI herein). In addition the ASI-ASI transfer requirements in MIL-STD-1760 paragraph 5.1.1.1.2 for attenuation, attenuation flatness, propagation delay, signal dispersion and harmonic distortion will significantly influence component selection and design approaches.

5.1.5.1.2 Type B signal distribution. Due to the broad frequency range of the Type B signal band (20 MHz to 1.60 GHz) and due to the upper frequency limit, the number of viable distribution network methods available is more restricted than those available for the Type A network.



T = TUNABLE FILTER
O = OSCILLATOR
C = CONTROL
A = AMPLIFIER
F = FILTER
D = DETECTOR

FIGURE 57. FDM modem block diagram - vestigal AM.

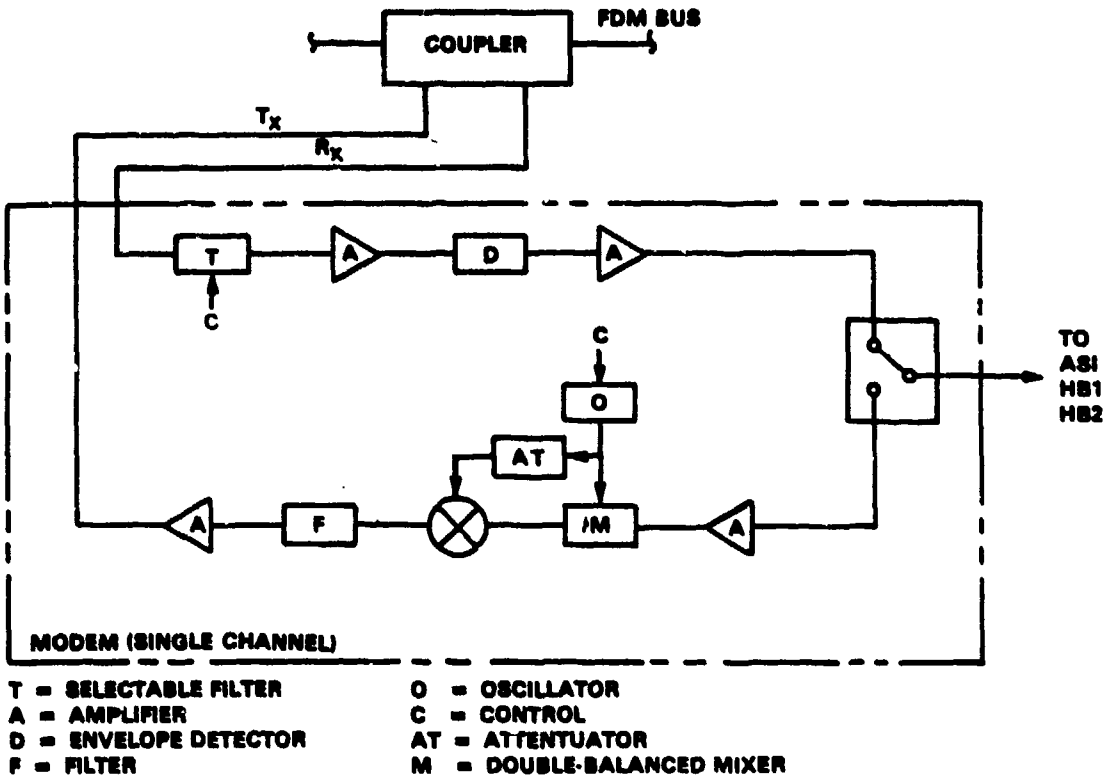


FIGURE 58. FDM modem block diagram - conventional AM.

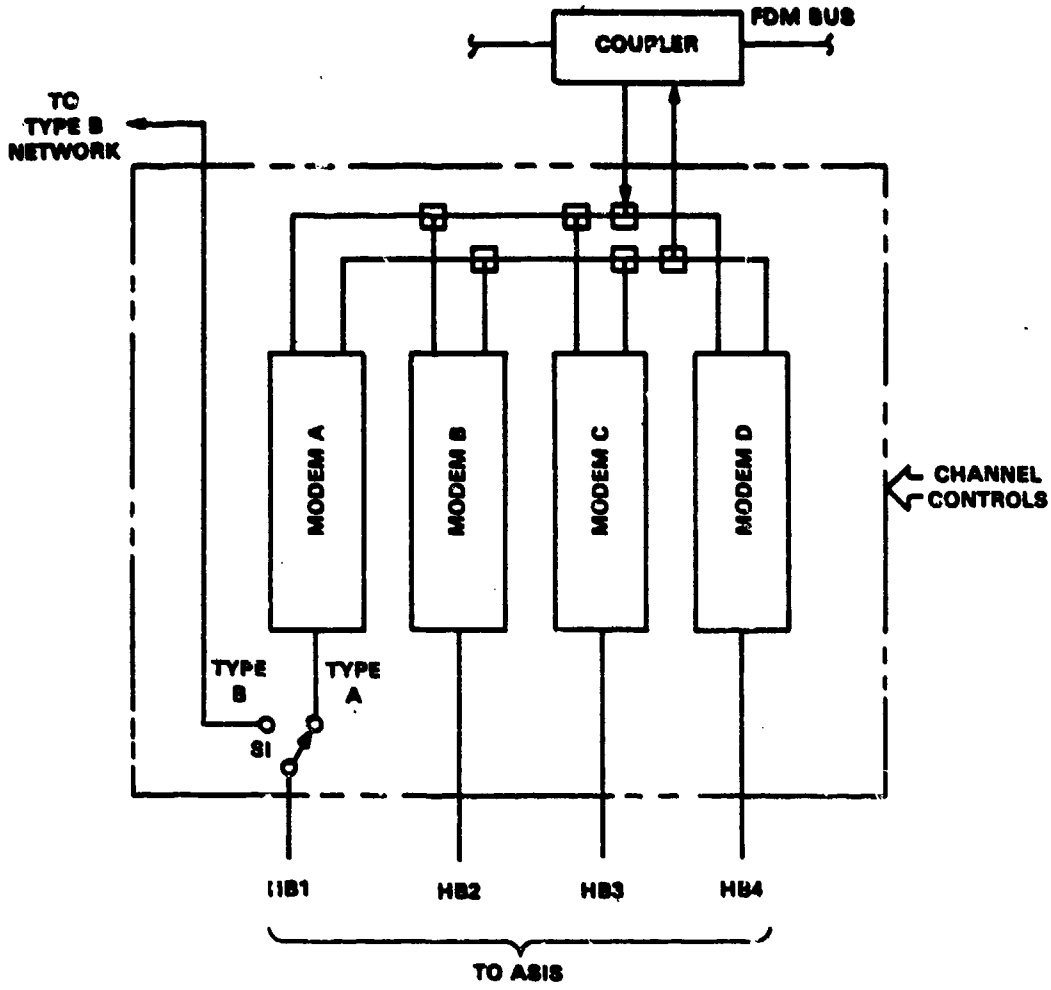


FIGURE 59. FDM store station equipment.

Since the HB1 port is required to support both Type A and B signals (though not simultaneously), an electromechanical RF switch (relay) must be used (into the foreseeable future) for at least the front end of the distribution network. (See, for example, switch S1 in figure 59. With current technology, switch S1 is an electromechanical relay since it must operate with signals from 20 Hz to 1.60 GHz.) Near term techniques divide into two categories: (1) Coaxial cable and RF switch based network, and (2) active networks. (See table IX.)

The first catagory is basically a simplified version of the switched matrix concepts covered in 5.1.5.1.1.1 above. The Type B network is "simplified" in that fewer nodes are required in the network since only one HB port at each ASI is rated for Type B service. This simplification, in combination with no MIL-STD-1760 specified requirement for ASI-ASI transfers of Type B signals, allows the use of a simple tree network. (See figure 60.) With the addition of a few more switches, more ASI-aircraft equipment paths or ASI-ASI paths can be added.

Current technology basically requires use of electromechanical RF switches (relays) for the switch functions due to the wide (20 MHz-1.6 GHz) passband of the Type B signal. Solid state switches (e.g. PIN diodes) which can handle this band are evolving but performance at the low frequency end of the band currently compromises solid state switch performance. (See 5.1.5.2.3.)

Due to the overall simplicity of the RF network and due to off-the-shelf availability of relatively small electromechanical RF switches, the switched matrix approach is very attractive for the near term. The primary disadvantage of this networking technique is that a single RF source (e.g. an aircraft GPS receiver/preamp) can only be connected to one RF sink (e.g. a store GPS receiver) at a time.

The active network mechanization circumvents this problem by building a more complex network using signal amplifiers and power dividers in addition to RF switches. Figure 61 illustrates a simplified schematic of an active network that allows one signal source (at ASI or in aircraft) to "broadcast" to multiple signal sinks. (The simplified diagram does not show switches for providing proper matched terminations on all disconnected paths.) For the Type B network, these path terminations need to be included particularly around the power divider. The diagram is also simplified in that a single power divider is shown. If the number of nodes is high (e.g. greater than 8) multiple cascaded dividers may be required.

If ASI-ASI transfers are not required and the system can achieve acceptable SNR for ASI-aircraft transfer, the three amplifiers (A2, A3 and A4) associated with each ASI could be eliminated and the aircraft amplifier (A1)

TABLE IX. Type B distribution techniques.

TIME PERIOD	METHODS
NEAR TERM: (Present-Late 80s)	1. Switching matrix (centralized or distributed, crosspoint or trees) Challenges: impedance matching (VSWR), attenuation, reliability, broadband solid state switches (20 MHz-1.6 GHz) 2. Active network (power splitters and amplifiers) Challenges: broadband (20 MHz-1.6 GHz) militarized amplifiers
INTERMEDIATE TERM: (Late 80s-Mid 90s)	1. Switching matrices (same as above except broadband solid state switches may be more readily available) 2. Active network (sames as above except broader availability of broadband, low noise amplifiers) 3. Potential emergence of fiber optic based distribution systems Chailenges: Militarized optical sources and detectors capable of handling 2 GHz 4. Transition to IF distribution vs. RF

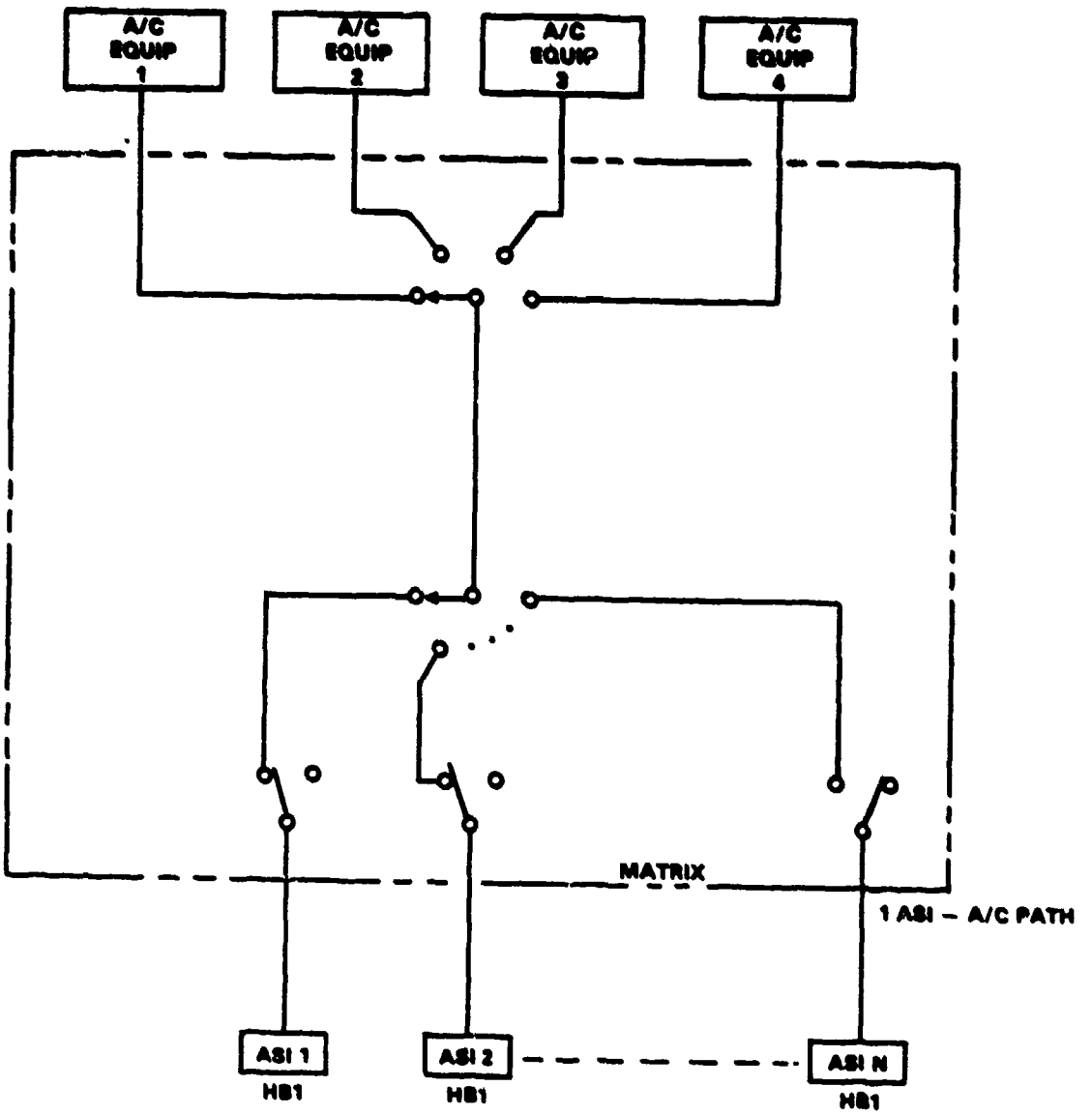


FIGURE 60. RF tree matrix.

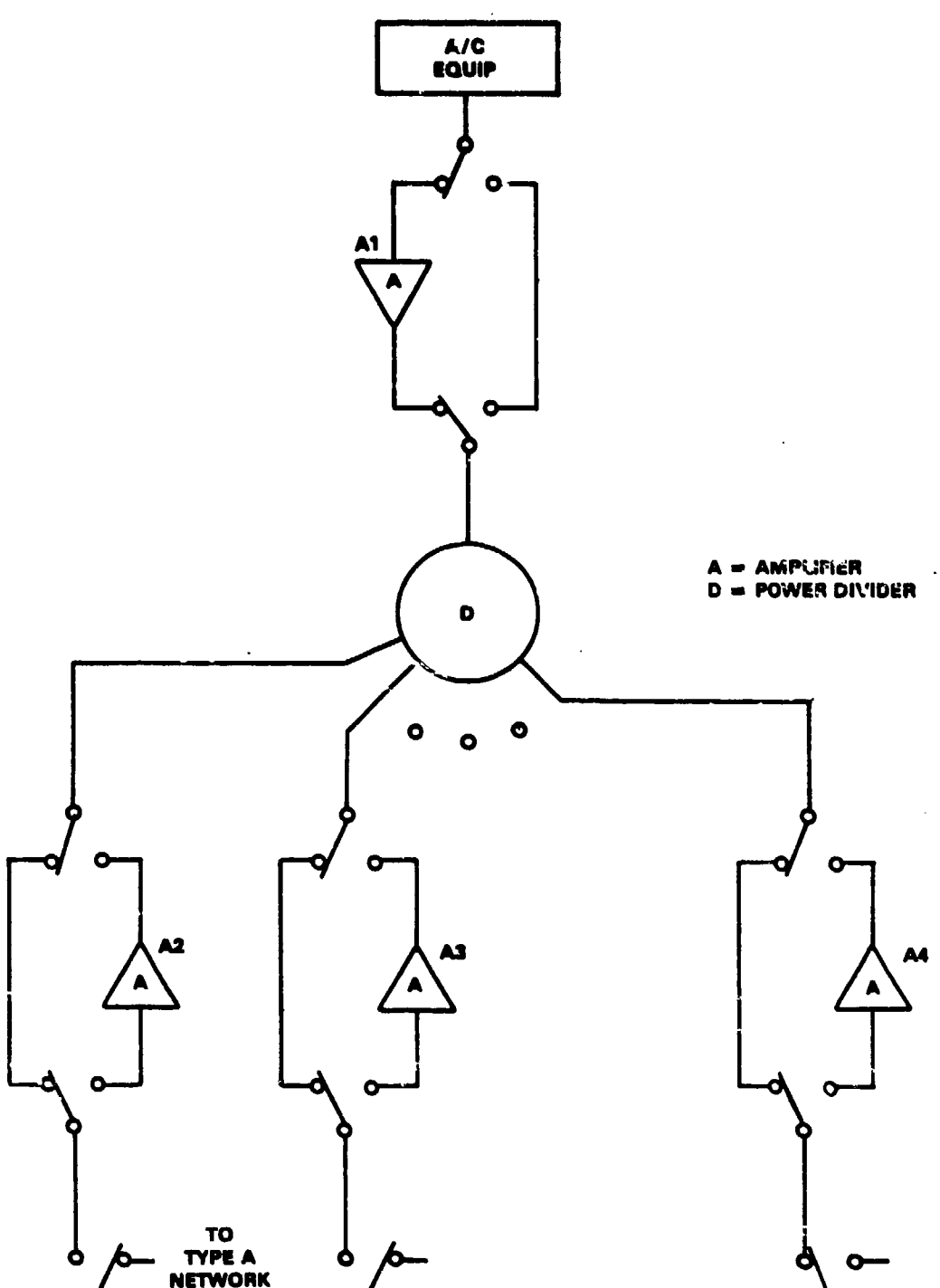


FIGURE 61. Active RF network.

rewired for bi-directional amplification. Eliminating these three amplifiers (and rewiring A1) will result in a lower SNR for ASI-aircraft transfer than available for aircraft-ASI transfers. The level of difference will depend on the gains and device noise for each network component (i.e. amplifiers, dividers, switches and cables).

5.1.5.2 Component characteristics and issues. The following paragraphs provide a broad overview of some design considerations for distribution network component selection.

5.1.5.2.1 Connectors. In general, two types of connectors are used to implement a high bandwidth network. MIL-STD-1760 connectors must be used at the ASI and dedicated RF connectors should be used within the aircraft distribution system. Figure 62 shows typical VSWR characteristics for various types of RF connectors. In general, one can expect a VSWR of 1.3 or better at frequencies up to 2.0 GHz.

An important factor in general connector performance, however, is proper termination of the coaxial cable to the connector contact and proper alignment of the contact set. Figure 63 shows the effect of contact set misalignment (perpendicular to the contact axis) on VSWR characteristics. This alignment effect plus axial misalignment is part of the cause for higher VSWR in MIL-STD-1760 compliant connectors over dedicated RF connectors. Some misalignment is necessary to insure aligment of all other contacts in one mating operation of the multi-contact connector.

Other factors that add to VSWR degradation in the MIL-STD-1760 compliant connector is wear due to repeated mating/unmating and contaminates due to contact exposure at the ASI. The extent of VSWR degradation from wear and contaminates is higher with MIL-STD-1760 connectors than with dedicated RF connectors because mating/unmating is more frequent. The MIL-STD-1760 connector is mated/unmated when any store is installed. Figure 64 shows return loss versus frequency for a mated set of the M39029/28 and 75 coaxial contacts defined for the MSI. Figure 65 plots similar data for an improved contact set that is intermateable with M39029/28 and 75 contacts.

The /28 and /75 contacts are uncontrolled impedance "shielded" contacts but are currently available from several suppliers. They provide adequate performance for use in HB2-HB4 applications but are marginal for HB1. The improved design is not currently (1986) qualified but provides good performance for HB1-HB4 due to its "true coaxial" design.

5.1.5.2.2 Coaxial cable. Coaxial cable performance characteristics are influenced by cable length and cable cross-section dimensions. Signal characteristics affected by the cable include attenuation, VSWR and impedance, power handling capability, propagation delay, pulse distortion and crosstalk.

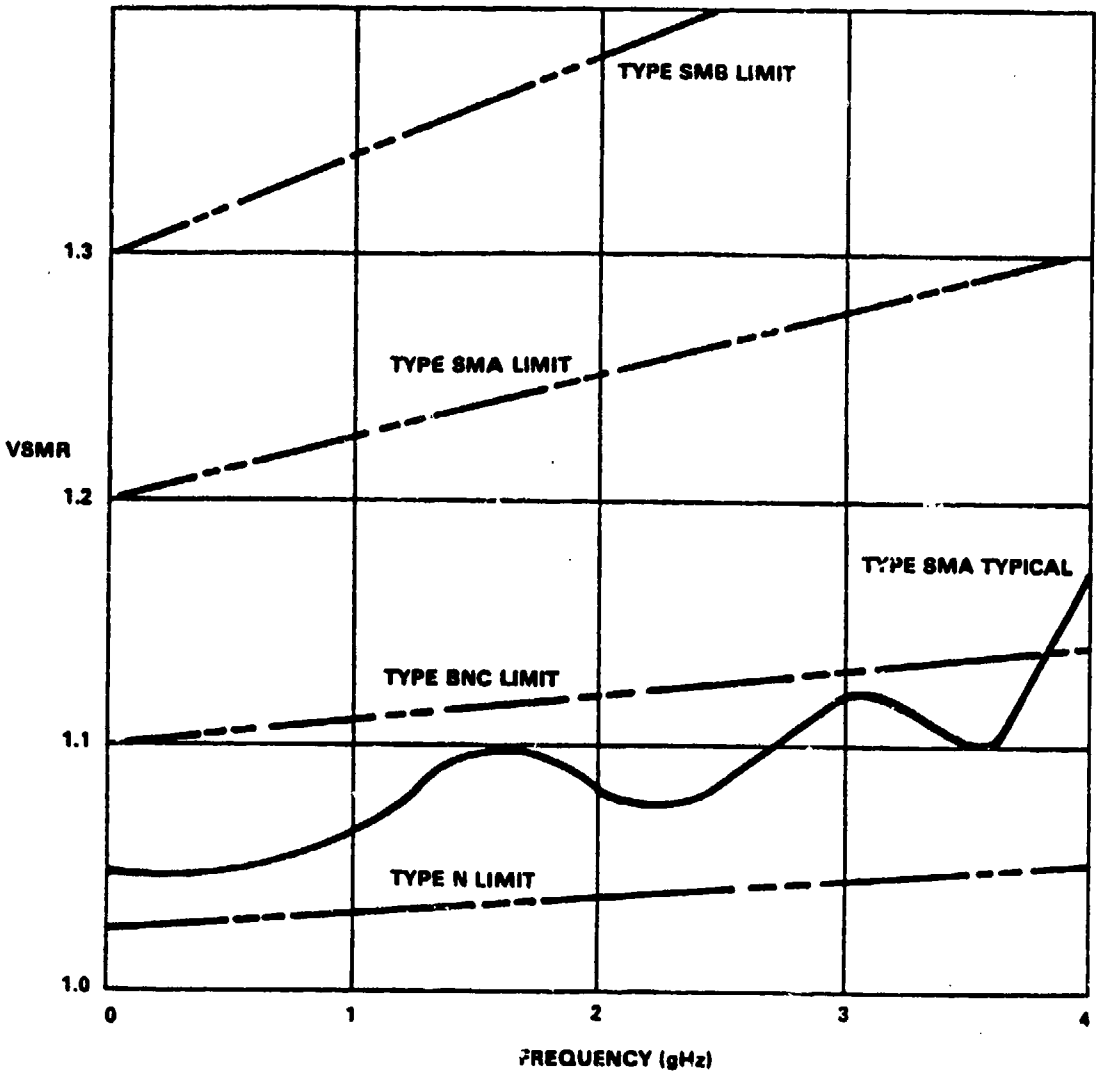


FIGURE 62. VSWR for RF connectors.

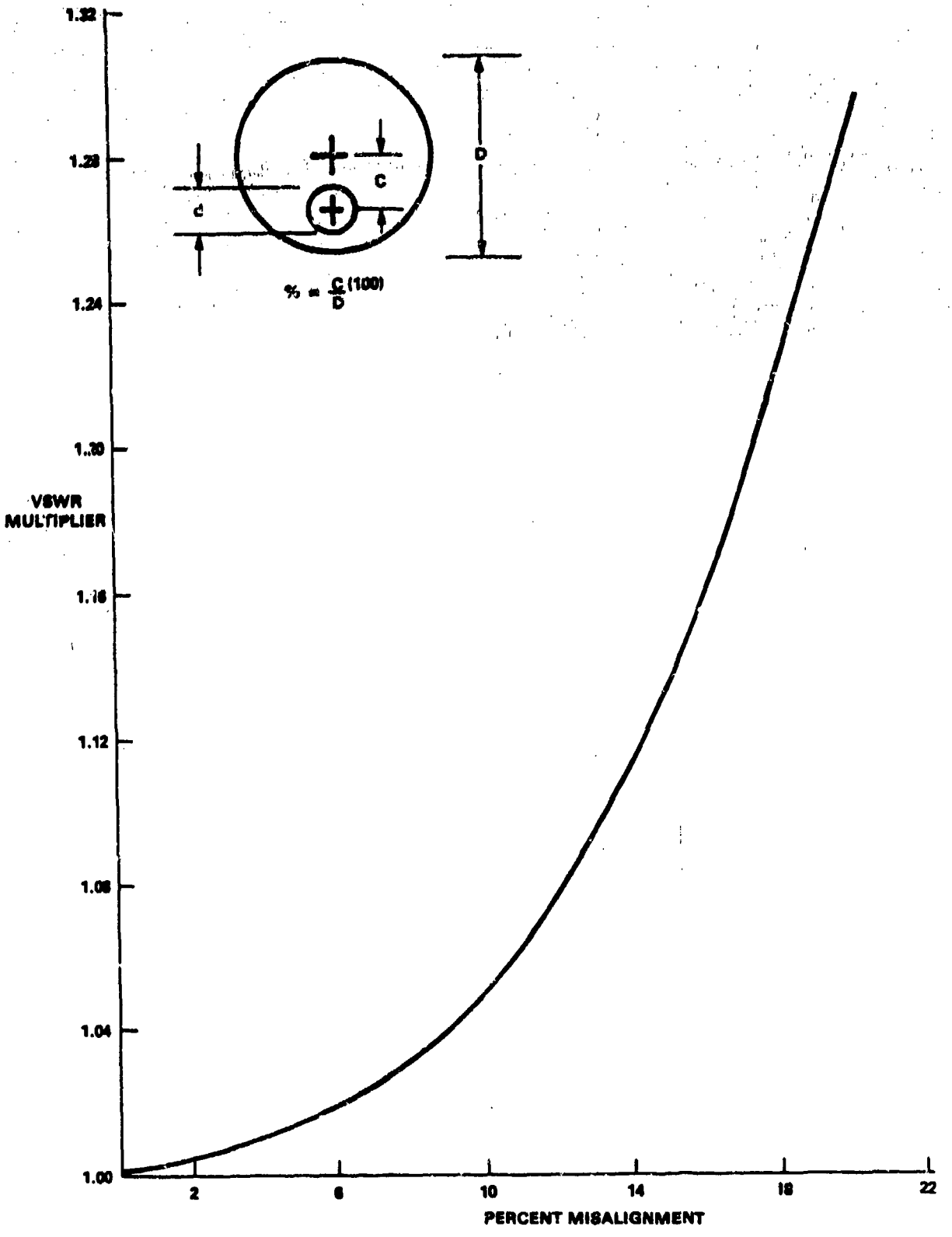


FIGURE 63. VSWR effect from misalignment of contacts.

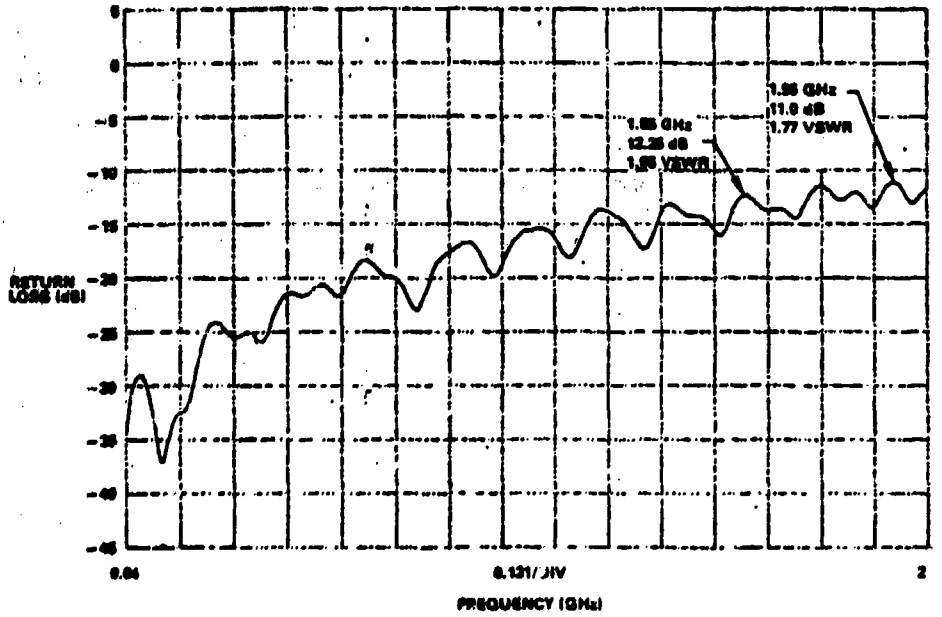


FIGURE 64. Typical return loss for MIL-C-39029/28 and 75 contact pair.

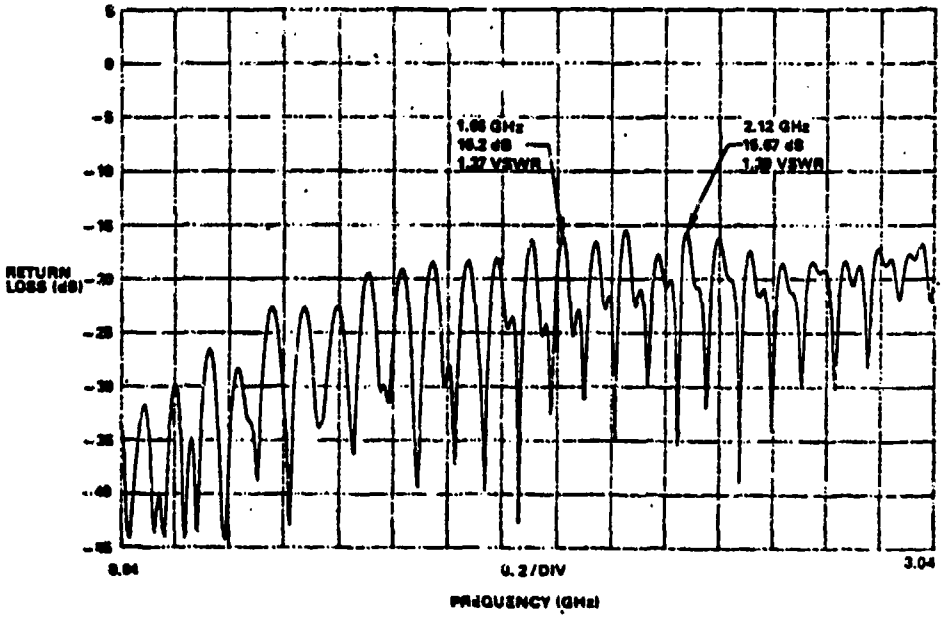


FIGURE 65. Typical return loss for improved contact.

a. Attenuation. Figure 66 shows the influence of cable size (braid inner diameter) on signal attenuation by plotting the attenuation of several cables. The plots are for a 50 ohm teflon dielectric cable. A desirable feature of a HB distribution circuit is to have uniformity of losses over the broad frequency band. Uniformity of losses for composite video can impact the quality of video presentation and the quality of digital data derived from the video data for signal processing. The attenuation flatness improves as the coaxial diameter increases. The attenuation and attenuation flatness limits specified in MIL-STD-1760, in general, can be met with the use of small (less than 0.142 OD) diameter cables. These small OD diameter cables (RG316 for 50 ohm and RG179 for 75 ohm) can be used in the umbilicals. Larger diameter cable can and should be used on the aircraft side of the ASI if the cable length is sufficiently long to prevent high losses which result if small OD cables are used. Figures 67 and 68 illustrate typical attenuation through 40 feet of subminature cable (RG316) and four connector mated pairs (M39029/28 and 75 contacts). While Type A band losses are realistic, the Type B band losses reflect a need to use lower loss (larger OD) cable for a large portion of the aircraft cable runs for HB1.

b. VSWR and characteristic impedance. Figure 69 shows typical specification values of VSWR for MIL-C-17 50 ohm cables. Similar VSWR characteristics can be expected for 75 ohm cables. VSWR performance of a cable assembly is further influenced (degraded) by cable length, cable termination mismatch and cable abuse (sharp bends). The cable length effects are due to the attenuation of the cable which masks the impedance discontinuities. Impedance discontinuities also exist at the cable terminations, more so in MIL-STD-1760 compliant connectors than in dedicated RF connectors. Cable abuse results from handling during harness fabrication, installation and field maintenance. Figures 70 and 71 illustrate VSWR levels that can be expected at an ASI and MSI looking into the aircraft when M39029/28 and 75 contacts are used with RG316 cable. While the ASI is barely within specification levels, the MSI (i.e. ASI plus umbilical) is outside of the allowed MIL-STD-1760 limits (2.0 maximum VSWR at the end of an umbilical). To bring the performance at the umbilical to store interface (MSI) into specification levels requires the use of better quality components in the aircraft and in the umbilical. Figures 72 and 73 illustrate the significant improvement simply by replacing the M39029/28 and 75 contacts with intermateable controlled impedance coaxial contacts. The VSWR performance

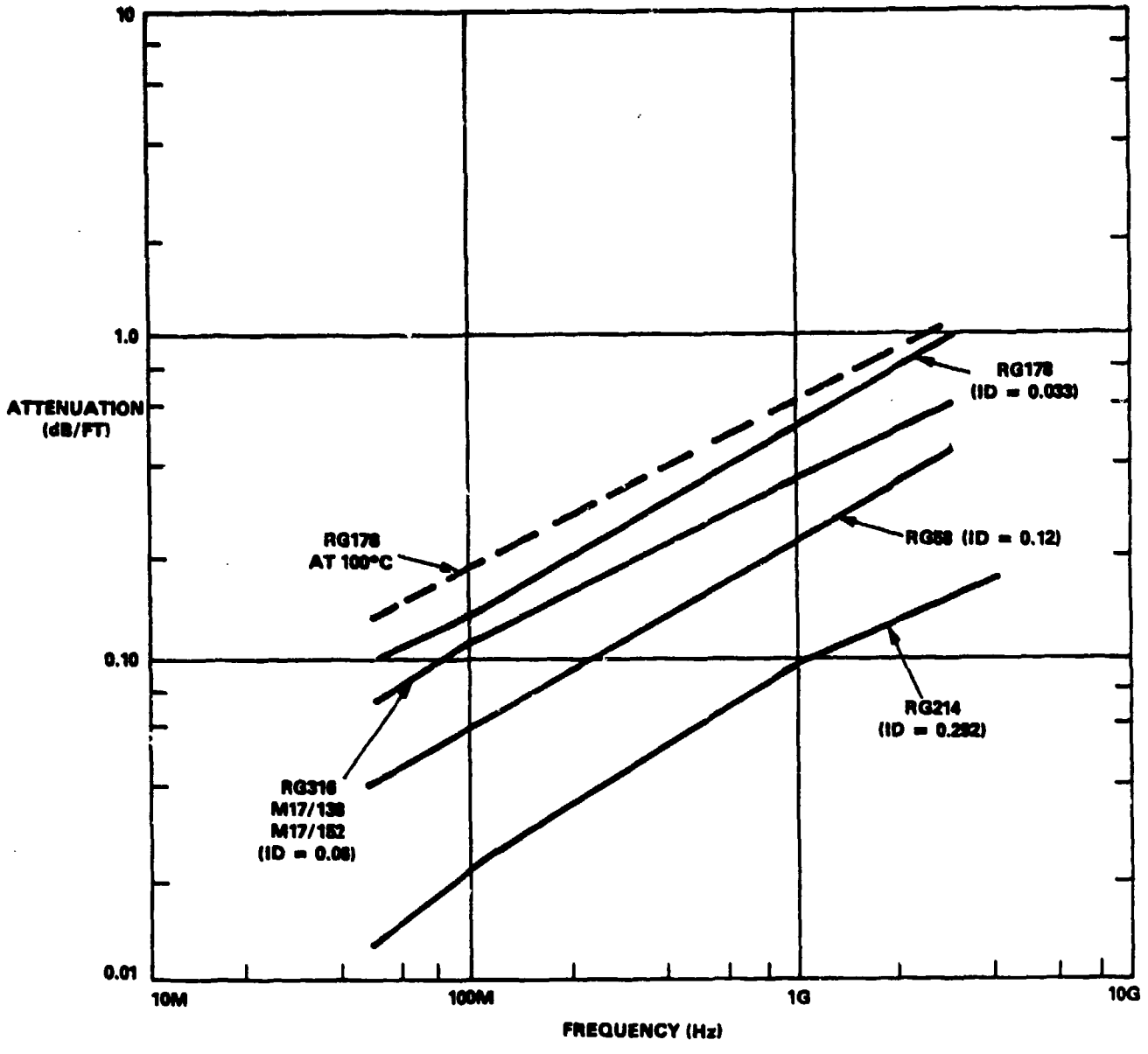


FIGURE 66. Attenuation vs. frequency for 50 ohm cables.

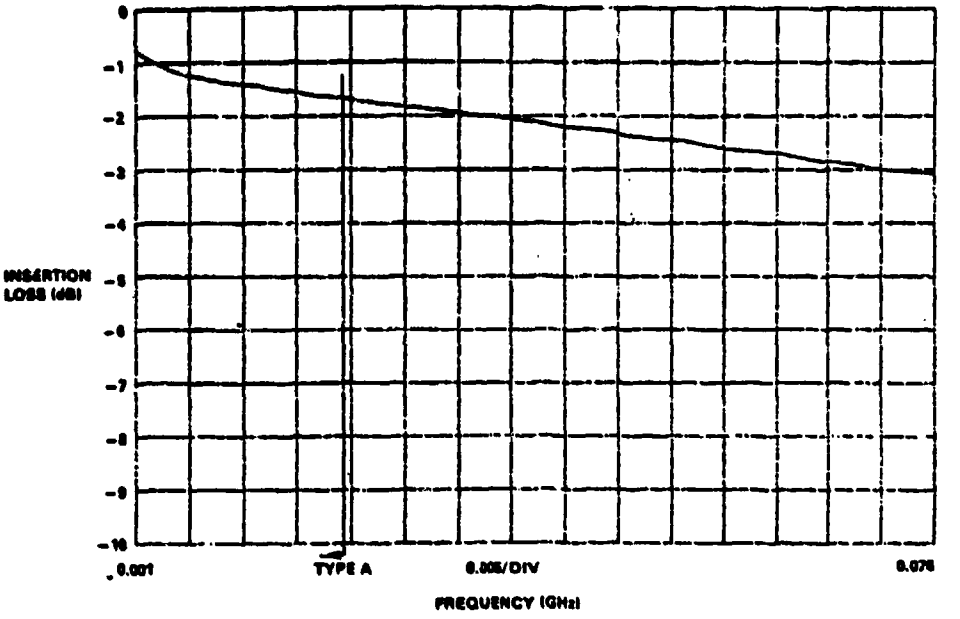


FIGURE 67. Typical Type A band aircraft-MSI attenuation (HB1).

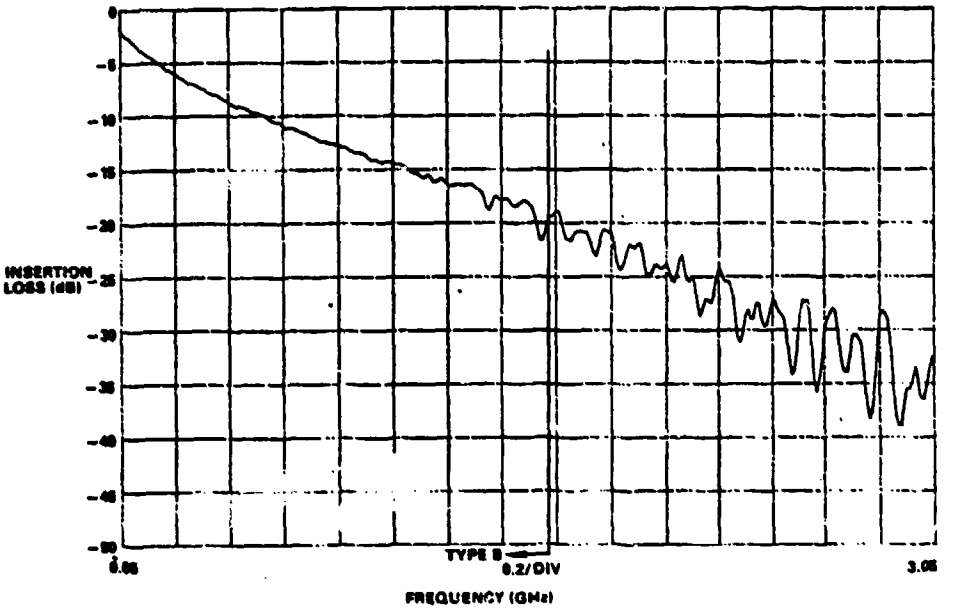


FIGURE 68. Typical Type B band aircraft-MSI attenuation (HB1).

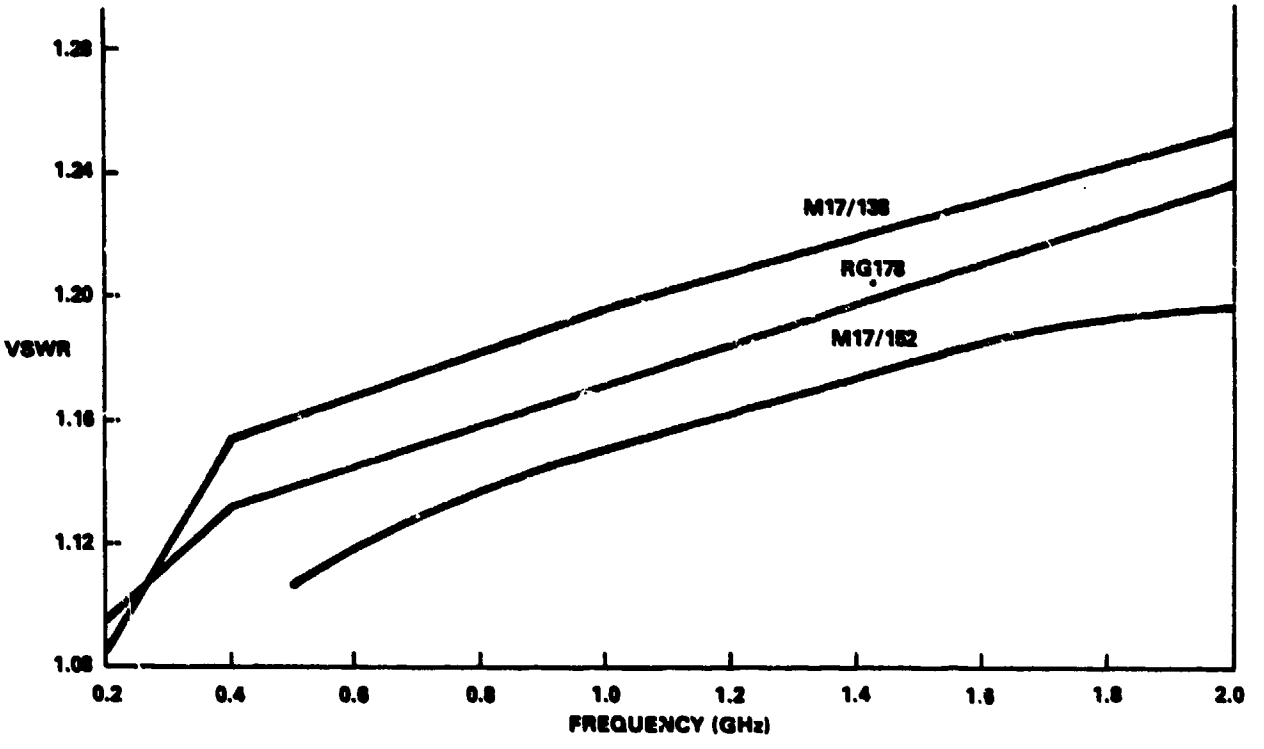


FIGURE 69. VSWR vs frequency for 50 ohm cables.

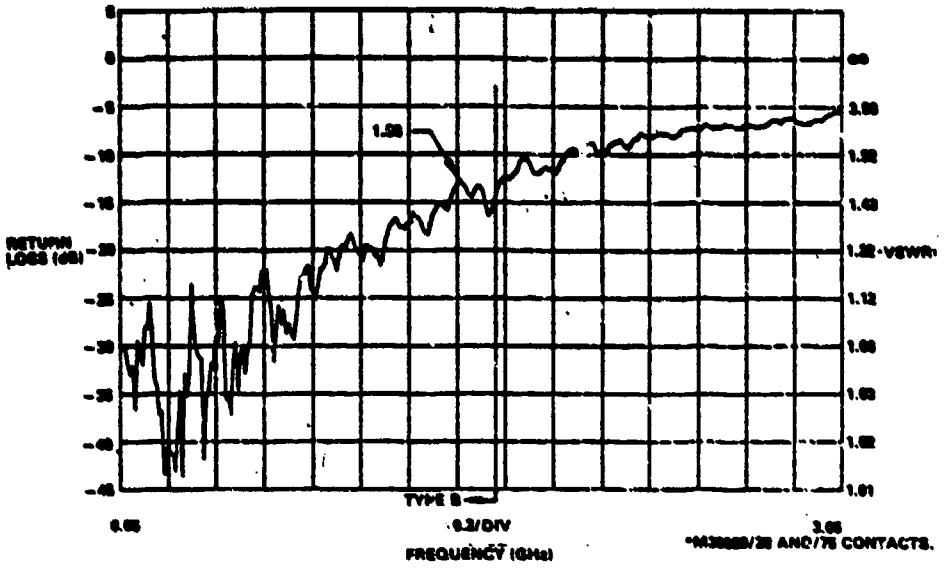


FIGURE 70. Return loss for typical HB1 port - ASI-to-aircraft.*

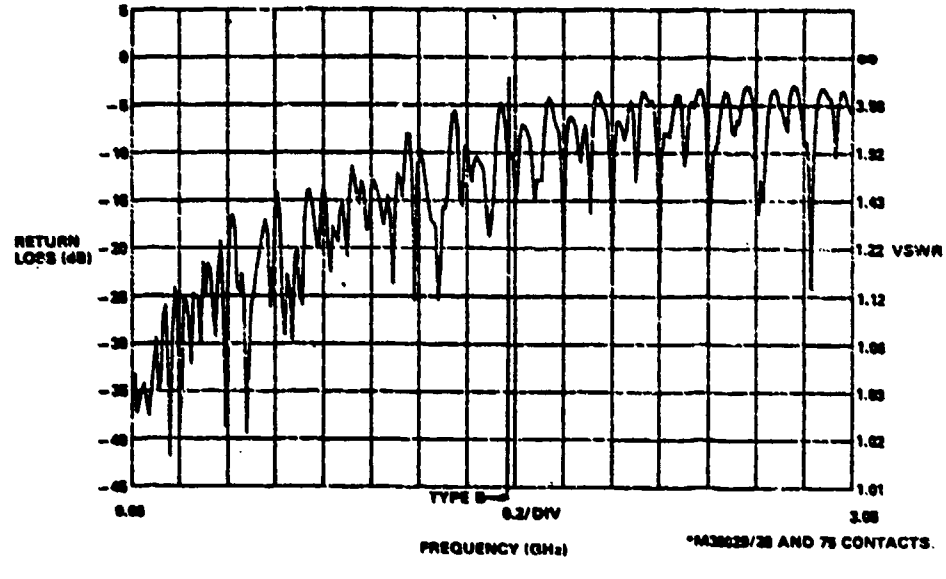


FIGURE 71. Return loss for typical HB1 port - MSI-to-aircraft.*

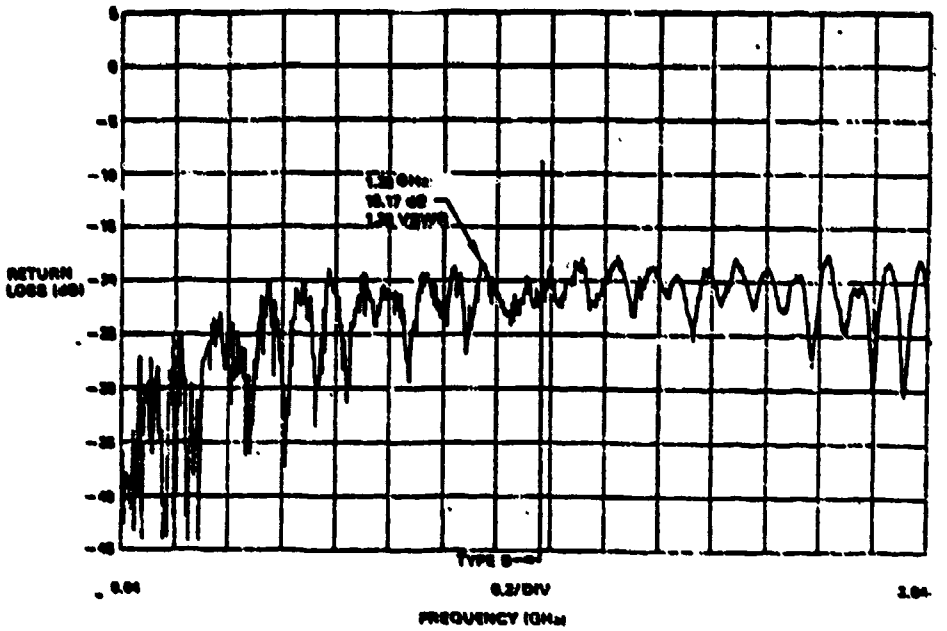


FIGURE 72. ASI return loss for typical HB1 port - coaxial contacts.

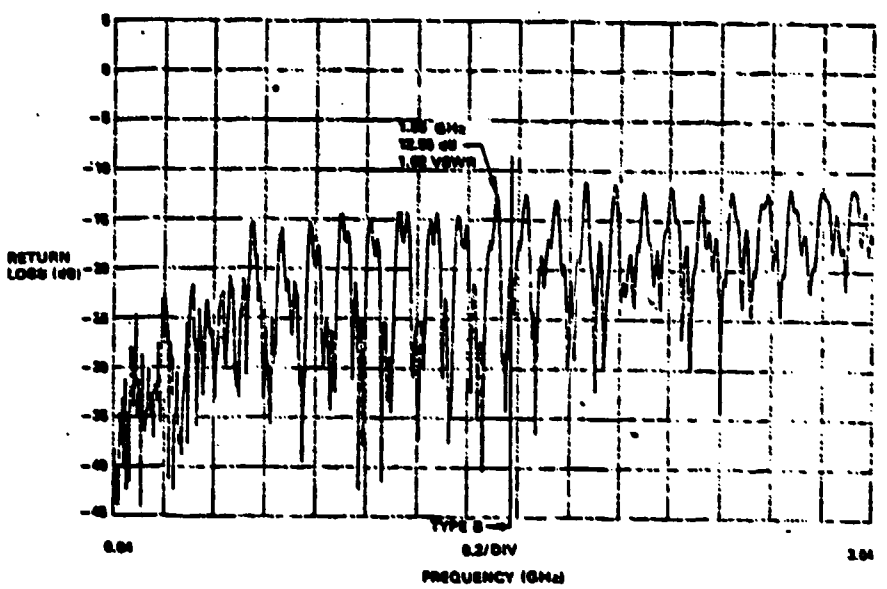


FIGURE 73. MSI return loss for typical HB1 port - coaxial contacts.

in the Type A signal frequencies is at acceptable levels for M39029/28 and 75 contact systems as well as the coaxial contact system.

c. Power handling capability. Given that the maximum signal power rating of allowed ASI HB signals is 300 milliwatts, the power handling limit of coaxial cables is not a design constraint.

d. Propagation delay. For high frequencies, the velocity of propagation (V) is determined by the dielectric constant of the material (e) as given by the equation:

$$V = 3 \times 10^8/(e)^{1/2}$$

or by the cable inductance and capacitance (per meter) as given by:

$$V = 1/(LC)^{1/2}$$

These equations yield a typical progapation velocity of 0.6 to 0.9 feet per nanosecond.

For low frequencies, the velocity of propagation is determined by a more complex phenomena. Signal frequency components below 1 MHz propagate at progressively slower speeds, which results in later "time-of-arrival" for the signal at the load end of the line. This spreading of signal delay results in a distortion phenomena referred to as dispersion (distortion). Figure 74 illustrates the beginning of this diverging delay on a short segment of RG316. In contrast, Figure 75 shows the propagation delay and delay variance through a 65 foot RG316 cable containing 8 sets of MIL-STD-1760 compliant connectors. The delay and delay variance are well within the required limits (3 microseconds and 50 nanoseconds respectively).

e. Pulse distortion. The critical TCP characteristic that must be maintained through the distribution network is the "time-of-arrival" of the pulse leading edge. This time-of-arrival is determined by the propagation delay and pulse rise time distortions caused by the network. A distinction is made between extremely narrow pulses and wide pulses. Figure 76a shows the conventional rise time definition. This definition basically applies when excitation pulse widths are approximately 3 to 4 times longer than the circuit time constant (t_c). Figure 76b, in contrast, applies

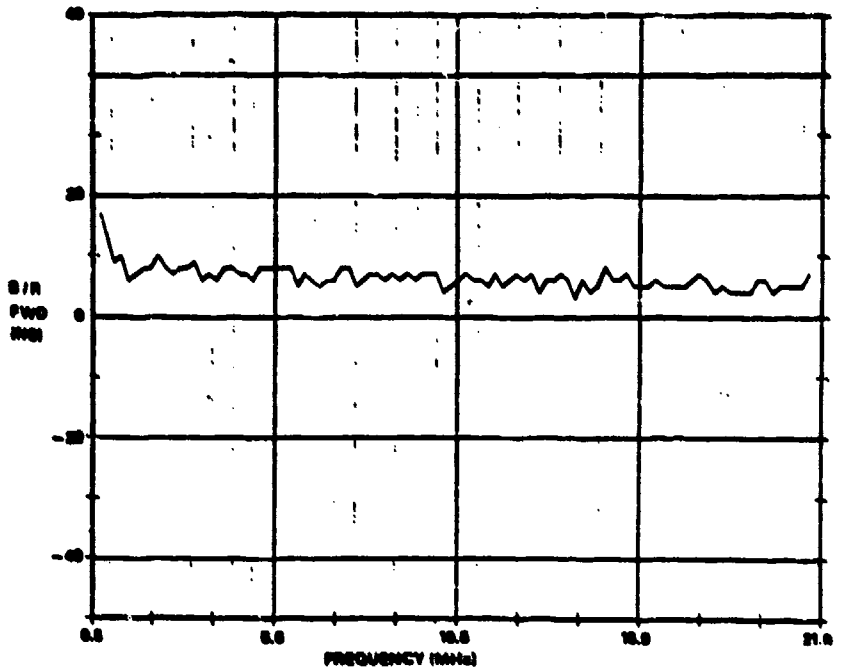


FIGURE 74. Propagation delay increase at low frequencies.

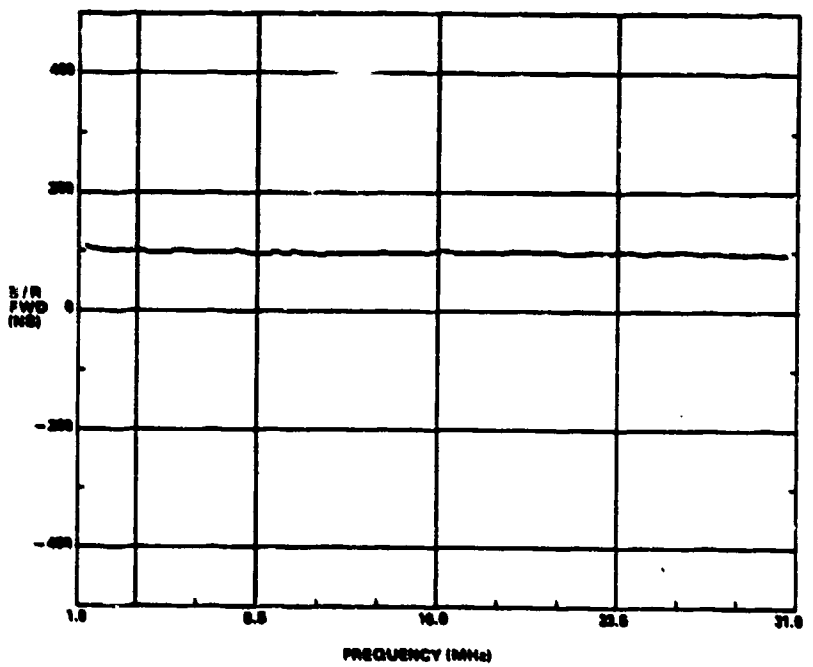


FIGURE 75. Propagation delay and variance through 65 foot cable.

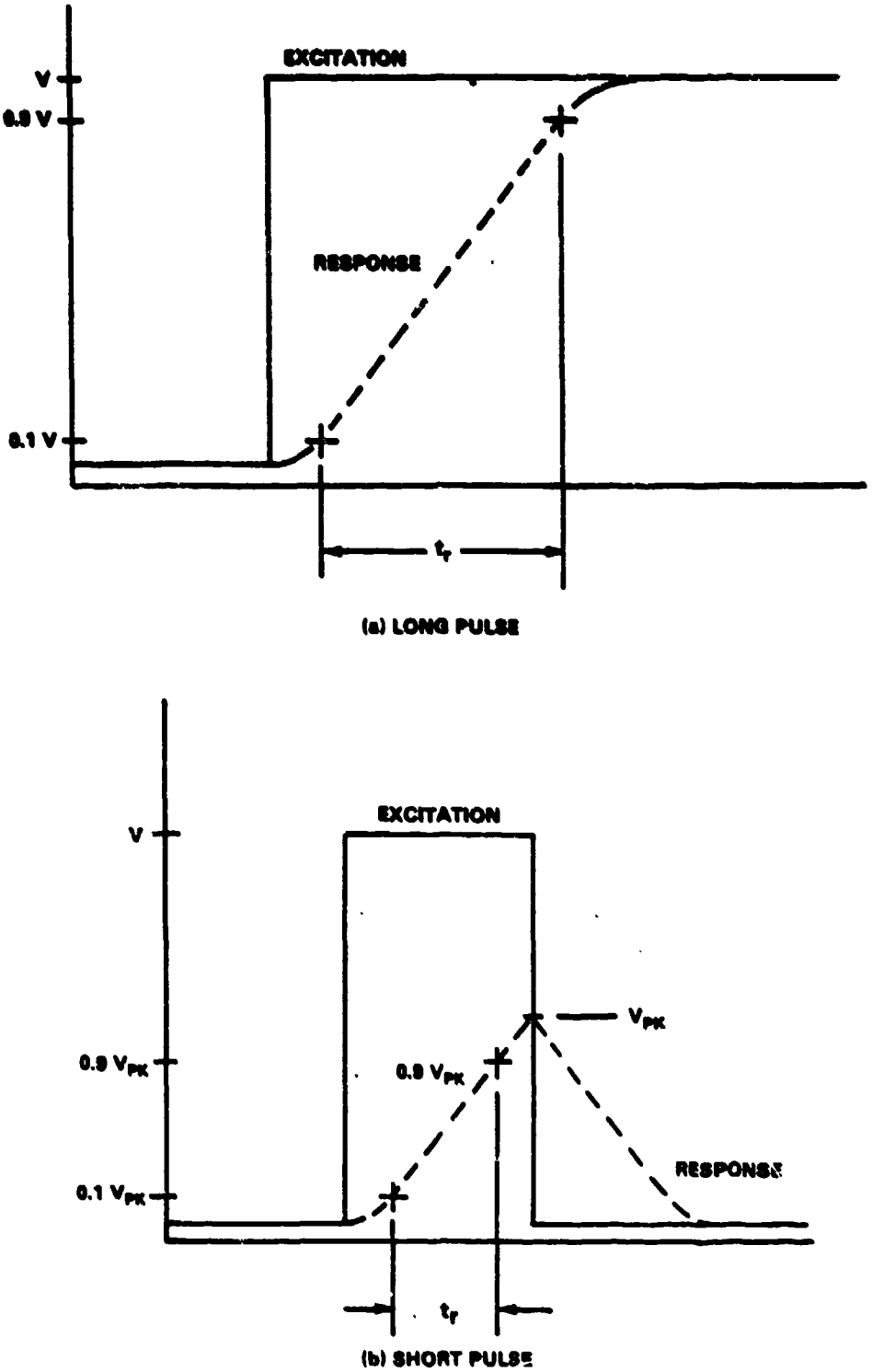


FIGURE 76. Pulse rise time definition.

when excitation pulses are removed before a circuit has a chance to reach steady state. For excitation pulse widths less than t_c, the pulse rise time approaches 0.8 x t_{pw}, where t_{pw} is the pulse width of the excitation signal. Also, the peak voltage at the output is significantly below the excitation pulse level for extremely short pulses. The definition problem can be avoided in part if the minimum pulse widths and rise times can be established based on expected cable lengths and characteristics. If the load and source impedances are matched to the cable (i.e., no reflections), then a minimum pulse width greater than the propagation time down the line provides a good start to avoiding rise time problems.

If the pulse duration is long compared to the total transmission line propagation delay, the pulse rise time characterization approaches the conventional rise time definition. In addition, the peak voltage amplitude is not reduced due to premature signal turn-off. If the worst case transmission line length were known, then a minimum pulse width and maximum rise time for TCP signals could be defined based on the known propagation delay.

The cable length expected for most tactical aircraft is on the order of 10 to 100 feet depending on the store station location. Larger bomber type aircraft can have longer cable runs but lengths in excess of 300 feet are not likely. These distances suggest minimum pulse widths on the order of 150 to 450 nanoseconds to avoid propagation delay effects on rise time.

Another method of defining the minimum pulse width is to begin with the rise time expected from the step response of the cable. This rise time is determined by the effective bandwidth of the cable. The bandwidth of a cable, however, is not easily defined. An analytical technique which is based on the attenuation specification of the cable can be used to estimate cable bandwidth. Using this technique indicates that the 10 to 80 percent rise times shown in table X result for various cables and cable lengths.

One point to note in the table is that one cable (such as RG179) may be "faster" for short line lengths and "slower" for long line lengths than another cable (such as RG302).

The rise time response is keyed to the slope of the attenuation curve for the cable. This slope is inversely proportional to the conductor diameter and characteristic impedance.

TABLE X. Representative cable rise time performance.

Cable Type	Rise Time (Nanoseconds) (10 to 80 Percent)				
	3FT	10 FT	40 FT	100 FT	300 FT
RG178 (small 50 ohm)	.054	.56	8.4	50	426
RG179 (small 75 ohm)	.0013	.064	5.4	100.8	3390
RG142/303 (larger 50 ohm)	.006	.06	.9	5.0	41.6
RG302 (larger 75 ohm)	.006	.06	.9	5.0	41.6

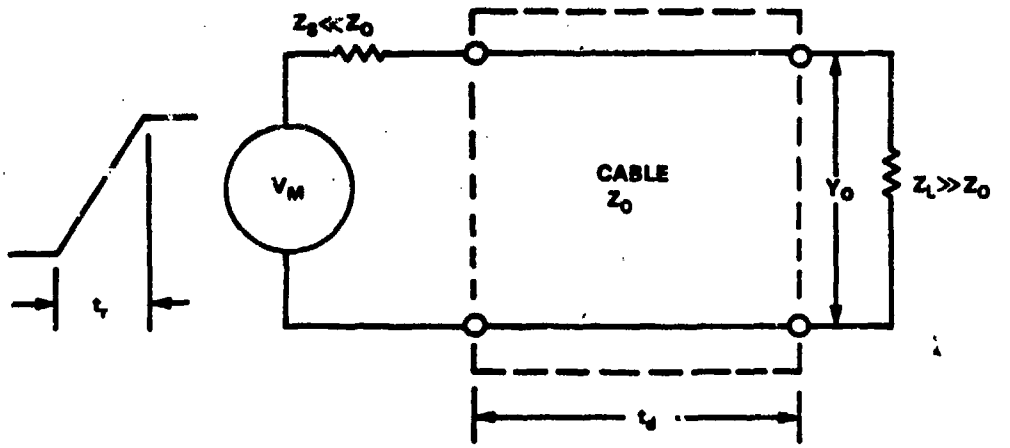
Data in the table shows that the "best" cable configuration with respect to rise time consists of a mix of small and large cables between short (e.g., umbilicals) and long (e.g., aircraft) wire runs. This mix matches well with the installation restrictions projected for cables in the umbilical and wing/pylon areas. Note that small cables (e.g., RG178 and RG179) can not be run for very long lengths before appreciable stretching of the pulse rise time results. However, line lengths on the order of 10 feet yield realistic rise time degradation for the subminiature cables.

The final pulse rise time factor concerns cases in which loads or sources are not impedance matched to the cable. This situation results in reflections of the pulse between load and source (and other discontinuities).

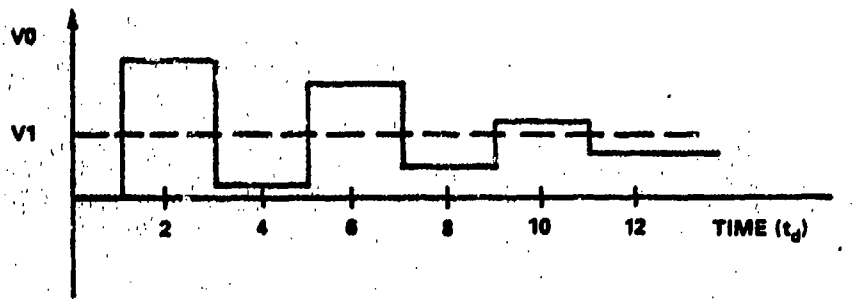
Figure 77 illustrates a simplified case where a ramped pulse is applied to a badly mismatched but lossless circuit. The load voltage is shown for various rise times. The rise times are normalized to the line time delay (i.e., line length divided by velocity of propagation).

The load voltage seen in the first two cases (b and c) appears to be an extreme overshoot and ringing plus application of a high overvoltage. This "ringing", however, is actually the result of reflections.

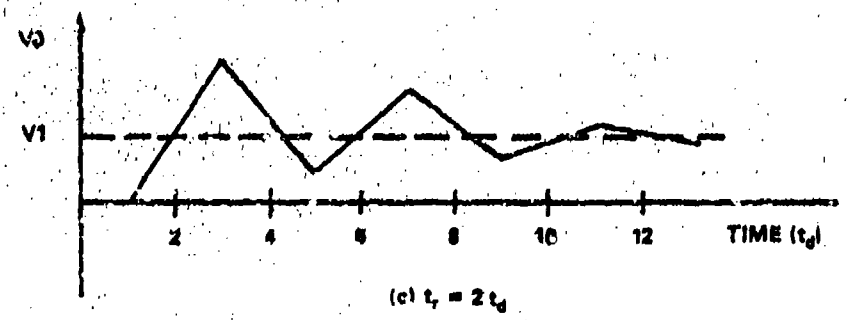
To promote clean waveforms and reduce overvoltage surges (even under severe mismatch), an input pulse rise time greater than four times the cable delay can be used. For a 100 foot cable



(a) SCHEMATIC



(b) $t_r \ll t_d$



(c) $t_r = 2\,t_d$

(d) $t_r = 4\,t_d$

FIGURE 77. Impact of rise time versus cable delay.

run, a 600 nanosecond rise time is required under these conditions. This does not compare well, however, with the 50 nanosecond rise time required by GPS. If, instead of lengthening the pulse rise time to accomodate cable delay, at least one end of the line is impedance matched to the cable, the reflections are stopped. This highlights the importance of impedance matching for pulse transfer to support fast rise times.

The data in table X indicates that sufficient flexibility exists for matching cable types for various line lengths to achieve the necessary overall rise time maximum.

5.1.5.2.3 Switching components. Either electromechanical or solid state components can be used to implement the switching matrix. In general, electromechanical devices have low insertion loss, high signal power rating and are low cost. Solid state devices have high reliability, high switching speed and are small in size. Electromechanical devices consist of coaxial relays (MIL-S-3928) and subminiature relays (MIL-R-39016). Coaxial relays are available that have maximum insertion losses of 0.2 dB to 0.3 dB, maximum isolation of 60 dB to 90 dB and a maximum VSWR of 1.2 between the frequency range of DC to 2.0 GHz. The power rating of coaxial relays is influenced by operating mode (switching, or non-switching) and signal frequency. Circuit design should provide for switching during "no-power" conditions. However, in some cases, this may not be practical - i.e. the source would need to be turned-off. Coaxial electromechanical relays, in general, have a maximum switching time of 20 milliseconds.

Subministure relays (such as M39016/8 TO-5 relays) are generally attractive because of their small size rather than their performance characteristics. Subminiature relays have a typical insertion loss of 0.02 to 0.2 dB at frequencies to 20 MHz and 0.4 to 0.5 dB at frequencies to 2.0 GHz. Isolation of 30 dB can be expected. This low isolation is a major weak link (other than the high insertion losses) with the TO-5 relays. The VSWR of the relay itself is very low due to its small size but the VSWR will be driven by the board layout used for mounting and connecting the relay to the network. Microstrip style board layouts are recommended for Type B networks. This style relay is most attractive for the lower frequency Type A band networks. Power handling is less than coaxial relays but suitable for AEIS applications. The switching time is typically 2.0 to 4.0 milliseconds.

Solid state switches primarily consist of PIN diode and FET switches. With respect to PIN switches, various combinations of multiple series switches, multiple shunt switches and combinations of series-shunts can be used to enhance one performance characteristic at the sacrifice of other characteristics. Physical placement of PIN switches within a switch module also influences circuit characteristics. Table XI lists a range of PIN diode switches with typical characteristics.

Both electromechanical relays and solid state switches have an uncontrolled VSWR during transition from one conducting path to the other. Solid state devices, however, have a much shorter transition time. Signal distortion of PIN diodes is higher than is experienced with electromechanical devices and is higher at low frequencies. PIN diode switch insertion loss at low frequencies is also a significant disadvantage.

Field Effect Transistors (FET) fall in the general classes of Junction FETs (JFETs) and Metal Oxide Semiconductor FETs (MOSFETs) with MOSFET switches generally providing better performance than JFETs. The MOSFET class includes a growing number of technology types. The types best suited to the AEIS application include Complimentary MOS (CMOS), Vertical MOS (VMOS) and Double Diffused MOS (DMOS). In addition to the two general classes, Gallium Arsenide (GaAs) FETs are available for use in the high frequency (tens of GigaHertz) range. Table XII summarizes typical switch performance characteristics of the FET devices. The only currently promising type for AEIS applications is the GaAs FET.

5.1.5.3 Summary of contributors to signal degradation. The aircraft high bandwidth signal distribution network influences the signal quality due to several factors. These factors are primarily related to the degree that the network approaches an idea transmission line. Perfect transmission lines can not be realized in actual hardware designs due to the imperfections of cables, connectors, switching devices and other network components including "transparent" components associated with FDM. These components introduce signal losses and distortions due to impedance mismatches, attenuation, phase distortions and harmonics. These losses and distortions, generally, increase as the signal frequency increases.

The AEIS standard establishes a limited set of requirements on the aircraft HB signal distribution network by defining characteristics measurable at the ASI. These network characteristics include Voltage Standing Wave Ratio (VSWR) limits at the ASI and attenuation, delay, dispersion and distortion limits for signals transferred from one ASI to another ASI. Each of these areas is summarized in the following sections.

5.1.5.3.1 VSWR. The aircraft is required by the standard to provide a VSWR of less than 1.75 at the ASI for both ASI-to-ASI and ASI-to-aircraft signal transfers. This VSWR applies from 5 MHz up to the applicable upper frequency limit (generally 1.6 GHz for HB1 and 20 MHz for HB2, HB3 and HB4).

VSWR limits are not specified in the lower frequency range (20 Hz to 5 MHz) of the Type A signal band due to measurement difficulties and also due to transmission line phenomena. (See 5.1.5.2.2.) As signal farequencies drop, cables stop functioning as transmission lines (wave propagation) and start functioning as conductors (current conduction). The frequency of transition in operating modes is dependent on the network geometry. The general rule

TABLE XI. Summary of typical PIN switch performance.

Bandwidth (Decades)	Freq (MHz) Min	Freq (MHz) Max	Insert Loss (dB)	Isolation (dB)	VSWR	t_{sw} (ns)	POWER (W) (Avg)
1.0	200	2000	0.5	50	1.5	200	1000
1.3	100	2000	0.7	50	1.5	200	1000
1.3	200	4000	1.5	60	1.6	2000	1000
1.7	10	500	1.8	80	1.5	2000	20
1.7	10	500	1.8	50	1.3	2000	100
2.1	10	1200	1.2	40	1.5	200	250
2.3	100	18000	3.1	55	1.9	500	1000
2.6	5	2000	2.2	50	1.5	2000	2000
3.0	5	500	6.0	50	1.75	N/A	100

TABLE XII. Summary of typical FET switch performance.

Device	Frequency	Voltage	Insertion Loss	Isolation	Signal	ITO
CMOS	DC-50MHz	+15V	5dB @ 20MHz	45dB @ 10MHz	500mW	30dBm
VMOS	DC-50MHz	+10V+	0.1dB @ 20MHz	33dB @ 10MHz	3W	42dBm
DMOS	DC-1GHz	+10V+	2dB @ 20MHz	50dB @ 10MHz	200mW	30dBm
GaAs	DC-2GHz	+5V	.6dB @ 2GHz	70dB @ 10MHz 20dB @ 2GHz	1W	22dBm

of thumb is that if the size (primarily length) of the network is greater than 1/10th to 1/20th of the applicable frequency wavelength, then the signals will begin to conduct through the network in a wave propagation mode. Discontinuities of this size range will start producing undesireable reflections. As a reference point, 1/20th of the wavelength for 20 MHz (in teflon) is approximately 20 inches. At 1.6 GHz, the 1/20th wavelength is 0.25 inches. From these dimensions, one can see that the design rules for the Type B signal distribution network are much more stringent than the design rules for the Type A (20Hz-20MHz) network.

This reduction in "dimensions of interest" for the Type B network impacts the quality of connector contacts and the internal layout and component quality of coaxial switching matrices.

In terms of meeting the ASI VSWR requirements of MIL-STD-1760, probably the most critical component is the coaxial contact in the ASI connector. This component is most critical because it is the closest component to the ASI. (Reflections produced by this contact will not be attenuated.) From a VSWR perspective, the next most critical component (for Type B signal networks) is the coaxial switches used to direct the signal through selected paths. Good quality switches are readily available - don't use junk.

If active networks (see 5.1.5.1.2) are selected for the Type B network, be sure to terminate (into 50 ohm loads) deselected paths out of the power dividers. A line out of a divider to an open switch will produce a reflected wave (reflection coefficient = 1) back to the divider and the reflection will be recombined in the divider with the original signal.

5.1.5.3.2 Attenuation. Attenuation is probably the second (if not the first) major area of concern in most distribution networks - especially passive networks. Probably the largest contributor to attenuation results from the constant concern of the aircraft installation engineers to reduce wire bundle diameters. A suggestion to install 1/4 inch or 1/2 coaxial cables through the aircraft (especially the wing) will only illicit unkind remarks. However, if there is no signal left after propagating through a long subminiature (roughly 0.1 inch OD) cable, then there is no purpose in installing the cable in the first place. For every 20 dB of attenuation, 9/10ths of the signal is lost. Referring back to figure 68 shows that 40 feet of RG316 (a subminiature cable) yields over 22 dB of loss at 1.6 GHz. Table XIII summarizes typical distribution network attenuation and attenuation flatness. A saving point, however, is that the cable attenuation problem is primarily associated with the Type B band for HB 1 (i.e., only one out of the four HB ports).

A second contributor to high attenuation results from the use of crosspoint style switch matrices. Due to the potential for a large number of series relay contacts, crosspoint matrices tend to produce high losses - especially if designed for the Type B signal frequencies.

TABLE XIII. Typical network attenuation performance.

End Points	Type A Signal (dB)		Type B Signal (dB)
	Attenuation	Flatness	Attenuation
ASI to aircraft equipment (1)	2.0	1.25	16
MSI to aircraft equipment (2)	2.3	1.75	22
ASI to ASI (3)	4.0	2.5	N/A
MSI to MSI (3)	4.6	3.5	N/A

(1) Tested configuration was 37 feet of RG316 (HB1 and HB2) or RG179 (HB3 and HB4) and two mated pairs of MIL-STD-1760 connectors with M39029/28 and 75 shielded contacts.

(2) Tested configuration was 40 feet of RG316 or RG179 and four mated pairs of MIL-STD-1760 connectors.

(3) Calculated from measured data.

A third potential contributor to high effective attenuation results from the implementation of an FDM system - particulary one using a passive bus with no receiver AGC (or some other gain adjustment method). The FDM designer needs to follow the attenuation and attenuation flatness requirements for ASI-ASI paths and also consider the video signal level ASI specifications in MIL-STD-1760. The range of allowed peak-peak signal voltage and the associated signal dynamic range can indirectly influence the effective attenuation requirements of FDM and other active systems.

5.1.5.3.3 Other areas. Issues of propagation delay, variance in delay (related to phase distortion) and harmonic distortion are primarily directed at FDM networks and active networks.

The propagation delay specification is high enough that switching matrix systems should have no problem complying. The delay is also high enough that good FDM electronic designs will yield compliant performance.

Delay variation (signal dispersion paragraph in MIL-STD-1760) is a little more of a challenge for the FDM system. In addition, passive switching networks can produce surprises in out-of-specification delay variance. These problems tend to appear in the passive switching networks for HB3 and HB4 due to the requirement to switch both the signal and signal return (shield) conductors. (See shield grounding requirement in 5.1.1.1.2.10 of MIL-STD-1760.) The use of triaxial RF switches (relays) or near-microstrip quality board layouts in the switching matrix is suggested. Figure 78 shows an example of delay variance resulting from a matrix designed with half crystal can relays and interconnected with an internal box wire harness (as opposed to a "microstrip" board).

The harmonic distortion requirements should also be carefully considered in the FDM designs, in active bus designs and in solid state switch based switching matrices. Basically, any component that has a significant voltage - current non-linearity is a potential source of harmonic distortions. In addition, under some cases, ferromagnetic materials (sometimes used in connectors, cables, electromechanical relays, etc.) can also generate harmonics. Usually the ferromagnetic generated harmonics require a much higher signal power level to trigger the effect than is available (allowed) through the AEIS.

5.1.5.4 Subsetting. Two classes for the Primary signal set are identified which affect the HB interfaces, i.e., class I and class II. A class I ASI provides the capability for transferring the full primary signal set where as the class II ASI provides the capability for transferring a reduced *subset) primary signal set. In the HB context, the class I requires all four HB ports while the class II requires only HB1 and HB3 ports. For maximum interoperability, the aircraft should implement the class I ASI. It is recognized that justification for the class I ASI may

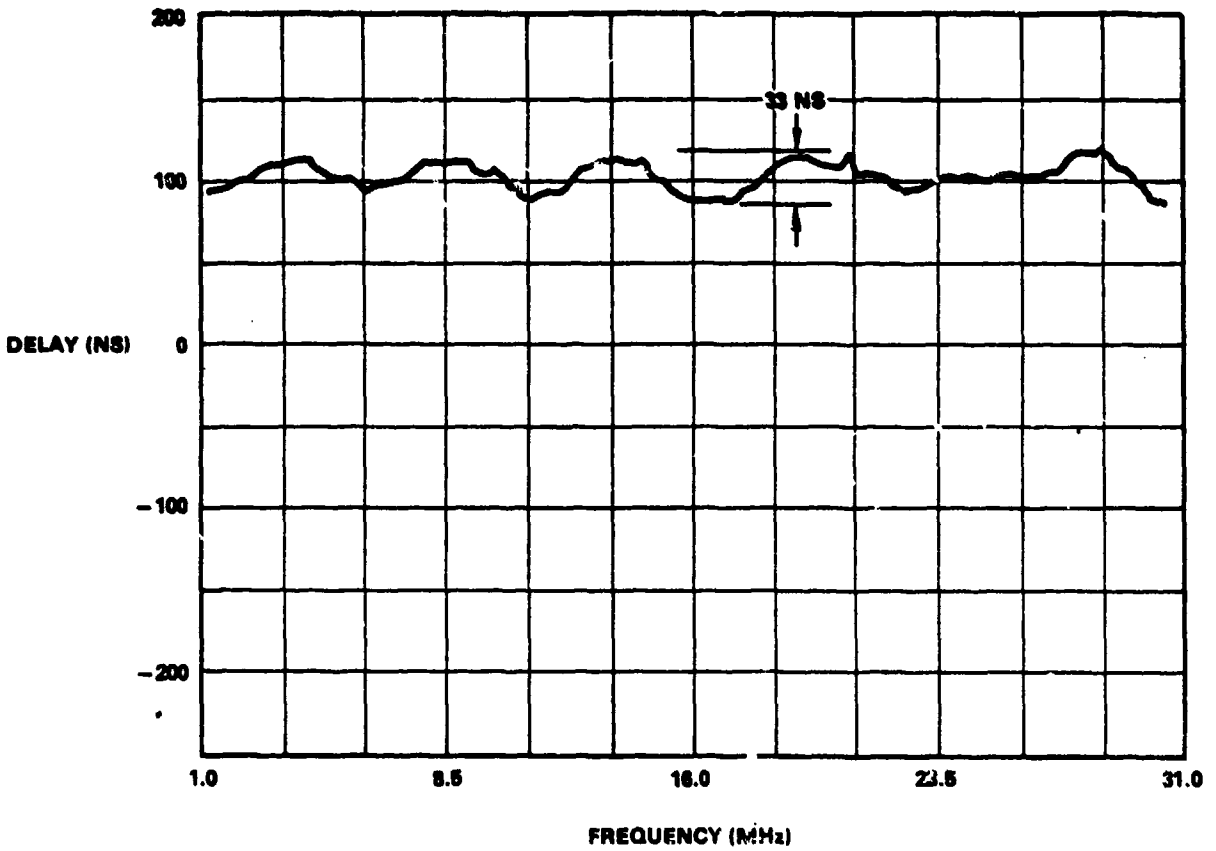


FIGURE 78. Delay variance with marginal matrix design.

not be obvious in some applications. It should be noted that while most stores will not require the capability provided by a class I ASI, some stores will require the capability. Several examples are: (1) Stores which contain "low cost" GPS receivers and rely on the aircraft to send both a raw GPS RF signal (HB1) and timing pulses (HB2) for receiver synchronization; (2) electronic pods such as the LANTIRN navigation pod which requires two blanking signals (HB1 and HB2) and a synthetic video (HB3); (3) some FLIR pods which also include a video combining function and therefore require video in and video out connections (HB3 and HB4); (4) proposed targeting pods which require video in and video out (HB3 and HB4); (5) ECM jammer pods which require blanking in and blanking out (HB1 and HB2); (6) longer term concepts of multi-sensor missiles (such as millimeter wave and electro-optical) which may require multiple synthetic video (HB3 and HB4) and blanking (HB1 or HB2) and (7) growth provisions for missiles using high speed data buses. The net result is that some applications currently exist which justify installation of a class I interface on at least some stations. In addition, the availability of multiple HB port services from the aircraft will tend to invite store designers to take advantage of that utility for improved store performance.

5.1.5.5 HB growth provisions. MIL-STD-1760 provides sufficient HB growth capability to eliminate risk of technical obsolence. This growth capability is achieved in part by providing a high bandwidth capability beyond the immediate needs for current typical signal implementations. Examples of this growth capability are listed in paragraph 5.1.5.4 for example items 6 and 7.

5.1.6 Low bandwidth interface. The low bandwidth distribution system consists of one twisted shielded pair for transferring bi-directional low bandwidth (DC to 50 kiloHertz) signals between each ASI and the aircraft electronic equipment. The only signals allowed to be transmitted on this line are tones and voice grade audio. It is recognized that future use of the line may be extended to a low cost, low speed serial digital interface for use on simple, low cost stores such as electronically fuzed bombs. This line must not be used for transmitting discrete signals since such use would be an obstacle to aircraft/store interoperability.

5.1.6.1 Design requirements. The aircraft is required to provide a Low Bandwidth (LB) interface at all ASIs. This LB interface feeds into an aircraft LB distribution network or at least what appears at the ASI to be a distribution network. The specific aircraft equipment that is the ultimate recipient (or source) of the LB signals is application dependent and not, therefore, defined by MIL-STD-1760. All that the AEIS standard requires is that the distribution network be capable of transferring signals with specific characteristics.

The AEIS standard defines the LB interface as a three terminal connection - a non-inverting line, an inverting line and a grounded shield. While the standard does not mandate use of a shielded twisted pair cable for implementing this interface, that is the underlying intent. (The standard does not define the specific type of cable to be used on any of the interfaces. Cable selection is considered an aircraft and store design issue.)

The voltage and current characteristics are defined on both a line-to-line and line-to-ground (shield) basis. The voltage range is defined as -12 to +12 volts peak with a 150 milliampere current maximum. In addition, the frequency range for transferred signals is DC to 50 kiloHertz. Similar to the discussion in 5.1.5, this frequency range is intended to define those signal frequencies which must be transferred by the network. The limit isn't specifically meant to ban outright signal harmonics at higher frequencies.

This frequency range and voltage/current limits accomodates the original intended use of this interface as an audio link (MIL-STD-1760 July 81) plus imbeds a network capacity for the possible future transfer of low speed digital data (e.g. 38 Kilobaud RS485 data link). The standard, however, currently restricts the line to audio functions only.

It should be noted at this point that the voltage level is below the amplitude typical of some current non-1760 audio sourcing missiles such as the Sidewinder. This lower amplitude is specifically selected to allow the aircraft to use solid state technologies for the internal distribution network. If an aircraft designers uses a common distribution network for 1760 LB signals and non-1760 audio signals (e.g. Sidewinder) then he can either attenuate the non-1760 audio signal amplitude or design his network to handle higher voltages. It is not, however, considered necessary or appropriate for 1760 to mandate a higher voltage signal distribution network.

The final interface electrical characteristic required by the AEIS standard is the input impedance and the expected load impedance. Both the input impedance seen looking into the ASI and the load impedance seen by the aircraft at the ASI are specified at a level greater than 70 ohms on a line-line basis. This impedance applies over the DC to 50 kHz range. (As identified in the standard this 70 ohm lower limit does not apply looking into a transmitting source.) These impedance limits are essentially an expansion of the voltage/current limits previously defined. In the case where an aircraft terminates an inputted LB signal into a distribution network terminal (such as an RDM modem or an active bus amplifier), the input impedance needs to be greater than 80 ohms (i.e. 12 volts/150 milliamperes) versus the 70 ohm minimum defined here. This 80 ohm requirement applies because the designer (of the FDM modem for example) must limit the current to 150 milliamperes if a full scale 12 volt signal is applied. If, however, the input impedance seen at an ASI is from a

specific aircraft equipment load which was designed for a lower voltage (e.g. 6 volts) from a specific pre-defined LB signal, then the lower 70 ohm minimum impedance applies. (This same 70/80 ohm issue applies to ASI load impedances.)

The input and load impedance are specified as a minimum impedance only. This allows the connection of a broad range of equipment to the LB port (e.g. 600 ohm audio systems, 120 ohm line receivers, etc.).

5.1.6.2 Network implementations. The LB signal distribution network in the aircraft can be implemented with basically the same technologies described in 5.1.5.1 for the High Bandwidth signals. These technologies include: (1) Brute force switching matrices using both electromechanical and solid state switches, (2) some FDM techniques, and (3) active analog buses. In addition, due to the low frequency range (DC-50 kHz), the LB signal can also be digitized and then transmitted over some form of digital data bus or point-to-point digital data link. As a general case, it is not practical to send digitized LB signals over MIL-STD-1553 unless a large percent of the multiplex bus's data capacity can be devoted to LB service or unless additional circuitry is included for achieving data compression.

If the aircraft uses a FDM system for distributing Type A HB signals, then the same system can also be used for LB signal transfer. Depending on the specific modulation scheme used in the FDM modems, the transfer of the DC and low frequency components of the DC-50 kHz band could add a layer of circuit complexity to the modem.

The paragraphs which follow highlight several design issues which are unique to the LB interface (versus the HB interface).

5.1.6.2.1 Signal power level. The signal power limit as a function of load impedance is established as follows:

- o Maintaining current through the network below 150 milliamperes (MIL-STD-1760 requirement) and
- o Maintaining voltage across the network below ± 12 volts (MIL-STD-1760 requirement).

The results of current and voltage levels on the signal power limit are shown in figure 79. The figure shows that as the load impedance increases, signal power shifts from being current limited to being voltage limited. The figure shows that maximum power capacity occurs at 80 ohms.

5.1.6.2.2 Cable characteristics. The cable should be a twisted shielded pair. The cable shield coverage should be 90 percent minimum. Since MIL-STD-1760 specifies concentric twinaxial contacts (MIL-C-39029/90 and 91) for the interface connectors, the two inner conductors are shielded through

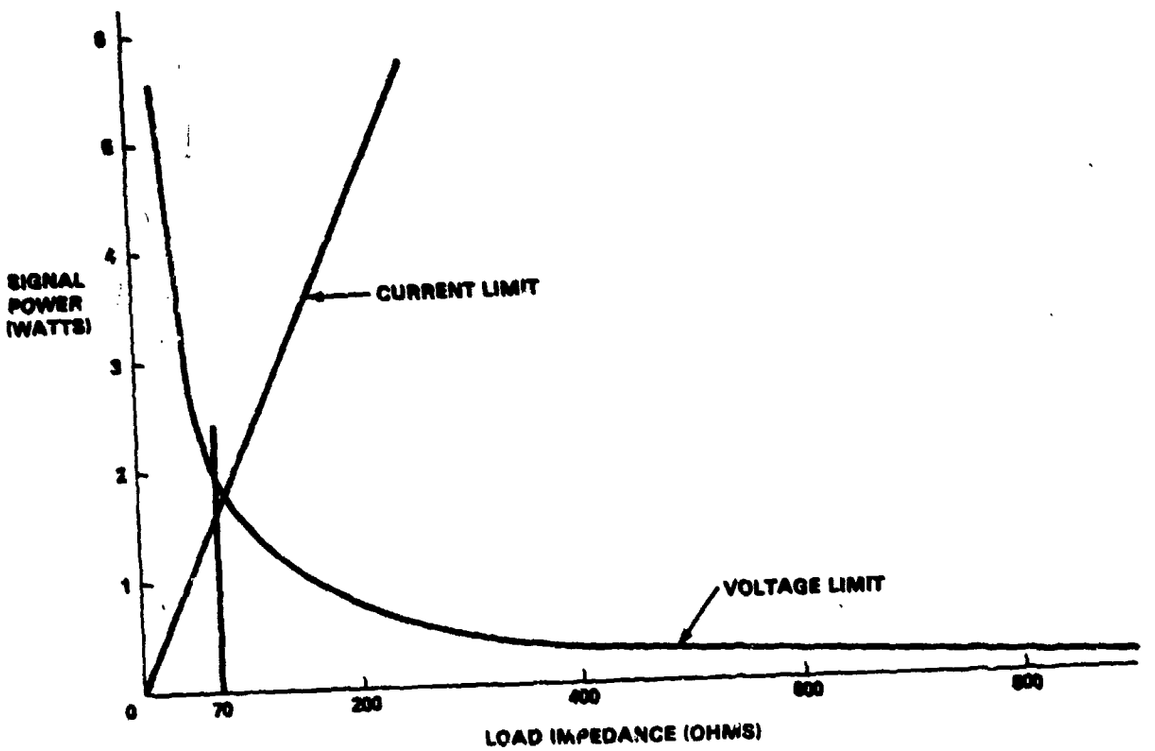


FIGURE 79. Signal power limit vs load impedance.

the interface connector. Maintaining this same coverage through other connectors (than the ASI and MSI) is highly recommended to minimize EMI. The two inner conductors should contain at least four twists per foot for audio signals to provide adequate noise protection. It is also recommended that the wire-to-wire distributed capacitance not exceed 30 picofarads per foot. The recommended size for the inner conductors is 24 gauge minimum. This wire size is compatible with LB signal, MIL-STD-1553 and mechanical requirements. Use of MIL-C-17/176 cable is suggested. It should be noted, however, that MIL-STD-1760 does not specify cable characteristics for any of the AEIS signals to maximize design flexibility and to stay within the concept of an interface standard - not a design standard.

5.1.6.2.3 Signal transmission options. Two signal transmission options are applicable to the LB interface, i.e. single-ended and differentially driven circuits. The single-ended option uses one conductor for signal transmission with a signal return. The differentially driven option uses two conductors for signal transmission and a common return. The differential system is basically two single-ended systems with a common signal return. One single-ended line is driven with the complement of the signal on the other single-ended line. The single-ended system requires two conductors while the differentially driven system requires three conductors. Since MIL-STD-1760 specifies interface connectors with twinaxial contacts, the capability exists for the LB line to be implemented either way, i.e. single-ended or differentially.

To provide a degree of immunity from differences in ground potential between the aircraft and store, differential systems are recommended. Two "differential" design approaches can be used as shown in figure 80. Balanced line transmitters and receivers (figure 80a) are readily available and used frequently with digital systems. The transmitter/receiver produces a DC content on a line-to-ground basis and can produce a DC content on a line-to-line basis depending on the data encoding scheme and data rate used. The balanced line receivers can operate in a relatively high common mode noise voltage environment.

Transformer coupled implementation (figure 80b) provides better isolation between aircraft and store signal grounds. However, at low frequencies the transformer size and weight may be unacceptable. Also, DC signals cannot be transmitted. Therefore, transformers if used need to be installed in the end using equipment - not in the aircraft signal distribution network.

MIL-STD-1760 restricts the use of the LB interface to tones and voice grade audio signals (i.e. no DC component). Consequently, isolation transformers can be used (see figure 81) to minimize EMC problems, i.e. the electronics power supply grounds in the aircraft and store can be isolated from each other. However, MIL-STD-1760 allows DC signals to be transmitted across

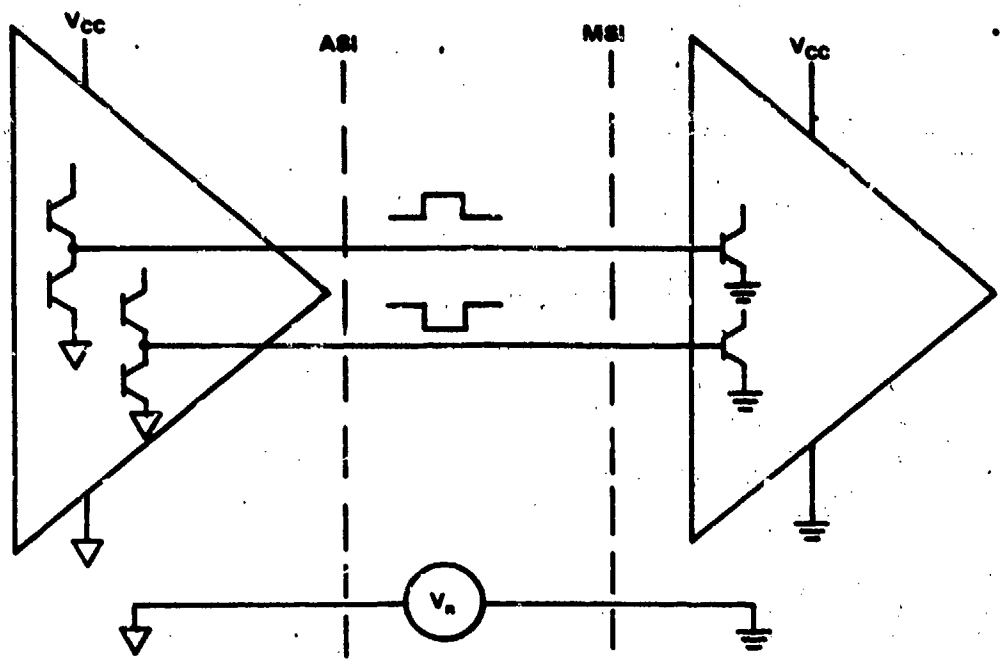


FIGURE 80a. Balanced line drivers and receivers.

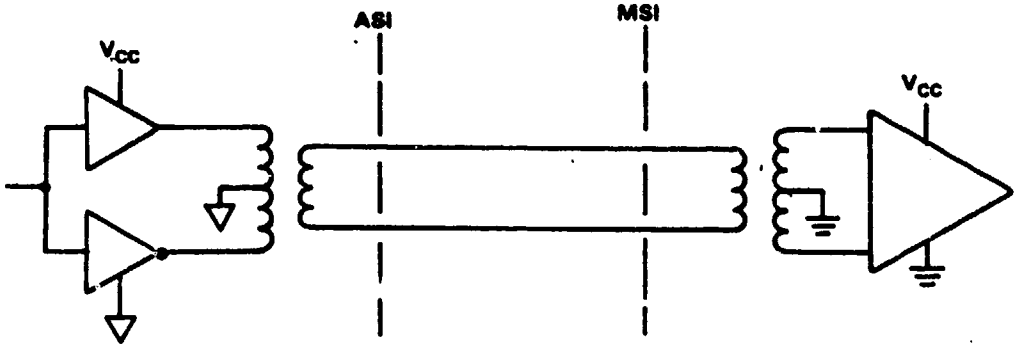


FIGURE 80b. Transformer coupling

FIGURE 80. Grounding options for LB interface.

the ASI. Figure 82 shows a typical implementation example using a bi-directional transceiver. Proper operation of the transceiver circuit requires the presence of a signal return path to the store's transceiver. This circuit reference is established by a connection to the aircraft structure through a 100 ohm resistor. Ground continuity to the mission store circuit is provided through the shield (and incidentally, the structure ground line). Due to the high common mode rejection of these differential receivers, acceptable operation is still available even with the poor quality (high noise content) of this return path.

5.1.7 Power interfaces. This section describes the electrical power characteristics at the ASI, the control of power to the ASI, overload protection, power source rating, interface deadfacing, phase sequence, carriage store power control and power allocation. The use of 270V DC as a power source, is also alluded to although it is recognized that MIL-STD-1760 presently delegates this power system to a "growth" status only, and is not to be used until performance requirements for 270V DC are added to the standard.

5.1.7.1 Power source rating. The aircraft electric power system must be capable of supplying 28V DC and 115/200V AC currents as defined by the "Maximum Load Current" curves of figure 83 and 84 as applicable. (These figures are reproductions of the curves in figures 7 and 8 of MIL-STD-1760.) The minimum requirement for a continuous operating condition is shown in table XIV. The 28V DC PWR 1, 28V DC PWR 2 and Auxiliary 28V DC power can be supplied from a common power source or from isolated power sources. Similarly, the 115/200V AC power can be supplied from a common or isolated power sources. The minimum power capacity required at a class I and class II ASI is 4,010 VA (3450 VA + 280 VA + 280 VA). The minimum power required at a class IA and class IIA interface is established by the auxiliary signal set requirement which is 11,190 VA (10,350 VA + 840 VA). (The minimum total capacity required at a class IA or IIA ASI through the combination of both primary and auxiliary connectors is 30 amperes of 28V DC and 30 amperes/phase of 115/200V AC.) The number of ASIs that can be powered simultaneously at these levels is dependent upon the power rating of the aircraft electric power system and is not specified by MIL-STD-1760.

TABLE XIV. Minimum continuous power rating at each ASI.

Voltage	Primary	Auxiliary
28V DC PWR 1	10A	-
28V DC PWR 2	10A	-
28V DC AUX	-	30A
115/200V AC	10A/PHASE	-
115/200V AC AUX	-	30A/PHASE
270V DC	-	-

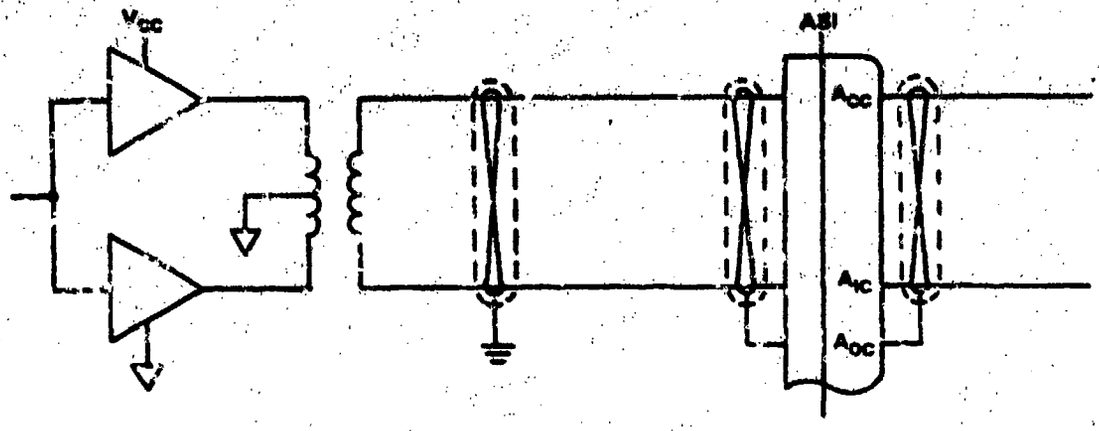


FIGURE 81. Transformer coupling implementations.

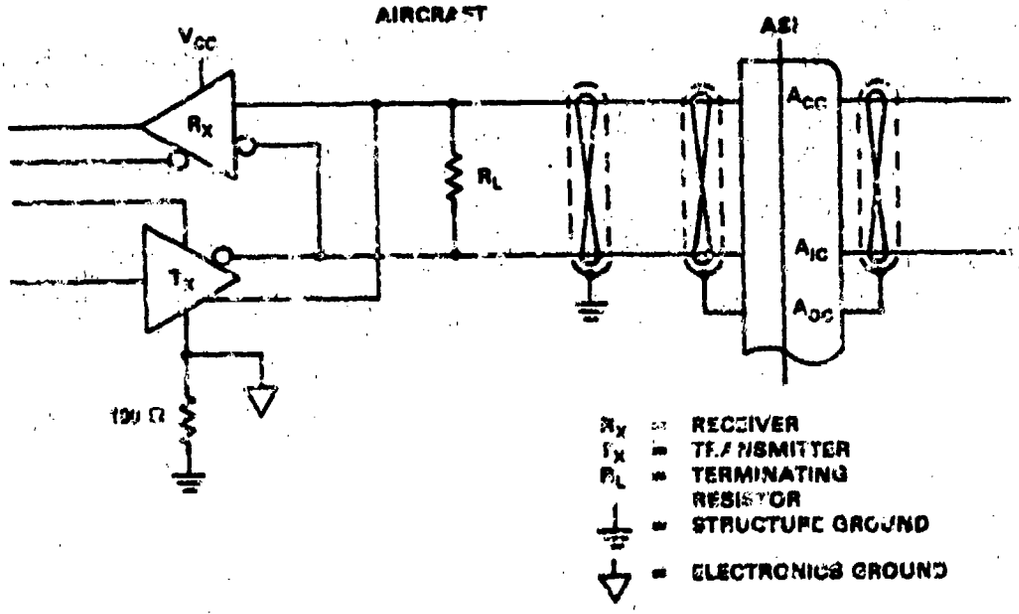


FIGURE 82. Balanced transmitter/receiver implementation.

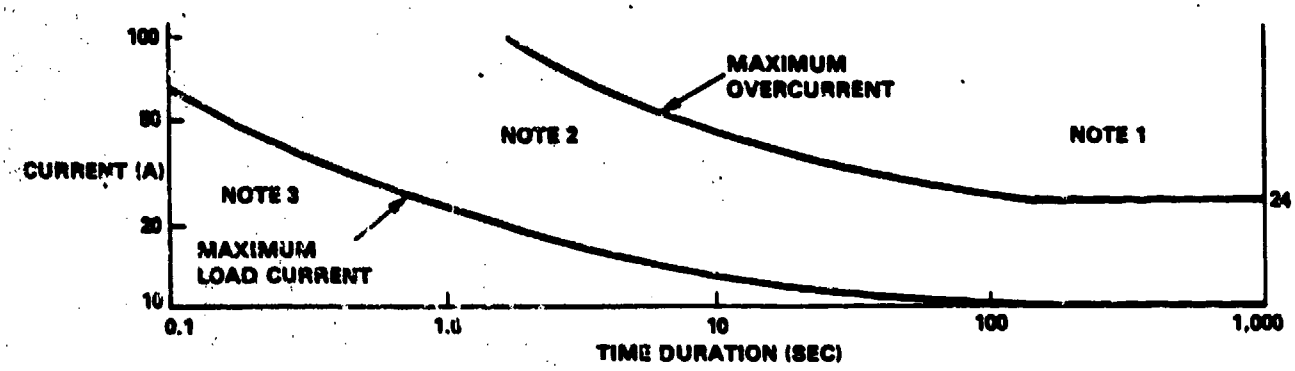


FIGURE 83. Primary interface current level.

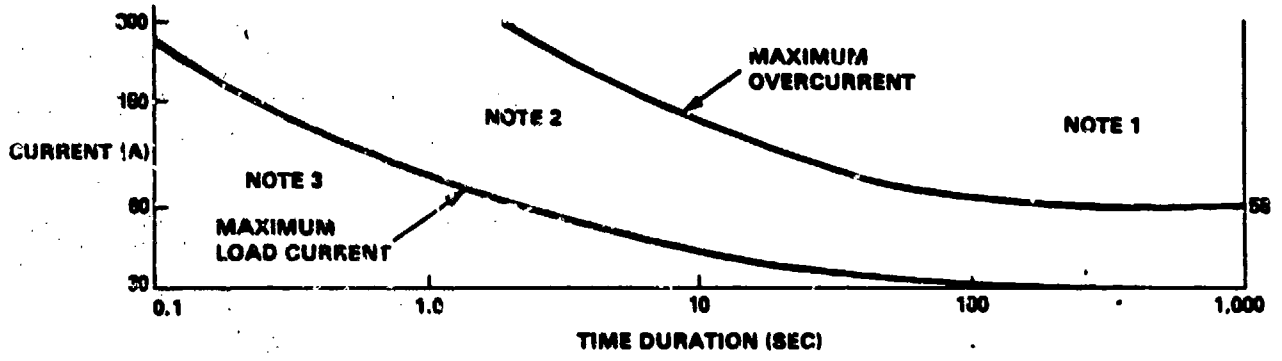


FIGURE 84. Auxiliary interface current level.

NOTES

1. The "Maximum Overcurrent" curve defines the maximum overload currents allowed at the ASI by the aircraft power distribution system. This current locus is allowed to occur at the ASI only when a fault occurs on the store side of the ASI.

2. The area bound by the "Maximum Overcurrent" curve and the "Maximum Load Current" curve defines the current-time limits within which the aircraft's protective device must trip.

3. The [illegible]um Load Current" curve defines the minimum normal current that must be available at the ASI from the aircraft's power distribution system.

The primary signal set interface is always present at the ASI. Whenever an auxiliary signal set interface is present, some of the auxiliary power can be used to power the primary interface.

CAUTION

Supplying power from the auxiliary interface through the primary interface is not recommended without the addition of another series protective device. The aircraft's protective devices used to protect the auxiliary circuits will not directly protect the primary circuits. (See 5.1.7.4.1.)

It is recognized that the aircraft's primary interface wiring can be designed to be compatible with the auxiliary interface circuit protection system. However, the primary interface circuit downstream from the ASI probably won't be compatible since the aircraft designer will have no control over this design. Furthermore, the "Maximum Overcurrent" of figure 83 will not be met at the ASI under these conditions without additional protection.

5.1.7.2 Aircraft power control and power characteristics at the ASI. A basic approach for providing power at the ASI in compliance with MIL-STD-1760 is shown in figure 85 for the primary signal set. Control of the auxiliary signal set is similar. Basically, MIL-STD-1760 requires each power source at the ASI to be under the control of the aircraft, i.e., the aircrafts' store management system and to be controlled independently of each other. Consequently, a contactor (or relay) must be used in each power line between the aircraft's regulated bus and the ASI.

WARNING

The aircraft must not energize primary 28V DC power 2 or auxiliary 28V DC until it has determined that the connected store can be safely powered with these sources.

This warning is a reflection of the power application requirements (paragraphs 5.1.1.8.2.7 and 5.1.1.9.2.10) of MIL-STD-1760. These requirements in conjunction with the transfer requirements (paragraphs 5.1.1.8.1 and 5.1.1.9.1) of MIL-STD-1760 result in the need for independent

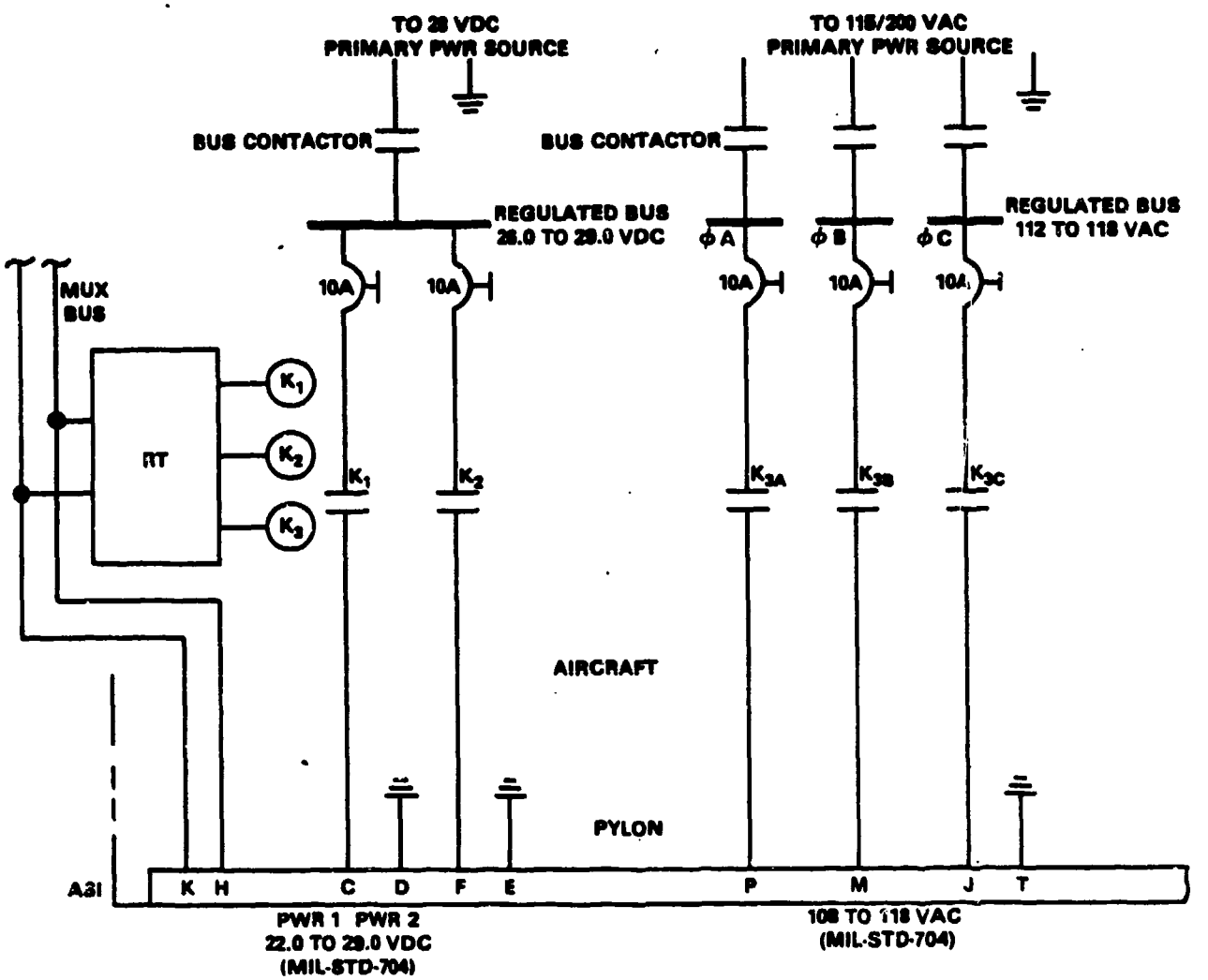


FIGURE 85. Typical primary signal set aircraft power control.

power interface control. (Note that the interpretation of "independent control" is that all three phases of a 115/200V AC power interface can be switched together, i.e., independent control of each phase is not required.)

The standard requires that the voltage characteristics at the ASI comply with the utilization equipment requirements of MIL-STD-704 (for steady state and transient voltages) and MIL-E-6051 (for voltage spikes). If the voltage levels at the aircraft's regulated power bus are typical levels, then requiring MIL-STD-704 levels at the ASI allows a net voltage drop (power plus power return) between the regulated bus and the ASI of 4 volts for 28V DC and for 115/200V AC.

5.1.7.3 Carriage store power control and distribution. If a carriage store is installed, the carriage store must provide independent on/off control of each 28V DC power interface and each 115/200V AC power interface to each CSSI for both the primary and auxiliary power interfaces as applicable. Power on/off control commands are provided by the aircraft SMS via the digital multiplex data interface. Each power type (28V DC PWR 1, 28V DC PWR 2 and 115/200V AC) should not be supplied to two or more mission stores simultaneously as this could overload the individual interfaces at the CSI. However, the carriage store should rely on the aircraft (which is issuing power control commands) to manage the total connected load at the CSI to prevent overloads at the ASI. As noted in paragraph 5.1.7.2, the voltage levels at the ASI and MSI are specified by MIL-STD-1760. Consequently, the voltage at the CSI and CSSI must allow for voltage drops in the two umbilicals (ASI-CSI and CSSI-MSI). A voltage drop of 0.2 volts minimum should be allowed for 28V DC circuits and 0.5 volts minimum for 115V AC circuits in each umbilical. Consequently, the voltage drop from CSI to CSSI must not exceed 1.6 volts for 28V DC circuits and 2.0 volts for 115V AC circuits. A typical implementation concept is shown in figure 86. The preferred ground return design is to have a dedicated line for each return as shown in the figure. Using the carriage store structure as a return path is an acceptable alternative.

CAUTION

The primary 28V DC No.1 and No. 2, and the auxiliary 28V DC inputs at the CSI must not be connected to a common bus in the carriage store. Similarly, the primary 115/200V AC and the auxiliary 115/200V AC inputs at the CSI must not be connected to a common bus. (Power from aircraft may be supplied from different sources which may be operating at slightly different voltages.)

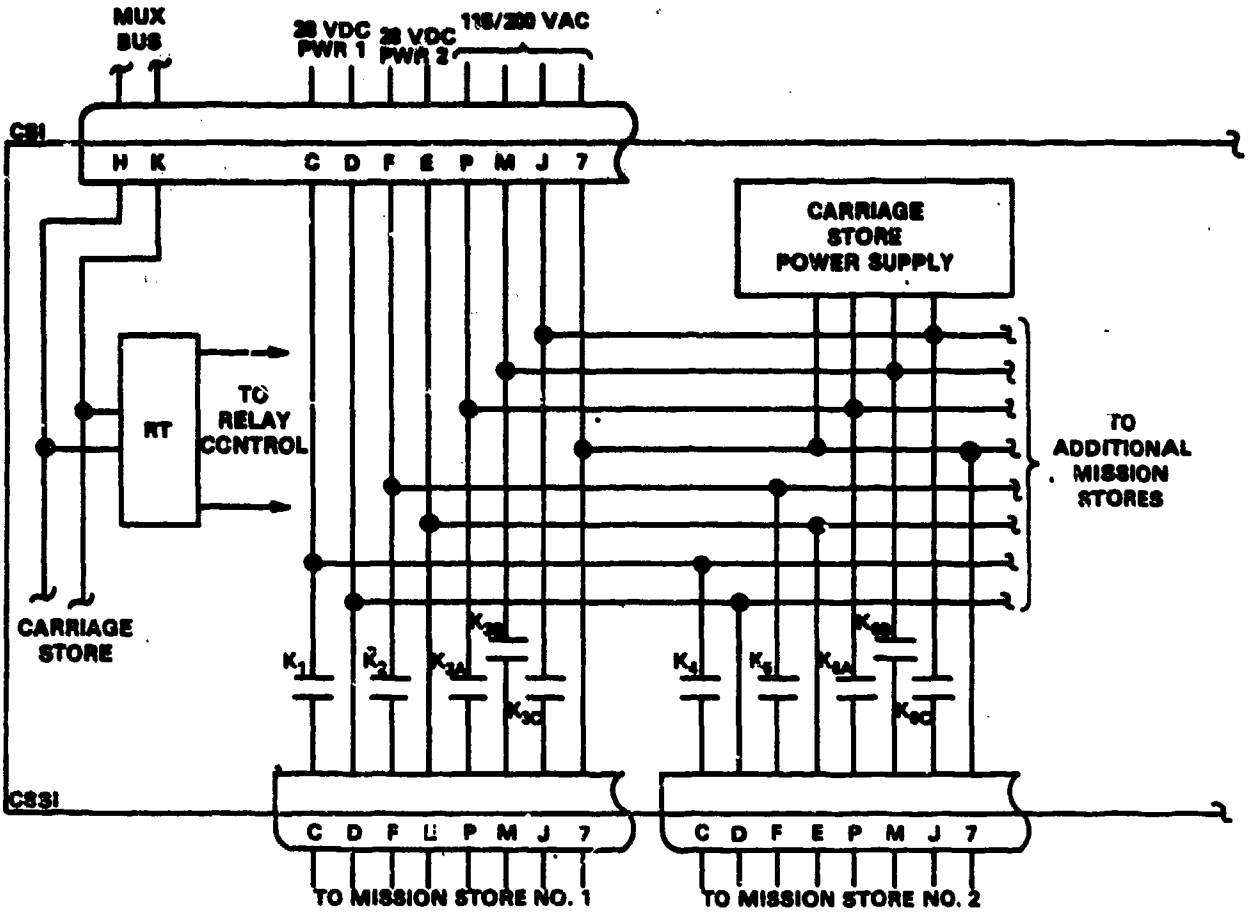


FIGURE 86. Typical carriage store power control.

The carriage store is allowed to decrease the output AC current supplied to each CSSI to 9.0 amperes per phase for the primary interface and to a total of 29.0 amperes per phase for the primary plus auxiliary interface. This decrease in output current allows the carriage store control electronics to be powered from the AC power input terminals to the carriage store. The control electronics load must not exceed 1 ampere per phase. Also, the 28V DC power must not be used for the carriage store control electronics. It should be noted that some mission stores only require 28V DC power. In these applications, a transformer-rectifier may be used within the carriage store to convert some or all 115V AC power to 28V DC power as shown in figure 87. This arrangement allows more than one mission store to be powered simultaneously if such an operation is required or desired. The trade-offs between this additional capability and the increase in carriage store complexity should be considered.

5.1.7.4 Circuit protection. Overload protection applies to the aircraft power distribution system and to the power distribution circuit downstream of the ASI. MIL-STD-1760 intends for the aircraft installed protective device to provide some level of protection for the complete circuit chain, i.e., aircraft, umbilicals, carriage store and mission store. This level of protection is directed at providing an upper bound on the fault current sourced by the aircraft in order for the stores and umbilicals to be designed to safely withstand faults.

5.1.7.4.1 Aircraft. MIL-STD-1760 defines the maximum overload and minimum capacity currents required at the ASI by the aircraft's power distribution system. These current limits are depicted in figure 83 for the primary interface and figure 84 for the auxiliary interface. The "maximum overcurrent" curve defines the maximum (fault) current allowed at the ASI. These maximum current-time limits are allowed to occur whenever a fault occurs downstream (store side) from the ASI. The "Maximum Load Current" curve defines the minimum (normal) current capacity that the aircraft power distribution system must supply to the ASI. The area between the "Maximum Overload Current" curve and "Maximum Load Current" curve defines the current-time band within which the aircraft's circuit protective device (e.g. circuit breaker) must trip.

Numerous Military Standard circuit protective devices have trip characteristics that fall within this area. These include circuit breakers, current limiters, remote controlled circuit breakers and solid state power controllers. Proper selection must result in a device with the lowest current rating that will not open inadvertently when conducting rated current as depicted by the "Maximum Load Current" curve in figures 83 and 84, as applicable.

The aircraft designer is responsible for protecting the aircraft's power distribution circuit to the ASI and normally his design responsibility stops at the ASI. However, MIL-STD-1760 intends for the aircraft's protective system to provide some level of protection to the power distribution system

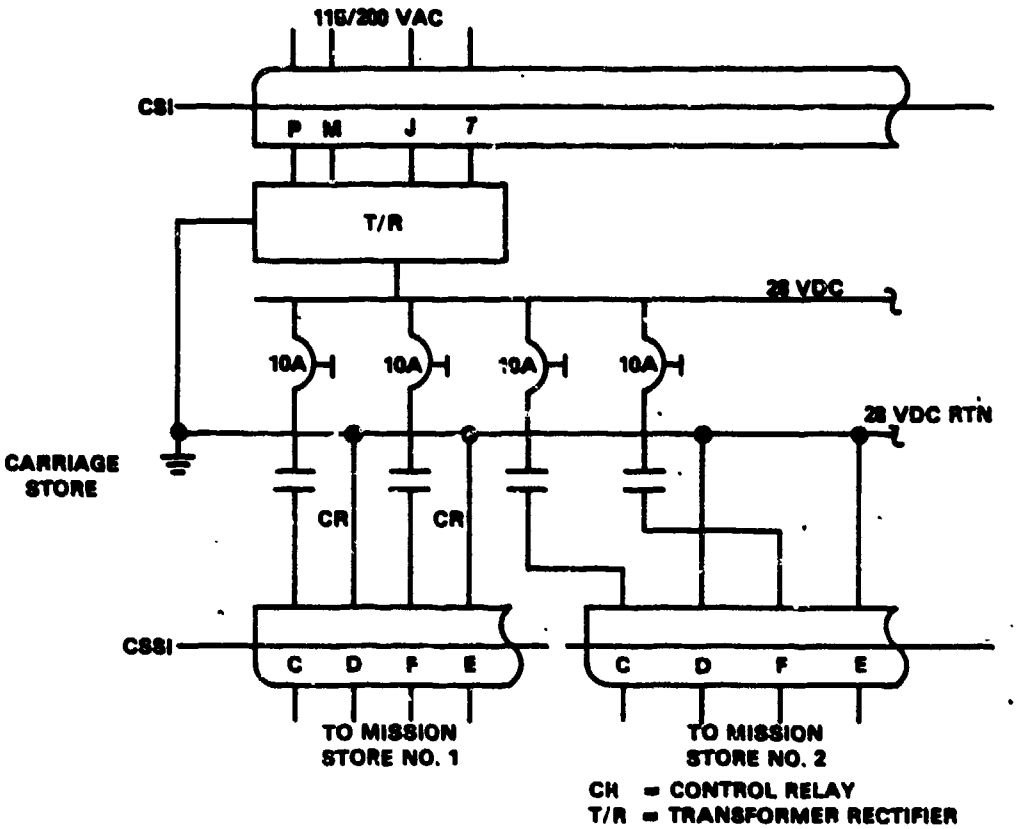


FIGURE 87. Power conversion in the carriage store.

downstream from the ASI as well. To meet this intent as well as to minimize weight in the aircraft, the designer should select the smallest gauge wire that will support the current (at the specified voltage) depicted by the "Maximum Load Current" curve and then select a protective device that will protect the wire. The current-time (trip) characteristics of the protective device selected must lie above the "Maximum Load Current" curve and below the current-time characteristics of the wire. In no case is the trip characteristics allowed to exceed the "Maximum Overcurrent" curve. It is recommended that wire gauges no larger than 16 for the primary interface and 10 for the auxiliary interface be used. These sizes are compatible with the power contacts contained on the interface connector and are adequate (i.e. low resistance) for all applications except extremely long cable lengths.

For aircraft stations with class IA or IIA interfaces, the designer may consider sharing a common power feeder to the station for both primary and auxiliary interfaces. When this choice is selected additional protection at the station will be required. Figure 88a illustrates the baseline approach for powering primary and auxiliary interfaces at a station. While the use of a common feeder (i.e. remove the two 10 ampere feeders) is acceptable, the protection provided by figure 88b is unacceptable. In this figure, overload currents on the primary interface power lines will exceed the Maximum Overcurrent curve of figure 83. Figure 88c shows an approach where the feeder wire weight savings is still achieved while the overcurrent requirements at the primary ASI are still met. In order to achieve remote resetting of the SSE installed protective devices, remote controlled circuit breakers or solid state power controllers should be used. These devices can also provide the power on/off control function.

5.1.7.4.2 Umbilical cable. Protection for the wire used in the umbilical cable is provided by the aircraft's circuit protection system. This is normally accomplished when the umbilical is designed by the aircraft designer for use on his specific airplane only. However, to be interoperable between various aircraft (i.e., a standard umbilical) the umbilical designer must comply with the current limits depicted in figures 83 and 84. This means the current-time characteristics of the wire must lie above the "Maximum Overcurrent" curve in figure 83 for the primary interface cable and figure 84 for the auxiliary interface cable. It is recognized that this may require the use of wire sizes larger than necessary to support some rated currents. However, it must be assumed that some aircraft circuit designs will allow overload currents to reach this maximum limit. It should be noted, however, that the "Maximum Overcurrent" curve represents currents that are allowed to occur during a fault condition, which is an "abnormal" operating condition. It is not necessary for the wire to conduct the current on a continuous basis as might be interpreted by observing the curve (i.e., 24 amperes for 1000 seconds for the primary interface and 58 amperes for 1000 seconds for the auxiliary interface). It is necessary for the wire to be able to conduct the currents for a relatively short time duration

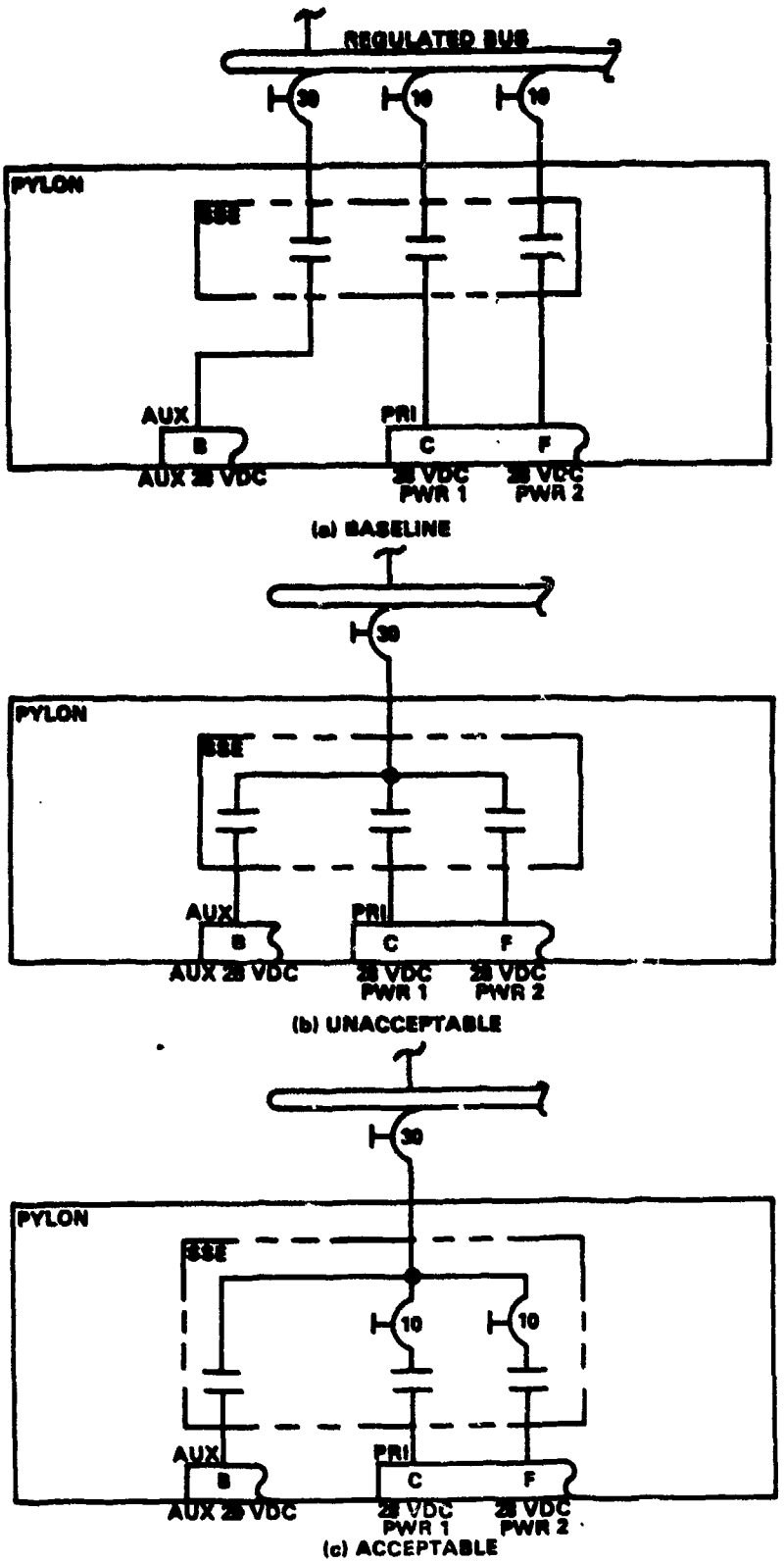


FIGURE 88. ASI overcurrent protection alternatives.

(compared to umbilical life) without resulting in an unsafe condition. This time duration is typically one flight time. It is noted that these current levels may never occur over the life of the umbilical. To ensure protection, it is recommended that wire no smaller than gauge 16 be used for the primary umbilical and wire no smaller than gauge 10 be used for the auxiliary umbilical. These wire sizes are not the largest permitted by the interface connector contacts but, should be adequate for most umbilicals if high temperature wire insulation is used.

5.1.7.4.3 Carriage store. Similar to the umbilical cable, the wire and power distribution components used in the carriage store are intended to be protected by the aircraft's circuit protection system. The current-time characteristics of wire and power distribution components must lie above the "maximum overcurrent" curve in figure 83 for the primary interface and figure 84 for the auxiliary interface. This requirement may impose a weight penalty on some weapon systems since the wire size as well as the power distribution components may be larger than necessary to support some load currents. However, in the interest of interoperability, it must be assumed that some aircraft power distribution circuits will allow fault currents equal to those depicted by the "Maximum Overcurrent" curve. It must be remembered that the curve represents an "abnormal" operating condition that can occur only for a short time condition (typically one flight time) or may never occur over the life of the carriage store. It is necessary, however, that the wire and power distribution components within the carriage store withstand this "abnormal" condition without causing an unsafe condition. To ensure protection, the wire should be Size 16 (or larger) for the primary circuits and Size 10 (or larger) for the auxiliary circuits. The use of high temperature wire insulation should be considered.

As an option, the carriage store designer may choose to use smaller gauge wire than required to meet the maximum overcurrent limits and install protective devices within the carriage store to protect the smaller wire. In addition to reducing weight, adding protective devices within the carriage store can provide fault isolation between the mission store power circuits. This is accomplished by installing a protective device in each power line to the mission store as shown in figure 89. A fault on any one line will not disrupt power to the remaining good lines. Coordination of trip limits between the aircraft breaker and the carriage store breaker is not required by MIL-STD-1760 since opening of either breaker will provide protection. However, coordination of trip limits is required to achieve the above fault isolation. The carriage store trip limits must be below the aircraft breaker trip limits. Due to the broad range of trip levels allowed the aircraft by figures 83 and 84, it will be a real challenge for the carriage store to achieve this coordination between a primary CSI and a primary CSSI. If the carriage store is busing an auxiliary CSI to primary CSSIs, then fault protection coordination is possible and would, in fact, be required.

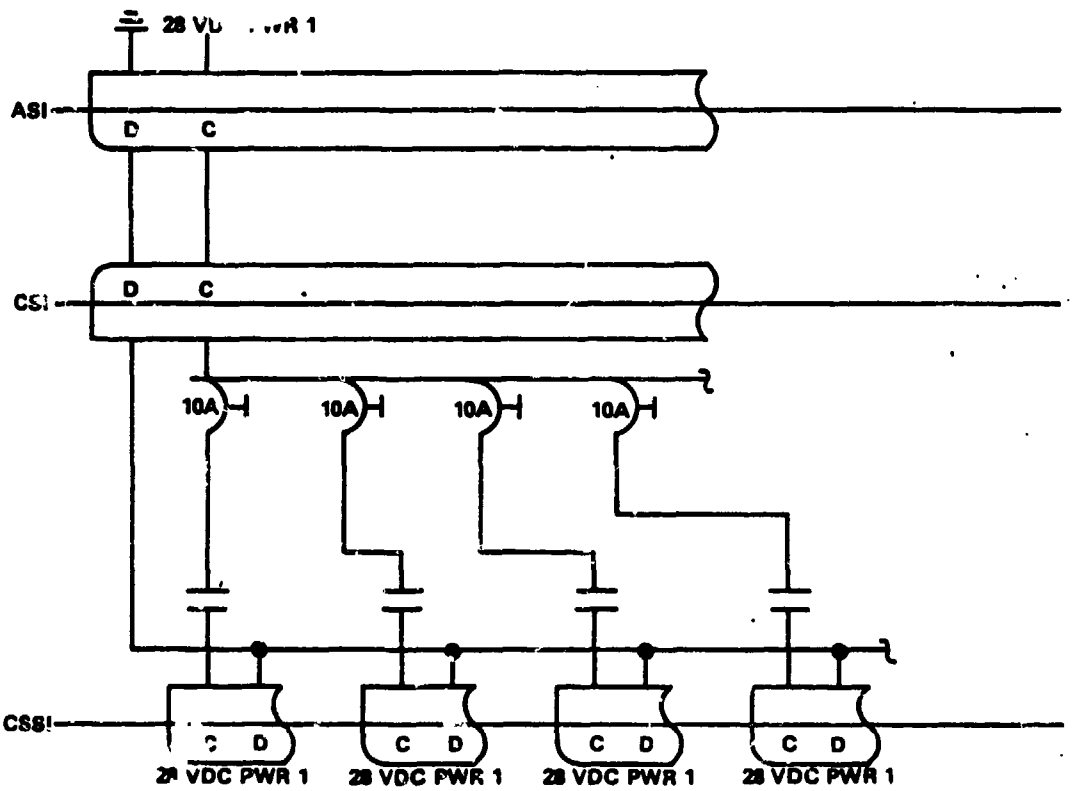


FIGURE 89. Circuit protection provided within the carriage store.

Adding circuit protection in the carriage store increases design complexity and makes it more difficult to meet the ASI-to-MSI voltage drop limits of 2.0 volts for 28V DC circuits and 3.0 volts for 115V AC circuits established by MIL-STD-1760. For this reason, MIL-STD-1760 does not require circuit protection to be added to the carriage store although it is allowed. If current protection is added, the "Maximum Load Current" limits defined by figures 83 and 84 must still be provided at the CSSI.

Applications that include a Transformer-Rectifier (T/R) within the carriage store to convert 115/200V AC to 28V DC must provide circuit protection at the T/R output as shown in figure 87. This arrangement provides fault isolation between power circuits. Current requirements at the CSSI are the same as those defined for the ASI, i.e., figure 83 for the primary interface and figure 84 for the auxiliary interface.

Primary interface CSSI power may be derived from the Auxiliary CSI interface. However, the following caution must be observed:

CAUTION

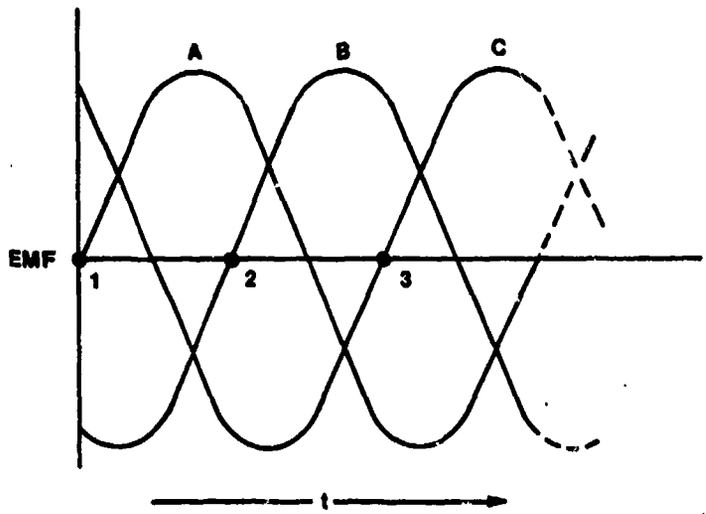
Aircraft protective devices used to protect the auxiliary circuits will not provide protection to the primary circuits.

5.1.7.4.4 Mission store. (See 5.2.8.5.)

5.1.7.5 Interface deadfacing. As a good design practice, aircraft power control should ensure that unmated connectors at the ASI are not powered. The aircraft power control sequence should be such that no power can be supplied to the ASI until a store mated condition is assured. The 28V DC and 115/200V AC power interfaces should be deactivated as soon as practical after "store release and preferably before store release to minimize connector degradation".

In the event 270V DC power is supplied through the ASI, the power must be deactivated prior to store release. If not, the arc resulting from the interruption of the 270V DC power circuit at the separating connector interface can result in severe damage to the connector and adjacent circuits.

5.1.7.6 Phase sequence. Phase sequence in a three phase power system means that the phase voltages cross zero volts at different times. This is illustrated in figure 90. Assuming a clockwise rotation of an AC generator, the emf of Phase B lags that of A by 120°. Also, the emf of phase C lags that of Phase B by 120°. The order in which the emf's come to their corresponding maximum values is ABC which is referred to as phase sequence



PHASE SEQUENCE	MIL-STD-1760 CONNECTOR PIN ASSIGNMENT	
	PRIMARY	AUXILIARY
A	P	A
B	M	C
C	J	E

FIGURE 90. Phase sequence.

ABC. In general, the phase sequence of the voltages applied to the ASI is fixed by the order in which the three-phase lines are connected. Interchanging any pair of lines reverses the phase sequence. Since many loads (such as induction motors) are affected by phase sequence, it is important that phase sequence be known. MIL-STD-1760 requires the phase sequence to be ABC, and connecting the three-phase lines as specified in tables IV and VI of MIL-STD-1760 will ensure the correct phase sequence.

The second important point is that while the sequence order is defined, the particular three-phase voltage line that is designated as "Phase A" is relative. Looking again at figure 90, "Phase A" was picked as the phase with its positive dv/dt crossing at point 1. The two remaining phases (B and C) have the second and third positive zero crossing. However, the voltage phase crossing at point 2 could have equally been named "Phase A" with phases B and C following at points 3 and 1. By "rotating" these phases at different ASIs while still maintaining the 0, 120, 240 degree sequence, the aircraft designer can sometimes help balance the power load on each of the generator phases. This can help offset phase load imbalances by stores. Usually, one would rotate phases at symetrical stations based on an assumption that identical stores are normally loaded on symetrical stations.

The AEIS standard, however, requires that the phase connections (A, B and C) at the primary connectors at each specific ASI be in phase (same zero crossing time) with the same phase connections in the auxiliary connector at the same ASI. Figure 91 illustrates this phase synchronization requirement as well as use of phase rotation.

5.1.7.7 Test data. Tables XV and XVI give the voltage drop test results (for the primary and auxiliary signal sets respectively) taken on typical AEIS networks (see Appendix A). The data shown is the +2 sigma extreme of all post-environmental test data on same gauge conductors independant of circuit functions. The MIL-STD-1760 voltage drop limits were exceeded for the primary signal set when a simulated carriage store circuit was included in the network. Approximately 40 feet of 16 AGW wire was used in the Primary signal set test circuit to simulate internal carriage store wiring (power and power return). This length of wire is not representative of internal carriage store wire lengths but, was used to represent probable worst case. The MIL-STD-1760 voltage drop limits can be met by reducing the wire length, increasing the wire size or using a combination of both.

5.1.8 Reserved functions.

5.1.8.1 Fiber optics. Two Size 16 contact locations in the primary interface connector (contacts U and Y) have been reserved by MIL-STD-1760 for future applications of fiber optics and are not to be used for any other function. It is intended that the two contacts will be used for a high speed data bus and possibly for audio and video distribution. When

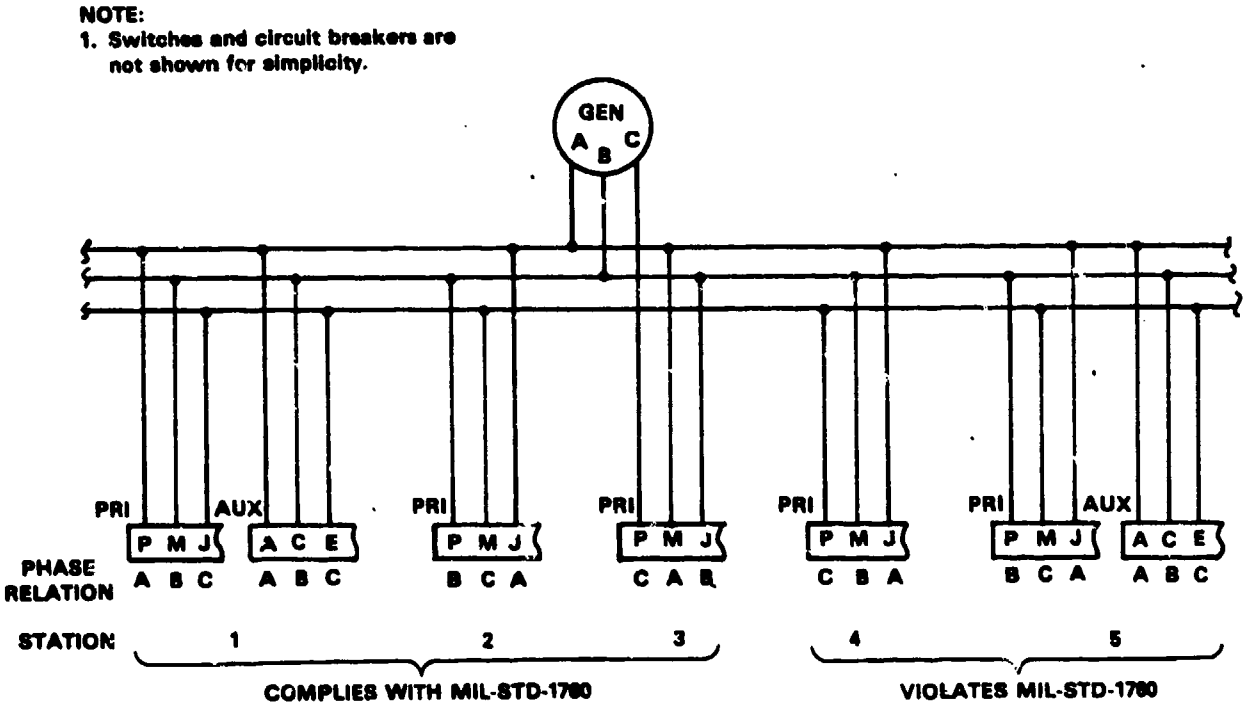


FIGURE 91. Examples of compliant and non-compliant phase connections.

TABLE XV. ASI-to-MSI voltage drop test results - primary.

Circuit	MIL-STD-1760 Requirement	Test Data (+2 sigma)
Without Carriage Store		
28V DC Power @ 10A	2.0V Max	0.80
115V AC Power @ 10A/ø	3.0V Max	0.80*
270V DC Power @ 10A	Not Defined	0.80
With Carriage Store		
28V DC Power @ 10A	2.0V Max	3.06V
115V AC Power @ 10A	3.0V Max	3.06V*
270V DC Power @ 10A	Not Defined	3.06V

TABLE XVI. ASI-to-MSI voltage drop test results - auxiliary.

Circuit	MIL-STD-1760 Requirement	Test Data (+2 sigma)
Without Carriage Store		
28V DC Power @ 30A	2.0V Max	0.25V
115V AC Power @ 30A/ø	3.0V Max	0.25V*
270V DC Power @ 30A	Not Defined	0.25V
With Carriage Store		
28V DC Power @ 30A	2.0V Max	1.98V
115V AC Power @ 30A/ø	3.0V Max	1.98V*
270V DC Power @ 30A	Not Defined	1.98V

*This voltage was measured at DC. The effective 400 Hertz voltage drop is dependent on phase load unbalance and cable construction (e.g., gross shielding, twisting, distance from structure). The effective voltage drop for single phase loads is significantly higher than balanced three-phase loads.

required, the characteristics of these optical links will be added to the AEIS standard - probably by reference to some other fiber optic standard.

5.1.8.2 High voltage dc. Two contact locations in the primary interface connector (contacts N and R) and the auxiliary interface connector (contacts F and H) have been reserved for the future application of 270 volt dc power. The use of 270V DC has certain interoperability implications. If both 115/200V AC power and 270V DC power is required to be supplied at the ASI, a significant weight and cost penalty is imposed on the aircraft design. On the other hand, requiring the aircraft to provide 115/200V AC or 270V DC imposes a cost and weight penalty on the store. Requiring all aircraft and stores to convert to 270V DC (no 115/200V AC) is also unrealistic from a cost standpoint. At this point the 270V DC contact funtions are reserved. Aircraft and stores are not permitted to require their counterpart (i.e. stores and aircraft, respectively) to implement a 270V DC power interface for system operation.

5.1.9 Electromagnetic compatibility (EMC). MIL-STD-1760 contains only limited aircraft EMC requirements. Paragraph 5.1.3 of the standard requires the aircraft to meet MIL-E-6051 requirements with stores connected to the interface and without stores connected (i.e. unterminated umbilicals or unconnected ASIs). This reference to MIL-E-6051 is primarily motherhood and simply points out that EMC is applicable for cases with and without stores.

The various sections within the standard, however, impose certain grounding requirements on the various signals. The standard also identifies specific connector and contact types which lead to implications on cable configurations for the interconnecting wiring.

At one point, considerations were given to specifing noise voltage limits at each signal port in addition to the signal voltage limits currently in the standard. This, in effect, would define the signal-to-noise ratio (SNR) for each signal port. More thorough investigation of this SNR specification approach concluded that it was impractical to impose from a testing standpoint. As a result, MIL-STD-1760 only defines the signal levels and does not directly address noise levels.

The following paragraphs point out various EMC related issues for the various signal ports and includes measured noise data from representative networks.

5.1.9.1 Grounding philosophy. The term "ground" is defined as the zero reference potential for a specific electrical/electronic system. Depending on the specific application the reference may or may not be connected to vehicle structure. For minimum interaction, this reference should be a single point return for all electrical sources and loads in the system. Since for some applications, a single point ground is not practical to implement in aircraft (e.g. due to the quantity of wire required), the

aircraft structure is typically used as the ground reference. This usually results in multiple grounding points which cause ground loop currents as shown in Figure 92.

The voltage levels generated by the ground loop currents can be sufficiently high to cause problems in the system. The ground loop current can be eliminated by removing the ground at one end or by providing electrical isolation. Removing the ground at one end is not always possible, consequently, providing electrical isolation is the more practical approach. Electrical isolation can be accomplished by using an isolation transformer, a differential amplifier or an optical isolator as shown in figure 93. The transformer can be used in AC power circuits and in the MIL-STD-1553 data bus. The differential amplifier can be used in analog and digital circuits where the signal is balanced above and below ground. The optical coupler can be used in DC discrete circuits.

5.1.9.1.1 Digital data circuits. The MIL-STD-1553 data bus stubs within the aircraft are generally electrically isolated from ground by using coupling transformers as shown in figure 94. The use of coupling transformers with grounded center taps is not directly addressed by MIL-STD-1760 but, in general, is discouraged. (See 5.1.4.)

The standard requires that the shield connection measured at the ASI (looking into the aircraft) show continuity to aircraft structure ground. (Mission store requirements also specify shield continuity to ground when measured at the MSI looking into the store.) This shield grounding scheme results in a multi-point shield ground.

Design experience backed up by EMI tests have shown that multi-point shield grounding provides more effective shielding for MIL-STD-1553 applications. Figure 95 illustrates typical induced noise levels on the multiplex data stubs (at the ASI) when exposed to a 200 volt/meter field. The two curves show noise levels with a mission store connected to the ASI and with a mission store connected to a carriage store connected to the ASI. This second configuration is essentially a long (25 foot) ASI to MSI bus stub. Tests with the same configuration but with a single point shield ground showed approximately 15 dB higher noise levels.

5.1.9.1.2 Discrete circuits. The different grounding issues for the interlock, address and release consent circuits are described below.

5.1.9.1.2.1 Interlock discrete circuit. The ground connection for interlock return is not specified by MIL-STD-1760. The standard requires the store to isolate all store circuitry from interlock and interlock return. (The store simply provides a continuity jumper from interlock to

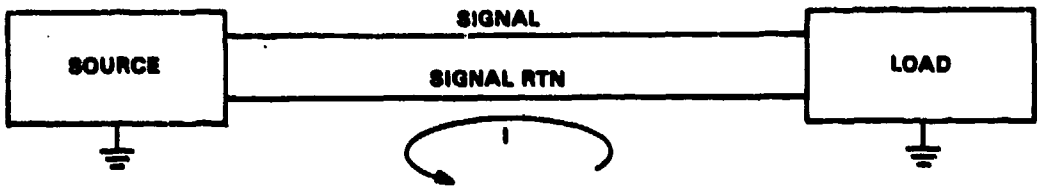


FIGURE 92. Ground loop current.

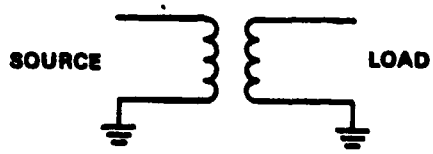


FIGURE 93a. Transformer.

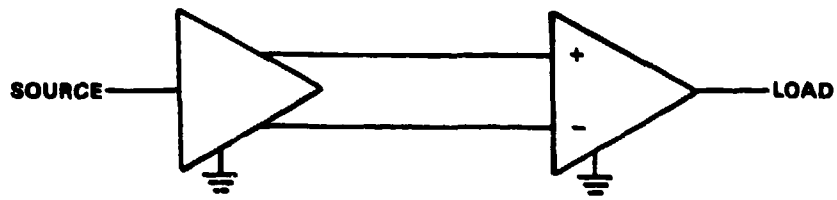


FIGURE 93b. Differential amplifier.

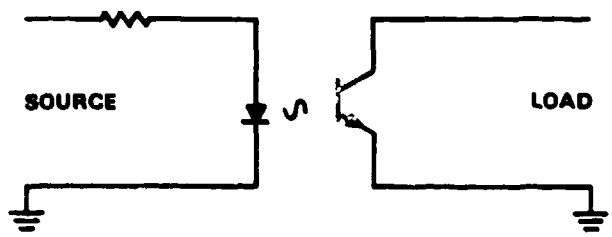


FIGURE 93c. Optical coupler.

FIGURE 93. Electrical isolation techniques.

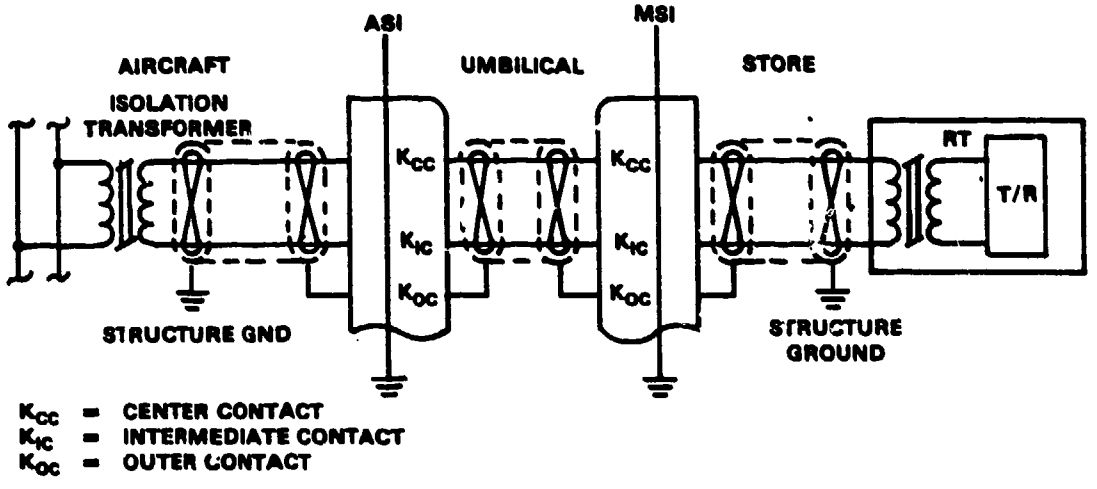


FIGURE 94. Digital data circuit grounds.

interlock return on the store side of the MSI). This allows the aircraft to connect interlock return to any appropriate aircraft reference (e.g. power return, structure return, internal SMS signal return, etc.).

One cautionary note, however, is that some stores designed prior to MIL-STD-1760A may, in fact, have circuitry connected to interlock return and are expecting continuity between return and aircraft structure. This continuity to structure ground was required by the July 1981 release of MIL-STD-1760. The September 1985 release of MIL-STD-1760A removed this mandatory structure ground connection due to concerns with coupling structure ground noise into SMS and store electronic circuits. Aircraft which are required by system specification to be compatible with any of these earlier stores (e.g. AIM-120A) still needs to provide this ground connection.

To improve noise rejection, the aircraft should use a twisted wire pair for the interlock. Figure 96 illustrates typical noise levels induced from a 200 volt/meter field. (The total interconnect system tested contained either a gross shield braid or was enclosed within a metallic structure.) The two curves illustrate noise levels at the ASI with a connected store and with a disconnected umbilical. The cable system tested used a twisted wire pair for interlock and interlock return with the return connected to structure ground.

5.1.9.1.2.2 Address discrete circuit. MIL-STD-1760 requires that the address lines (including return) be isolated from all aircraft power returns, structure ground and from address circuits at other ASIs. This requires a totally isolated address set at each ASI using one of the techniques shown in figure 48.

Noise levels were measured on a representative interconnect system while exposed to a 200 volt/meter field. (See figure 97.) The address line set was twisted around the address return. The entire cable run was shielded with either a gross braid or with metallic structure. In the configuration tested, the address "jumpers" were installed approximately 35 feet from the ASI. When the jumpers are installed directly at the ASI, the noise levels drop 20 to 30 dB (drop is frequency dependent).

5.1.9.1.2.3 Release consent discrete circuit. MIL-STD-1760 requires release consent to be referenced to 28V DC power 2 return. This reference is selected as a compromise to avoid increasing the interface connector size. The disadvantage of this selection is that it results in 28V DC power 2 return noise being injected into the release consent monitor circuit in the store. To some extent, the noise on power 2 return is that generated by the store itself. Whatever the source of noise, however, the store monitor circuit must attempt to isolate this noise from the store electronics and also account for 28V DC power noise levels in setting the release consent enable detection thresholds. (See section 5.1.4.2 and figure 42.)

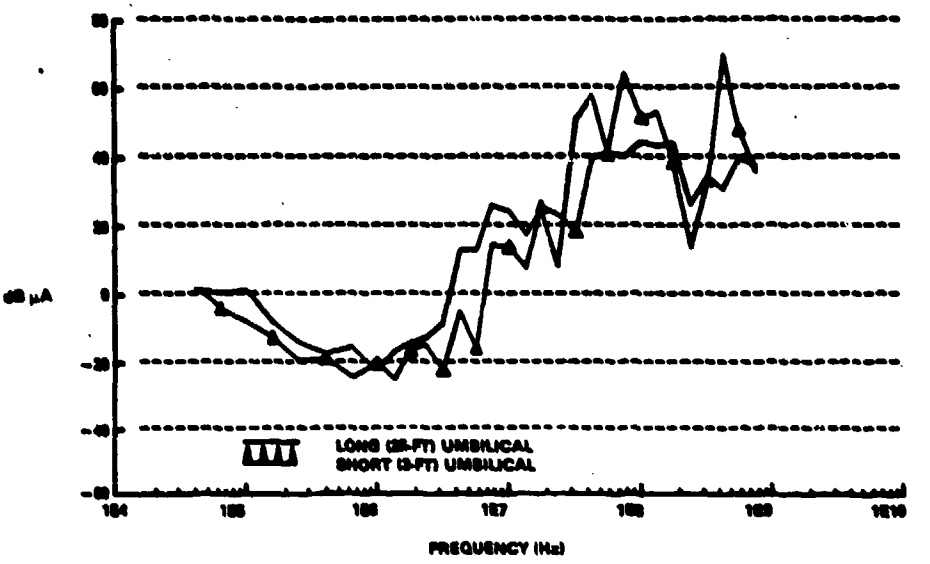


FIGURE 95. Typical field induced noise on multiplex data interface.

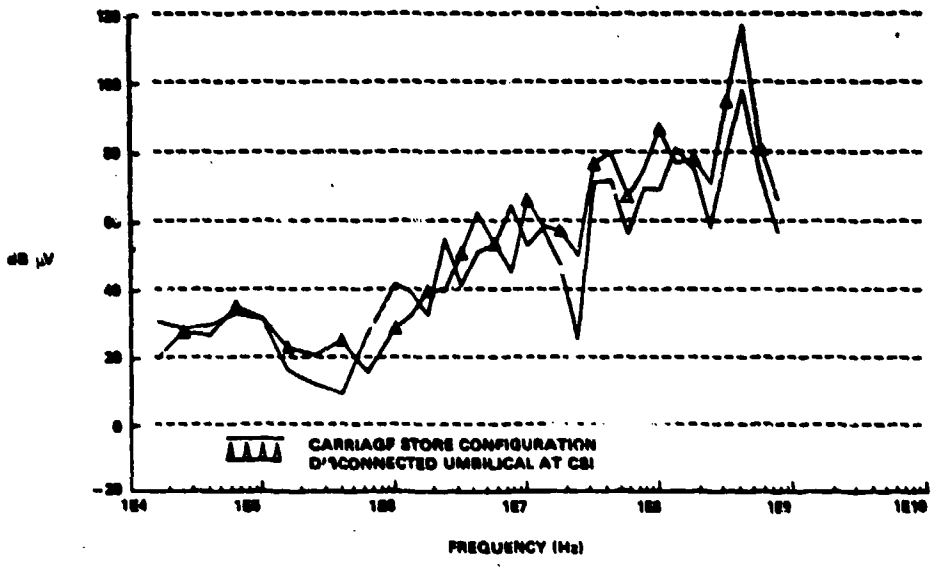


FIGURE 96. Typical field induced noise on interlock interface.

Figure 98 shows typical noise levels induced at the ASI by a 200 volt/meter field. These levels are comparable to the other discrete circuits. The noise level increases to approximately 90 dB microvolt at frequencies below 10 kiloHertz when MIL-STD-461 CE01 limits are injected onto the 28V DC power 2 line.

5.1.9.1.3 Power circuits. Power ground returns are a frequent cause of interference problems due to the relatively high currents involved. It is imperative that the ground return path (e.g., aircraft structure or conductor) provide a low resistance to current flow. Figure 99 illustrates three options for grounding the return line (AC or DC). Figure 99a shows the best approach from an EMC perspective since the power delivered to the store is free of structure induced noise. However, this approach requires additional wire for the power return all the way back to the power source or distribution bus). This adds weight to the aircraft and consequently, is seldom used. A more likely design is shown in figure 99b. The power return line is connected to the aircraft structure at a location near the ASI. However, this couples some structure ground noise into the power circuit. The approach shown in figure 99c is the least desirable, although acceptable and necessary for some applications.

It is recommended that noise sensitive stores isolate the return from store structure to minimize coupling the additional noise into the power circuit. As an alternative, the store can use a transformer coupled power converter with sufficient regulation and filtering to attenuate a large portion of the structure noise. In either case, the power line and return line should be twisted to reduce magnetic coupling fields. The twisting applies to 28V DC, 270V DC and 115/200V AC circuits. The noise levels induced by a 200 volt/meter field in a test of a representative network were approximately 10 dB below those shown in figure 98.

5.1.9.1.4 Low bandwidth circuit. The low bandwidth circuit defined in MIL-STD-1760 must be capable of transmitting bi-directional signals in the DC to 50 kiloHertz range. MIL-STD-1760 also defines a three terminal connection (twinaxial line) for signal transmission which is conducive to differential driven techniques. The preferred ground scheme is a single point system grounded at the source or load. From a practical viewpoint, however, a single point ground system can not be achieved when dealing with interconnecting two vehicle systems (an aircraft and store) which are mechanically attached to each other. The next best alternative is to isolate the signal systems of the two vehicles such that structure ground noise can not loop through the two systems even if their structures are linked together.

Three methods for achieving this are identified in figure 93: Transformer coupling, differntial amplifier coupling and optical coupling. The LB

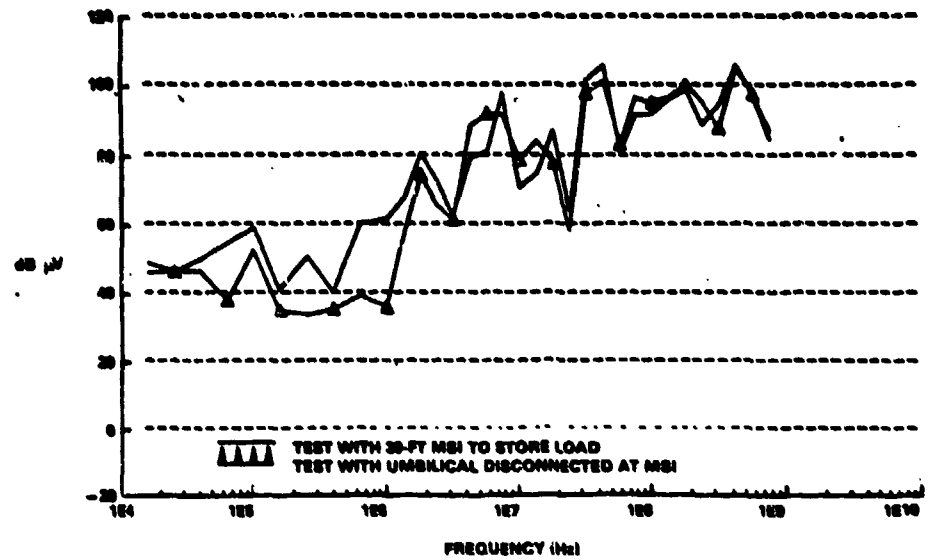


FIGURE 97. Typical field induced noise on address interface.

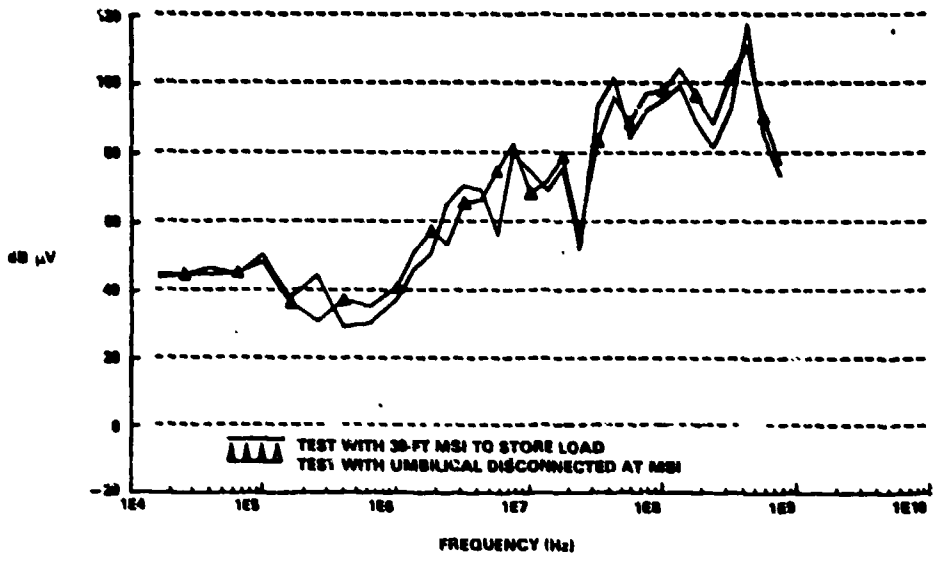


FIGURE 98. Typical field induced noise on release consent.

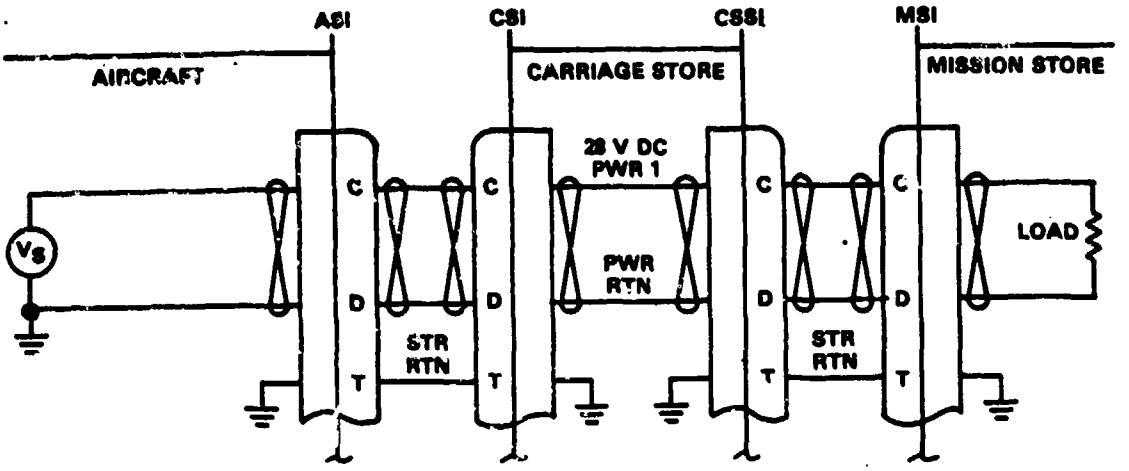


FIGURE 99a. Single-point ground.

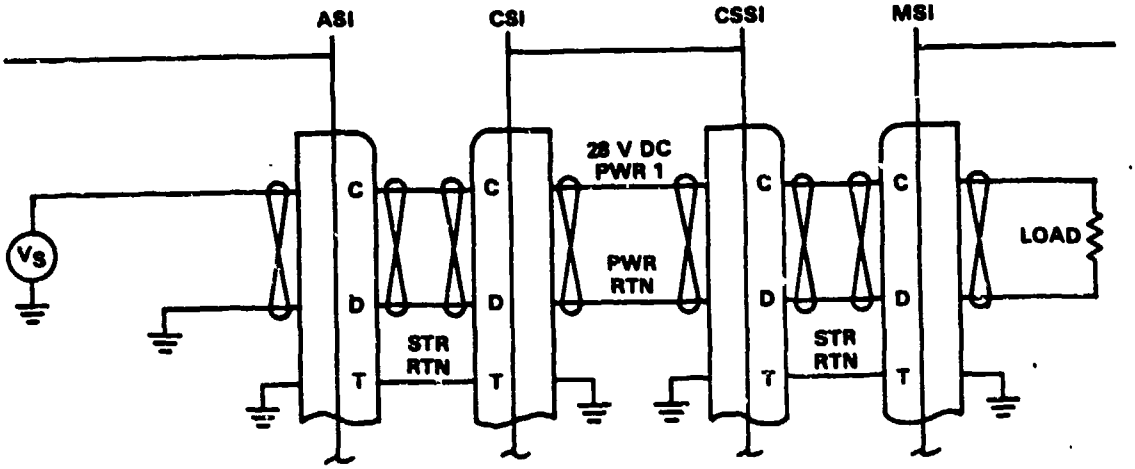


FIGURE 99b. Isolated return to aircraft structure.

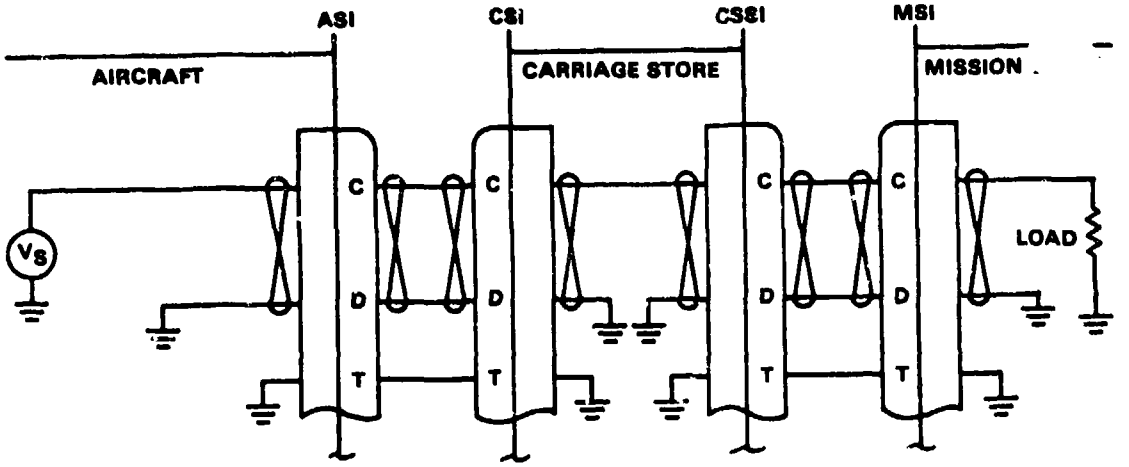


FIGURE 99c. Nonisolated return.

FIGURE 99. Power ground options.

interface definition in MIL-STD-1760 allows all three implementations providing the voltage and current limits (both line-line and line-ground) are met. Figure 100 illustrates general circuit diagrams for these three methods. Figures 100a and 100b show two variations on transformer coupling. The primary advantages of figure 100a over 100b are: (1) The additional design flexibility offered the store designer in selecting load voltage/current combinations on the right side of transformer T2, and (2) desensitizing the store load circuitry from line imbalances throughout the aircraft distribution network.

Obviously, transformer coupling will not pass any DC components of a specific signal. This is one reason the transformer in the two figures is shown on the aircraft equipment side of the aircraft's LB distribution network. If a specific LB application has no DC signal components (such as audio) then transformer coupling can be used. If DC components are required, then alternative load and source coupling is needed.

An alternative is the electronic coupling of differential receivers as shown in figure 100c. This method relies on the high input impedance at the line receiver and the differential operating mode to cancel any voltages which are common to both lines. However, since the circuit contains electronic coupling, a current return path is required from the store's signal ground to the aircraft's signal ground. This path is provided from store signal ground through R_S to shield through R_A to aircraft signal ground. The resistor values for R_A and R_S should be as high as practical to achieve the desired level of signal ground-to-structure ground isolation. However, the higher these resistor values, the lower the differential signal becomes. A value of 100 ohms is typically used for digital level signals.

The final coupling (optical) is illustrated in figure 100d. While the previous methods are suitable for both digital and analog signals, the optical method is best used for digital only. The main advantage of this method is elimination of the need for the aircraft and store signal grounds to be interconnected (even through a "high" impedance). The inverting and non-inverting lines of the LB interface take turns as the signal return as the signal polarity reverses. (A similar configuration can be used in a unipolar mode also.)

5.1.9.1.5 High bandwidth circuits. MIL-STD-1760 defines two high bandwidth signal types (Type A and Type B). The Type A signal has a passband between 20 Hertz and 20 MegaHertz. The Type B signal has a passband between 20 MegaHertz and 1.6 GigaHertz. MIL-STD-1760 specifies the use of coaxial contacts in the interface connectors for these signals although triaxial as well as coaxial cable can be used.

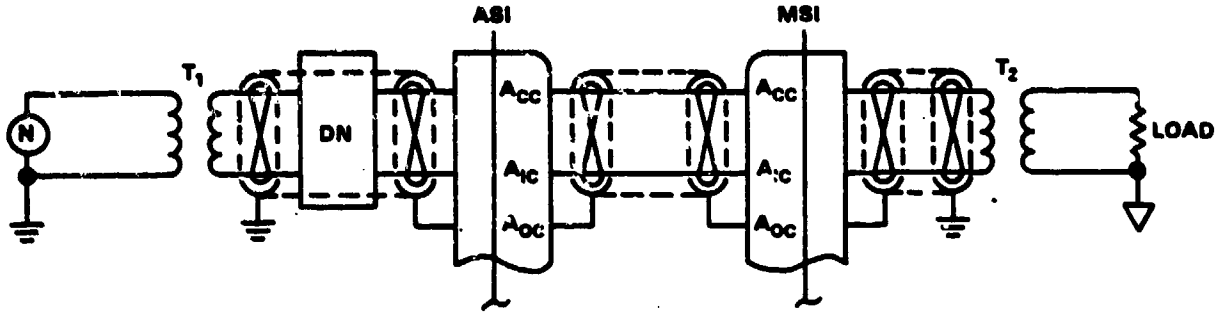


FIGURE 100a. Dual transformer.

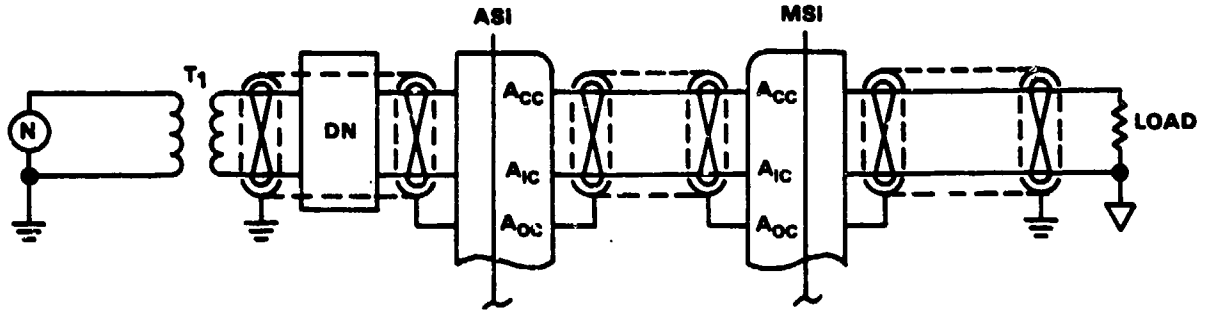


FIGURE 100b. Single transformer.

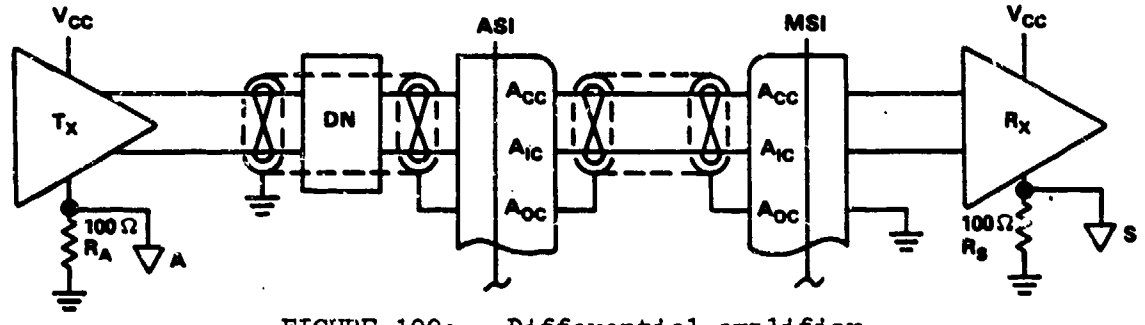


FIGURE 100c. Differential amplifier.

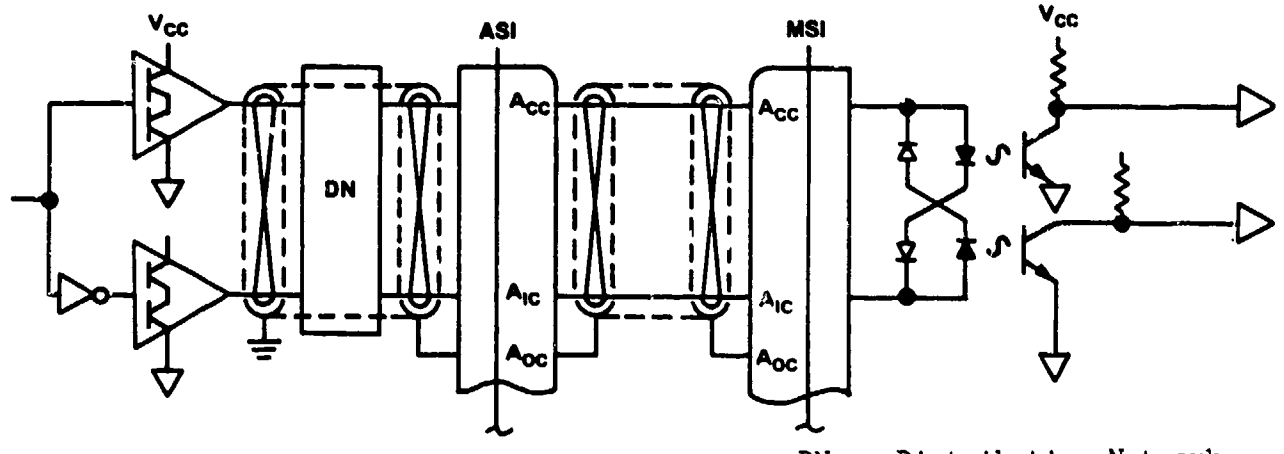


FIGURE 100d. Optical coupler.

DN - Distribution Network
ACC - Center Contact
AIC - Intermediate Contact
COC - Outer Contact

FIGURE 100. Low bandwidth grounding options.

It is not feasible to maintain a single point signal ground at the Type B frequencies because of stray capacitance in the circuits (e.g., between shield and structure). As an example, a stray capacitance to ground of 20 picofarads has an impedance of 80 ohms at 100 MHz. For a 50 ohm signal network, an 80 ohm stray impedance is significant.

As a result, RF signal circuits must utilize coaxial (or triaxial) cables with the shield (signal return) grounded at each end of the transmission line. Preferrably, the shield is also grounded at intermediate points on the transmission line, such as bulkhead feedthrough connectors, to provide a controlled ground. Where the optimum grounding for low frequency applications is a single point ground, the optimum grounding for RF is multiple point grounds.

5.1.9.1.5.1 20 Hz to 20 MHz passband. The lines rated for 20 Hz to 20 MHz passband are within a frequency range where single point ground is possible - but not easy - to implement.

A typical implementation requirement for conventional video signals (bandwidth of approximately 5 MHz) requires a single point ground with the ground at the signal source (the store). With careful design, this can be achieved and is being achieved in present aircraft. (For example, most aircraft video displays have an ungrounded signal return for the composite video input signal.) One complication, however, results. To achieve shield isolation from aircraft ground requires switching the coaxial shield as well as the coaxial center conductor. This doubles the switch hardware required to implement the switching matrix or requires use of triaxial switches. This complication can be avoided by implementing design concepts discussed in Section 5.1.5.1.2. Other methods such as integrating a differential line receiver into the front end of a matrix can be used. This allows electrically relocating the "load" from a display (for example) imbedded deep in the aircraft to the matrix. The transmission circuit from the matrix to the display can then contain a separate grounding system.

An area that increases design complexity is in the upper signal frequency range of 20 MHz. This higher frequency increases the danger that stray capacitance will nullify the effects of single-end grounding, especially on long transmission lines. As the line length approaches a tenth of a wavelength (of the signal or noise of concern), the effectiveness of the single point ground diminishes. The ground return circuit transitions from an ohmic conductor to a transmission "waveguide". A partial solution involves the use of triaxial cable and grounding the outer shield at as many locations as practical. It is almost mandatory that aircraft use triaxial cable in the HB network to provide adequate shielding over the Type A frequency band.

Figure 101a illustrates the coupling of noise into the coaxial shield via stray capacitance. The noise source (V_N) includes potential differences

between store structure and some structure point in the aircraft such as the cockpit. The noise source also includes magnetic pickup due to the large loop antenna formed from A-B-B'-A'-A through the stray capacitance (C_{ST}) between structure and cable shield. The net effect is a noise current flow (I_N) through the coaxial shield. Since the coaxial shield is the signal return circuit, the noise voltage produced by the noise current is induced into the load voltage.

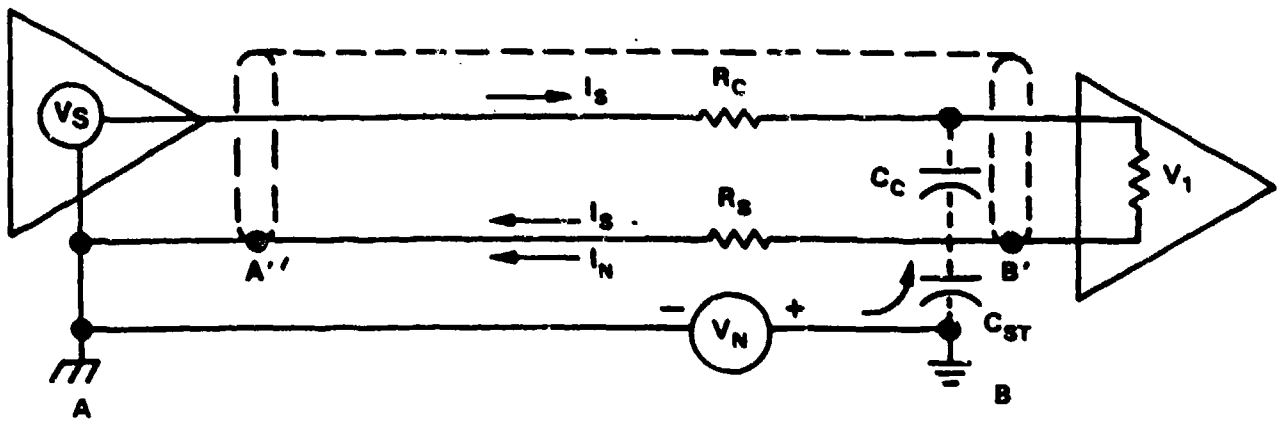
Figure 101b illustrates the redirection of noise current when a triaxial cable is used. The load end of the triaxial outer shield can be grounded or ungrounded, depending on the level of electrostatic protection desired. The net effect of the triaxial cable is that the noise current is redirected out of the inner shield (i.e., the signal return) and into the outer shield. The noise currents can then safely be returned to ground.

The MIL-STD-1760 specifies coaxial (as opposed to triaxial) contacts in the interface connectors for high bandwidth lines. However, this does not preclude the use of triaxial cable in the aircraft, umbilical or store. It just means that the shield coverage of the triaxial cable outer conductor will be reduced at the AEIS connector interface.

Due to the short cable lengths expected in the umbilicals (less than 3 feet), the signal or noise frequency at which single point grounding becomes marginal is around 23 to 33 MHz. Since actual umbilicals typically will be around 18 inches in length, the frequency of concern is moved even higher (above 45 MHz). Due to these high frequency levels, triaxial cables in the umbilical may not be necessary for the video/TCP type signals. Installation of triaxial cables will,, however, significantly improve performance in the aircraft if long transmission line runs are necessary. As a result, use of triaxial cable in the aircraft distribution network is highly recommended. In fact, aircraft designers probably will be challenged by the EMC gurus both within his company and within the government if coaxial cable is used instead of triaxial cable.

If a signal point ground is implemented, concern arises on the ground location, i.e., at the source or the load. Unlike low bandwidth signal(s), the use of a coupling transformer with good performance for the entire range between 20 Hz to 20 MHz is unrealistic. Grounding at the source (or load) assumes that the network always will be used in a simplex mode. A duplex or half-duplex operation does not have a clear definition of source or load.

Historically, video lines have been grounded in the store. This occurred because the signal source was in the store (i.e. video sensor) and the best solution is to locate the ground at the signal power supply (i.e. source). As mentioned above, the introduction of half-duplex operation complicates the "ground at source" concept by placing sources at each end of the

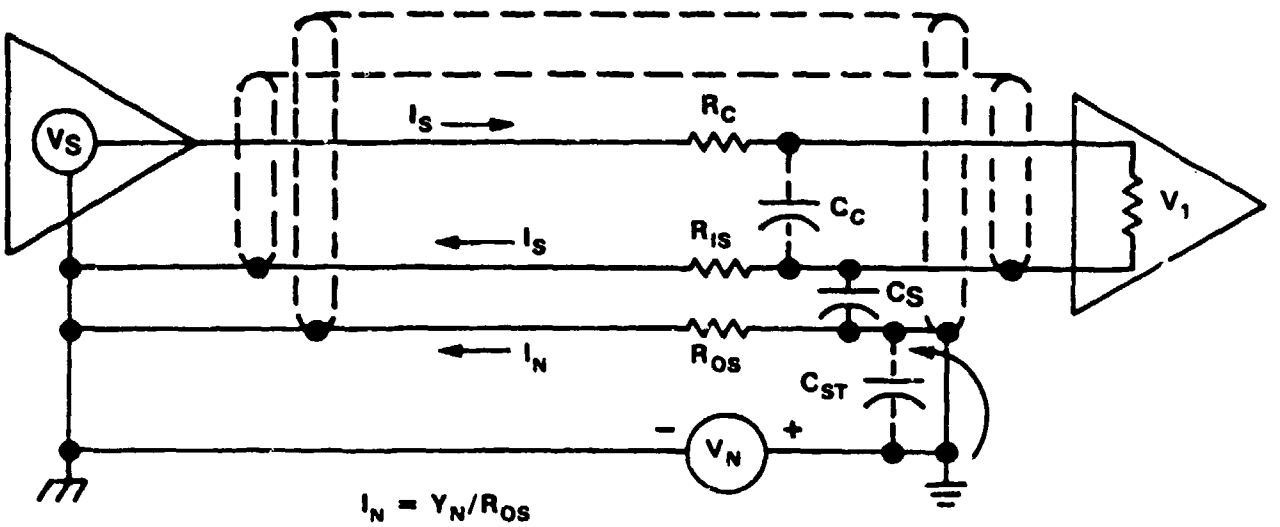


$$I_N = V_N W C_{ST}$$

$$V_1 = V_S - I_S (R_C + R_S) - I_N R_S$$

$$\text{SINCE } \frac{1}{WC_C} \gg R_S$$

FIGURE 101a. Noise coupling into coax at medium frequencies.



$$I_N = Y_N / R_{OS}$$

$$\text{SINCE } \frac{1}{WC_S} \gg R_{OS}$$

FIGURE 101b. Noise coupling into outer triaxial shield.

FIGURE 101. Single end ground.

network. As a compromise to this impass, HB3 and HB4 are designated to be grounded at the store side of the MSI to eliminate a signal source power supply isolation requirement on the mission store. (HB1 and HB2 are grounded at both ASI and MSI.) The aircraft is then required to isolate the signal return from aircraft structure ground when measured at the ASI looking into the aircraft. This requires the aircraft to provide an "isolated" power source for the HB3 (and HB4) line drivers in the aircraft. The standard, however, does not define the level of this isolation.

5.1.9.1.5.2 20 MegaHertz to 1.6 GigaHertz passband. The implementation of a network at 1.6 GHz mandates grounding at each end of the network - at the source and at the load. Additionally, the lines should be grounded at as many intermediate points as practical; ideally, every one twentieth to one tenth of the wavelength. One caution, however, is noted. Once the network is grounded at multiple points, the network may be "noisy" for low frequency applications. Caution must be exercised when using this line for low frequency (Type A) signals.

5.1.9.1.6. Structure ground. The purpose for the structure ground line is to minimize the electrical potentials between aircraft and store structures emanating from magnetic and electric fields or from power faults. The line must not be relied on to conduct signal and power return currents except that under fault conditions it must be capable of carrying currents given in figures 83 and 84.

One small concern with the structure ground line is that it can introduce noise voltages (that exist between aircraft and store structures) inside a gross shielded umbilical cable. This concern was traded-off against personnel hazard protection needs which require a structure ground connection in the interfacing connector. Several umbilical design alternatives are available to minimize this internal noise. (See 5.3.4.)

5.1.9.2 Lightning. MIL-STD-1760 does not impose lightning protection design requirements. However, lightning protection should be incorporated as a good design practice. This is accomplished by providing sufficient current carrying capability from the wire harness to the airframe. The cross-sectional area specified in MIL-B-5087 for lightning current carrying conductors is 40,000 circular mils. This is easily achieved by providing a double gross shield on the ASI to MSI umbilical. Currents generated by lightning are also returned to structure via the structure ground line and by mechanical connections between the aircraft and store.

5.1.9.3 Electromagnetic pulse (EMP). As with general EMC issues, MIL-STD-1760 does not impose EMP requirements on the aircraft or store interfaces. It is expected that EMP levels at which specific weapon systems are to survive will be defined (uniquely) in the specific aircraft and store system specifications. The interface characteristics and contact/connector facilities required by MIL-STD-1760 provide sufficient design flexibility

for protecting the vehicle against EMP as well as other electromagnetic environments.

5.1.9.4 Shielding. MII-STD-1760 does not impose shielding design requirements. Design requirements need to specify isolation, frequency range, coupling (magnetic, electrostatic) and environment. Isolation is defined as the difference between undesired field levels and tolerable field levels, and is stated in dB. The frequency range and types of coupling is dependent upon circuit requirements. Environment is location dependent. In general, the following design practices should be followed:

5.1.9.4.1 Power circuits. Power circuits need not be shielded. Twisting of the power line with return line is recommended.

5.1.9.4.2 Discrete circuits. Discrete circuits need not be shielded. Twisting of the discrete lines with their associated return is recommended.

5.1.9.4.3 Multiplex data bus. Multiplex Data Bus stubs should be shielded with the shield grounded at each end of the line as a minimum and every 15 to 30 feet where practical. Providing a good bonded connection from cable shield to bus coupler to structure will, generally, satisfy this requirement. The Mux bus stub shield should be grounded on the aircraft side of the ASI, the mission store side of the MSI and the carriage store side of the CSI and CSSI.

5.1.9.4.4 Low bandwidth circuit. The low bandwidth circuit (twisted pair) should be shielded with the shield grounded at each end similar to the Mux bus stub lines.

5.1.9.4.5 High bandwidth circuit. Crosstalk between triaxial (or coaxial) cables and other cables (wire) is quantified by shielding effectiveness. Shielding effectiveness is determined by the design of the coaxial and triaxial braid and the degree of control available in the manufacturing process. Design choices available in MIL qualified cable (MIL-C-17) include:

a. Single braid coverage with typically 85 to 95 percent coverage (e.g., RG178, RG179, RG316, etc.).

b. Double braid coverage with each braid having typically 85 to 95 percent coverage (e.g., M17/152).

c. Triaxial Cables - Similar to double braid coverage but with each braid insulated from the other (e.g., RG403).

Approximately 40 dB of isolation can be expected at 2.0 GigaHertz between the center conductor of a single braided coax (RG178) and the outer environment. If the noise source is from a similar coax, then 80 dB of

isolation is provided between center conductors of the two cables. The use of triaxial cables increases the isolation by approximately 30 dB. The 75 ohm (HB3 and HB4) coaxial shield should be single end grounded at the store only. The 50 ohm (HB1 and HB2) coaxial shield should be grounded at each end.

5.1.9.4.6 Umbilical gross shield. A double gross shield should enclose all the wires of the umbilical to enhance the probability of surviving high levels of Electromagnetic Radiation (EMR), Electromagnetic Pulse (EMP) and lightning. The shield should be 360 degree bonded to the connector shell at both ends of the umbilical. The shield should have adequate cross sectional area to comply with MIL-B-5087 for Class L service (40,000 circular mils).

5.1.9.5 Test results. EMI tests were performed on ABIS networks that simulate typical aircraft/store applications (see Appendix A). The networks included: (1) A configuration that interfaces a mission store to the aircraft via an umbilical, and (2) a configuration that interfaces a mission store to the aircraft via a carriage store and two umbilicals. The general conclusions resulting from the tests are as follows:

5.1.9.5.1 Power wiring. There were no unusual problems with either crosstalk or field-to-wire coupling associated with power wiring design. The noise coupled onto the lines can be reduced to acceptable levels by implementing available standard design practices. The use of filters and decoupling techniques on these lines are recommended. (See 5.1.9.1.3.)

5.1.9.5.2 Interlock and release consent. No problems were evident on the interlock and release consent lines when exposed to a 200 volt/meter field. See 5.1.9.1.2 and figures 96, 97 and 98 for representative recorded noise levels. Figures 102 and 103 illustrate representative spikes induced in the interlock and release consent interfaces, respectively, when a total of 30 amperes of 28V DC is simultaneously switched through both primary and auxiliary interfaces. (This switching was accomplished with electromechanical relays and no power line filtering.) The spikes shown are sufficiently high to consider some filtering in aircraft circuitry. Measured levels of spikes varied considerably with different cable constructions, carriage configurations and measurement points. In several instances, the unfiltered spikes on the interlock exceeded 1.5 volts peak-peak.

5.1.9.5.3 High bandwidth lines. The noise levels induced in the high bandwidth lines for the set-ups tested are generally acceptable. Typical noise levels for field-to-wire coupling from a 200 volt/meter field are shown in figures 104 and 105. The induced noise from switching (with relays, no filters), is shown in figures 106 and 107 for HB1 and HB3 respectively. (Triaxial cable was not used in either of these tests.)

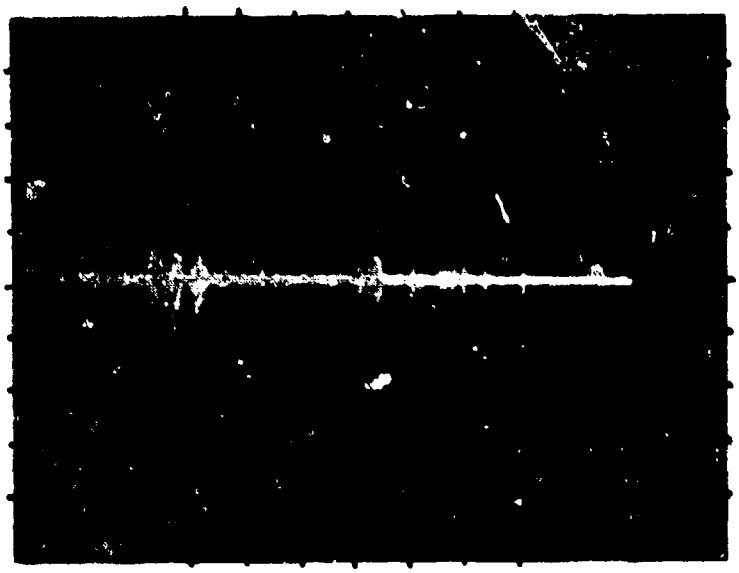


FIGURE 102. Power (28V DC) switching transient on interlock.

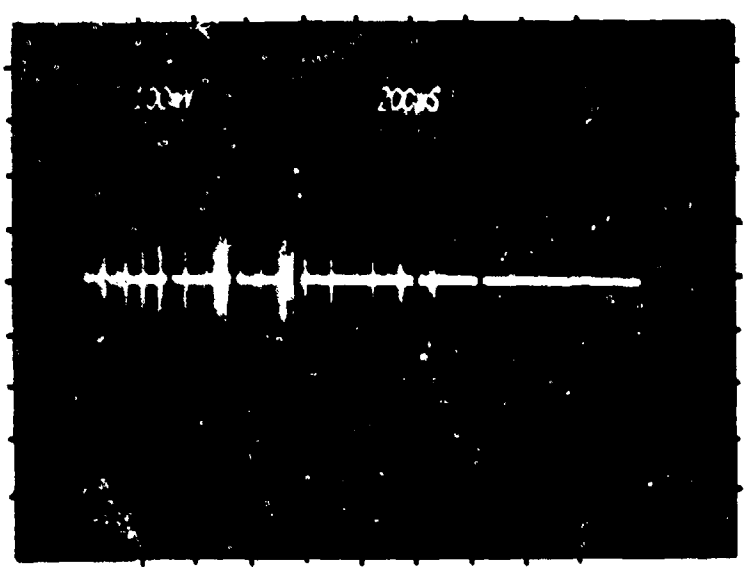


FIGURE 103. Power (28V DC) switching transient on release consent.

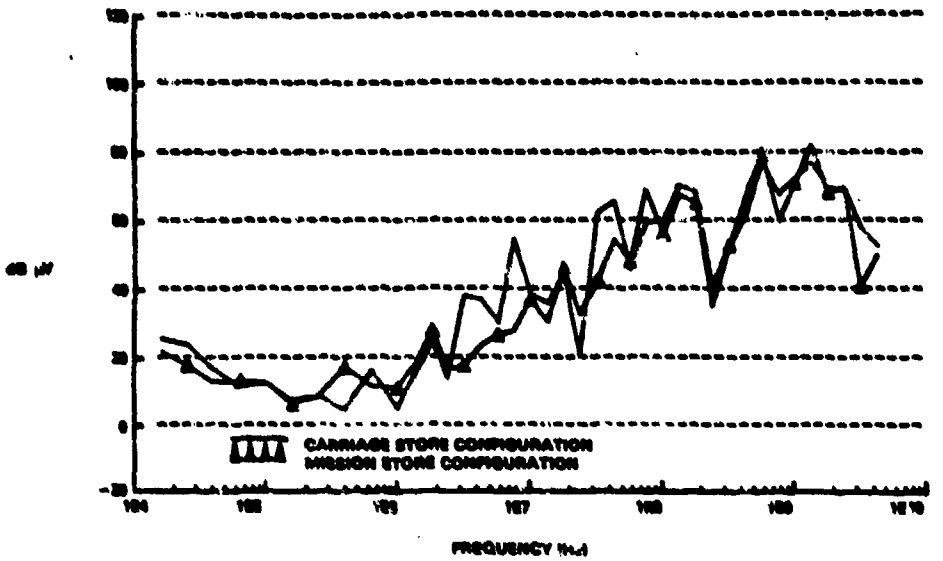


FIGURE 104. Typical HB1 field induced noise.

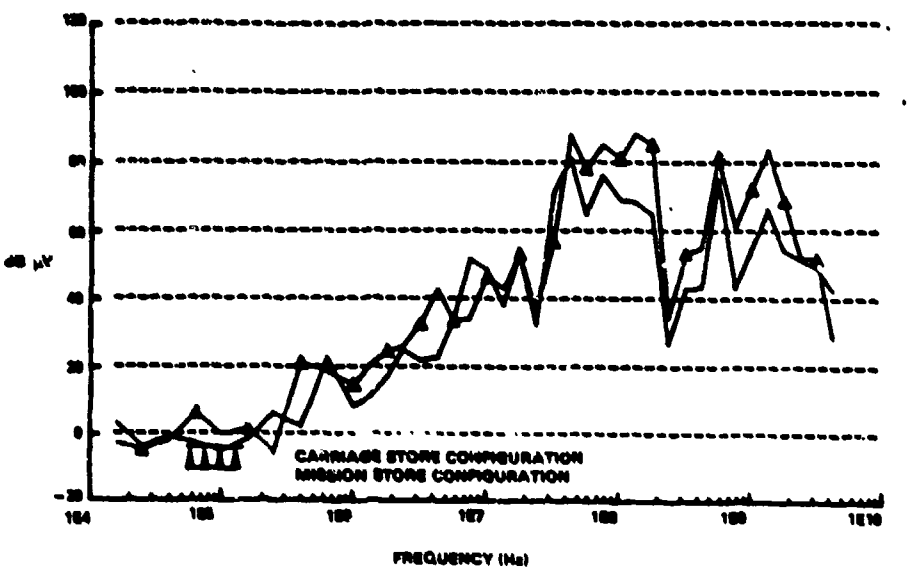


FIGURE 105. Typical HB3 field induced noise.

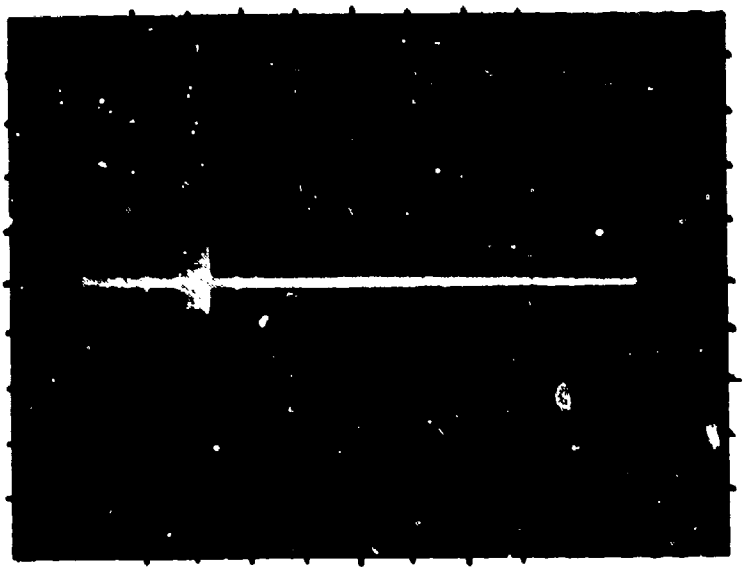


FIGURE 106. Power switching transient on HB1.

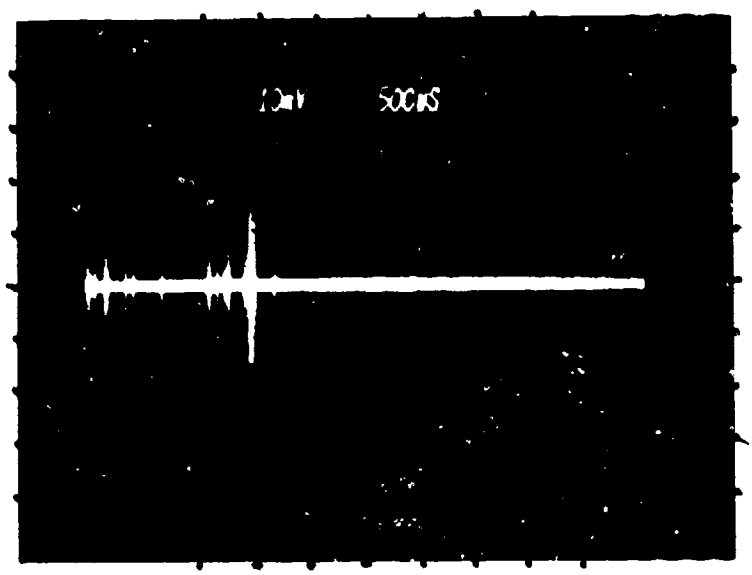


FIGURE 107. Power switching transient on HB3.

These levels are generally reasonable (except for power transients) for the Type A signals, i.e., composite video and timing pulses. The field-to-wire levels may be too high for GPS applications if the noise is broadband. Since GPS uses spread spectrum techniques, it is fairly immune to narrowband interference.

The radiated emissions expected to be experienced from the MIL-STD-1760 implementation are generally acceptable from a MIL-STD-461 standpoint. However, if signals at the maximum power level allowed by MIL-STD-1760 are transferred through coaxial (as opposed to triaxial) cable, the resulting radiated emissions could exceed the MIL-STD-461 narrowband RE02 limits. Figure 108 illustrates measured emissions from a six foot coaxial cable (RG179) in an unshielded harness assembly (figure 108a) and in a gross shielded harness assembly (figure 108b) at the maximum HB3/4 Type A signal power level (23 dBm). While adding a gross shield over the entire bundle helped lower the emissions, low frequency emissions still exceed MIL-STD-461 limits.

Similarly figure 109 compares unshielded and shielded harness assembly emissions from an RG316 coaxial cable transferring maximum HB1 power level Type A (25 dBm) and Type B (10 dBm) signals.

Both sets of curves emphasize the need to use triaxial cables in the aircraft network to maintain suitable EMI performance.

The HB1 and HB2 lines were grounded at multiple points whereas the HB3 and HB4 lines were grounded at a single point (at the store). The data illustrates a variation in noise levels for the different grounding schemes. Tests made at the 400 Hz power frequency showed the noise levels on the HB3 and HB4 lines increased 44 dB (due to ground loops) when the shield was grounded at both ends, i.e., store and aircraft, as opposed to the single ended ground required.

5.1.9.5.4 MIL-STD-1553 multiplex lines. Field-to-wire coupling and crosstalk pose no problem to the Mux A and Mux B lines. The noise levels never exceeded the 200 millivolt line-to-line, peak-peak, non-response level requirement of MIL-STD-1553 except for the power switching transient test described below. The in-band measured noise levels were typically below line-to-line, peak-to-peak. Typical induced noise levels from a 200 volt/meter field are shown in figure 95.

In comparing data (figure 95) on standard 20 gauge contacts, it must be noted that only one connector set out of a chain of six connector sets contained standard 20 gauge contacts (and pigtailed shields) for the multiplex bus. The other five connectors provided the full 360° shield coverage afforded by the concentric twinaxial contacts. Although the noise levels on this test set-up were still below the MIL-STD-1553 detection threshold, the noise level at the MSI was observed to be about 20 dB higher

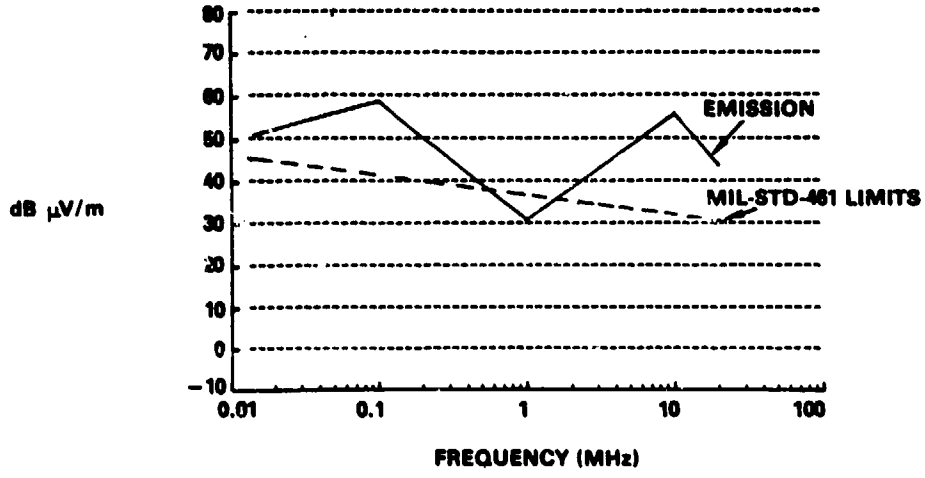


FIGURE 108a. Unshielded harness assembly.

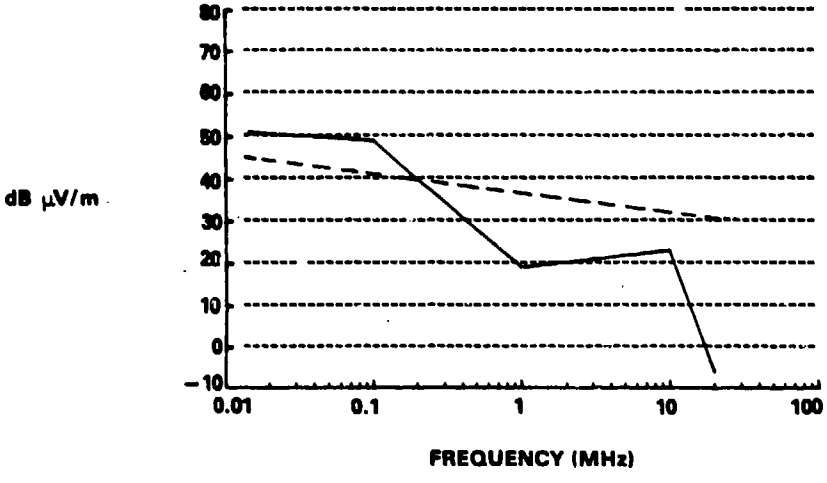


FIGURE 108b. Shielded harness assembly.

FIGURE 108. Radiated emissions from HB3 and HB4 at maximum signal power.

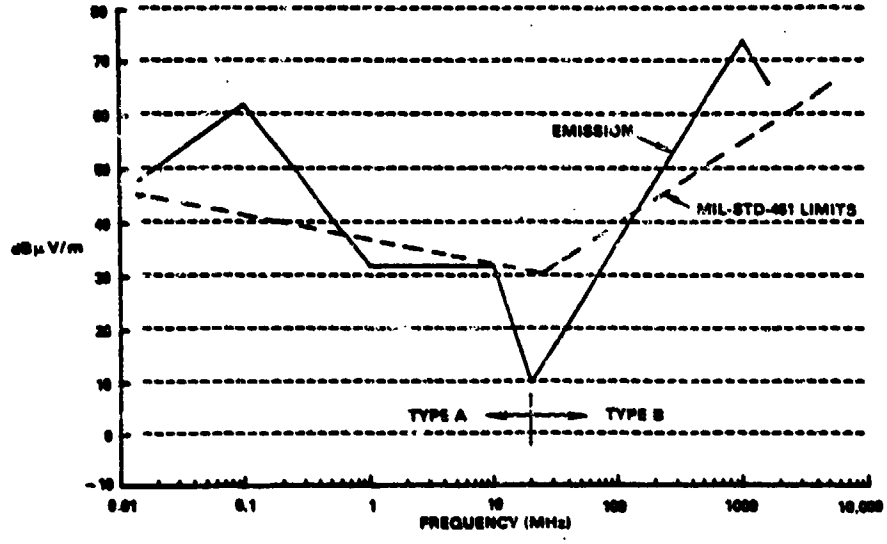


FIGURE 109a. Unshielded harness assembly.

FIGURE 109a: Unshielded harness assembly.

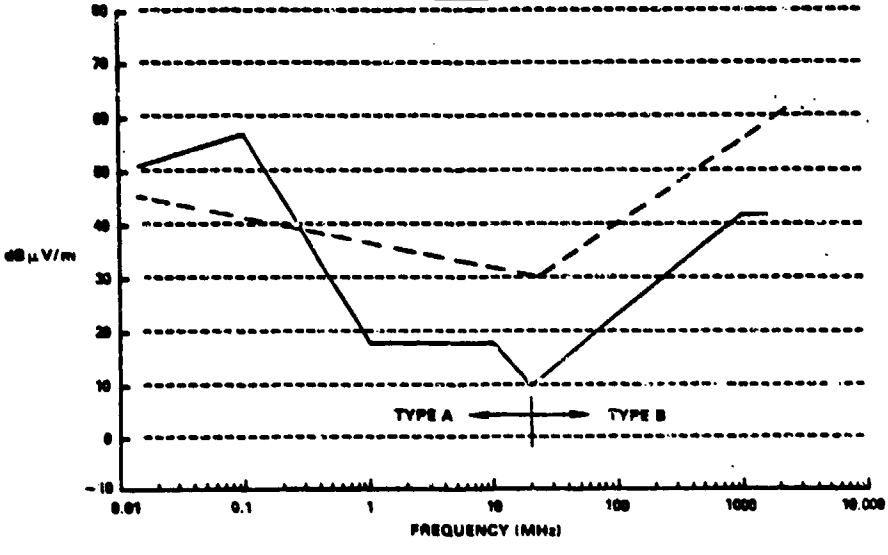


FIGURE 109b. Shielded harness assembly.

FIGURE 109. Radiated emissions from HB1 at maximum signal power.

than for the concentric twinaxial contacts at high frequencies. The difference was approximately 5 dB within the MIL-STD-1553 passband. While it can not be catagorically stated from these test results that the use of standard 20 gauge contacts is unacceptable, caution must be used in any application using unshielded contacts in lieu of concentric twinaxial contacts. (See 5.1.3.4.2 for detailed discussion of unshielded contact performance.)

The noise induced in the data bus from power switching did exceed the MIL-STD-1553 200 millivolt threshold by a small amount when a total of 30 amperes of 28V DC was simultaneously switched in the primary and auxiliary interfaces. This supports experiences on some aircraft where message errors are known to have occurred during power switching. The probability of an undetected message error is fairly remote, however, due to error checks available to the remote terminal.

5.1.9.5.5 Low bandwidth. The in-band noise levels were typically below 1 millivolt which should not present any interference problems to the LB system. At the higher frequencies, the noise levels approach 10 millivolts with the umbilical connected and 100 millivolts with it disconnected. Whether or not this level of RF presents a problem depends on the design of the LB circuitry. In some designs, envelope detection of RF is possible, such that the pulse repetition frequency of pulsed RF source is detected as an audio tone. Based on the disconnected umbilical test data, and the resultant 20 dB increase in noise levels, the LB shield grounding was changed to being grounded at both the aircraft and the store. This double ended shield ground dropped the noise levels to values comparable to 95.

5.1.9.5.6 Address. No problems were associated with either the low impedance (Logic 0) or high impedance (Logic 1) states of these signal lines. The induced noise from a 200 volt/meter field remained below 100 millivolts with typical in-band noise below 1 millivolt. (See figure 97.) Figure 110 illustrates typical power switching transient induced noise. These levels are sufficiently high to require filtering in the store address monitor circuit. The test results shown in the figure, however, were derived from an ASI address circuit where the address jumpers were located 35 feet from the ASI rather than directly at the ASI. This long wire length resulted in increased noise levels.

5.2 Mission store electrical interface. This section provides supplementary explanations of MIL-STD-1760 requirements and design considerations applicable to the Mission Store Interface. This information is applicable primarily to the mission store system designer. Store signal characteristics defined by MIL-STD-1760 and report paragraphs that describe the characteristics along with circuit implementation concepts are shown in Figure 111.

5.2.1 Selection of interface classes. The mission store must be compatible with one (or more) of the four aircraft station interface classes. The signal mix in each of these four classes is identified in 5.1.2 and the associated table I.

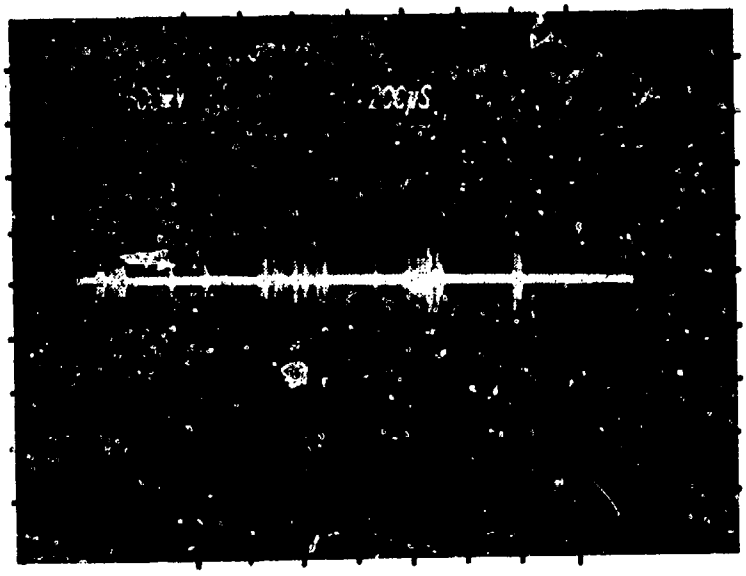


FIGURE 110a. Logic 1 state.

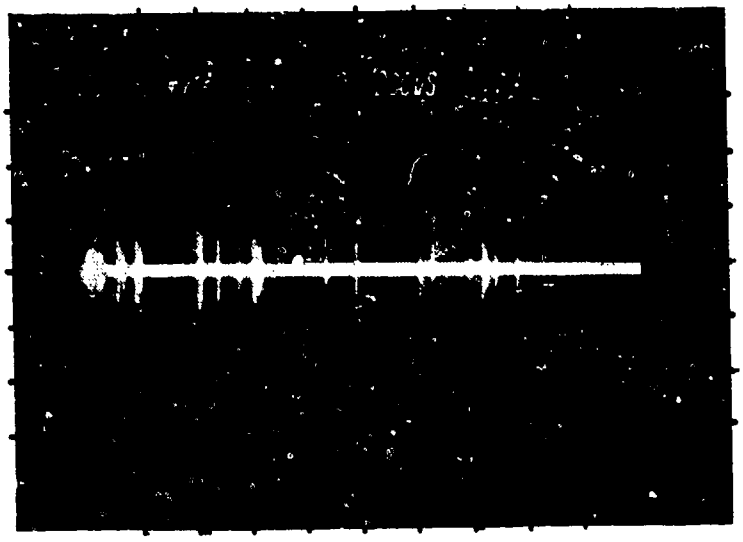


FIGURE 110b. Logic 0 state.

FIGURE 110. Power switching transient on address lines.

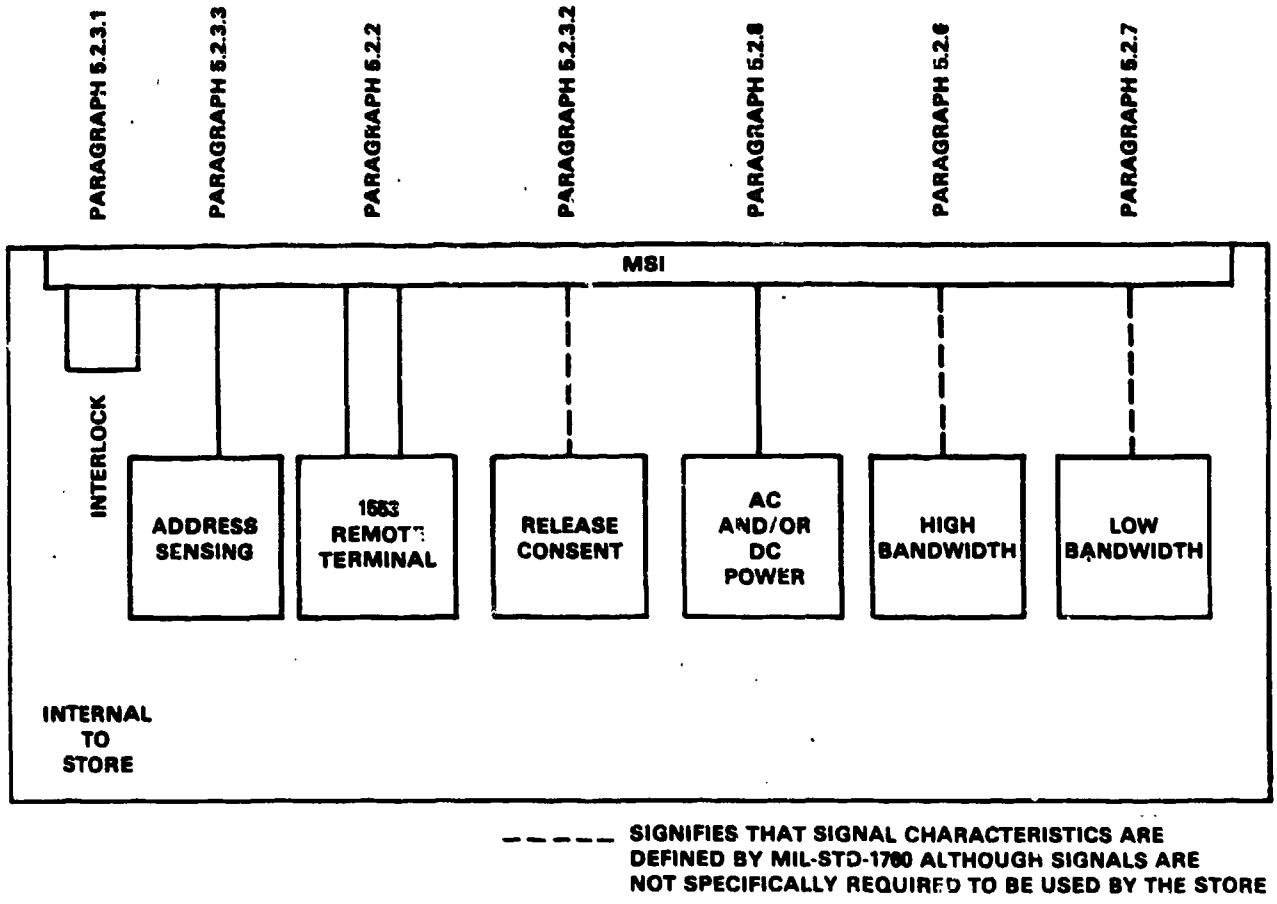


FIGURE 111. Mission store electrical requirements.

One major issue that the store designer must consider when selecting the MSI interface class is the classes available on the aircraft targeted for store carriage. Section 5.1.2 identified expected capabilities for different stations on various aircraft (see table II). The one conclusion that is obvious from this table is that a mission store which is expected to have broad usage on a number of aircraft models and to be compatible with a large number of stations should attempt to restrict the MSI signal subsets (see 5.2.10) to the class II interface. If the store requires some service available in a class I or IA interface that is not available in class II, the number of aircraft stations with which the store will be compatible drops considerably.

A second refinement on ASI signal set availability deals with the highbandwidth interfaces. Although class II interfaces are defined as including HB1 and HB3 ports, the retrofit of MIL-STD-1760 capability into some early blocks of aircraft resulted in "shortchanging" the HB area. In some cases, HB1 is either not available or uses a very high attenuation cable run. Also, some instances have occurred where the HB3 port is provided through 95 ohm cable instead of the 75 ohm impedance required by the standard. Some applications of HB3 (such as low bandwidth [6 MHz] composite video) can generally be designed to operate with a broad range of cable impedances from 50 to 95 ohms without significant degradation. Higher frequency signals, however, may show significant performance degradation when operated into these 95 ohm networks.

The last area of concern in selecting an interface class deals with the load imposed by the mission store on the various power interfaces. In this power area, the recommendation to attempt to stay within the class II capabilities still applies. Additionally, the designer needs to minimize the MSI imposed load on 28V DC power 1, power 2 and the three phase 115/200V AC power. While a 10 amperes capacity is defined for each of these primary signal set power interfaces, the full 10 amperes per line may not always be available from the aircraft due to the aircraft total store loadout. MIL-STD-1760 does not require the aircraft to simultaneously supply 10 amperes per line at each ASI. (Many aircraft would significantly overload their generators and power converters if all ASIs were simultaneously loaded at rated level. This is particularly true considering that the typical tactical aircraft contains 8 to 9 stations and may have a total generating capacity of 40 to 80 KVA and a total 28V DC conversion capacity of 200-400 amperes.) The advice to the store designers is to go easy on the MSI 28V DC loads and use three phase AC power where possible.

5.2.2 MIL-STD-1553 digital data bus. The application of MIL-STD-1553 to the aircraft-store interface results in several design considerations which are not covered by the MIL-HDBK-1553 Multiplex Applications Handbook. The purpose of this report section is to supplement MIL-HDBK-1553. With

this goal, duplication of information contained in MIL-HDBK-1553 is avoided and the reader is encouraged to review the Multiplex Application Handbook for typical MIL-STD-1553 application issues and solutions and for an explanation of 1553 requirements.

The aircraft-store interface peculiar design issues on mission store applications of MIL-STD-1553 are centered primarily around the location of interface specification in MIL-STD-1760. The multiplex standard defines interface requirements at the input/output terminals of the RT. In contrast, MIL-STD-1760 defines interface requirements at the MSI where the MSI can be located several feet (of cable) away from the RT electronics. In effect, this location is at a point between the RT and the data bus coupler. This different location (compared to MIL-STD-1553's "Point A" test location) could impact input impedance and input/output voltage levels.

The majority of MIL-STD-1553 design issues peculiar to the AEIS impact the aircraft's bus network (or perceived bus network) and are covered in 5.1.3 of this report. Store design issues are limited primarily to RT considerations and are presented below.

5.2.2.1 Communication requirements. The intent of the AEIS standard is to rely on the MIL-STD-1553 interface as the basic communication media between stores and aircraft. (In time, this reliance may shift to other future communication standards such as fiber optic or high speed data buses. However, for the immediate future, MIL-STD-1553 provides an adequate communication system.) Although MIL-STD-1760 does not mandate that a store contain an operational MIL-STD-1553 interface (Mux A and Mux B) at the MSI, most mission stores are expected to do so. A MIL-STD-1760 compliant store which does not include this digital interface is the exception case. (Note that the power interfaces are not to be used for discrete control functions and the limited discretes in the MSI are assigned specific funtions.) The only other alternative for a store to receive or send information to the aircraft (or carriage store) is through the potential future use of the Low Bandwidth interface as a low speed serial data link (or as an audio interface). Use of the low speed serial data is not, however, currently allowed. (See 4.3.3.)

5.2.2.1.1 Communication modes. All stores (with the possible exception of low cost stores addressed in 4.3.3) should contain a MIL-STD-1553 remote terminal (RT). Stores which contain an interface RT must operate the RT in the dual standby redundant mode. The store is not required to implement the bus controller (BC) functions defined in MIL-STD-1553. The store RT must support the BC-RT, RT-BC and RT-RT information transfer modes described in the multiplex standard. These three transfer modes are not specifically mandated by MIL-STD-1760 and MIL-STD-1553B is subject to some interpretation as to whether the RT-RT modes is mandatory for all RTs. The store RT should, however, implement all three modes because they will be mandated by the future incorporation of the Logical Element into MIL-STD-1760 and by

MIL-STD-1553B Notice 2 currently in review. Implementation of all three transfer modes avoids interface incompatibilities with some SMS architectures. Supporting the RT-RT mode also simplifies communications between two stores when required.

5.2.2.1.2 Addressing modes. Two communication addressing modes are defined by MIL-STD-1553-RT unique address and broadcast. The store's MSI RT must implement the RT unique addressing mode. The RT's assigned address is determined by the store monitoring the interface address discretes (5.2.3.3) and accepting any valid (passes parity check and is not equal to 31) address as its unique RT address. Command words received (over Mux A and Mux B interfaces) which contain an address field which matches the store's assigned address will be responded to as specified in MIL-STD-1553.

The broadcast addressing mode is optional in MIL-STD-1553B and also optional in MIL-STD-1760. (A broadcast is recognized by detecting a command word address field of 31. This broadcast address provides a common address by which all stores (which implement broadcast) can simultaneously receive the same message.)

Although broadcast is identified as an option and its use is constantly awash in controversy, it is recommended that the store RT be capable of receiving at least the following MIL-STD-1553 mode commands in a broadcast mode:

Reset remote terminal
Transmitter shutdown
Override transmitter shutdown

It is also recommended that if the store is capable of receiving other mode commands or data messages in the broadcast addressing mode that it also be capable of distinguishing between commands or messages received in the broadcast mode versus in the RT unique addressing mode. These two recommendations are based on a currently proposed notice to MIL-STD-1553B (Notice 2) and on the MIL-STD-1760 Logical Element still under development.

5.2.2.1.3 Subaddress restrictions. The use of subaddress (SA) 19 is strictly limited to controlling nuclear warheads in stores. Stores must not use this subaddress for any non-nuclear transmit or receive commands. Non-nuclear stores which (through error) receive a "transmit SA 19" command should respond as defined in MIL-STD-1553 for illegal commands or respond with the appropriate number of 0 or 1 filled data words. Non-nuclear stores which receive a "receive SA 19" command should respond as defined in MIL-STD-1553 for illegal commands or respond normally but ignore all received SA 19 data.

NOTE: MIL-STD-1760A reserved SA 7 for nuclear weapons. Notice 2 changed this reserved SA from 7 to 19. Stores contracted against MIL-STD-1760A less Notice 2 should avoid use of both subaddresses. (See 5.1.3.2.3 for additional background on the need for restricting subaddress usage to improve nuclear weapon control safety.)

5.2.2.1.4 Communication redundancy. The multiplex standard, in general, defines communication requirements for a single (non-redundant) RT interface. The standard also includes special requirements for RT's with redundant input/output ports. The AEIS standard specifically requires that the MSI implement the digital multiplex interface with a redundant set of ports (Mux A and Mux B) and operate this interface in the dual standby redundant mode defined in MIL-STD-1553. This redundancy level is required at the MSI for improving the mission success probability when the mission store is connected to an aircraft bus system. This terminal redundancy allows the aircraft to switch communication channels if one of the redundant buses fail. With a large number of terminals (e.g. stores and avionic equipments) connected to a common bus, the vulnerability of the bus is increased. Hence, the addition in the aircraft of a second (redundant) bus operating in a standby mode significantly increases mission success. Since the store has no prior knowledge on which bus stub (Mux A or Mux B) an aircraft may need to use for store communication, the store must support both multiplex interface ports.

The AEIS standard requires the store to operate at its MSI in this redundant mode. The standard does not, however, define how deep into the store's electronics that this redundancy is carried. Figure 112 shows several possible levels. Figure 112a most likely represents the lowest redundancy level permitted to support the dual standby redundant RT operation of MIL-STD-1553.

5.2.2.2 Electrical characteristics issues. The mission store is required by MIL-STD-1760 to provide MIL-STD-1553 transformer coupled RT input and output electrical charateristics at the MSI with several additional requirements. These additional requirements are driven by two issues. The first issue is the location where the electrical characteristics are measured. MIL-STD-1553 requires the measurement to be made "very close" to the remote terminal's transceiver hardware. In contrast, MIL-STD-1760 defines characteristics at the MSI which can be several feet (of transmission line) from the RT electronics. This first issue affects the input impedance measured at the MSI. This impedance issue is covered in 5.2.2.2.1 below.

The second issue is that the mission store RT is driving a potentially heavily loaded data bus on the aircraft side of the ASI and is driving this bus in a high EMR environment. This second issue affects the drive voltages required from the mission store and is addressed in 5.2.2.2.2.

5.2.2.2.1 Input impedance. The input impedance requirements of MIL-STD-1553 requires transformer coupled RTs to provide a specific minimum line-line impedance. This impedance (magnitude) must be at least 1000 ohms over the frequency range of 75 kHz through 1.0 MHz when measured at "Point

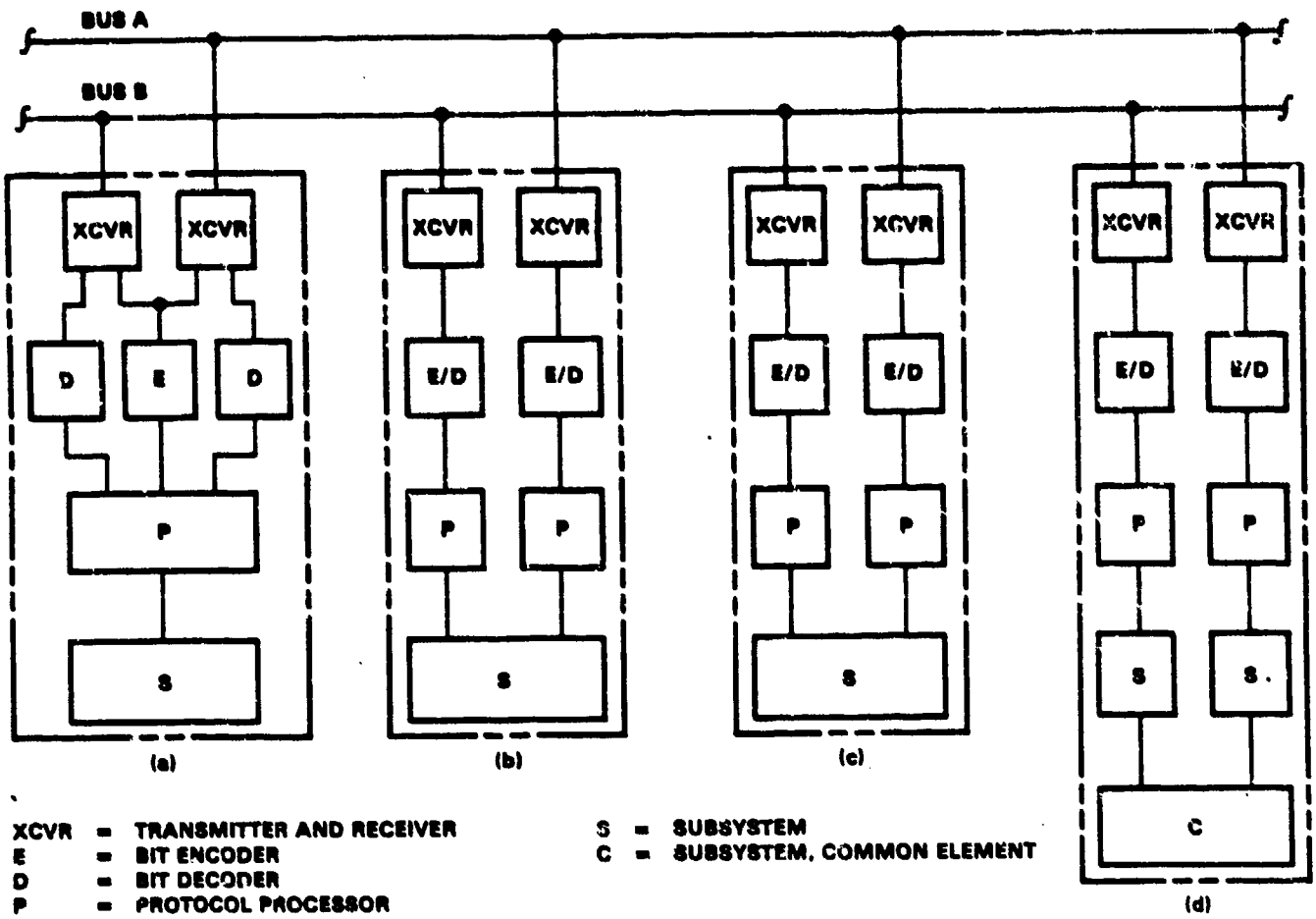


FIGURE 112. Levels of store redundancy.

A" of MIL-STD-1553 figure 9. Point A is defined as the connections to the (remote) terminal. The problem that arises in MIL-STD-1760 is that the terminal is not located at the MSI but can be a number of electrical feet deeper in the mission store. (It would not be too unusual for 8 feet or more of twinaxial cable to be between the MSI and the RT transceiver for a large mission store.)

Based on the physics of transmission lines, the measurement of impedance at the end of a long 77 ohm transmission line terminated with a MIL-STD-1553 compliant transceiver indicates an impedance well below the 1000 ohm limit. (This assumes that the transceiver impedance is close to the 1000 ohm limit.) Since it is desirable to use off-the-shelf MIL-STD-1553 compliant transceivers, some accomodation of the laws of physics is appropriate. In addition, the intent of the high terminal impedance (i.e., return [reflect] a large portion of the stub signal back to the main bus to minimize bus loading) can still be retained by requiring a high impedance (1000 ohms or more) termination at the end of the mission store's multiplex data stub.

The impact of cable length (between MSI and store RT) on measured line-line impedance is shown in figure 113. The two curves define measured and calculated impedances of various cable lengths terminated with a 1000 ohm resistive load for a 1 MHz frequency. The three points marked with an X represent measured impedances (at 1 MHz) of 5, 10 and 20 foot cables terminated into an actual MIL-STD-1553 compliant transceiver. As the cable length shortens, the impedance measured with actual RTs tends to rise above the 1 MHz curve. This occurs because the input impedance of this tested RT was closer to 1800 ohms versus the 1000 ohm minimum MIL-STD-1553 requirement.

MIL-STD-1760 accomodates this transmission line induced lower (perceived) input impedance by requiring that the line-line impedance measured at the MSI be greater than 300 ohms over the 75 KHz to 1 MHz range. This lower measured impedance allows installation of nearly 20 feet of 1553 compliant cable between the MSI and the store RT hardware.

By allowing this lower impedance, off-the-shelf transceivers can be used in the store. In addition, this re-specification avoids store designers from needing to install special impedance matching networks or special electronics simply to meet an "artificial" impedance requirement meant to apply to the end stub termination as opposed to a line-line measurement at some mid-stub location. (e.g., the MSI.)

5.2.2.2.2 Output voltage. The AEIS standard requires mission stores to guarantee a higher (than MIL-STD-1553) minimum output voltage at the MSI when the store RT is transmitting. The multiplex standard allows the terminal output voltage to drop as low as 18 volts p-p, line-line when tested into a 70 ohm ±2 percent load. The AEIS standard requires a minimum

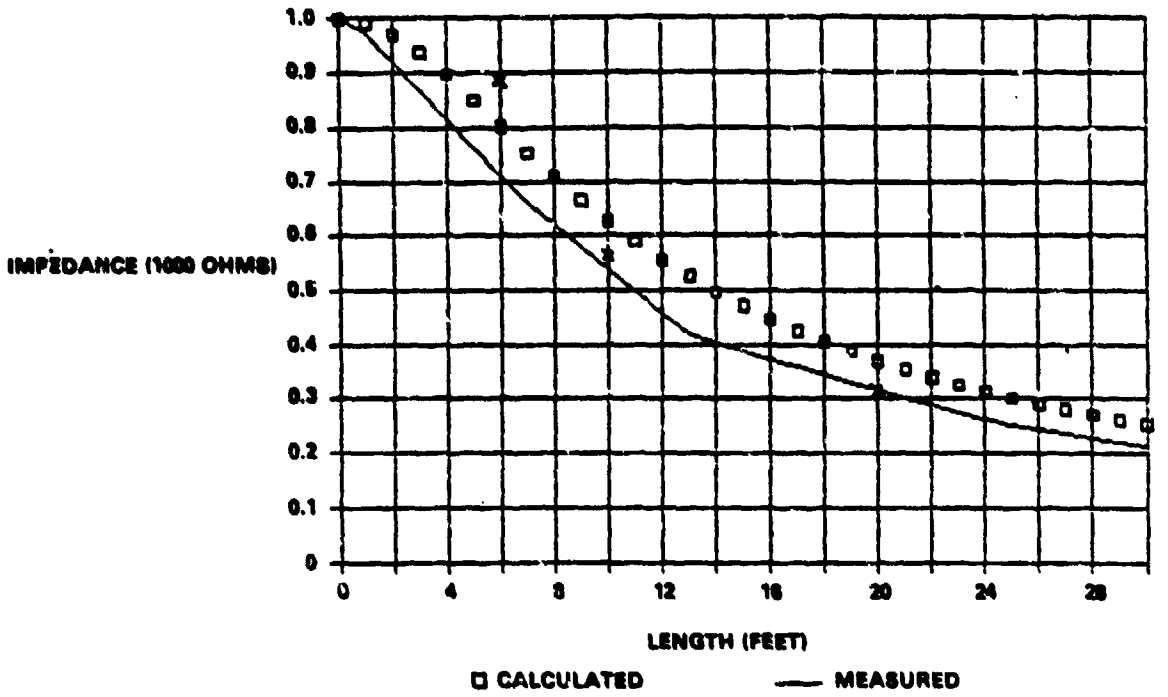


FIGURE 113. MSI input impedance.

of 20 volts at the MSI when tested into the same 70 ohm test load. This higher voltage is required for two reasons.

First, the potential loads expected at the MSI (loads on the store's RT transmitter) can be less than the 70 ohm test level required by MIL-STD-1553. This is particularly true if the aircraft contains a heavily loaded SMS data bus. For a simple calculation, one can assume that a short bus is loaded with thirty 1000 ohm terminals directly at nominal winding transformers. A thirty first terminal will see a 70.2 ohm load at Z_0 of 77 ohms. Since Z_0 is allowed by MIL-STD-1553 to vary from 70 to 84 ohms, this same terminal output load impedance will range from 64.2 to 76.2 ohms. From this point, the calculations can be complicated by assuming longer stubs (lowers load impedance), larger distance between couplers (raises load impedance), tolerances on transformer windings (raise or lower impedance), and longer cable length between coupler and point of impedance measurement (raises impedance). The main point, however, is that the 1553 test load represents only the nominal load condition seen by an RT. To provide for design margin at the lower load impedance (64 ohms), a higher output voltage is required by MIL-STD-1760 when tested into the nominal load.

The second reason for requiring the higher output voltage is to increase the design margin for providing a good signal-to-noise ratio (SNR) at the interface. Since the MSI is expected to be located in external EMR fields (not typical of conventional MIL-STD-1553 applications), a higher induced noise is injected into the data bus stub. (Figure 114 illustrates a typical noise level which can be expected on the MSI multiplex interface from a 200 volt/meter field. Curve A reflects a carriage store configuration while Curve B represents a mission store connected to the aircraft through a gross shielded umbilical cable.) In addition, aircraft with long data buses or a large number of connected terminals will result in a potentially large signal for RT-RT transfers between distant ASIs or for BC-RT and RT-BC transfers between the bus controller and a distant mission store. Since the aircraft has been required to guarantee (see 5.1.3) a 1.4 volt signal at the ASI, a higher input voltage from the store will aid in assuring this voltage level while also increasing the SNR.

5.2.3 Discrete signals. Dedicated discrete signals are available at the MSI for interlock, address and release consent functions. Design issues associated with these discretes are covered below.

5.2.3.1 Interlock. The purpose of the interlock circuit is to provide a means for the aircraft to determine if the store is electrically mated to the aircraft. The store circuit requirement is met by simply providing a closed circuit (jumper wire) between the interlock and interlock return connections at the MSI (contacts R and S on the store's primary receptacle and contacts K and L on the store's auxiliary receptacle) (see figure 41).

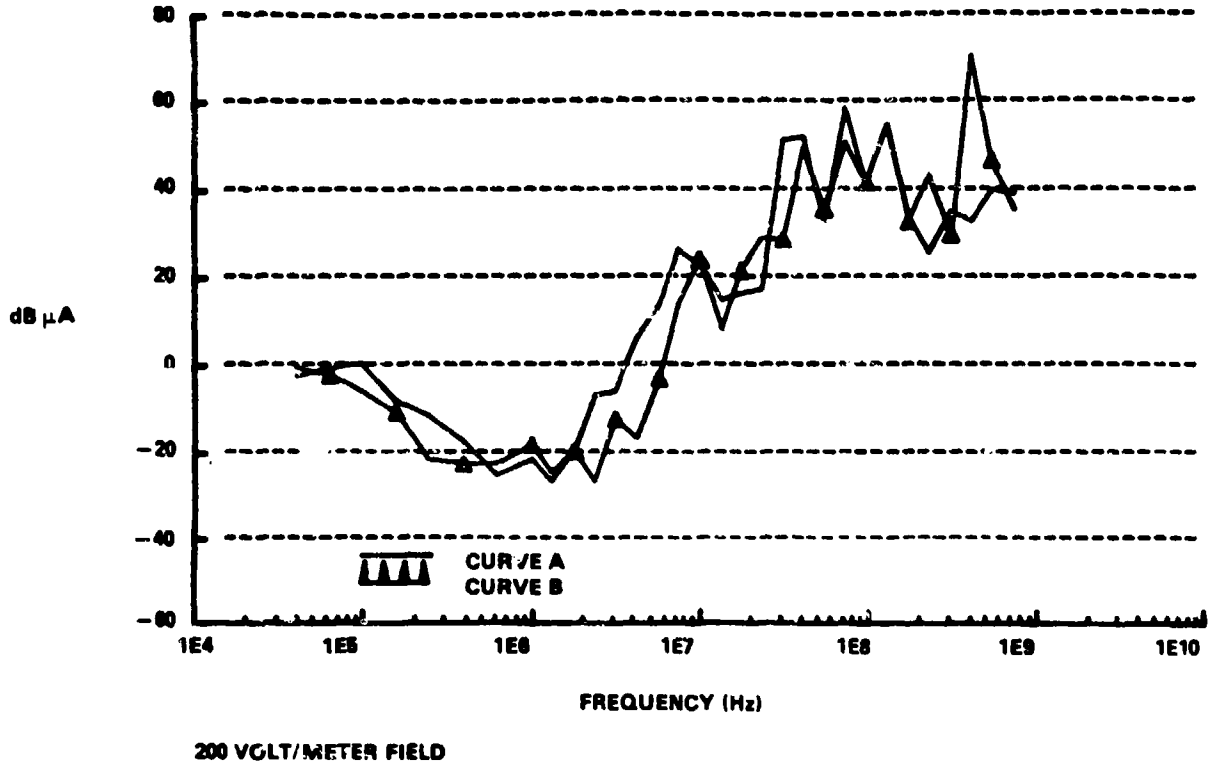


FIGURE 114. Expected noise levels at MSI multiplex interface.

The closed circuit must have an impedance of 500 milliohms or less over the frequency range of DC to 4.0 kiloHertz. This requirement is met with the use of 22 gauge wire whose length is less than 20 feet assuming a high temperature environment. The circuit must be capable of supplying the 500 milliohm maximum equivalent resistance when currents ranging from 5 milliamperes to 100 milliamperes are passed through the interface. This length is more than adequate considering that the store should simply add a short (i.e. less than 6 inches) jumper between the interlock and interlock return contacts in the MSI receptacle.

Some past weapon system implementations of comparable interlock functions have routed the interlock signal through a number of internal store connectors. (See figure 115.) This variation, while possibly providing useful information to the aircraft, changes the meaning of the MSI interlock from "MSI mated" to a function that is more properly one small part of mission store BIT - i.e. all internal store subsystems hooked-up. The interlock signal is intended to only be an indication that electrical mating at the MSI exists.

The interlock (and interlock return) is the only function that the mission store is mandated to provide at an MSI (assuming, of course, that the mission store has an MSI). Furthermore, the mission store is required to provide this interface at both the primary and auxiliary MSI connectors, whichever are installed on the mission store. The auxiliary MSI connector interlock and interlock return are independent and isolated from the primary MSI connector interlock and interlock return. As an example, the store circuit of figure 116b is not a legal store implementation of interlock, while figure 116a reflects the independent/isolated requirement.

The mission store is required to maintain 100 kilohms of electrical isolation between all mission store circuits (including grounds) and the interlock/interlock return connections. (This isolation value applies over the range of DC to 4 kiloHertz.) This isolation effectively disallows the store from monitoring the interlock or interlock return for an indication of aircraft presence. This isolation requirement is a change in concept from what was allowed in the July 1981 MIL-STD-1760. The July version required the aircraft to connect interlock return to structure ground and then allowed the store to monitor interlock return for continuity to structure ground. This requirement on the aircraft for a connection to structure was removed by the September 1985 version of the standard and the store was required to stay off the interlock return line. This change was made due to EMI concerns when stores and aircraft connect their logic signal circuits together and then reference the circuits to a noisy structure ground.

As a result, mission stores which need an indication of aircraft mated status need to use the address interface (see 5.2.3.3) to determine this status.

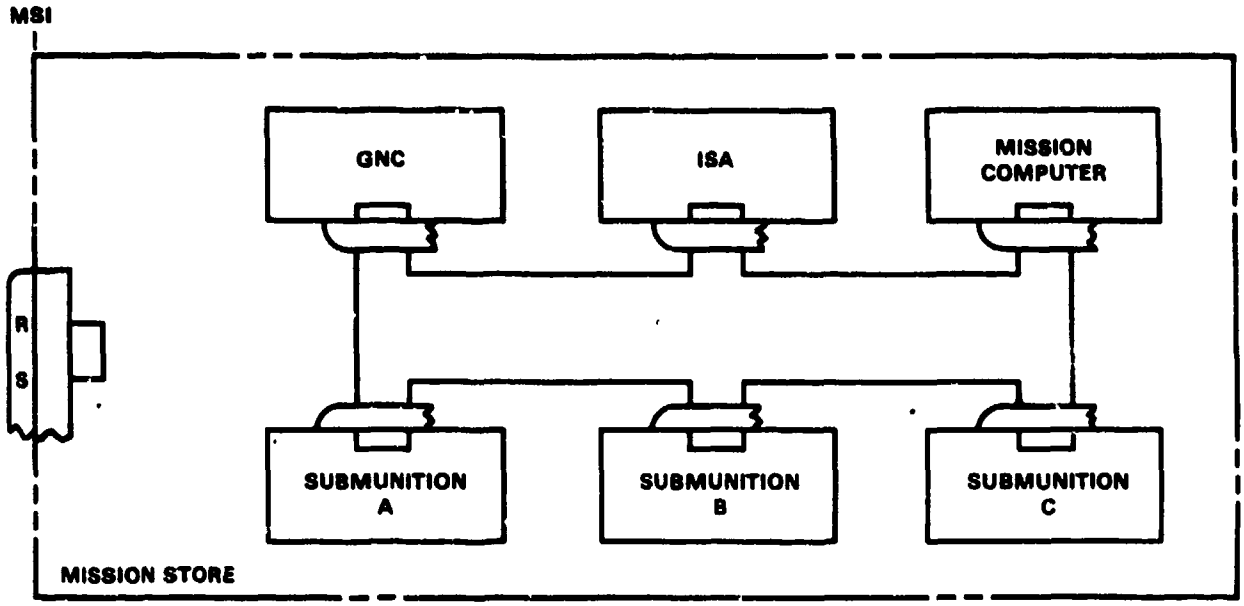


FIGURE 115a. Intended application.

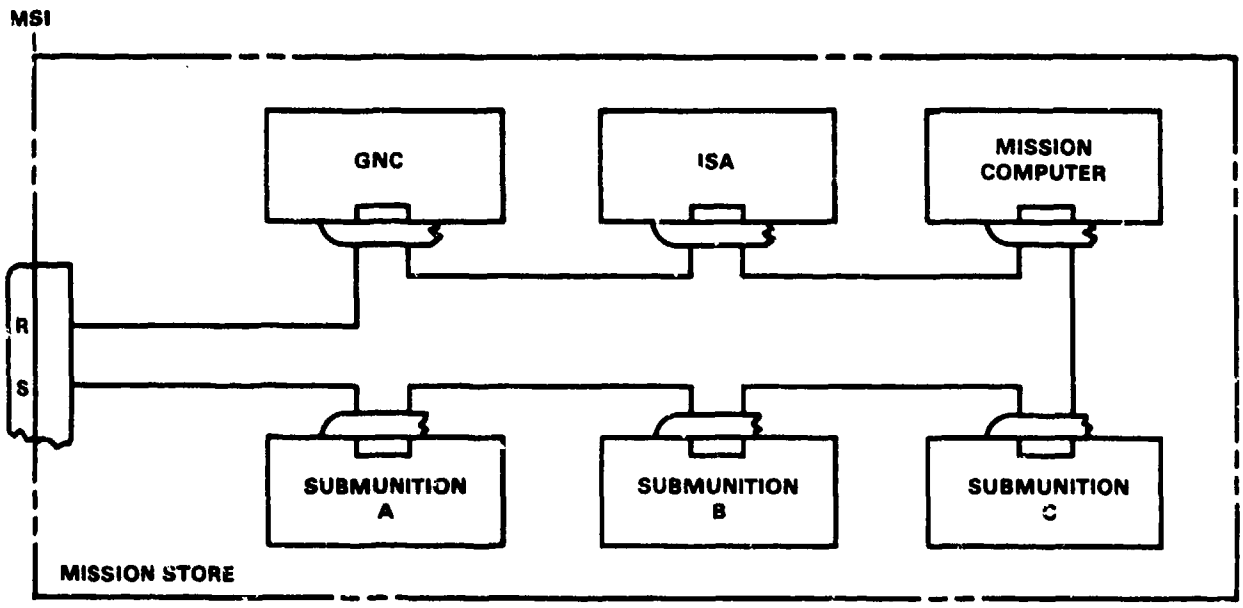


FIGURE 115b. Not intended.

FIGURE 115. Mission store interlock function.

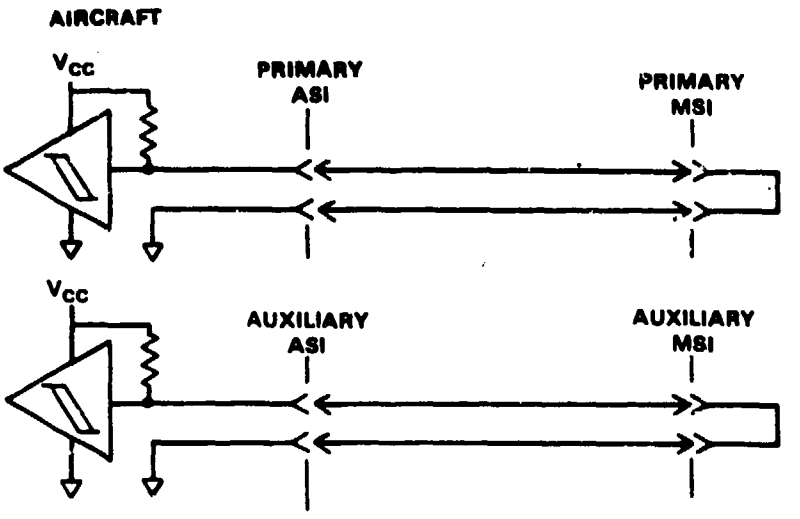


FIGURE 116a. MIL-STD-1760 compliant.

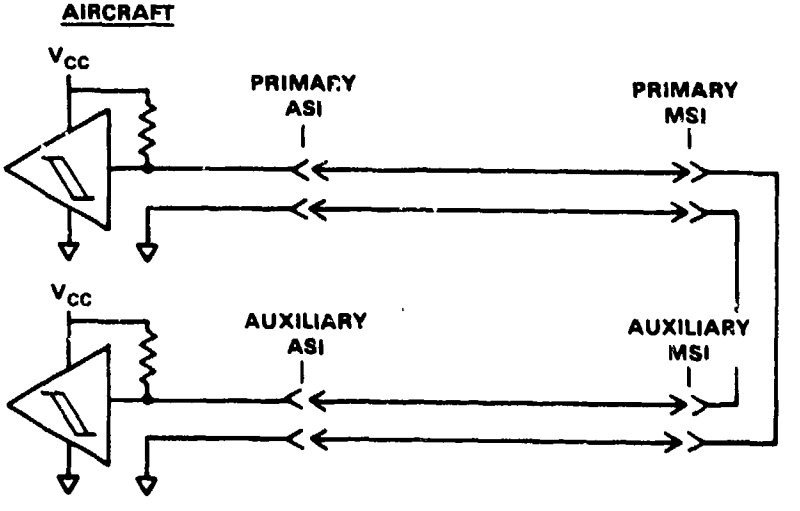


FIGURE 116b. Not MIL-STD-1760 compliant.

FIGURE 116. Primary and auxiliary interlocks.

MIL-STD-1760 requires the aircraft to furnish an address to the store at all times. This address may change with different store loadouts, but there must always be a valid address at the MSI when a store is active. Since the address includes six logic bits with an odd parity check, there is always at least one line with continuity through the ASI and MSI. Consequently, a connector "electrically" mated status is provided whenever continuity is seen on any one of these address lines. It must be remembered that the store does not know what address it will be assigned, and all address lines must be monitored to determine aircraft presence. Consequently, the following caution note must be heeded:

CAUTION

The Address interface shall not be used as the sole criteria for establishing "aircraft mated" functions which could result in an unsafe condition if any one of the address lines fails open.

This "aircraft mated" detection function can be accomplished by simply monitoring the address lines for continuity. Electrical characteristics for the continuity circuit are discussed in paragraph 5.1.4.3 and 5.2.3.3.

5.2.3.2 Release consent. The purpose of the release consent circuit is to provide a hardwired override to disable store acceptance of safety critical commands. The release consent line is used by the aircraft to transmit an enable/inhibit signal to the MSI for the purpose of granting consent to the store to act upon safety critical commands sent to the store over the digital multiplex bus.

CAUTION

The mission store must not use the release consent signal to activate any internal store mode or function except those modes or functions required to accept or reject safety critical messages received by the store's remote terminal.

Whether or not the store implements the release consent interface will be determined by the store system specification. MIL-STD-1760 does not directly require the store to use release consent. This lack of mandatory

use by the standard exists because it is felt that the specific commanded functions which are considered critical can vary considerably with each aircraft-store application. However, the intent behind release consent is that it be used as an enable/inhibit signal for the store to act on or to reject the following types (list incomplete) of commands sent to the store over the multiplex bus:

a. To mission stores:
   i. Ignite rocket motor. (Tends to be applicable to rail launched missiles.)
   ii. Fire a gun, eject a submunition.
   iii. Start an arming process. (Actual warhead arming will occur at some point after a release environment has been detected.)
   iv. Irreversible activation of a power source or function (electrical, pneumatic, thermal, etc.) such that the life of the store is limited after activations. Example - firing a thermal battery.
   v. Allow an emission (RF, laser, etc.) from the store which could increase the aircraft's "visibility" to other vehicles.

b. To carriage stores:
   i. Eject, fire or launch a mission store, submunition, etc.
   ii. Activate release consent at a CSSI.
   iii. Activate arming mechanisms such as bomb rack arming solenoids.

5.2.3.2.1 Circuit characteristics. The release consent circuit consists of a single discrete line for signal transmission and the 28V DC power 2 return line for signal return. The mission store establishes the appropriate enable or inhibit state when the voltages depicted in figure 117 are provided at the MSI. The normal current demand by the store electronics is between 5.0 and 100 milliamperes (as required by MIL-STD-1760) when an "enable" voltage is applied. Typical currents of 0 to 5 milliamperes results when an "inhibit" voltage is applied. If the mission store does not use the release consent function, the circuit (contacts 1 and E in the interface connector) must be left open. The 100 kilohms specified in MIL-STD-1760 is meant to define an open circuit.

The mission store designer may choose to use the release consent line to activate an electromechanical device or provide an input to a logical circuit. Due to safety related applications of release consent in some stores, it may be desirable to use the line to cause a mechanical "break or make" function in the circuit rather than to provide a logic input. The line must not be used to directly fire an Electro Explosive Device (EED) since this results in an irreversible action.

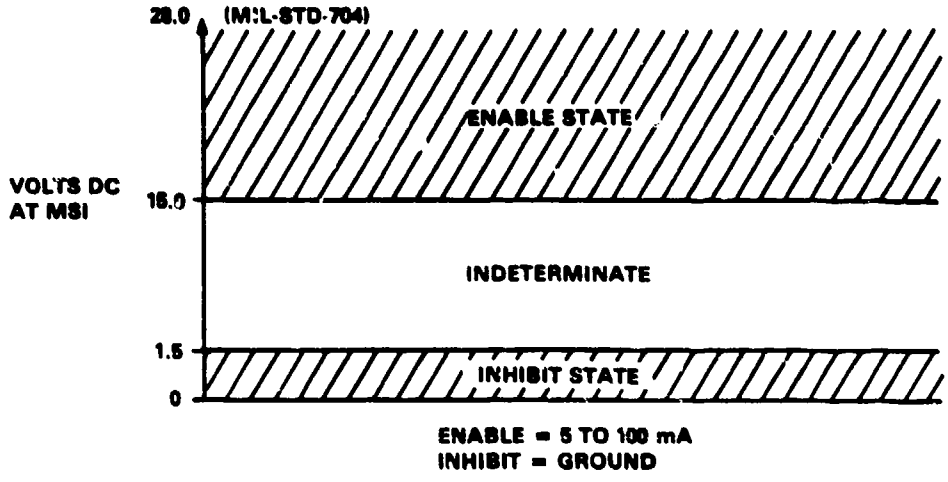


FIGURE 117. Store release consent signal state.

One practical use of release consent is to actuate electromechanical relays. A broad range of relays are available which are compatible with the current and voltage limits established by MIL-STD-1760. The relay in turn could be used to close a path to ignitors, EEDs or similar loads - in effect, arm the EED circuit. Typical implementations are shown in figure 118.

If the release consent line is used to provide an input to a logic circuit, the current demand must be no less than 5.0 milliamperes at the minimum enable voltage. Ideally, this current level should be well above 5.0 milliamperes at this voltage (15V DC) since this line may be switched by relays in the aircraft or carriage store. The selected current level must consider the broad range of allowed enable voltages, - i.e. 15 volts up to the MIL-STD-704 28V DC upper limits.

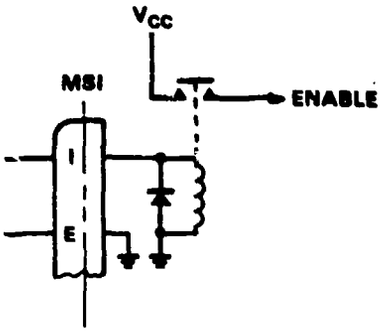


FIGURE 118a. Electromechanical relay.

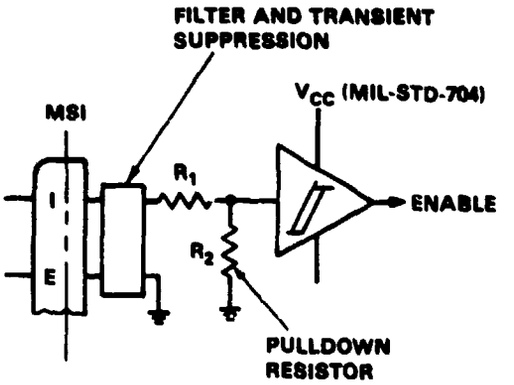


FIGURE 118b. Solid state.

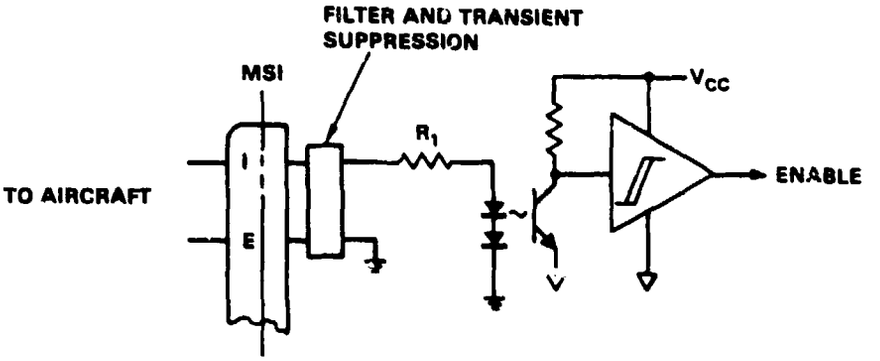


FIGURE 118c. Optical coupler.

FIGURE 118. Store release consent circuit examples.

If the release consent line is used to provide an input to a solid state logic circuit, a pull-down resistor must be used as shown in figure 118b. MIL-STD-1760 does not require the aircraft side of the circuit to have a low impedance path to ground when in the "inhibit" state. MIL-STD-1760 allows the aircraft to provide an open circuit for the "inhibit" state. Therefore, the store needs to provide a circuit to pull a potentially open line to ground potential (or close to ground potential). The noise levels on the release consent input from the aircraft can be fairly high e.g., 1 volt p-p spikes (see 5.2.9.3) when in the inhibit state. The spikes seen in the enable state can approach the MIL-E-6051 limits for 28V DC systems (i.e. -42 volts to + 42 volts). As a result, the circuits of figure 118b and c should include filtering or transient suppressors or both.

For applications where the store environment will permit the use of optical couplers, the circuit of figure 118c provides the distinct advantage of decoupling the release consent and its noisy return (28V DC power 2 return) from the store's electronics power and signal ground. The use of Schmitt trigger type buffers is also recommended to provide a "snap action" for the state transition.

5.2.3.2.2 Circuit protection. The AEIS standard does not specifically mandate that the store safely withstand overcurrents associated with internal store release consent circuit faults. (In contrast, such a requirement is mandated on the store for internal power circuit faults.) However, it is the intent that, from a store safety perspective, the store not become unsafe if a fault occurs in the store's release consent circuit. It is also the intent that the store rely on aircraft protection devices to aid in safely withstanding these faults. In theory then, the store wiring should safely withstand store induced fault currents up to the current-time limits defined by the "maximum overcurrent" curve of figure 83. From a practical viewpoint, however, the wire size required to meet this overcurrent level may be too large for the Size 20 contacts contained in the primary MSI connector for release consent. As previously discussed in 5.1.4.2.3, in order to be compatible with the connector design constraints, the aircraft needs to provide fault protection levels compatible with 20 gauge (or smaller diameter) wire. Thus the connector constraint becomes the driving element on allowed fault current levels sourced by the aircraft. Stores designed to safely withstand 20 gauge conductor fault levels should be adequately protected. Specific mission stores which require a higher level of safety can include additional fault protective devices within the store.

5.2.3.3 Addressing discretes. The purpose for the address interface is to provide a means for the store to detect the assigned store digital data bus address. If the mission store is required to determine the mated status at the MSI, it must also use the address lines for this purpose. The address interface includes five binary encoded address bit connections

(A_0, A_1, A_2, A_3, and A_4), one address parity connection and one common address return connection. The mission store monitors the five binary encoded address bit lines for Logic 0 and Logic 1 states. The remote terminal address is defined as:

$$\text{Remote terminal address} = (A_4)x2^4+(A_3)x2^3+(A_2)x2^2+(A_1)x2^1+(A_0)x2^0$$

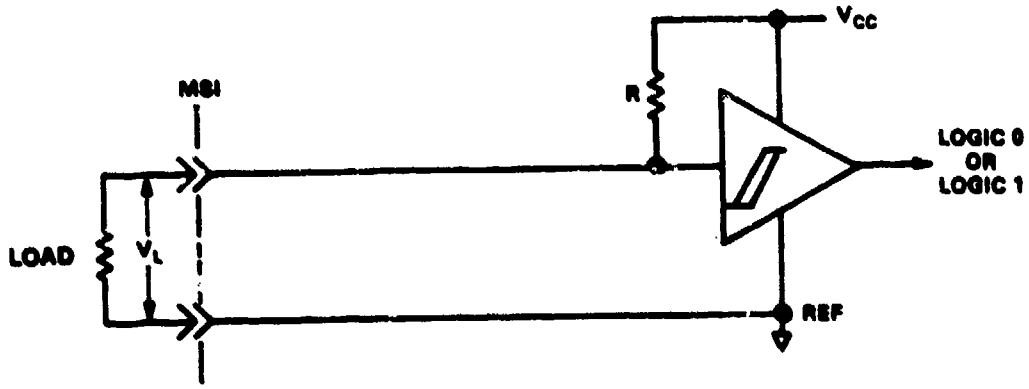
The mission store monitors the address parity line for Logic 0 and logic 1 states and accepts the assigned address as a valid remote terminal address if the address parity logic state indicates odd parity. NOTE: The store is required to conduct this parity check and not accept the address if parity fails. Odd parity is defined as an odd number of Logic 1 states on the five address bit lines and the address parity line.

5.2.3.3.1 Circuit requirements. The nominal operating mode of the five address bit connections and the address parity connection is for an "open circuit" (Logic 1) or "short circuit" (Logic 0) to be applied to the aircraft side of the MSI. Figure 119 defines the general signal characteristics for each address line. Figure 119a shows a simplified circuit diagram with limits on various characteristics. This diagram is shown for explanation purposes - not as a design. (See 5.2.3.3.2 below for design examples.) Figures 119b and 119c illustrate the logic transition voltages for circuits with and without hysteresis. MIL-STD-1760 does not mandate circuit hysteresis but defines the Logic 1 and Logic 0 threshold limits such that hysteresis can be provided.

One of the main points in the figure is that the actual maximum detection threshold for the logic 1 state is determined by the store circuit through the selection of the circuit's supply voltage (V_S) and the value of the pull-up resistor (R) or its equivalent. As will be seem in the examples of 5.2.3.3.2, MIL-STD-1760 allows a broad range of circuit implementations and voltage (current) levels for the address interface.

To allow for the effects of potential filtering and active circuitry in the aircraft's address discrete interface, the store must allow 10 milliseconds following application of the address excitation for the voltages and currents at the MSI to stabilize. If the store also includes filtering devices between the MSI and store circuitry, this stabilization time will increase (based on the filter characteristics).

Finally, some store applications which have significant thermal constraints or power dissipation constraints may opt for a more complex circuit that periodically pulses the addresses lines (possibly even one line at a time) to determine the assigned address. (For example, a store which continuously



	LOGIC 1	LOGIC 0	$V_{CC}/R \leq 100$ mA $(V_{CC} - 1.5V)/R \geq$ mA
NOMINAL LOAD	OPEN	SHORT	$V_L = 4 + (R \times 300\ \mu A)$
STORE SOURCED EXCITATION	4-31.5V DC	5-100 mA	$V_L \leq V_{CC} \leq 31.5V$ DC
DETECTION THRESHOLD	$\leq 300\ \mu A$	$\leq 1.5V$ DC	$1.5V < REF \leq V_{CC} - (R \times 300\ \mu A)$

FIGURE 119a. General circuit description.

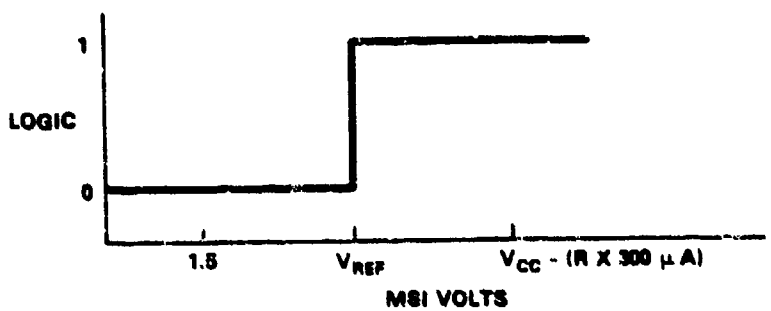


FIGURE 119b. Logic levels without hystersis.

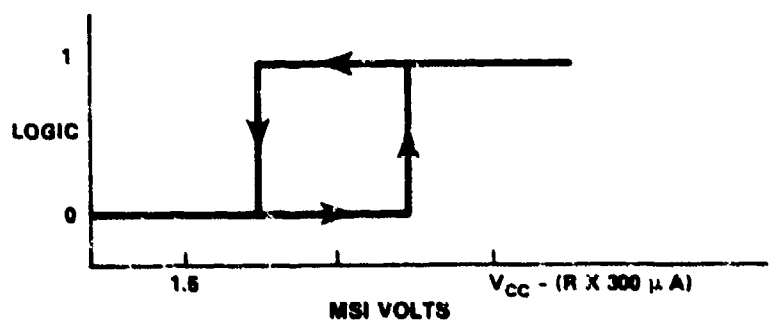


FIGURE 119c. Logic levels with hystersis.

FIGURE 119. Mission store address description.

sources 100 milliamperes with a 28V DC open circuit voltage through each address line dissipates more than 16.8 watts in the address monitor circuit. The limits in MIL-STD-1760 dictate 120 milliwatts minimum dissipation if continuous excitation of all address lines is used. Most circuits will probably select a value between these two power limits in order to provide a reasonable SNR for address detection.) If address line pulsing is selected by the store designer, the rise and fall time limits of the excitation need to be controlled. MIL-STD-1760 requires that the rise and fall time not be longer than 10 milliseconds but does not define minimum rise and fall times. Minimum times will be indirectly imposed in the store in order to meet specific EMC requirements of the store's system specification.

5.2.3.3.2 Circuit examples. Examples of circuit implementations to meet these requirements are given in figure 120. The voltage supplied to the MSI (or CSI) by the store, must not exceed 31.5 volts. If 28V DC (MIL-STD-704) power is used as the power source, the voltage above 31.5 volts must be suppressed with a Zener diode as shown in figure 120 or by some equivalent means. The diode in the address line is used to protect the store electronics in the event power is applied to the interface connector. MIL-STD-1760 defines address characteristics at the ASI and MSI such that a periodic pulsing/sampling option is available to the store designer. (See figure 121.) While, in general, a pulsing system requires more complex store circuitry, it may provide a viable option to reducing store circuit power dissipation. The main consideration in using pulse/sample method (figure 121a) is to allow enough time for the voltage/current characteristics to stabilize after the analog switch is advanced to the next address line. The store must allow at least 10 milliseconds at each line for stabilization of circuitry on the aircraft side of the MSI before accepting the output of the comparator as valid. Figure 121b illustrates an alternative where all address lines are powered, the address is read and stored in a register and then power is removed from the address lines. The duration that power is applied to the address lines is in the tens of milliseconds with a very low (average) power dissipation resulting.

Since the address and parity lines are current limited, no wire protection is required. It is only necessary that these lines be capable of sustaining these currents continuously. The address return wire must be capable of sustaining 600 milliamperes continuously. The detection threshold selected by the store needs to consider the address return line voltage when currents from all six address lines are flowing through the return.

5.2.4 Arming and fuzing. Arming and fuzing of a store's warhead does not directly occur as a result of data or discrete signals sent through the MSI. Data or signals through the MSI may, however, influence the arming and fuzing process within well defined, controlled bounds.

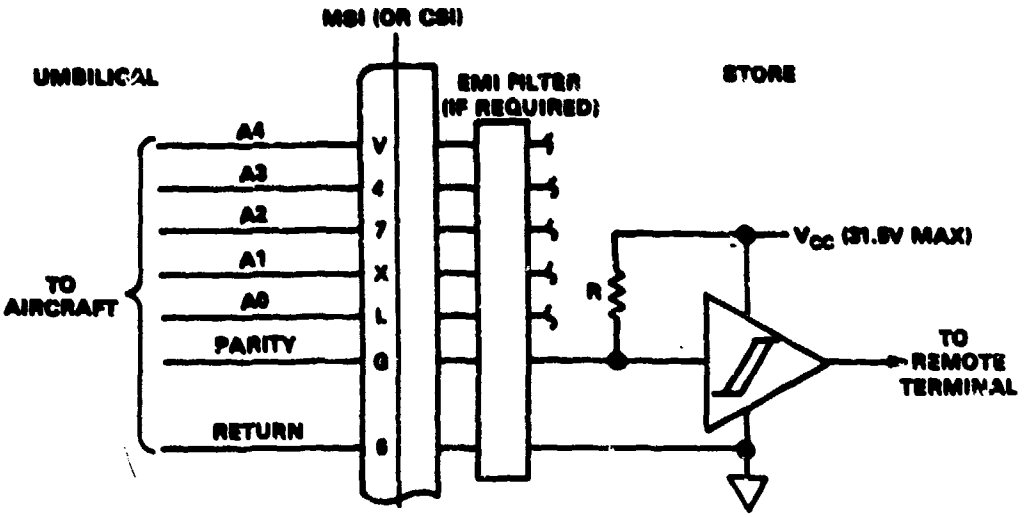


FIGURE 120a. Solid state.

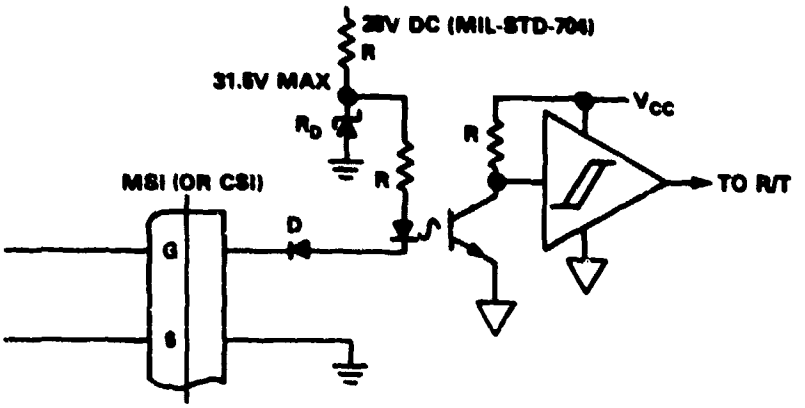


FIGURE 120b. Optical coupler.

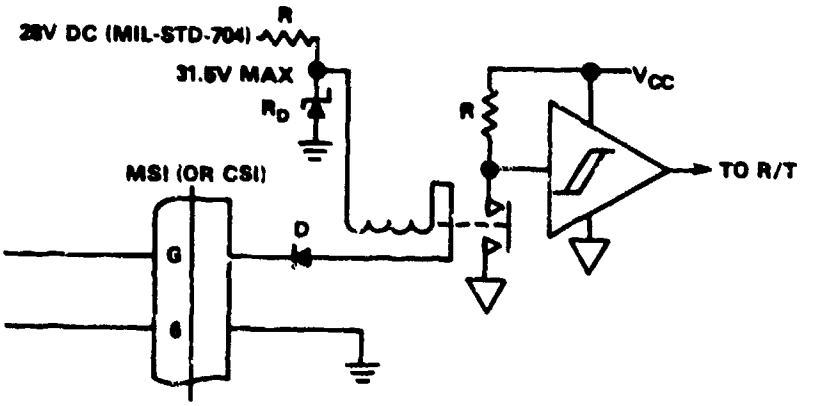


FIGURE 120c. Electromechanical relay.

FIGURE 120. Store address line circuit examples.

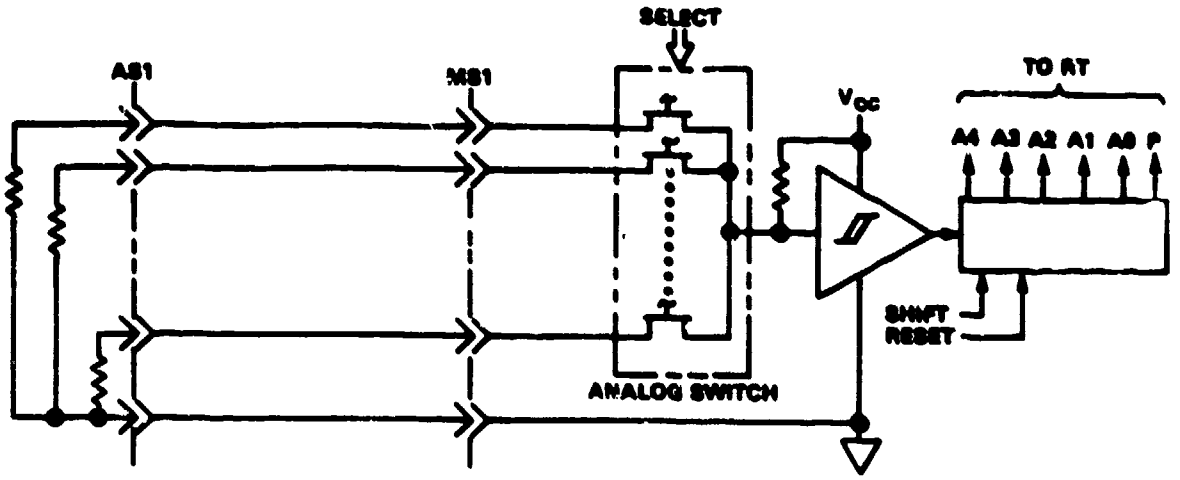


FIGURE 121a. Individual line pulse and sample.

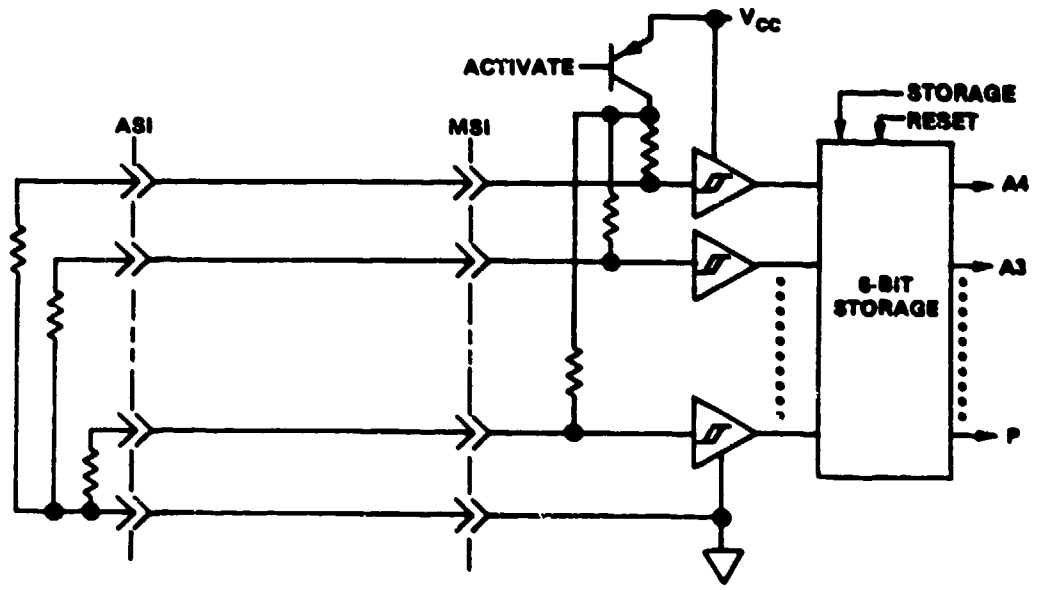


FIGURE 121b. Activate - strobe - deactivate.

FIGURE 121. Store address circuit - sampling methods.

A baseline condition or rule in store design is that a warhead is never armed while attached to the airplane. Data or signals may be sent by the aircraft to the store through the MSI to enable (or disable) the arming process or to select arming and fuzing options. However, the actual arming occurs after the store leaves the aircraft and after some time, distance, acceleration duration, etc. has transpired.

A typical arming operation for a missile might consist of the following steps. An "arming enable" command is sent to the store over the multiplex bus while the release consent signal is in the enable state. The store receives the command, verifies that the command is error-free, verifies that release consent is in enable and that store subsystems are in GO. If these checks pass, the store activates a mechanical lock that releases an acceleration sensor. If the missile is fired, acceleration from the missile results in the gradual movement of a device that was disrupting an explosive train. After the acceleration has continued for a predefined length of time, the explosive train will no longer be disrupted and the missile will be armed. (This description is mechanically oriented. Similar arming sequence could occur using guidance computer integration of inertial sensor derived acceleration data with a final command to align the explosive trains for an armed weapon.)

With the explosive train aligned, the warhead can be detonated by the fuzing system initiating the explosive train. The fuzing system might detonate the warhead based on proximity sensors, optical sensors, high negative g-load due to impact, or a number of other exotic or simplistic target detection methods. As with arming commands and signals, fuzing "commands" might also be sent through the MSI. However, these commands will not result in weapon fuzing with the store attached to the aircraft. Instead the fuzing command contains data for selecting fuzing options such as fuze function delay time after impact, detonation altitude, target signature, etc.

The main point of this example is that fuzing and arming data is critical and should be well protected in its transfer over the data bus (including possible interlocking with release consent). However, the data is not so critical that the store is actually being armed and fuzed while on the aircraft. As a result, the data transfer can be sufficiently protected so that use of the AEIS for its transfer is a viable option over the use of mechanical arming wires and similar devices being used today.

5.2.5 Store jettison. An overview of jettison is covered in 4.1.3.2 where several catagories of jettison are described. In the AEIS context, jettison can be divided into two catagories. First catagory of jettison deals with the unarmed release of a store from the aircraft's parent bomb rack. This jettision catagory is handled directly by signals from the SMS to the bomb rack and does not involve AEIS interfaces. (This does not preclude the possibility that messages may be sent to the store through the AEIS to prepare the store for jettison. Examples include deselection of the

arming process, erasing classified data, destructing classified equipment, etc.)

The second catagory of jettison deals with unarmed release commands sent to stores. This catagory can be further subdivided into commands to carriage stores and to mission stores (generally rail launched missiles). However, both of these subcatagories require similar actions. Since jettison is a safety concern, commands issued through the AEIS need to be well protected and generally interlocked with release consent. The command protection needs to consider several errors: (1) Messages directed to the (correct) store but misinterpreted as a jettison command; (2) a jettison command to a different store erroneously received by the store; and (3) a non-jettison command to a different store erroneously received by the store as a jettison command.

5.2.6 High bandwidth interface. The high bandwidth (HB) requirements basically apply only to mission stores which require an HB interface for store operation. If the store does not use the HB interface, the only HB requirements applicable are: (1) To provide MSI connector compatibility with HB contacts in the mating connector, and (2) to provide a sufficiently "high" impedance termination (such as an open circuit) between each unused HB signal and signal return contact connections in the MSI mating connector.

In contrast, if the mission store uses any of the HB interfaces, then the requirements of MIL-STD-1760 paragraph 5.2.1.1 apply to the implemented HB interface. Furthermore, the comments in the paragraphs below may be of interest to designers of these mission stores.

5.2.6.1 General application. The mission store designer has a choice of two interface support classes theoretically available from aircraft station interfaces. Within the high bandwidth area, a class I ASI supplies all four HB ports for supporting: (1) Up to three Type A signals and one Type B signal, or (2) up to four Type A signals and no Type B signal. Similarly, the class II ASI supports two HB ports (HB1 and HB3) for : (1) Up to one Type A and one Type B signal, or (2) up to two Type A signals.

While these HB service levels are identified in MIL-STD-1760, the store designer must consider the HB provisions supplied by aircraft retrofitted with an AEIS capability. The two areas in the AEIS interface that seem to be sacrificed some in aircraft retrofitted implementations are the power capacity available through the interface and the HB network support. For the near term, few aircraft or limited stations on aircraft are expected to contain all four HB ports (class I) in the ASI. However, the class II interface level (i.e. HB1 and HB3) should be available at a number of stations. Some aircraft (or some blocks of aircraft) may only provide a HB3 path wired to support video functions. This last case primarily applies

to early models of aircraft which tend to lack high bandwidth avionic subsystem support for more than video functions.

As a result of these aircraft HB limitations, the store designer should consider serial digital (MIL-STD-1553) or other alternatives for functions which can be achieved without the need for extensive aircraft HB network capabilities. Where HB ports are still required, the general preference for ports is shown in table XVII. This preference order is based on expected aircraft station capabilities.

The second general application issue is the signals that can be placed on each HB port. Table XVIII identifies the signal catagories that are assigned for the two interface classes. Most aircraft are expected to be capable of sinking composite raster scan video signals into a cockpit display or other video equipment. In addition, the detailed electrical and waveform encoding characteristics are well defined for video signals by reference to video standards (see 5.2.1.1.2.1 of MIL-STD-1760A).

In contrast, detailed electrical and functional requirements for RF and time correlation pulses (TCP) are not included in the AEIS standard. For example, RF could encompass raw RF signals for Global Positioning System, Joint Tactical Information Distribution System, Precision Location Strike System, Pave Mover, etc. None of these signals are defined in detail by MIL-STD-1760. Secondly, and of more importance, just because an aircraft contains ASIs with HB1 interfaces provides no assurance that the aircraft will contain the supporting avionic equipment required to supply, for example, raw GPS RF signals to a station. Likewise, detailed electrical and functional requirements for TCP signals are not included in MIL-STD-1760. For the case of ECM blanking functions, the aircraft needs a black box which would: (1) Accept appropriate pulses from the store and "blank" the applicable aircraft (or other store) receivers, or (2) transmit appropriate pulses to store receivers prior to an aircraft RF transmission. The equipment to be blanked and the timing of the pulses are all application dependent design issues. All that MIL-STD-1760 requires is that a distribution facility be available between ASIs and from ASIs to appropriate aircraft areas.

5.2.6.2 Signal characteristics. Within the application strategy described above, the AEIS standard defines limits on the interface signals. These limits apply to signals sourced by the store or required by the store from the aircraft. The general signal limits of table VI (MIL-STD-1760A table I) are defined to bound signal characteristics sufficiently to allow designers to construct a general purpose signal distribution network in the aircraft. As a result, store designers must select characteristics for their specific signal(s) which fall within the table VI bounds if the signal is to be compatible with aircraft.

TABLE XVII. HB port usage preference.

Preference Order	HB Ports			
	HB1	HB2	HB3	HB4
1			X	
2	X		X	
3	X		X	X
4	X	X	X	X

TABLE XVIII. HB signal assignment.

Interface Class	Signal		HB Ports			
	Type	Description	HB1	HB2	HB3	HB4
I	B	RF	X			
	A	TCP*	X	X		
	A	VIDEO			X	X
II	B	RF	X			
	A	TCP	X			
	A	VIDEO			X	

*TCP - Time correlation pulses (e.g. synchronization, blanking, clocking, etc.)

This table provides a fairly broad range of characteristics. However, several points need to be highlighted.

First, it is not totally obvious from the mission store requirements of MIL-STD-1760 paragraph 5.2 that the signal placed on HB1 at an MSI can be either a Type A or a Type B signal but not both at the same time. This restriction results from the requirements imposed on the aircraft (see 5.1.1.1.1 and 6.3 of MIL-STD-1760). The aircraft is required to be capable of transferring Type A or Type B signals on HB1 through any ASI but is not required to simultaneously transfer both signal types through any given ASI. The HB1 network is divided into two separate bands - 20 Hz to 20 MHz and 20 MHz to 1.60 GHz. The HB1 port passband is not required to be contiguous from 20 Hz to 1.6 GHz. The aircraft is allowed to split the HB1 port into two separate bands to expand the number of distribution network technology options. If a single contiguous 20 Hz to 1.6 GHz band were imposed by MIL-STD-1760, the choices of network designs would have been essentially narrowed to one, i.e. electromechanical switches. (See 5.1.5 for more details on network technologies.) As a result, the store designer must provide HB signals which comply with either the Type A signal requirements or the Type B signal requirements. Signals with frequency components outside of these bands may be incompatible with aircraft distribution networks.

A further point on frequency limits applies to the Type A band. This band has a 20 Hertz lower frequency limit. This precludes the passing of signals with DC components through the aircraft's distribution network with the DC component intact. Generally, aircraft with networks based on coaxial cables and electromechanical RF switches can pass the DC component. However, aircraft with some types of FDM networks or other active bus systems can not transfer the DC.

Technically, a store is not allowed to source any Type A signal with frequency components below 20 Hertz or above 20 MHz. (This same restriction applies to aircraft.) In actual practice, excluding all harmonics above 20 MHz may not be practical for some signals. Removing low frequency components due to switching signals on and off or due to a sudden change in a video image also may not be practical. The main point of the frequency limits is not so much of disallowing the generation of these frequencies as it is for precluding an application which requires the transfer of these frequencies to retain information or provide for proper circuit operation. A good example of the low frequency cutoff is found in video standards (e.g. STANAG 3350). For a display to function properly, a known DC reference level from the composite signal is required. The video standards, in effect, require a "DC restoration" circuit to be included in the video receiver to faithfully recover the correct reference level.

Similar DC problems can exist in TCP signals. To faithfully retain pulse width information for leading/trailing edge timing, a conventional unipolar return-to-zero pulse can not be used. Figure 122 illustrates the loss of amplitude information if unpolar pulses are used. The loss of amplitude

can impact leading edge and trailing edge detection and pulse width information. The amount or extent of timing information loss depends on sourced signal level, network losses, pulse duration, repetition rate, and receiver thresholds plus the actual shape of the network transfer function.

Figure 123 illustrates one solution for maintaining TCP information content - a bipolar return-to-zero pulse can be launched onto the distribution network. If extremely long equivalent pulse widths are needed, then "start" and "stop" pulses can be used.

Another signal characteristic issue that is highlighted concerns the signal level. The defined signal characteristics (table VI) includes minimum (1 volt p-p) and a maximum (12 volts p-p) limit on the "full scale" signal voltage plus maximum dynamic range (30 dB) of the signal. For example, a store can source a specific signal with a maximum peak-peak voltage of 10 volts (falls within the 1 to 12 volt p-p limits). The store can expect faithfull transfer of this signal and the information encoded in the signal by voltages as low as 30 dB below the 10 volt p-p level. Likewise, a different store can source a specific signal with a maximum peak-peak voltage of 2.6 volts (also falls within the 1 to 12 volt p-p limits) and expect faithfull transfer of signal voltage components as low as 30 dB below the 2.6 volt p-p level.

This method of signal specification is used primarily due to expected use of electronic signal distribution, such as FDM, in the aircraft. The modems in an FDM system can adjust the input and output signal amplitudes based on data (via MIL-STD-1553 for example) on the specific signal requirements. However, the modems have some limits on the signal dynamic range that can be reproduced after the modulation and demodulation processes.

5.2.6.3 MSI connector HB issues. As indicated in the introduction to 5.2.6, the mission store is required to provide contact "facilities" in the MSI connector (receptacle) for unused HB ports. These "facilities" can range from an assembled coaxial socket contact with a 50 or 75 ohm RF load to a contact cavity in the receptacle with no installed coaxial contact assembly. (See 5.3 for connector physical requirements.)

For those applications where an HB port is used, the store designer can install any contact intermateable with the MIL-C-39029/28 pin contact (which will be installed in the MSI's mating plug). The only additional AEIS requirement on the selected contact is that the MIL-STD-1760 electrical characteristics specified at the MSI are met. These requirements are contained in 5.2.1.1.2 of MIL-STD-1760.

From the perspective of the MSI connector, the only significant electrical characteristic that can be a problem is the VSWR levels at the high

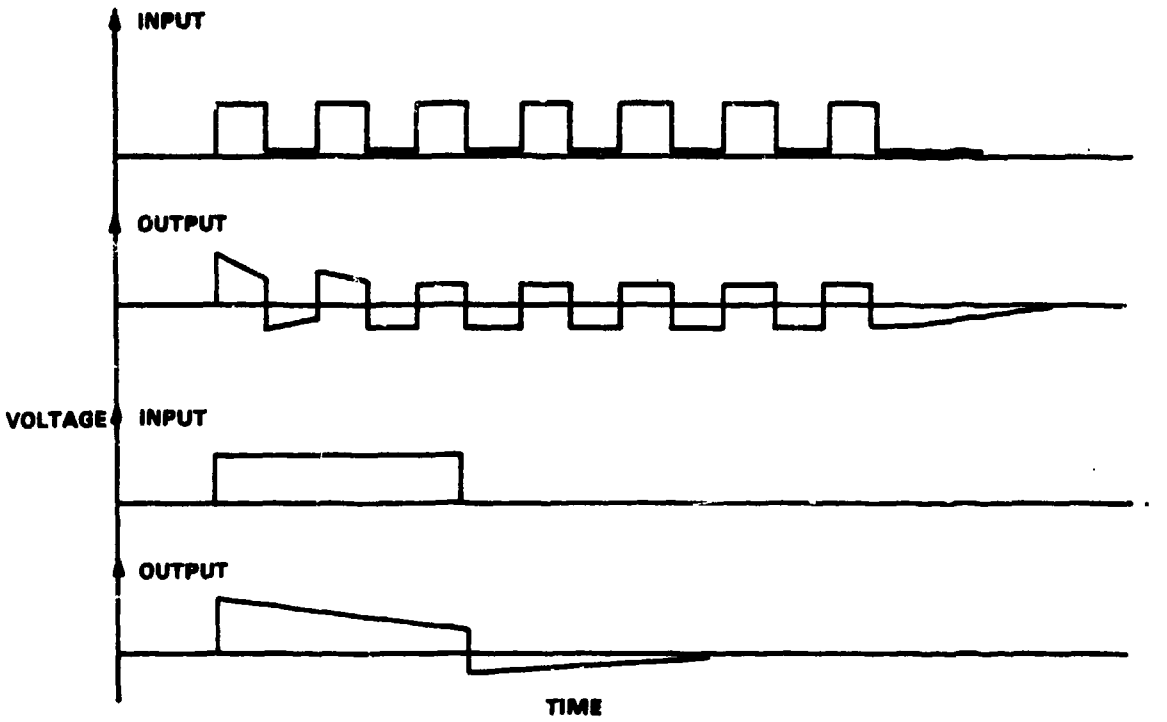


FIGURE 122. Pulse distortion due to low frequency exclusion.

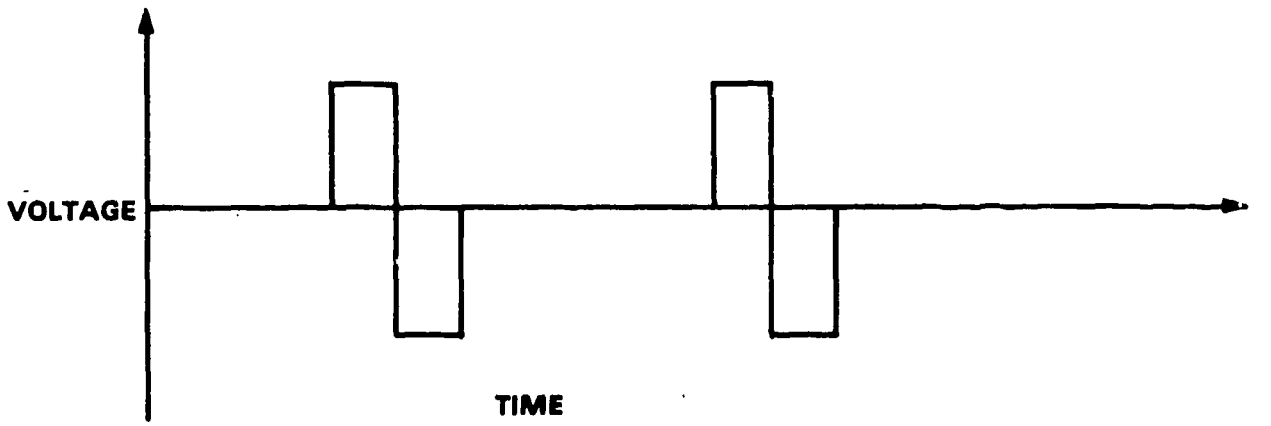


FIGURE 123. Bi-polar pulses.

frequency range of the Type B signal. VSWR requirements are shown in figure 124. Two types of requirements are defined, i.e. maximum VSWR allowed to be generated by the mission store and minimum VSWR with which the mission store must be compatible. These mission store requirements are defined at the MSI and also at the ASI when the umbilical cable is the responsibility of the mission store.

The VSWR measured looking into the MSI (i.e. into the store) is driven by the performance of the MSI connector contact for high frequency applications (above a few hundred MegaHertz). As is addressed in 5.1.5.2.1, the shielded M39029/75 (and /28) contacts provide marginal VSWR performance as signal frequencies approach the upper end of the Type B signal frequency range. Better performing contacts (but not currently QPL'd) are available for a much lower VSWR. (See 5.1.5.2.1 for details on these contacts.)

5.2.6.4 Network compatibility. At the conclusion of the store design process, the mission store's HB port performance levels and requirements must be compatible with the aircraft distribution network performance. This network performance and associated network design considerations are addressed in 5.1.5.1 through 5.1.5.3 of this report. Refer to those sections for network compatibility considerations.

5.2.7 Low bandwidth interface. The low bandwidth (LB) interface requirements only apply to those mission stores which use the LB interface. If the store does not use the LB interface, then only a limited set of requirements apply. These are: (1) The MSI receptacle must be compatible with mating umbilical plugs which contain the LB interface twinaxial contact; (2) impedance measurements made with this mating plug at the MSI must indicate a line-line (non-inverting to inverting connection) impedance of 70 ohms or greater, i.e. can be an open circuit; and (3) measurement of the LB shield connection at the MSI must indicate either an open circuit or continuity to store structure ground.

In contrast, if the store uses the LB signal interface, then the requirements of MIL-STD-1760 paragraph 5.2.1.3 apply and the comments below should be considered by the store designer.

5.2.7.1 Application restrictions. The LB interface is restricted by the AEIS standard to an audio signal function. (Audio is intended to refer to tones and voice signals that are generally destined for the human ear.) As mentioned in note 6.9 of MIL-STD-1760, the LB interface characteristics are selected so that future use of the LB interface as a point-to-point low speed serial data link would be a potential option. This link might be patterned after an EIA-STD-RS-485 system using Manchester encoding and operating at 38 kilobaud. This use, however, is currently not allowed and will not be permitted without DoD approval. If a low speed serial link is added at a future time, the signal characteristics, waveform encoding details and protocol will be standardized and included in MIL-STD-1760.

FREQUENCY RANGE	HB1	HB2	HB3	HB4
5 TO 20 MHz	X	X	X	X
20 TO 1.6 GHz	X			

NOTE: THE FREQUENCY RANGE IS AS SHOWN IN THE TABLE OR, WHEN APPLICABLE, A LOWER RANGE AS SPECIFIED BY THE EQUIPMENT LOAD

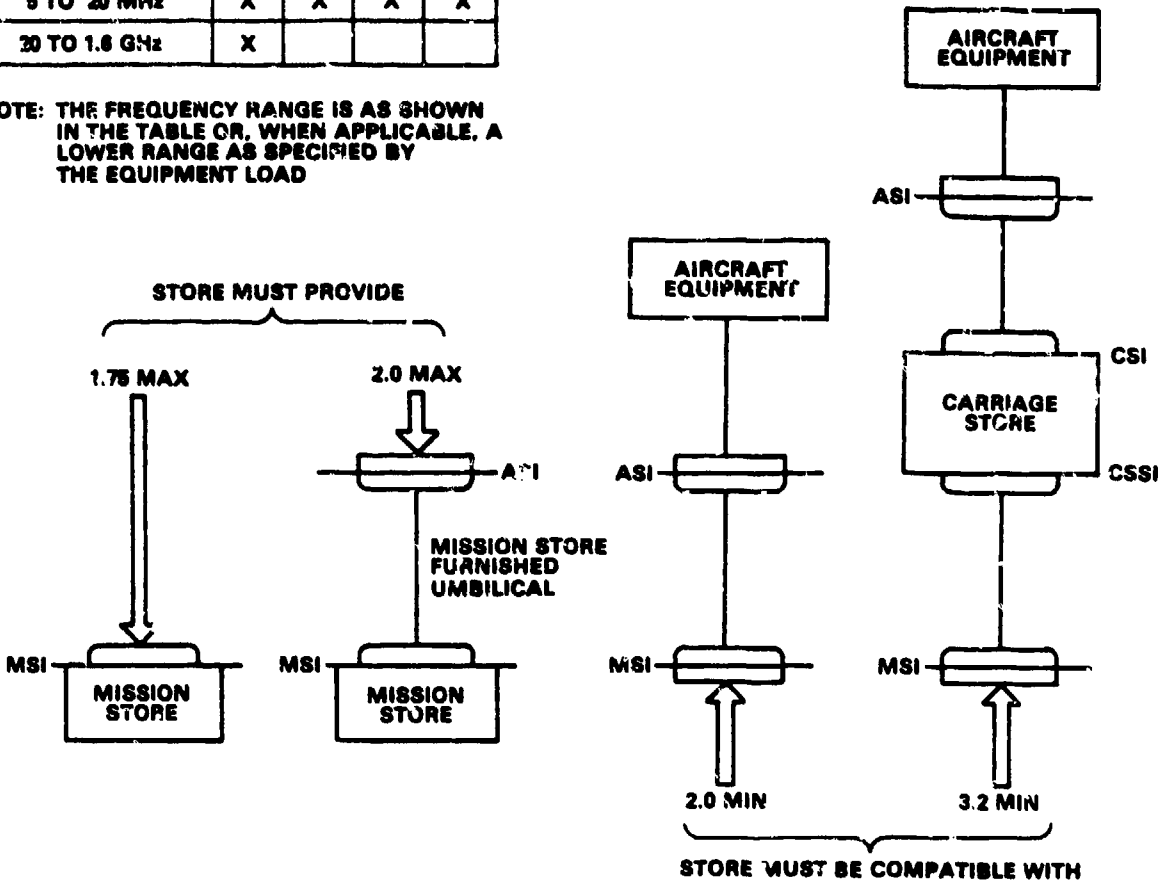


FIGURE 124. Mission store VSWR requirements.

As a result of the restriction, the store designer must consider the use of MIL-STD-1553 based serial data interface (see 5.2.2) for data transfer functions between the store and the aircraft.

5.2.7.2 Design requirements. The LB interface requirements in MIL-STD-1760 are limited to impedance bounds (input and load) and signal characteristics (voltage, current, frequency).

The LB signal voltage (sourced by the store or delivered to the store by the aircraft) is bounded by limits of -12 volts to +12 volts peak over a frequency range of DC to 50 kiloHertz. The signal current is restricted to a maximum of 150 milliamperes. The DC to 50 kiloHertz is intended to define the passband of the aircraft's distribution network. As a result, a store's signal might contain frequency components outside this band (harmonics, for example) but the store must not depend on having these out-of-band signal components delivered to load equipment. Likewise, store LB receivers must not assume that signals sourced to the store will not contain frequencies components beyond 50 kiloHertz. The store is permitted, however, to filter out or otherwise discard these out-of-band components.

Both the MSI input impedance seen looking into the store and the load impedance at the MSI seen by the store are required to be greater than 70 ohms over the DC to 50 kiloHertz frequency. (This impedance requirement does not apply when looking into a transmitting source.)

One point that needs to be clarified is that the actual impedance needs to be selected such that the voltage and current limits are not exceeded. For example if the specific signal used in an application has a 12 volt level, the store must provide an impedance greater than 80 ohms instead of the 70 ohms in order to meet the 150 milliampere maximum current requirement. In contrast, the 70 ohm load can be used if the application calls for a signal with a maximum voltage level less than 10.5 volts. (For example, a 7.0 volt digital signal can use the 70 ohm load.)

The aircraft LB discussion (5.1.6.1) stated that if the aircraft uses a LB signal distribution network technology that results in signal termination within the network (e.g. a FDM system), then the load impedance provided by the aircraft would be 80 ohms minimum across the LB frequency band. Therefore the store can transmit a full level voltage (12 volts) if required for specific applications.

The second point is that the impedance is defined at 70 ohms minimum over the DC to 50 kiloHertz band. However, this band definition only applies to the aircraft's signal distribution network. Specific equipment (e.g. store or aircraft avionic subsystem) connected to the LB network can have input

impedances below this 70 ohm limit at specific frequencies outside the frequency band of interest for a specific application. For example, figure 125 illustrates the 70 ohm impedance level across the entire 50 kHz band as it applies to the distribution network. The figure also shows that a specific equipment (for example, an audio amplifier) connected to the network may only be interested in a smaller band within the 50 kHz range - e.g. 300 Hz to 3 kiloHertz. As a result of this narrower frequency range of interest, the connected end using equipment (audio amplifier in the example) may contain a bandpass filter or other components such as a transformer which yields a lower impedance outside the 300 to 3 kiloHertz range but not inside the DC to 50 kiloHertz band. This narrowing of the band for applying the 70 ohms minimum impedance to a specific signal application is acceptable.

5.2.7.3 Circuit implementations. The store LB circuit design needs to be compatible with the aircraft network characteristics discussed in 5.1.6 and the design requirements described in 5.2.7.2.

Since MIL-STD-1760 presently limits the use of the LB interface to audio (tones and voice) functions, the use of transformer coupling as shown in figure 126 is a viable design choice. Transformer coupling provides the opportunity to decouple the store signal ground from the aircraft subsystem signal ground. This decoupling significantly reduce the injection of structure ground noise into the audio system.

As mentioned in 5.2.7.1, the MIL-STD-1760 LB interface characteristics encompass a frequency range broad enough to support the transfer of low speed serial digital data. However, use of the interface for this application is currently not allowed by the standard. If allowed in the future, characteristics of the low speed data link will be added to the standard.

The inclusion of low speed data compatibility in the interface definition results in spreading the conventional audio band down to DC and up to 50 kiloHertz. (Conventional audio is defined in different bands depending on whose definition is being used. Voice based systems are typically rated from 300 to 3500 Hertz with possible expansion to a 200 to 6000 Hertz range to fully capture intelligible information.) Driving the LB frequency range down to DC is done to allow direct connection of digital line drivers such as EIA-STD-RS-485 devices. (See figure 127a.) The RS485 driver is a balanced line system but results in a DC component on a line-ground basis and may result in a DC component line-line. The line-line DC component can be removed by selecting particular bit encoding methods such as phase encoding. The major disadvantage of the figure 127a circuit is that a connection to a common signal return with the aircraft circuit is required. (The figure shows using the shield and resistor R for this connection.) This connection results in inducing structure ground noise into the signal (mostly as common mode) with a resulting degradation in performance.

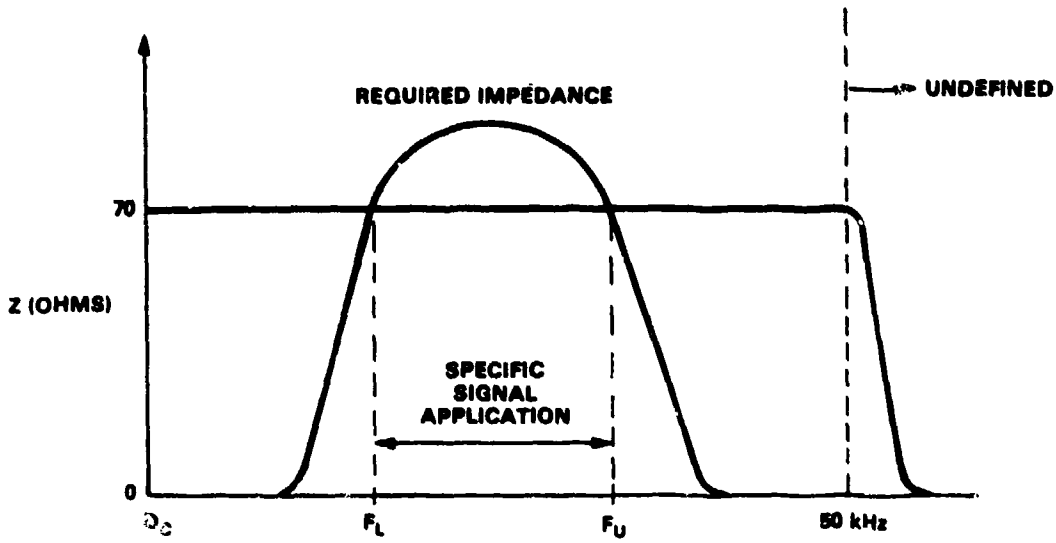


FIGURE 125. Impedance requirements.

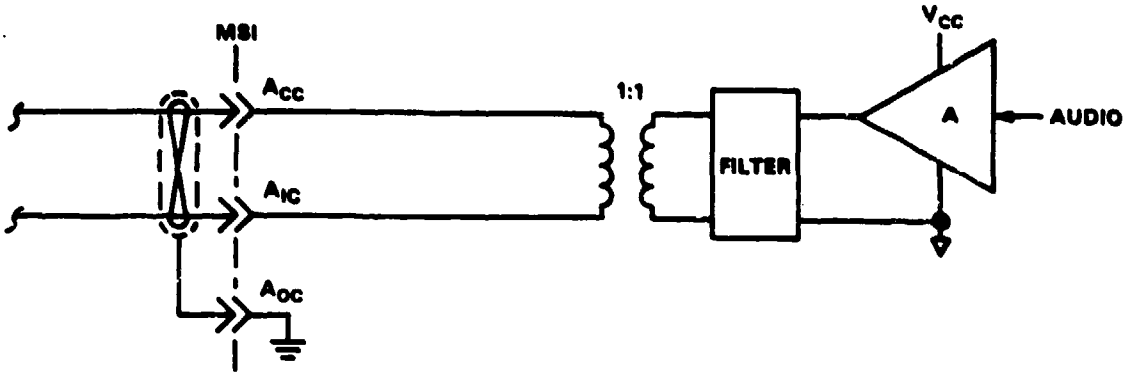


FIGURE 126a. Audio source.

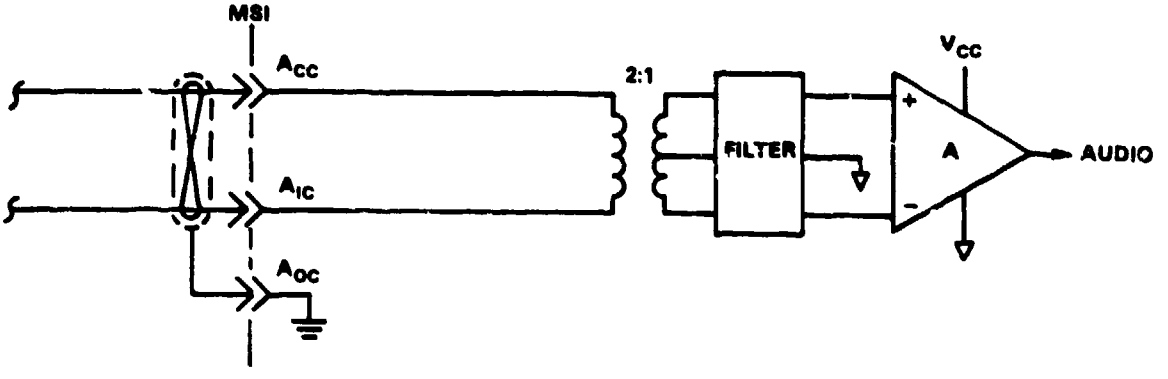


FIGURE 126b. Audio receiver.

FIGURE 126. Transformer coupled audio.

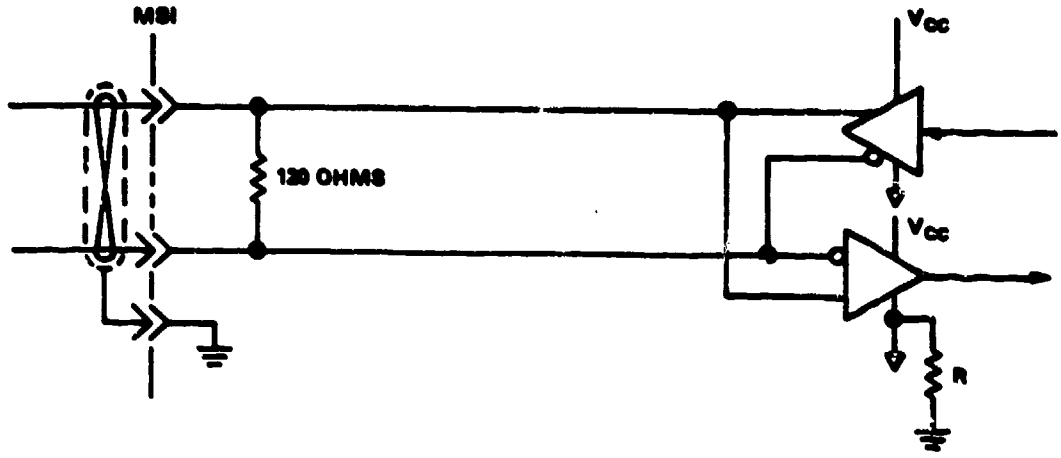


FIGURE 127a. Direct connect balanced line data link.

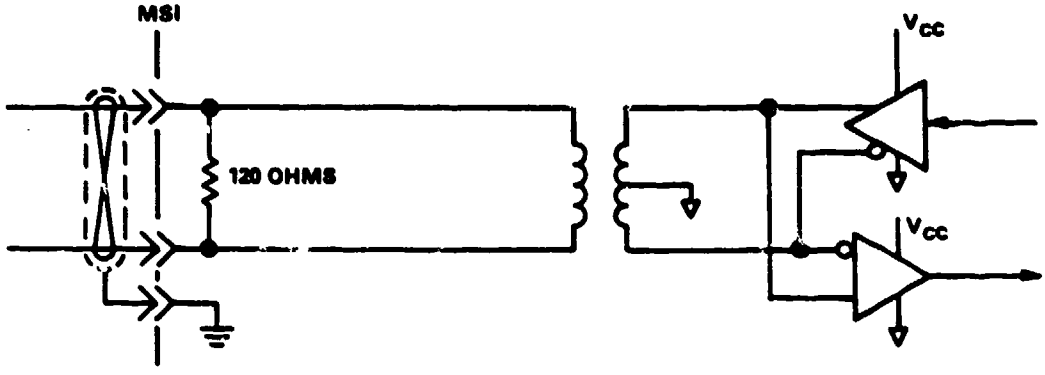


FIGURE 127b. Transformer coupled data link.

FIGURE 127. Low speed data application.

Figure 127b illustrates a solution for this ground noise problem by decoupling the signal ground of the store and aircraft with a transformer. The use of a transformer, however, increases the component count in the store and requires use of a balanced bipolar bit encoding technique such as bi-phase.

5.2.8 Power interface. This section discusses the voltage characteristics and power available at the MSI, power isolation, wire sizing and protection, power loss requirements, power factor, phase unbalance and connector deadfacing for the mission store.

5.2.8.1 Voltage characteristics at the MSI. MIL-STD-1760 allows a 2.0 volt drop between the ASI and MSI for 28V DC power and a 3.0 volt drop for 115V AC power. The allowed voltage drop for 270V DC power is not defined. The voltage drop allocations apply with and without the use of a carriage store. Subtracting these voltage drops from the voltage characteristics defined for the ASI results in the characteristics shown in figure 128 for 28V DC power and figure 129 for 115V AC power for the equivalent of MIL-STD-704 "normal" characteristics. The mission store is required to provide the full performance defined by its specification, when supplied this normal voltage. The mission store is not required to meet its performance requirements when supplied voltage characteristics that are abnormal. Abnormal voltages are voltages outside the limits shown in figures 128 and 129, and are caused by a malfunction or failure in the aircraft electric power system. Unless designated in the system specifications, the mission store is also not required to perform during a momentary loss of power as occurs during a power bus transfer. However, during an abnormal voltage condition or momentary loss of power, the mission store:

a. Is permitted a degradation in performance (unless specifically required otherwise by the mission store specification).

b. Must not produce a damaging or unsafe condition, and

c. Must automatically recover to full specified performance when the voltage is restored to normal conditions.

5.2.8.2 Power availability. The continuous power available at the MSI is depicted in table XIX. However, see 5.2.1 for qualifications on the availability of these levels particularly when the aircraft is carrying a large store loadout.

5.2.8.3 Store power demand. The mission store must limit its continuous and instantaneous current demand to values equal to or below the "Maximum Load Current" curve of figures 83 and 84 when connected to the MSI.

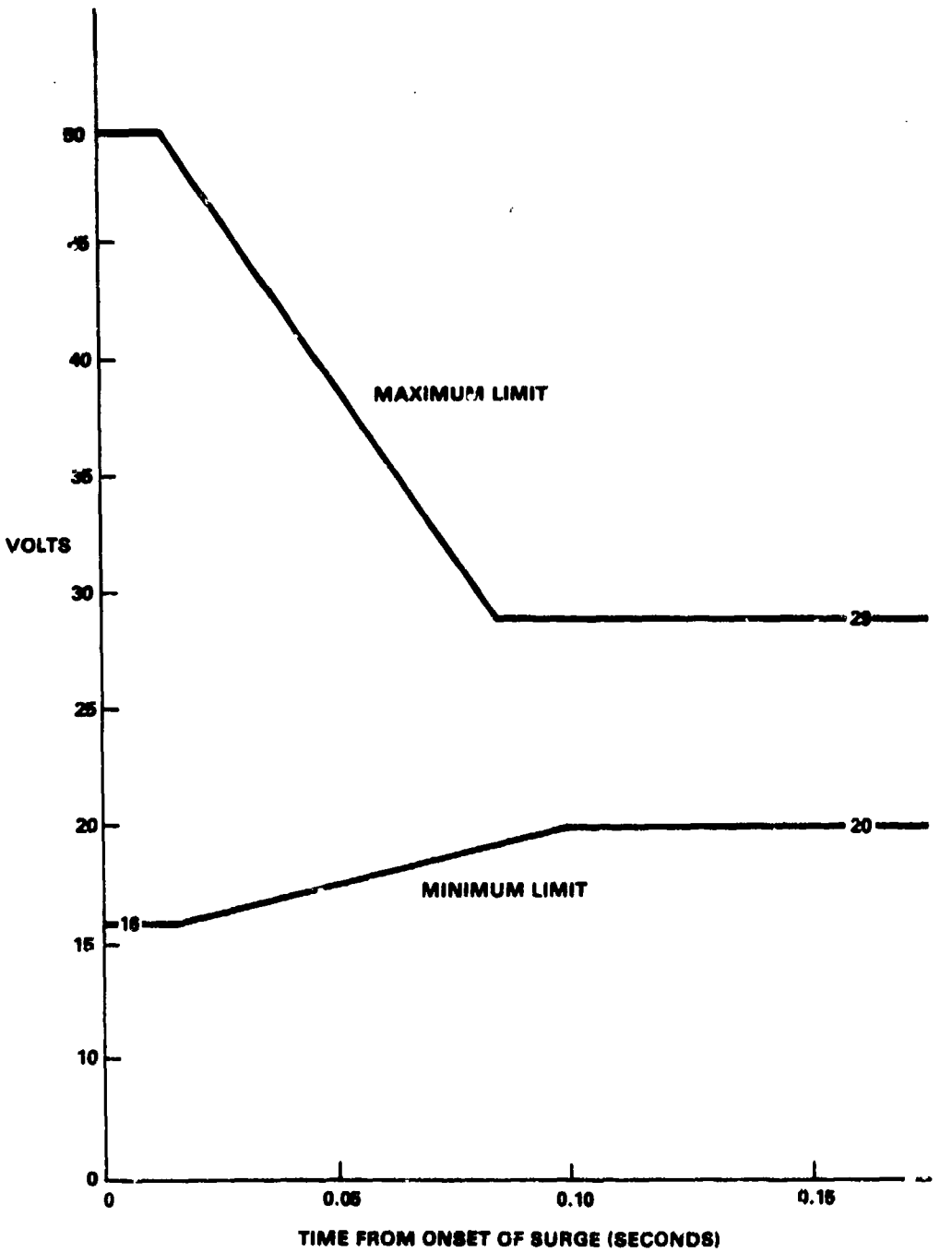


FIGURE 128. Envelope of normal DC voltage at MSI.

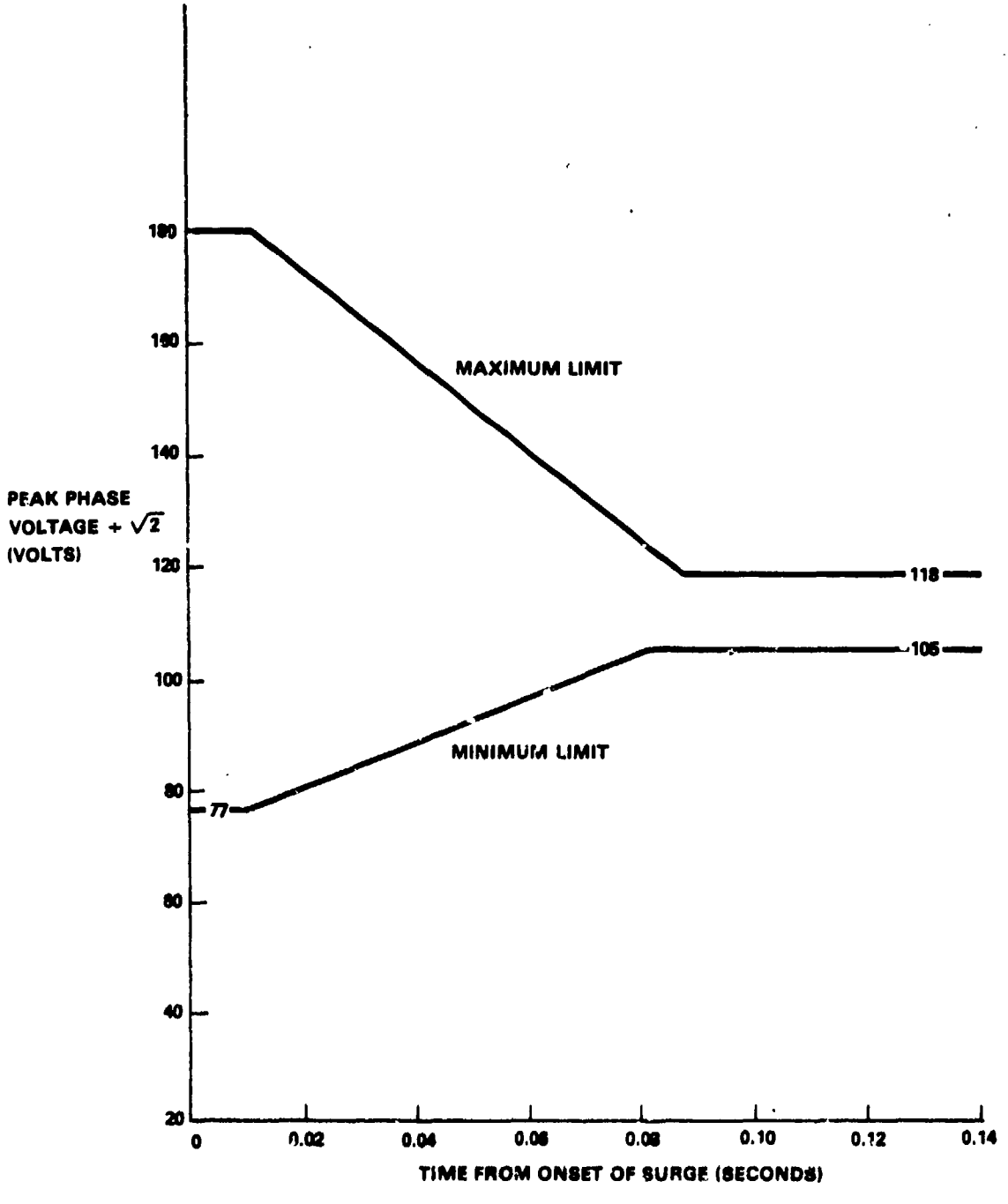


FIGURE 129. Envelope of normal AC voltage at MSI.

TABLE XIX. Continuous power available at the MSI.

Voltage	Rated Current (Amperes)	
	Primary Interface	Auxiliary Interface
20.0 to 29.0V DC	-	30 2/
20.0 to 29.0V DC PWR 1	10	-
20.0 to 29.0V DC PWR 2	10	-
105-118V AC	10 1/	30 1/ 2/
270V DC	- 3/	- 3/

1/ The current available at the MSI is reduced to 90 percent of the per phase current for the primary interface and to a total of 29.0 amperes per phase for the class IA and IIA interfaces if the current is supplied through a carriage store.

2/ This limit defines the maximum total current available at the MSI for both the primary and auxiliary interfaces.

3/ 270V DC power is a growth provision and presently not available at the MSI.

NOTE

The mission store AC current demand must not exceed 90 percent of the per phase current (figure 83) for the primary interface and must not exceed a total of 29 amperes per phase for class IA or IIA interfaces when the mission store is operated from a MIL-STD-1760 type carriage store.

The mission store may be designed to use power from either the primary interface or the auxiliary interface. However, it should be noted that the auxiliary interface is available at a very limited number of aircraft stations. (See 5.2.1 for considerations on selection of store interface classes.)

The store should be designed to operate from the aircraft's main electric power source which is generally 115/200 volt AC power. Operating from other power sources, i.e., 28V DC, results in a less efficient weapon system since these 28V DC power sources are obtained by converting the 115/200V AC power. Also, the store should be designed to operate from three phase power rather than single phase power. A severe problem can arise for the aircraft electric system when large amounts of single phase power are used. A large single phase load can cause a voltage unbalance which, in turn, can degrade the performance of other equipment using this power. The maximum single phase power allowed by MIL-STD-704 is 500 volt-amperes. (See 5.2.8.7.)

5 2.8.4 Power isolation. Power to the MSI can be supplied from different power sources. Consequently, it is important that isolation be provided within the mission store to prevent interaction between the power sources.

CAUTION

The store must not connect 28V DC power 1 and 28V DC power 2 nor primary interface 28V DC power and auxiliary 28V DC power to a common "bus" in the store. Similarly, primary 115/200V AC and auxiliary 115/200V AC must not be connected to a common internal store bus.

This caution is highlighted because the voltage level of one power source (e.g. 28V DC power 1) can be different than the voltage level from a second source (e.g. 28V DC power 2). These unequal voltages can result in current

from the higher voltage source to flow into the store then back out the store toward the second power source (aircraft bus). Another problem is that the unequal voltages will result in unequal load division between the two power sources and could result in tripping the aircraft power circuit protection device. Figure 130 shows acceptable, preferred and unacceptable designs for the store power load connections.

5.2.8.5 Wire sizing and protection. MIL-STD-1760 requires the mission store to be compatible (i.e. safely withstand) with the overcurrents available at the MSI. These overcurrents as well as the time durations for the overcurrents are given by the "Maximum Overcurrent" curve in figure 83 for the primary interface and figure 84 for the auxiliary interface. This curve defines the maximum current that can be sourced to the MSI during a fault condition when the fault occurs on the mission store side of the MSI. The mission store wiring and power distribution components must be able to support this current without becoming unsafe. It must be remembered that the "Maximum Overcurrent" curve represents an abnormal condition which may never occur over the life of the mission store. Nevertheless, it must be assumed that this condition can occur and the continuous current of 24 amperes for the primary interface and 58 amperes for the auxiliary interface could last for an appreciable long period of time, i.e., one flight time. If the mission store circuit designer chooses to use the aircraft protective system for mission store protection, the wire and power distribution components within the store must be able to withstand this abnormal condition for at least one flight time. It is assumed the fault will be corrected after the flight by removing the faulty store.

If a store designer chooses to use the aircraft protection system to protect the store wire, it is recommended that the wire be no smaller than gauge 16 for the primary interface and no smaller than gauge 10 for the auxiliary interface.

An optional design for meeting the compatibility requirement is to include protection within the mission store. This may be a viable option, especially if the mission store current demand is much less than 10 amperes for the Primary interface and 30 amperes for the Auxiliary interface. The mission store protective device can be a fuze, circuit breaker or current limiter. A trade-off between reliability degradation and safety resulting from including a protective device should be made during store design.

The store's protective device fault clearing capability can be lower than is normally required because the fault current is limited by the aircraft protection system. Coordination of the store protective device with the aircraft protective device is not required since tripping of either device will protect the store power distribution system. The disadvantage of using protection within the store is the added design complexity and voltage drop resulting from using these devices.

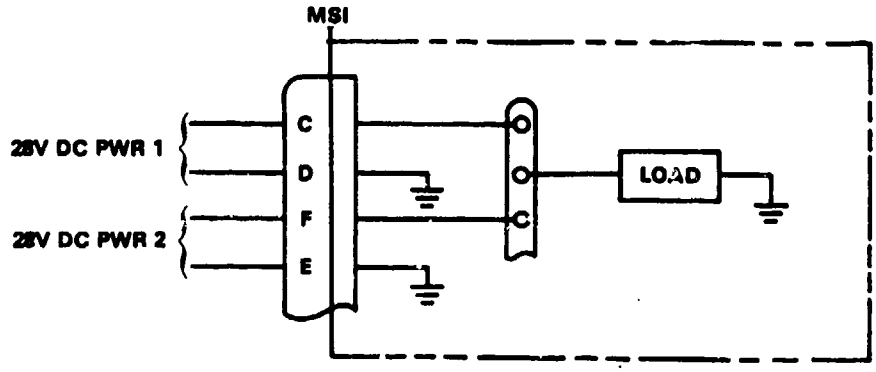


FIGURE 130a. Unacceptable.

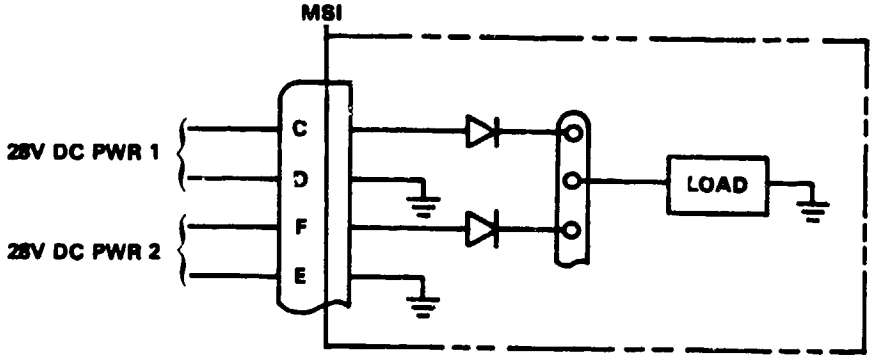


FIGURE 130b. Conditionally acceptable.

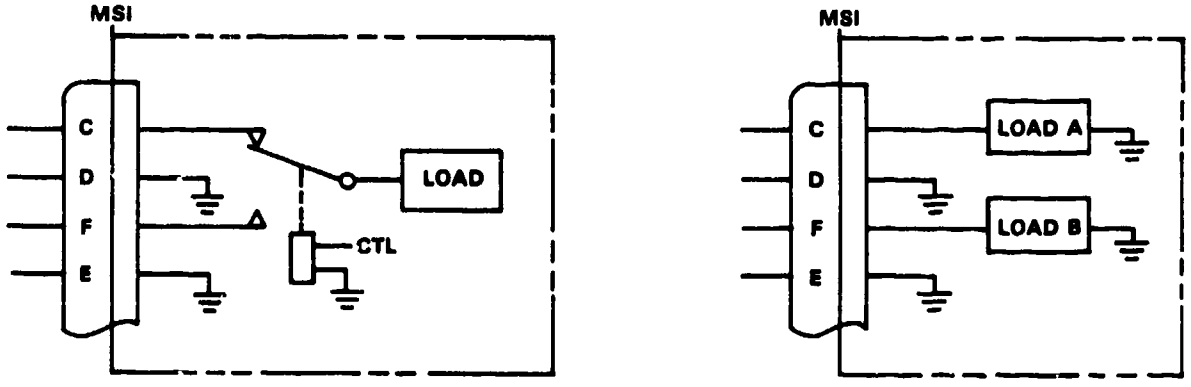


FIGURE 130c. Preferred.

FIGURE 130. Store power load connections.

5.2.8.6 Power phase loss. In a three phase power system, one phase may become inoperative (de-energized). This can result from a single phase fault and subsequent opening of a single phase circuit breaker, a wire breakage or a failure of a power switching component. In general, a mission store is not required to perform in the event one or two phases become inoperative. The mission store detail specification will dictate if degraded or full performance operation is required during this condition. However, the mission store must not produce a damaging or unsafe condition upon the loss of one or more phases of power. This requirement is representative of requirements imposed on utilization equipment by MIL-STD-704.

5.2.8.7 Phase unbalance and power factor. Mission stores utilizing AC power must be designed to present as near a unity power factor as practicable for all modes of operation. The store is required to present a power factor on the worst phase not less than the limits specified in figure 131. These limits are the same as those specified in MIL-STD-704A for Category A and Category B equipment. (Subsequent revisions to MIL-STD-704 removed the phase power factor requirement. Hence, it is included in MIL-STD-1760.)

Similarly, mission stores requiring three phase AC power must be designed to require equal phase volt-amperes insofar as practicable. The phase volt-ampere difference between the highest and lowest phase values must not exceed the limits specified in figure 132 (assuming balanced voltages).

If a carriage store is used, balancing loads between phases can be improved by rotating phases within the carriage store, providing the phase sequence of ABC is maintained. (See 5.1.7.6 for phase sequence discussion.)

5.2.9 Electromagnetic compatibility. The AEIS standard contains only limited EMC requirements on the mission store. This limited coverage exists because a store's system specification will define the specific EMC applicable to the store and the levels of performance expected under various EMC conditions.

Usually, the system specification will require EMC compliance to MIL-STD-461 emission and susceptibility limits and require testing by the methods of MIL-STD-462. A general goal exists to develop stores which are compatible with a number of aircraft (some of which do not even exist when the store is designed). Since the aircraft cabling network to which the store will mate varies with each aircraft, paragraph 5.2.3 of MIL-STD-1760 defines a common set of test cables for use in conducting the MIL-STD-462 tests. The standard therefore requires that if the store system specification requires MIL-STD-462 testing, then at least one set of tests must be run with the standard test cables. This does not preclude the store system specification from also requiring the store to be tested to MIL-STD-462 using cable configurations representative of the specific airplane(s) identified in the system specification.

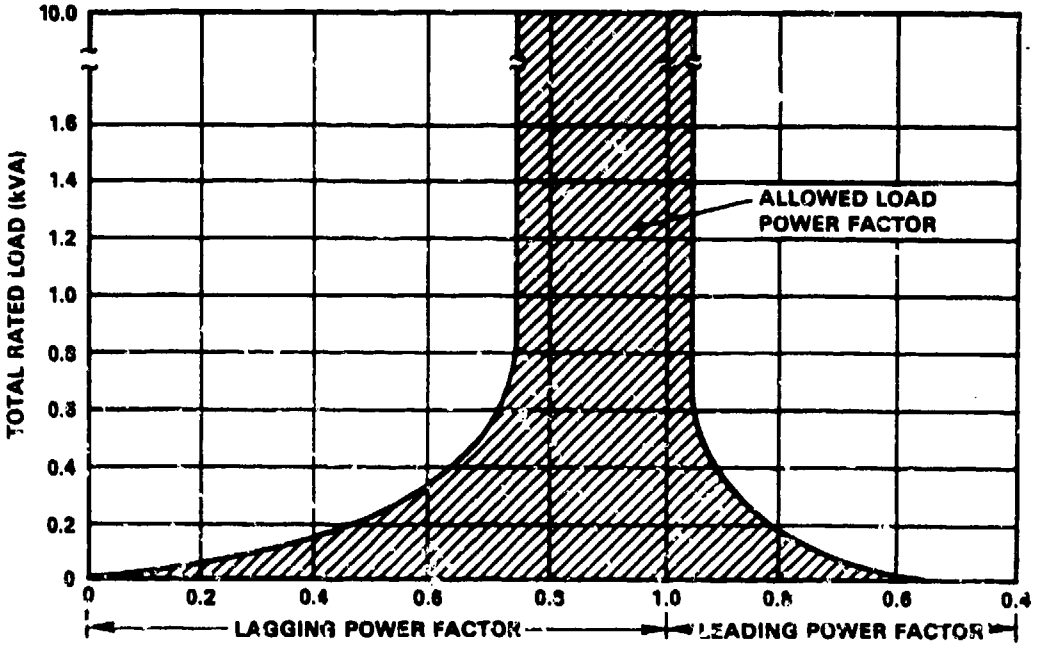


FIGURE 131. Mission store power factor limits.

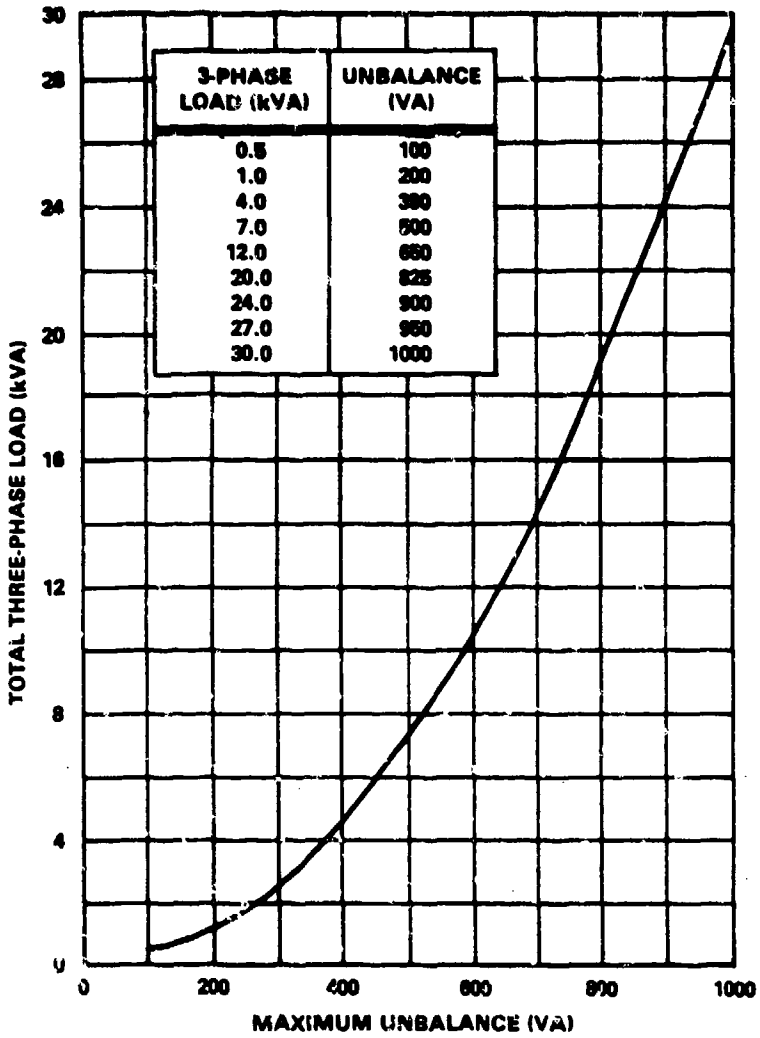


FIGURE 132. Unbalance limits for three phase mission store loads.

It should be noted that MIL-STD-461 and MIL-STD-462 essentially test a store as a black box to evaluate the store against a set of EMI levels which are not representative of any specific aircraft. The levels include a margin of safety in order to help assure a high chance of electromagnetic compatibility when the store is installed on the aircraft. The test cables defined by MIL-STD-1760 continue this philosophy by being defined with construction requirements which reflect a non-optimum cable design from an EMI perspective. While the design is non-optimum, it does reflect part of a typical cable configuration in an aircraft.

While the AEIS standard does not directly impose EMC requirements on the store, the standard does include interface requirements which influence the EMC characteristics of the overall weapon system. Examples include required shield ground connections, required ground references and allowed signal levels (which affect the SNR). The paragraphs which follow point out some of these considerations and also includes representative EMI levels that can be expected at the MSI during some of the MIL-STD-461 tests with the standard test cables.

5.2.9.1 Interface grounding and shielding. A consistent grounding and shielding philosophy between the aircraft and store substantially reduces EMC problems. Section 5.1.9 presents the grounding and shielding requirements and options from the perspective of the aircraft. The paragraphs below present a similar discussion from the mission store viewpoint. Unless otherwise designated, the measured noise levels discussed below were generated using the standard EMI test cables under exposure to fields of 200 volts/meter for the gross shielded cables and fields of 20 volts/meter for the unshielded cable assemblies. The figures show data measured in two sample cables of each type.

5.2.9.1.1 Digital data interface. The AEIS standard requires the store to ground the digital data interface shields (Mux A and Mux B) to the store structure. The standard also requires use of MIL-STD-1553 compliant remote terminals in the store. This requirement results in the use of tranformer coupling between the data bus stub at the MSI and the internal remote terminal electronics to minimize the effects of structure ground noise due to voltage differences between the aircraft and store. As discussed in 5.1.3, the use of grounded center tapped transformers on the bus side of the store RT transformer is not recommended. The introduction of this grounded center tap can degrade the line-ground balance between the data high and data low lines of the digital data interface unless very good quality transformers are used with a tightly controlled tap tolerance.

The noise levels injected into the data interface by various aircraft-store configurations are presented in 5.1.9.1.1 and 5.1.9.5. Figure 133 shows the noise levels expected when the MIL-STD-461 RS03 tests are run on a store

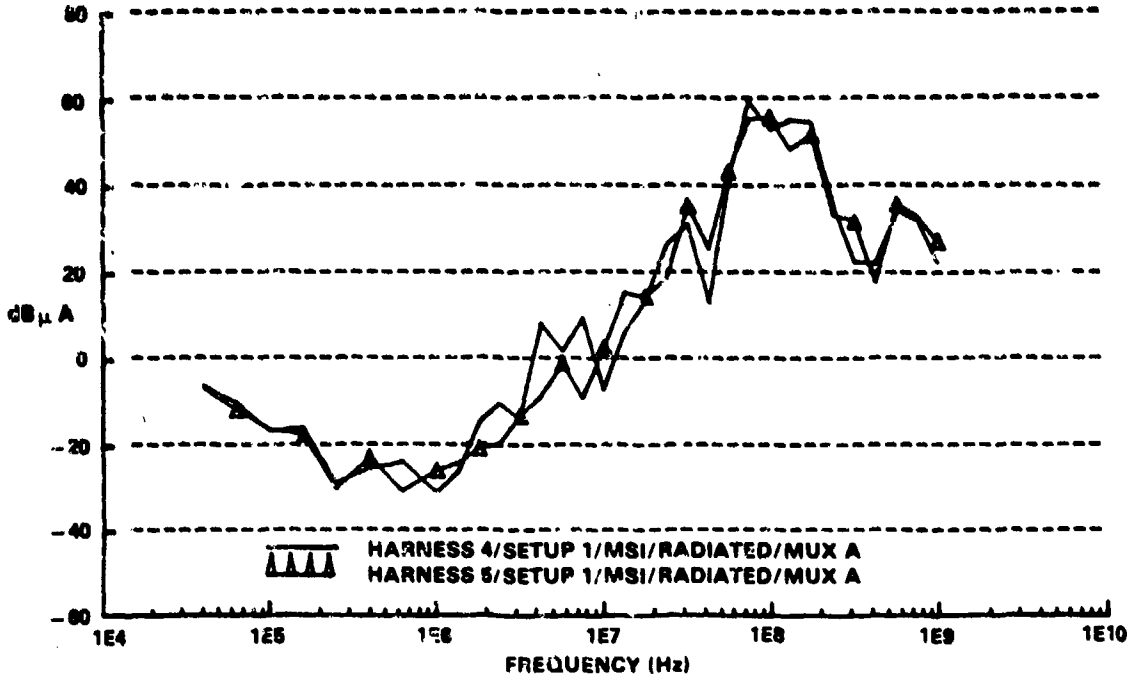


FIGURE 133a. Unshielded umbilical - 20 volts/meter field.

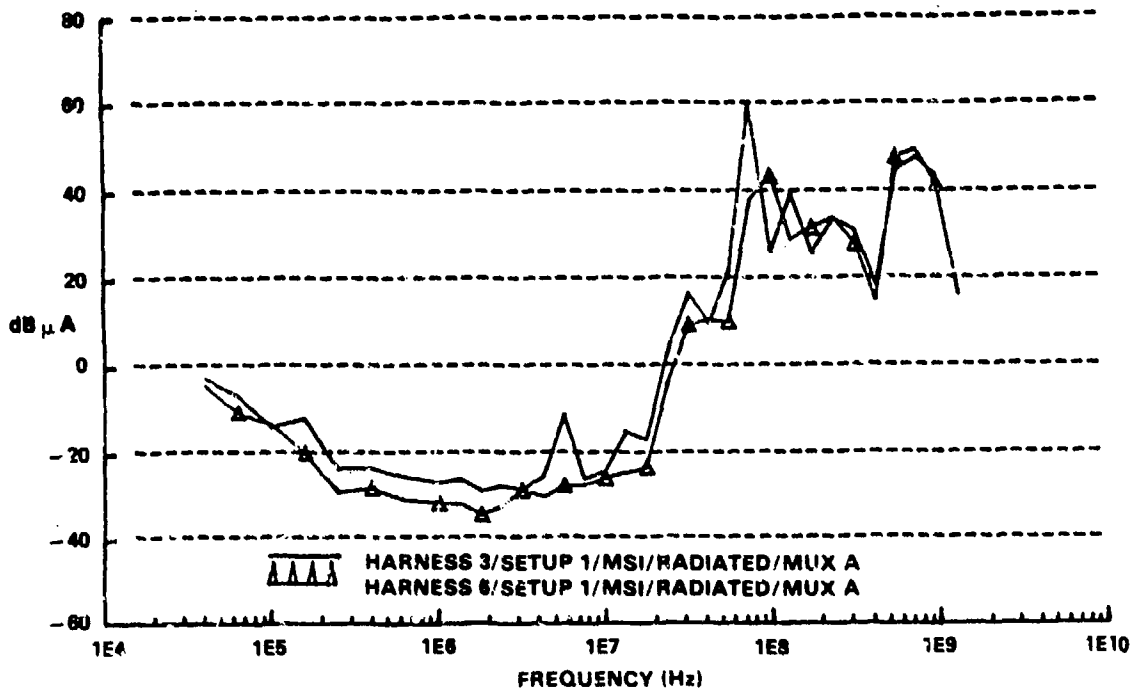


FIGURE 133b. Shielded umbilical - 200 volts/meter field.

FIGURE 133. Field induced noise levels at MSI - digital data interface.

using the standard test cables. As can be seen by comparing this figure with section 5.1.9 figures, the levels are comparable.

5.2.9.1.2 Interlock interface. To meet the interlock requirements, the store is only required to provide a jumper between the interlock and interlock return contacts on the store side of the MSI. As a result, the noise on the interlock interface from the aircraft can generally be kept out of the store electronics. The difference between the July 1981 and September 1985 revisions of MIL-STD-1760 in the use of interlock by the store also helps minimize EMI concerns by the store on interlock. (The July 1981 MIL-STD-1760 identified the use of interlock return referenced to structure ground as the mechanism for the store to determine "aircraft mated" status. The September 1985 MIL-STD-1760A requires the store to be totally isolated from the interlock interface and use the address discretes for "aircraft mated" status if such an indication is required.)

The noise levels on interlock for various aircraft-store configurations are contained in 5.1.9.1.2.1 and 5.1.9.5 for ASI measurements. Levels at the MSI are not much different. Figure 134 illustrates noise levels induced at the MSI interlock interface obtained during RS03 type tests with the standard EMI test cables. As can be seen, tests made with the standard cable yielded about 15 dB less noise than tests made with representative aircraft networks.

5.2.9.1.3 Address interface. MIL-STD-1760 requires that the aircraft isolate all aircraft circuitry (including grounds) from the address discretes. As a result, grounding of the address return occurs only in the store and at the ground point of the store's choosing, e.g., signal ground, power ground or structure ground. Even though the aircraft isolates the address discretes from aircraft power, signals and grounds, noise can still be injected onto the address lines due to electrostatic and electromagnetic coupling. Examples of typical induced levels for various aircraft-store configurations are presented in 5.1.9.1.2.2 and 5.1.9.5. As shown in 5.1.9.5, the power switching induced spikes can get rather high (e.g., 1 volt p-p). Figure 135 shows the noise levels induced into the address lines under RS03 field exposure with the standard test cables. In all of the cable configurations tested, the address discretes were twisted with the address return to cut down on electromagnetic coupling.

5.2.9.1.4 Release consent. The release consent interface is required by the AEIS standard to use the 28V DC power 2 return as its reference. From an EMI design perspective, selection of the power 2 return for the reference is not optimum. However, since release consent is characterized as a MIL-STD-704 power quality discrete, the mission store needs to treat the discrete as a "noisy" signal. Also, including a dedicated release consent return in the interface connector is undesirable from a connector size perspective. This reference does somewhat complicate the store's release

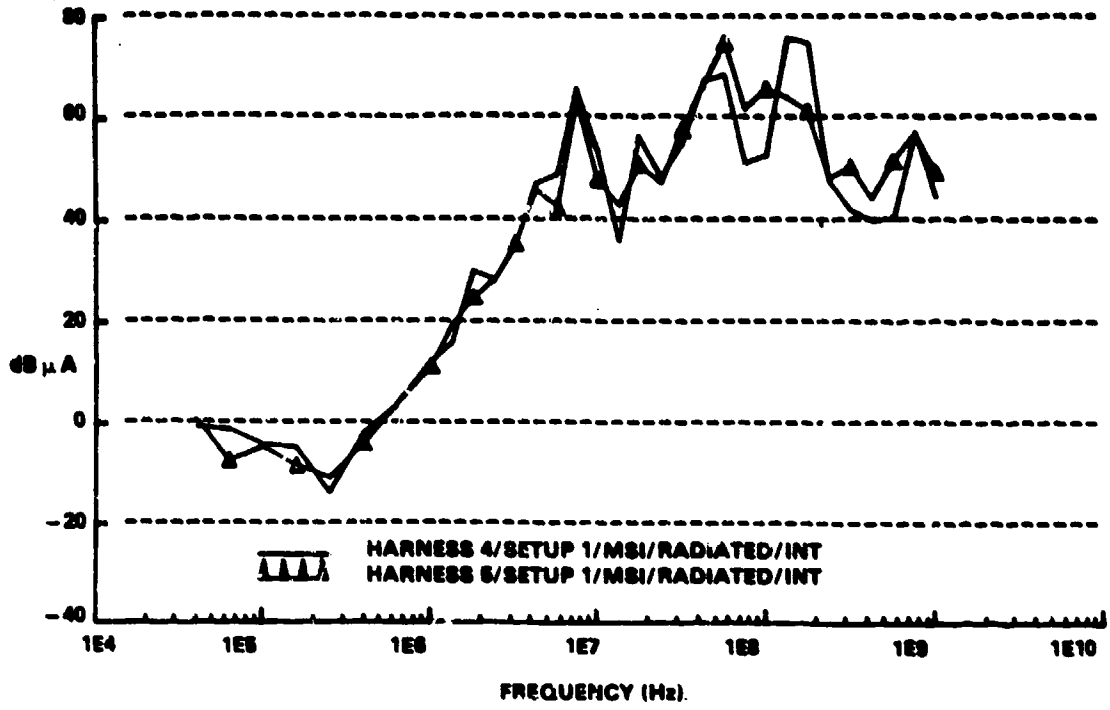


FIGURE 134a. Unshielded umbilical - 20 volts/meter field.

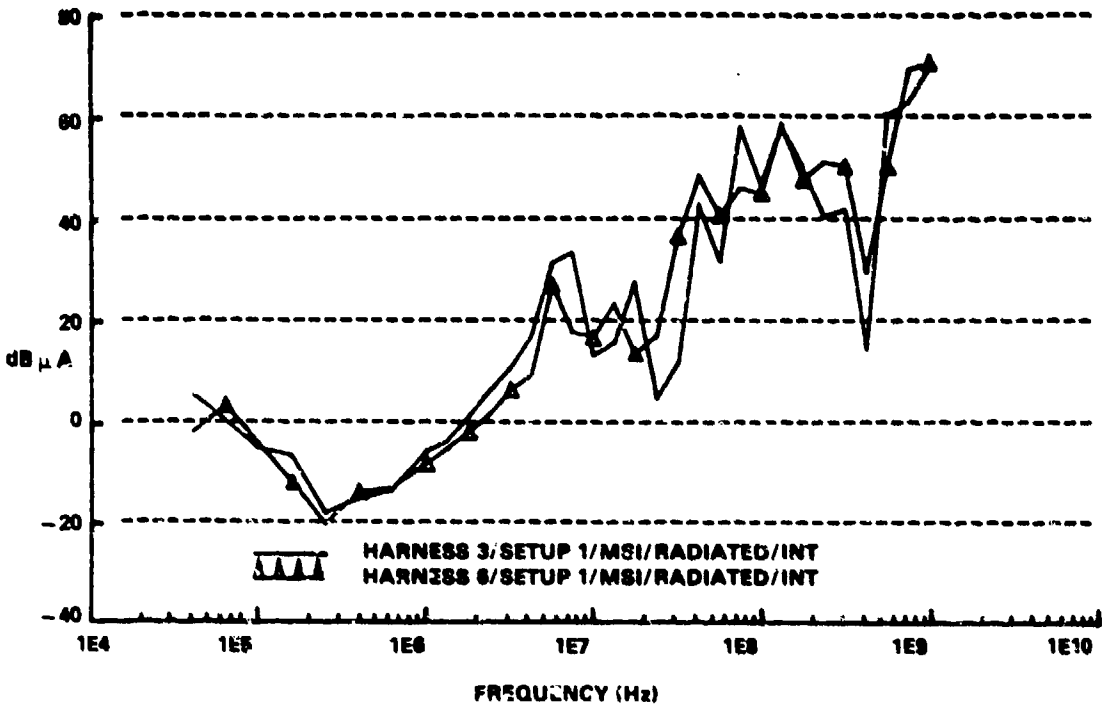


FIGURE 134b. Shielded umbilical - 200 volts/meter field.

FIGURE 134. Field induced noise levels at MSI - interlock interface.

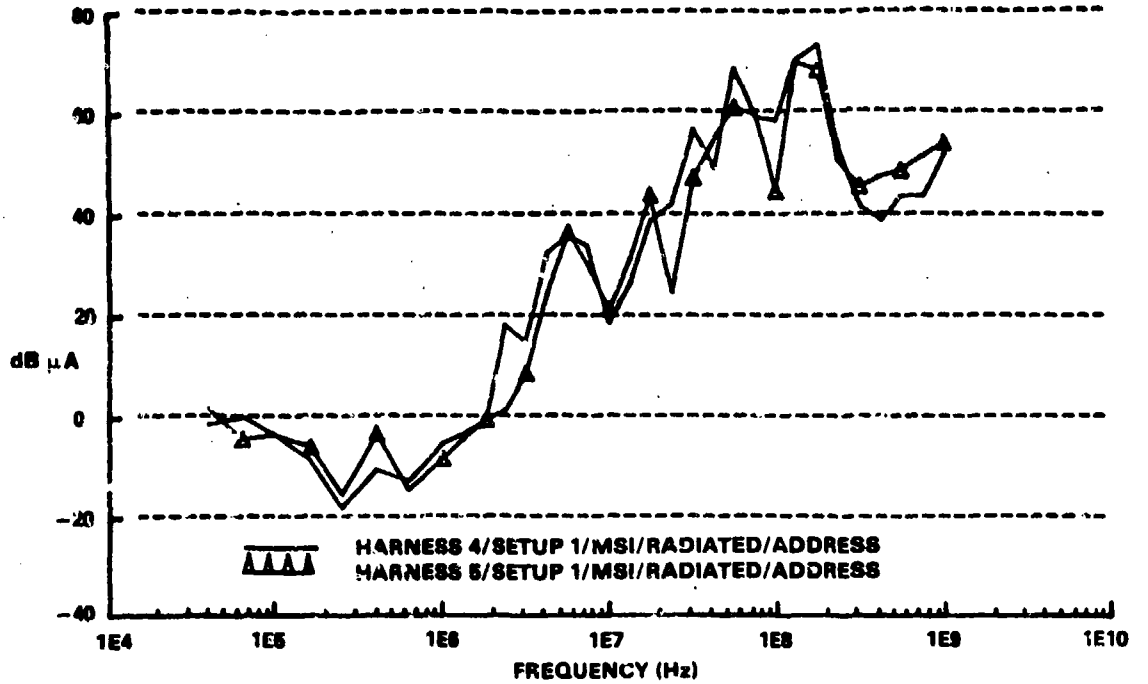


FIGURE 135a. Unshielded umbilical - 20 volts/meter field.

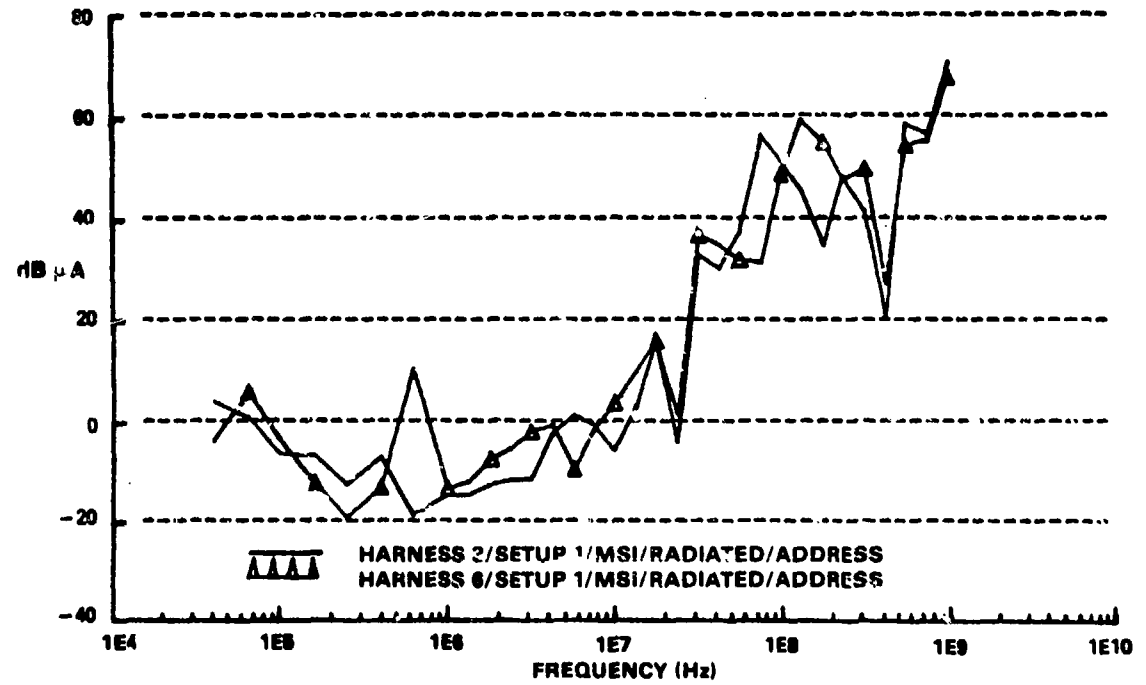


FIGURE 135b. Shielded umbilical - 200 volts/meter field.

FIGURE 135. Field induced noise levels at MSI - address discretes.

consent monitor circuit by requiring the signal to be referenced to 28V DC power 2 return. Figure 118 in 5.2.3 illustrates several circuit solutions for this reference problem.

The noise levels induced into the release consent interface are presented in 5.1.9.1.2.3 and 5.1.9.5 for measurements taken at the ASI. Similar data is shown in figure 136 for RS03 induced levels in the standard EMI test cables. This figure illustrates induced noise measured at the MSI. The levels with the test cables are approximately 20 dB lower in magnitude to the ASI levels measured with representative aircraft-store network configurations after adjusting for plotted units. The cables in all of these tests were constructed with the release consent line not twisted with the power 2 return. As a result, the release consent field induced noise levels are approximately 10 dB higher than levels obtained with similar tests on the 28V DC power 1 and power 2 interfaces. It is expected, however, that the noise levels induced into release consent during 28V DC power switching transient tests would have been higher than the levels shown in 5.1.9.5 if the release consent line was twisted with the power 2 interface line set.

5.2.9.1.5 Power interfaces. The AEIS standard requires a dedicated power return (or neutral) connection in the interface for each power type (i.e., 28V DC power 1, 28V DC power 2, auxiliary 28V DC, primary 115/200V AC, auxiliary 115/200V AC, primary 270V DC and auxiliary 270V DC). Also, the standard does not require any specific relationship between the power returns and structure ground in the store. The standard does, however, require the store to be compatible with aircraft which connect the power returns to aircraft structure and with aircraft which isolate power returns from aircraft structure. While this latter case complicates the aircraft's power system design (in order to meet personnel hazard requirements), it still might exist on some future aircraft systems.

Various power grounding schemes are discussed in 5.1.9.1.3 and are not repeated here. However, in general, the single point grounding scheme discussed in 5.1.9.1.3 is not practical because at some point in the store's operation, it will be disconnected from aircraft power (and its ground) and will then need its own connection to structure ground within the mission store. In addition, the internal store electronics will contain leakage paths to ground (such as stray capacitance) and provide unintentional paths to ground. An example of an unintentional path is a fired electroexplosive device (EED) shorted to ground because explosive residue provided a path between the firing element and EED case. The store electronics needs a consistent connection to structure ground rather than an intermittent and variable impedance connection. With this connection to structure, however, comes the potential of inducing noise voltages into the store electronics due to differences in voltage between the aircraft and store structures. Techniques to minimize this problem include use of transformer coupled power converters in the store for deriving store power from aircraft power and use of an internal store single point ground.

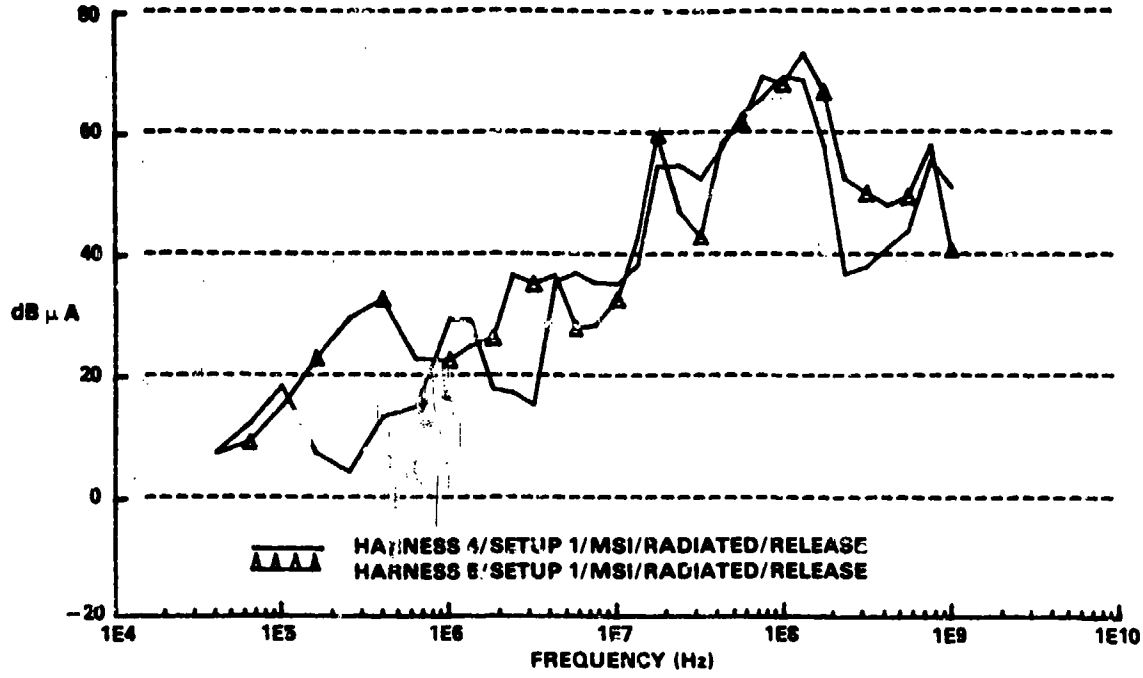


FIGURE 136a. Unshielded umbilical - 20 volts/meter field.

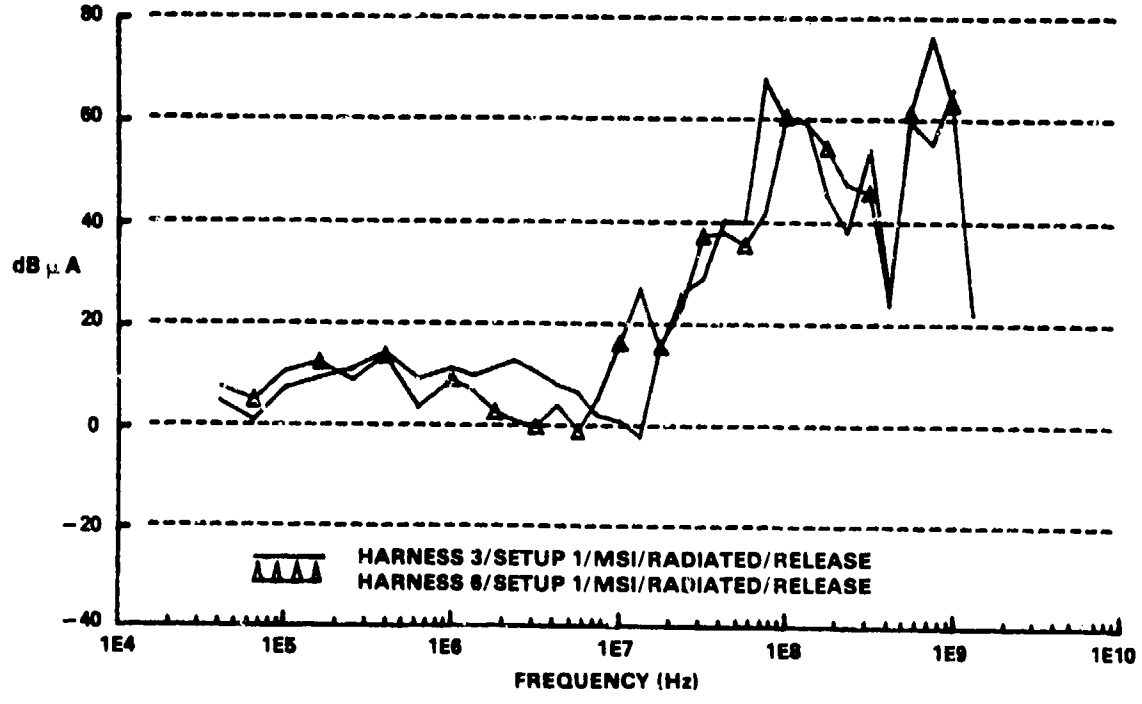


FIGURE 136b. Shielded umbilical - 200 volts/meter field.

FIGURE 136. Field induced noise levels at MSI - release consent.

To minimize additional pick-up of induced noise and to minimize power line radiated emissions, the store should use twisted wire pairs for each set of 28V DC (and 270V DC for potential future systems) power interface and twisted wire quadruplets for each 115/200V AC interface. Generally, no advantages are gained in noise reduction by shielding the power lines due to the relatively low frequency of the offending noise and the poor shielding effectiveness of shields at these low frequencies.

Typical noise levels induced into the power interfaces for representative aircraft and store network configurations are discussed in 5.1.9.1.3 and 5.1.9.5 for ASI measurement points. These levels are illustrated for both radiated field coupled and power switching transients. Comparable field induced levels are shown in figure 137 for 28V DC interfaces and in figure 138 for 115/200V AC interfaces. These values were measured at a primary interface using the standard EMI test cables but are comparable for the auxiliary interface also.

5.2.9.1.6 Low bandwidth interface. MIL-STD-1760 requires the Low Bandwidth (LB) interface shield be grounded on the store side of the MSI. This ground connection, when combined with the aircraft requirement to ground the LB shield, results in a multi-point shield ground for the LB interface. Test results indicate that even though the LB interface operates at relatively low frequencies (which generally suggests a single ended shield ground), a multi-point shield ground provides lower induced noise levels from external fields. These test results are somewhat expected given that the LB line uses a shielded twisted wire pair. The twisted wire pair provides the electromagnetic decoupling which allows the shield to be used as an electrostatic shield. Electrostatic shielding is more effective if multi-point grounding is provided.

The relationship of the inverting and non-inverting connections of the LB interface to store ground is not specifically defined by MIL-STD-1760. This lack of defined ground relationship exists because of the different potential LB interface uses. (See 5.2.7.2 and 5.2.7.3.) The standard does state that both non-inverting and inverting connections can be up to 12 volts above ground potential. The implication then is that neither line may be grounded in some applications. In general, it is recommended (see 5.2.7.3) that the LB interface be transformer coupled in the store to the store's electronics. This recommendation is made to help maintain a degree of signal decoupling between store signal grounds and aircraft signal grounds. The transformer coupling also allows a large portion of the line-to-ground noise to be cancelled by the common mode rejection (typically at least 40 dB) of the transformer.

Representative noise levels induced into the LB interface by external 200 volt/meter fields and by power switching transients are presented in 5.1.9.5. These levels were measured at the ASI. Similar levels measured at the MSI using the standard EMI test cables are shown in figure 139.

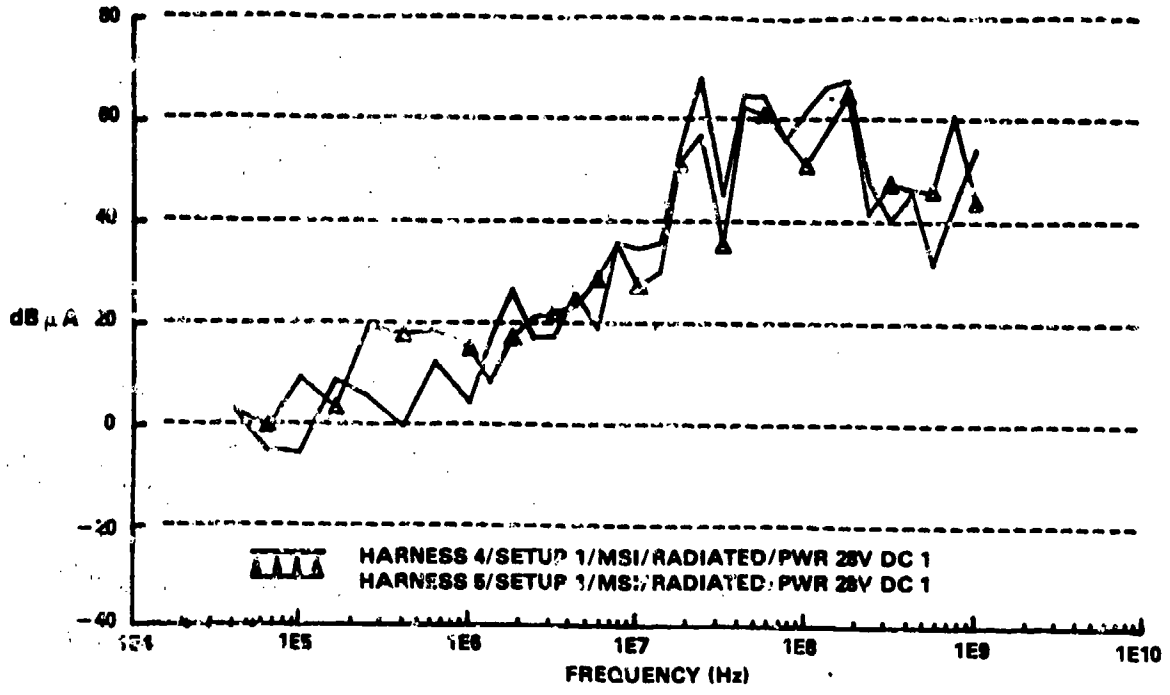


FIGURE 137a. Unshielded umbilical - 20 volts/meter field.

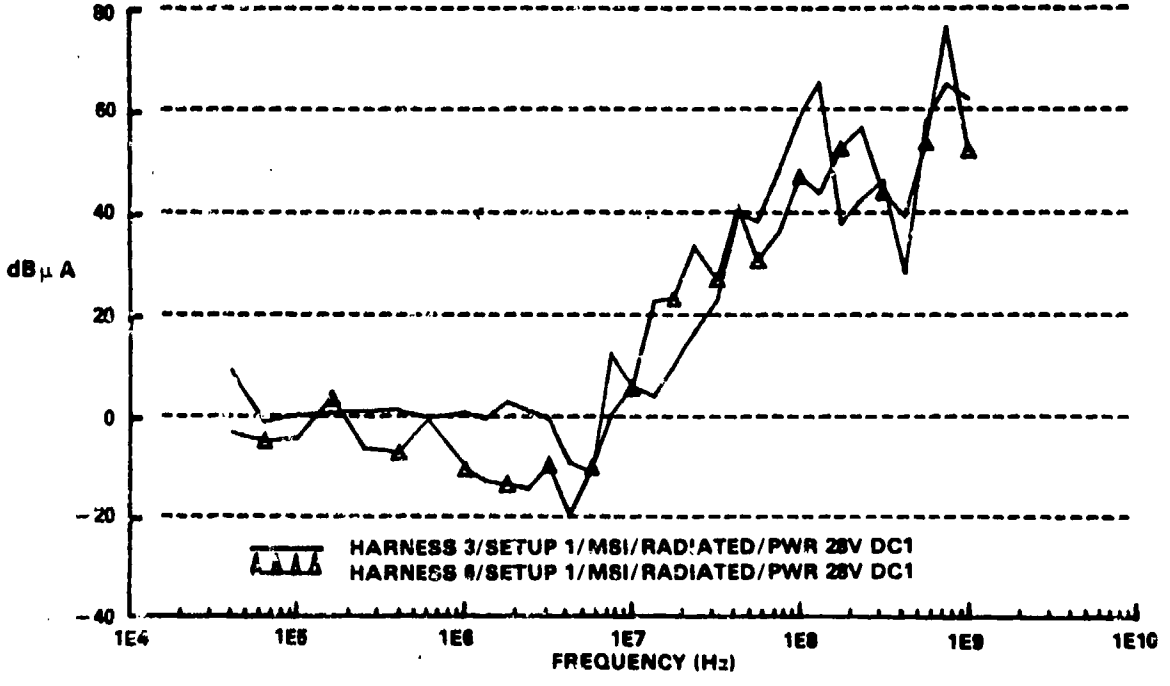


FIGURE 137b. Shielded umbilical - 200 volts/meter field.

FIGURE 137. Field induced noise levels at MSI - 28V DC power.

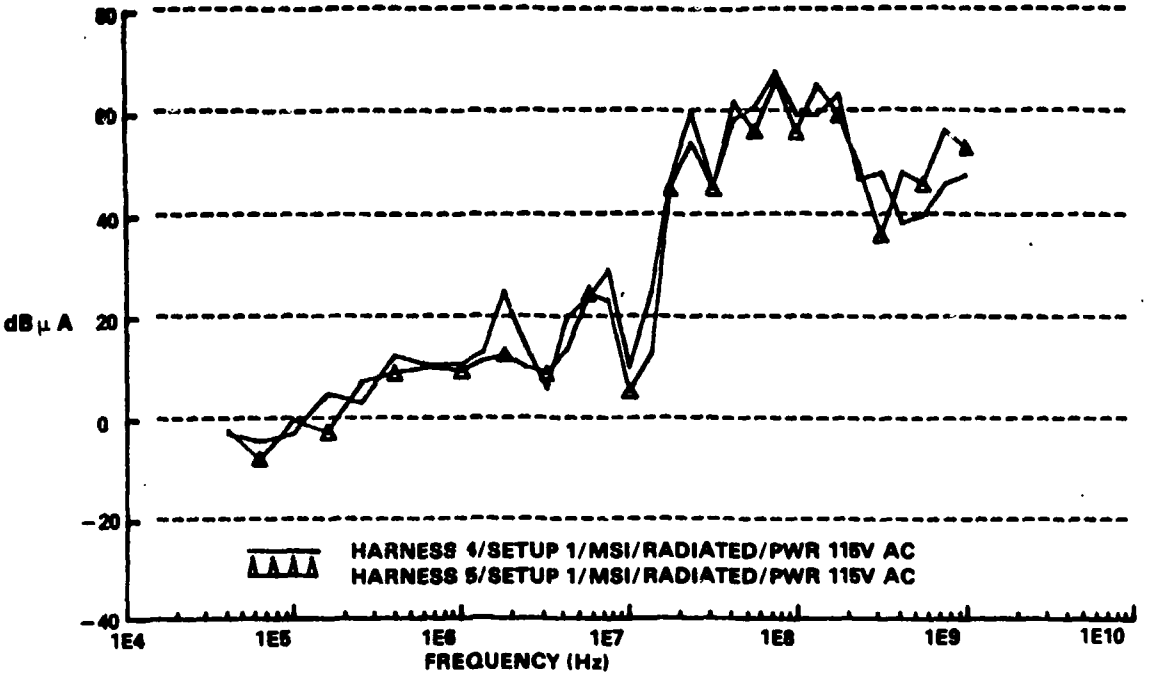


FIGURE 138a. Unshielded umbilical - 20 volts/meter field.

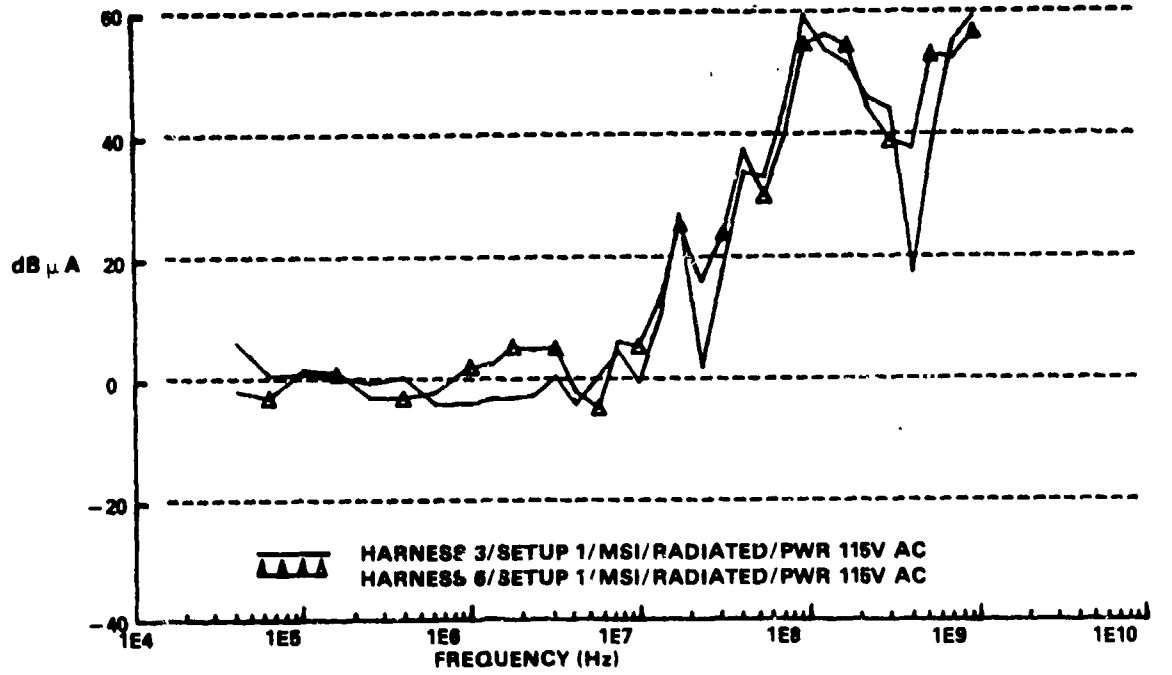


FIGURE 138b. Shielded umbilical - 200 volts/meter field.

FIGURE 138. Field induced noise levels at MSI - 115V AC power.

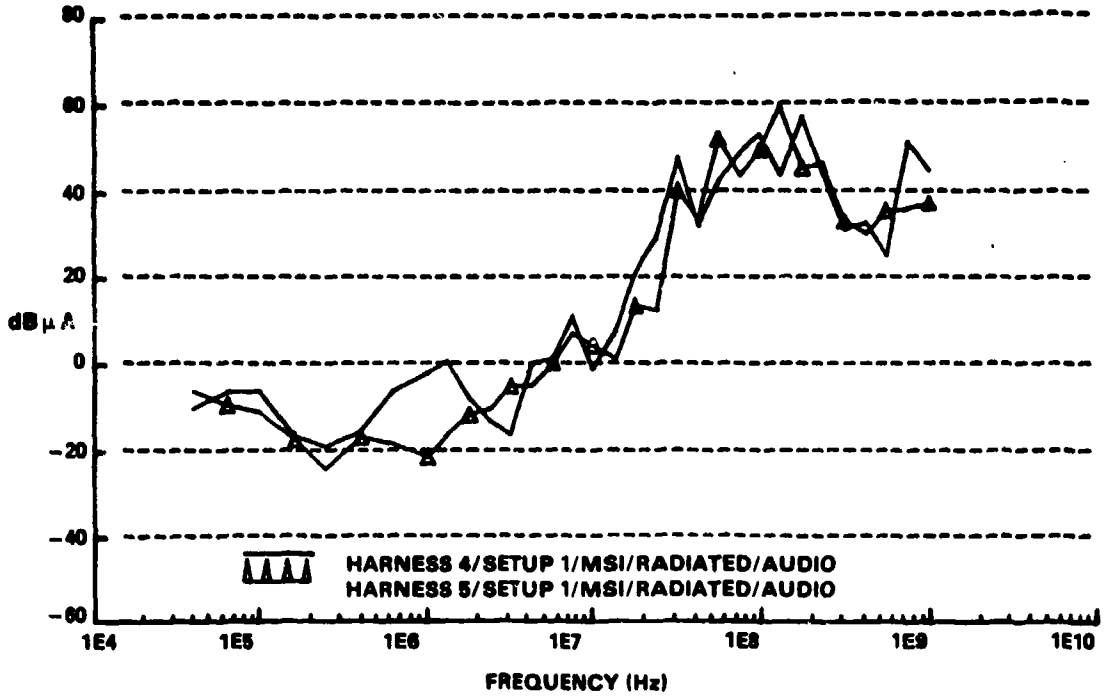


FIGURE 139a. Unshielded umbilical - 20 volts/meter field.

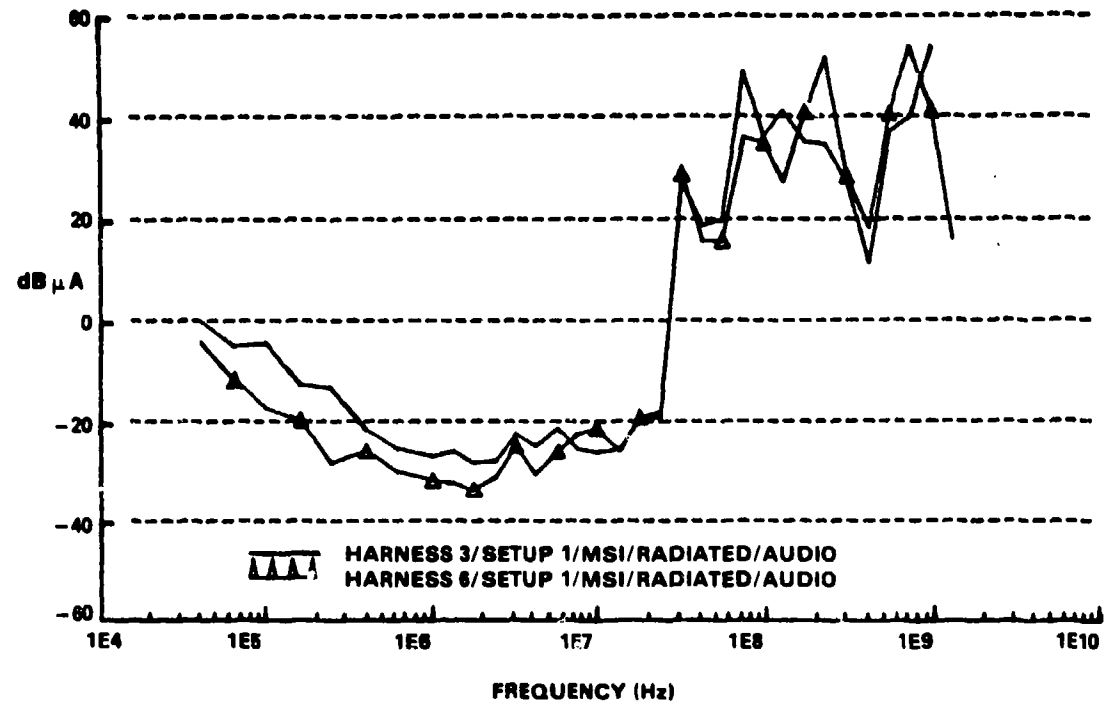


FIGURE 139b. Shielded umbilical - 200 volts/meter field.

FIGURE 139. Field induced noise levels at MSI - LB interface.

5.2.9.1.7 High bandwidth interfaces. While 5.1.9.1.5 divides the High Bandwidth (HB) interface grounding discussion into two segments (one for the HB1 and HB2 ports and one for the HB3 and HB4 ports), the signal return grounding in the store is identical for all four interface ports. The signal return (shield of the coaxial cable or inner shield of the triaxial cable) for all four HB ports is grounded on the store side of the MSI. As discussed in 5.1.9.1.5, the signal returns for HB1 and HB2 are also grounded on the aircraft side of the ASI. In contrast, the signal returns for HB3 and HB4 are isolated from grounds on the aircraft side of the ASI. This results in a multi-point grounding system for HB1 and HB2 and a single ended grounding system for HB3 and HB4. (Note that for cabling systems that use coaxial cable, the shield ground is also the signal ground because the coaxial cable shield is also the signal return. In contrast, a triaxial cabling system provides separate signal return and shield "conductors".)

The aircraft EMC discussion on the HB interfaces (see 5.1.9.1.5 and 5.1.9.5) strongly recommends the use of triaxial cables for implementing the aircraft signal distribution network. The use of triaxial cables is also suggested for umbilical cables but is not strongly emphasized due to the generally short length of the umbilical and also due to the typical gross overbraid shielding which needs to be used on essentially all future umbilicals. The extent that triaxial cables need to be used in the mission store depends primarily on the length of cable and on the expected internal store EMI. As a general recommendation, triaxial cables should be used in the mission store as well as the aircraft. However, if the cable length in the store is extremely short (less than 1/20th of the wavelength of the applicable signal frequency), then use of coaxial cable versus triaxial cable does not result in a noticable EMI degradation.

Noise levels induced into the HB interfaces from external (200 volt/meter) fields and from power switching transients are shown in 5.1.9.5 for representative aircraft-store network configurations. These measured levels apply to the ASI. Figures 140 and 141 illustrate similar noise levels measured at the MSI during RS03 type tests using the standard EMI test cables.

5.2.9.1.8 Structure ground. The purpose of the structure ground line is to minimize the electrical potentials between aircraft and store structures emanating from magnetic and electric fields or from power faults. This line must not be relied on by the store for conducting signal or power return currents except under fault conditions.

Due to the function of this interface line, the structure ground line must be connected to store structure ground. This connection must meet the MIL-B-5087 Class H bonding requirements. Obviously, by its very function, this line is not to be shielded.

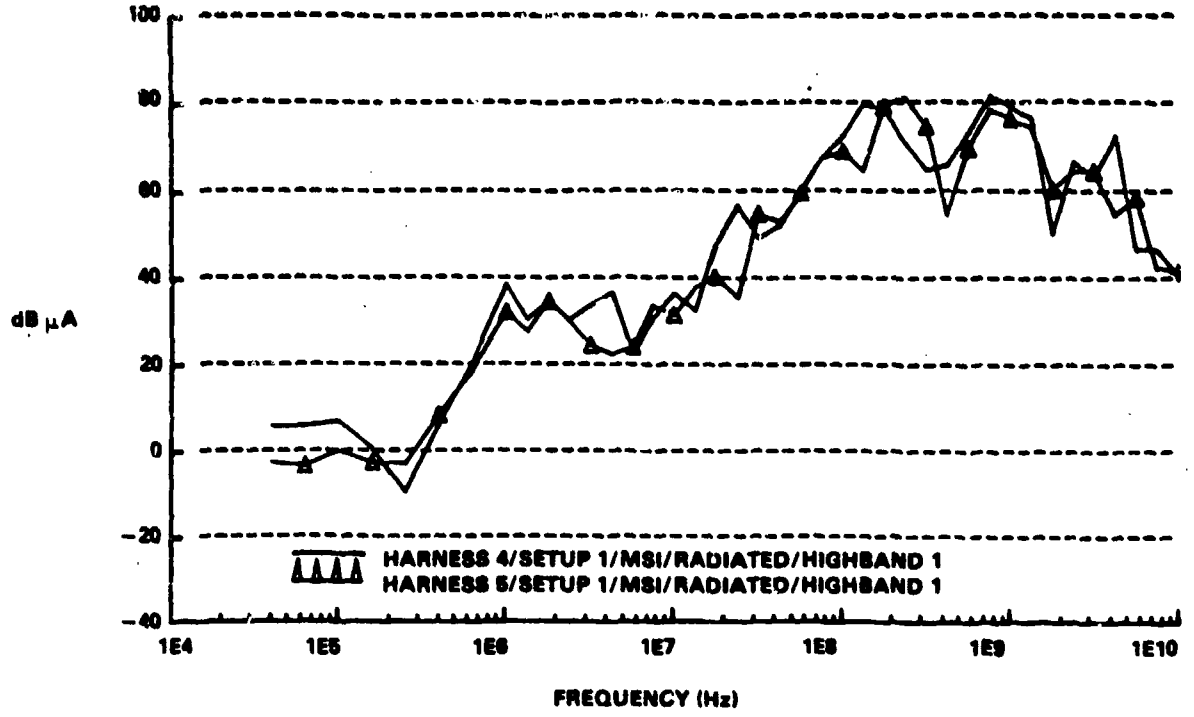


FIGURE 140a. Unshielded umbilical - 20 volts/meter field.

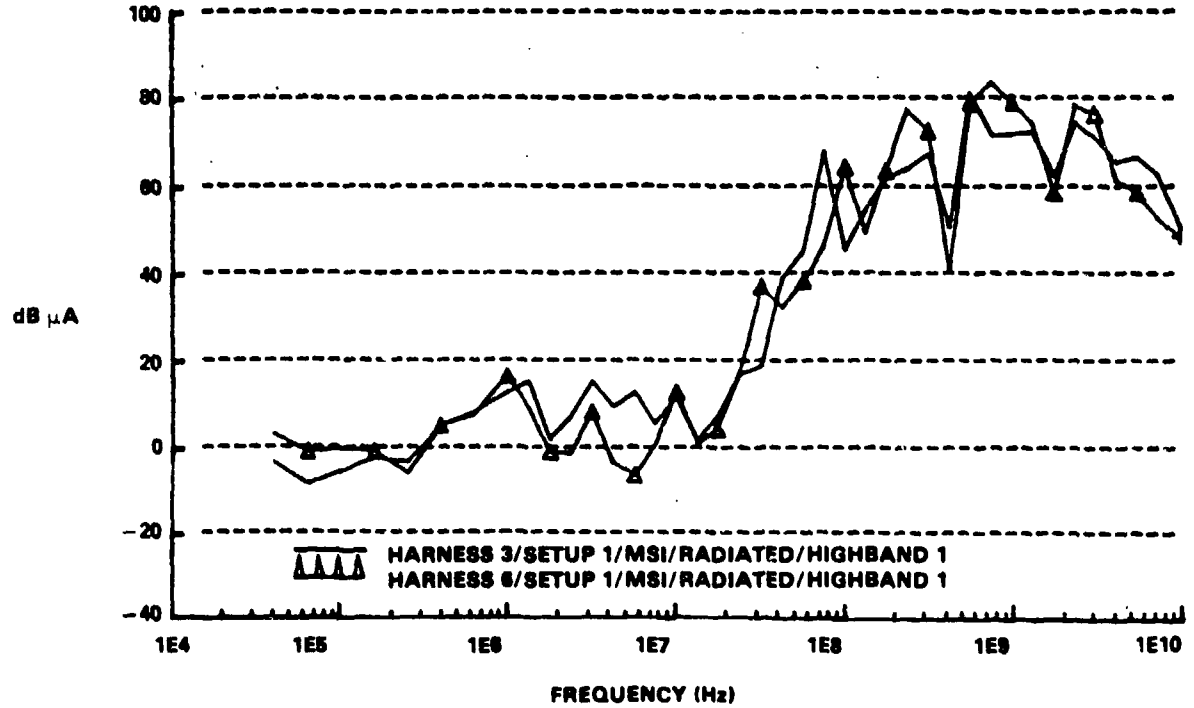


FIGURE 140b. Shielded umbilical - 200 volts/meter field.

FIGURE 140. Field induced noise levels at MSI - HB1 and HB2.

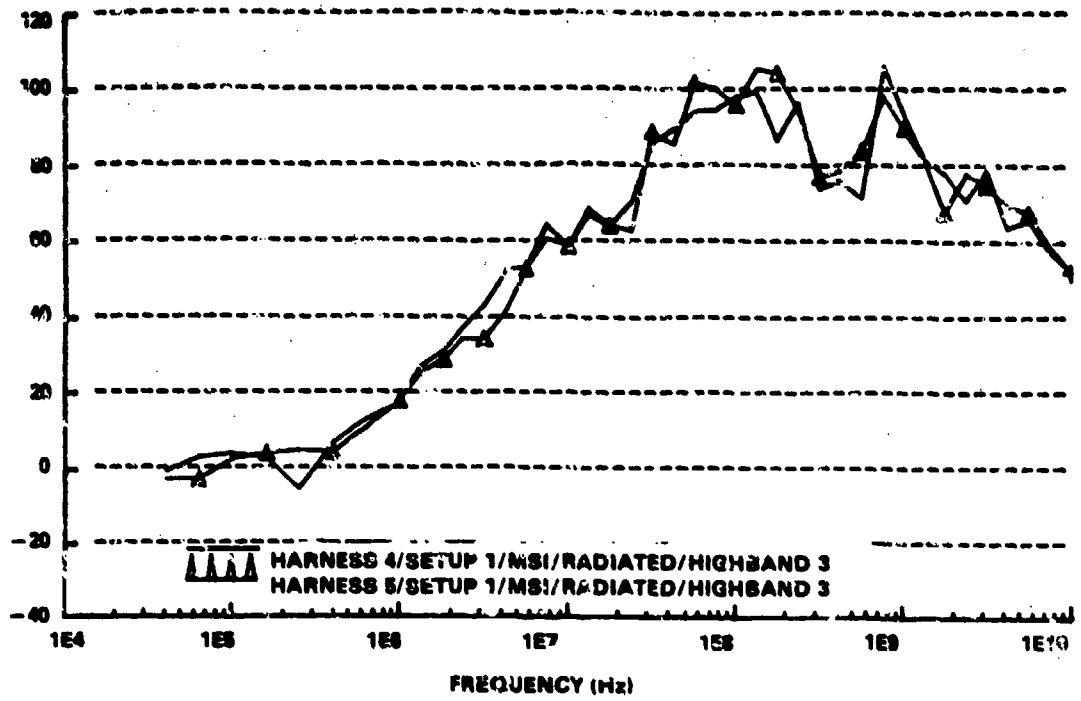


FIGURE 141a. Unshielded umbilical - 20 volts/meter field.

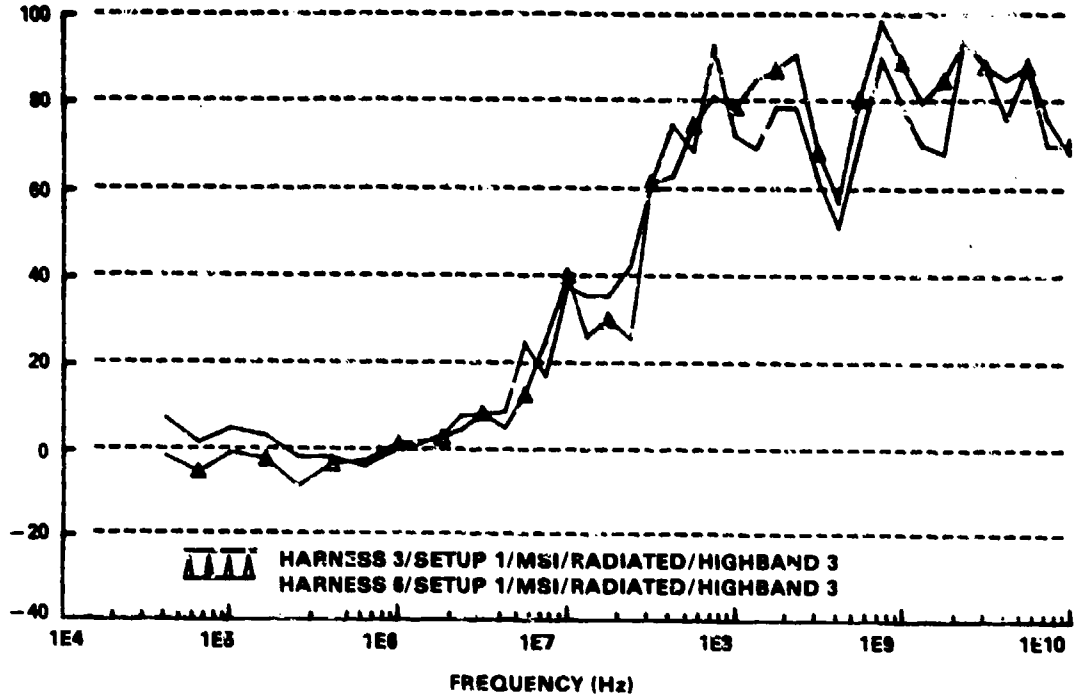


FIGURE 141b. Shielded umbilical - 200 volts/meter field.

FIGURE 141. Field induced noise levels at MSI - HB3 and HB4.

The amount of noise on the structure ground line depends significantly on the quality of store to aircraft mechanical bonding and other conductive paths between the store and aircraft. Figure 142 depicts noise levels measured on this line during tests with the standard EMI test cables. The actual levels, however, will likely be somewhat higher in most current aircraft due to the aircraft tendancies to use aircraft structure as a power return path. This could result in much power frequency noise on the structure including relatively high frequency components from DC-DC converters.

5.2.9.2 Lightning. The AEIS standard does not impose lightning protection design requirements on the store. It is expected that such requirements will be included, as appropriate, in the store system specification. Not withstanding, lightning protection should be incorporated into the store as a good design practice. Due to the store's location on the aircraft (particularly wing-tip mounted stores), the store is in the likely discharge path for lightning streamers and for general precipitation static discharge.

The AEIS interface can provide mechanisms to assist in this protection. First, the structure ground line in the interface provides a current path between the aircraft and store. This path, by itself, is generally insufficient to meet the lightning protection requirements in MIL-B-5087.

The second mechanism in the AEIS interface is the gross overbraid shield of the umbilical connector. The cross-sectional area specified in MIL-B-5087 for lightning current carrying conductors is 40,000 circular mils. This level of conductor can be provided by a double braided gross shield over the umbilical. The shield must then be bonded to the connector backshell at each end of the umbilical. This then requires the store receptacle to also be bonded to the store structure.

The third mechanism available is external to the AEIS interface. This third mechanism is the mechanical attachment between the aircraft and the store for retaining the store on the aircraft. Between these three lightning current paths, sufficient current carrying capacity should be available for meeting the lightning protection levels of MIL-B-5087.

5.2.9.3 Electromagnetic pulse protection. As with the general EMC issues of 5.2.9.1 and 5.2.9.2, MIL-STD-1760 does not impose specific EMP requirements on the store. It is expected that any EMP environment that the store is expected to survive will be identified in the store system specification. This EMP environment and the permitted degradation in system performance tends to vary with each store application primarily due to differences in the stores' missions.

The interface characteristics and contact/connector facilities required by the AEIS standard provide sufficient design flexibility for protecting the store against EMP as well as the other electromagnetic environments.

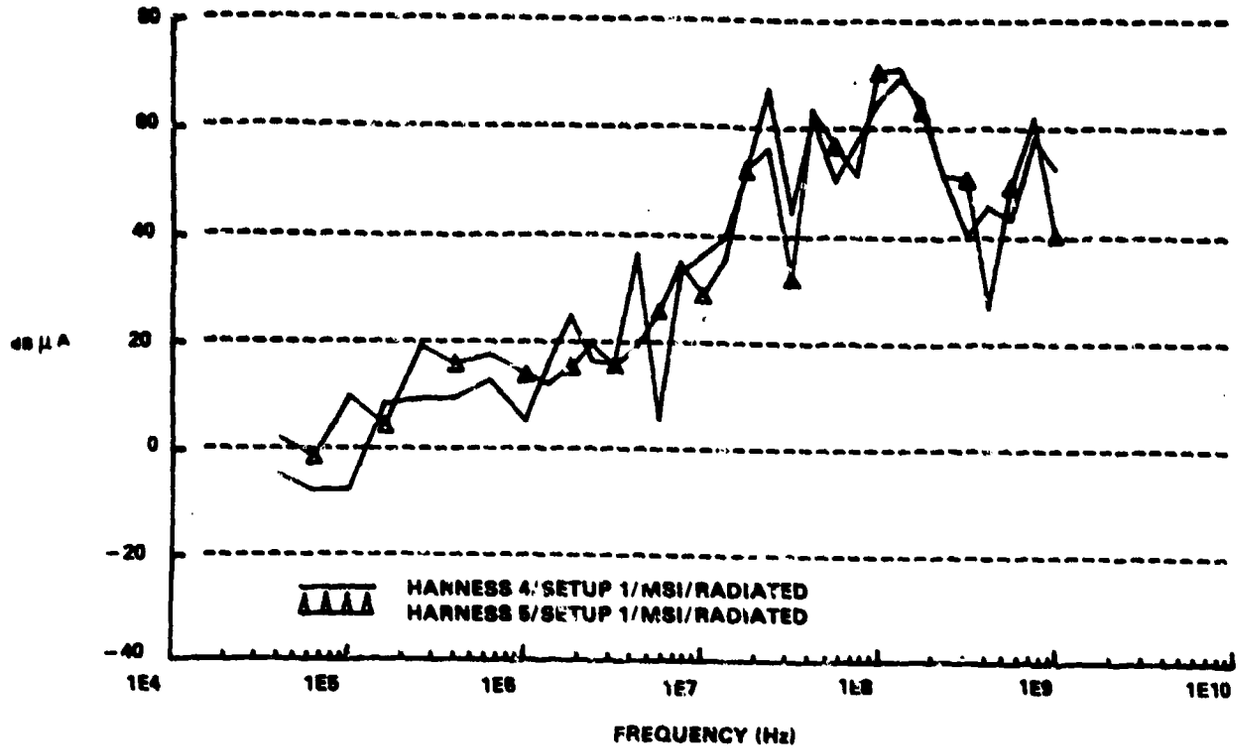


FIGURE 142a. Unshielded umbilical - 20 volts/meter field.

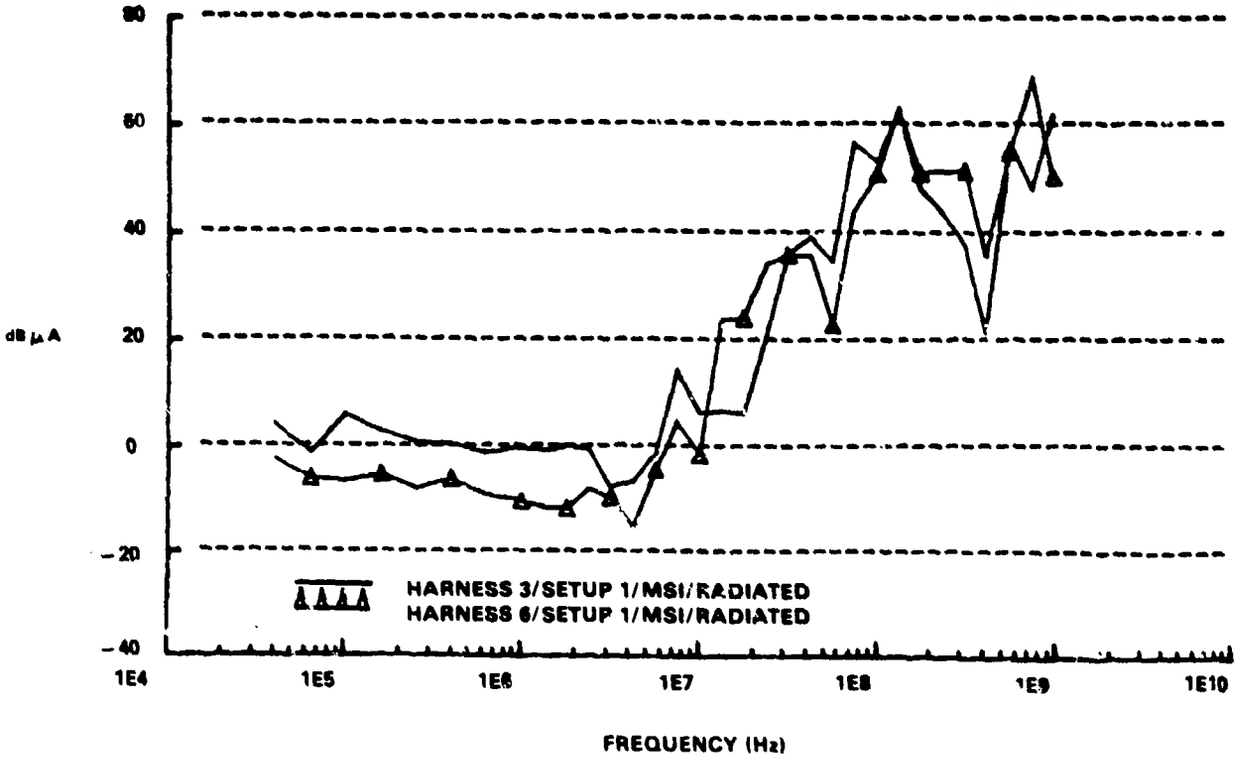


FIGURE 142b. Shielded umbilical - 200 volts/meter field.

FIGURE 142. Field induced noise levels at MSI - structure ground.

5.2.9.4 Static discharge. Similar to the other EMC issues, the AEIS standard does not define static discharge survival requirements on the MSI. Store designers should expect, however, to see a pin injection static discharge survival requirement imposed by the system specification (probably by reference to some other specification). This discharge requirement usually specifies that each external connected circuit must be capable of surviving without performance degradation a certain number of discharges from the test circuit of figure 143. The values for V, R, and C tend to vary with different applications. The table included in the figure lists two typical sets of values. The discharge survival requirement is directed at protecting the store from static discharge occuring from crew handling, from precipitation static produced in flight and from static produced from rocket or engine exhaust.

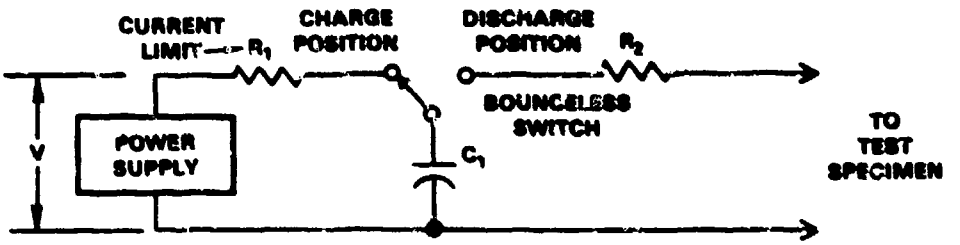
Typical protection circuits consist of back-to-back high speed zener diodes, varistors or other devices. The primary challenge to the protection device is to have a fast response while minimizing the impact on normal circuit operation.

5.2.10 Signal subsets for the MSI. The selection of an interface class for the MSI is covered in 5.2.1 and is not repeated here. However, once the interface class for which the store is to be compatible has been selected, the store has freedom to select a smaller subset of signals from this class to be implemented by the store. That is, the store is not required to implement all signals in any given interface class. There are, however, some subsetting "rules" that are buried in various sections of MIL-STD-1760. These "rules" are summarized below.

5.2.10.1 Interlock interface. The mission store is required to implement interlock and interlock return in each interface (primary and auxiliary) used by the store. The interlock signal is one of the few non-optionable interface signals in the AEIS. The only "option" associated with interlock is whether the primary or auxiliary interface is actually installed at the MSI.

5.2.10.2 Power interfaces. It is difficult to envision a mission store which will not require a source of external (aircraft) power for operating the store until time for store release. (Note that MIL-STD-1760 applies to stores which require an electrical interface. The standard is not applicable to stores which only require a mechanical interface and therefore the entire issue of signal subsets is not applicable to non-electrical interfaced stores.)

Due to safety concerns (and to provide a common initialization facility), the store must implement either: (1) 28V DC power 1, (2) primary 115/200V AC power, or (3) auxiliary 115/200V AC power. These choices preclude the store from using 28V DC power 2 or auxiliary 28V DC without one of the three power interfaces listed above. (See MIL-STD-1760 paragraphs 5.2.1.8.2.7 and 5.2.1.9.2.9.)



V (KILOVOLTS)	R_2 (KILOHMS)	C_1 (PICOFARADS)
25 15	5 1.5	500 100

FIGURE 143. Static discharge test circuit.

If the store implements one of the 115/200V AC power interfaces, then the store designer needs to consider the phase unbalance requirements of the standard and provide three phase loads if the current levels are sufficiently high to require a three phase connection. Basically, once the 115V AC load exceeds 500 volt-amperes, the store is required to use a three phase connection instead of a single or two phase connection.

5.2.10.3 Communication interface. This catagory is used to encompass the digital data interface (Mux A and Mux B) and the address and release consent discretes. While not specifically mandated by the standard, MIL-STD-1760 strongly implies that all stores - at least into the foreseeable future - must use the digital data interface for receiving store control commands from the aircraft and for providing the aircraft with store status data. The only alternatives alluded to in the standard are references to possible future use of the LB interface as a low cost store digital interface or the HB or fiber optic interface for high speed data bus connections. However, these alternatives are not currently permitted by the standard.

The use of the digital multiplex data interface requires the store to implement both of the redundant data ports (Mux A and Mux B). Allowing implementation of one data port only has been considered occasionally in an attempt to address the low cost store concern (see 4.3.3). However, the cost savings of eliminating one of the two MIL-STD-1553 transceivers does not result in sufficient savings to justify the reduction in system level probability of mission success.

The use of the digital multiplex data interface also requires the mission store to implement the address discrete set. This is due to the multiplex remote terminal's need for a data bus address when connected to the aircraft. In addition to supplying the store its RT bus address, the address discretes are also available for use in monitoring an "aircraft mated" condition. (See 5.2.3.3.) Due to this second use, it is possible that the address interface could be used in a store application that did not implement the digital multiplex data interface.

The release consent interface is included in the communication interface subset discussion as an option. Due to the function of release consent, it is not expected that release consent will be used without also implementing the digital data interface and the address discretes. However, not all mission stores will require the release consent. (See 5.2.3.2 for those applications where release consent is expected to be required.)

5.2.10.4 Low bandwidth interface. In general, the LB interface is available for the transfer of audio signals between the aircraft and the store. It is intended to be used in support of the communication interface

discussed in 5.2.10.3 for transferring signals which have an information bandwidth too high for efficient support by MIL-STD-1553.

Sections 4.3.3, 5.1.6 and 5.2.7 include discussions on the use of the LB interface as a low speed digital data link for low cost, simple stores. It is emphasized that this is a potential future use for the interface and is not currently allowed by the standard. With that qualification, use of the LB interface as a low speed digital link will occur under a new interface class definition (e.g., interface class III). This new interface class will contain a unique signal subset of the class II interface signal mix. Since this alternate use of the LB interface is currently not defined, the associated signal mix in the class III interface is also not defined. Signal mixes which have been considered and are still being studied generally consist of: the LB interface, 28V DC power 1 and power 2, structure ground, and interlock. Additional options considered are release consent and an "aircraft mated" signal derived from the address discretes. When a decision is made on a low cost store interface alternate, the AEIS standard will be updated to identify the appropriate requirements for the class III signal set.

5.2.10.5 High bandwidth interfaces. The high bandwidth interfaces are available for store use for transferring specific HB signals (see 5.2.6.1) through the MSI. All four HB interfaces are available from the class I and IA primary interfaces while only HB1 and HB3 are available from the class II and IIA primary interfaces. As discussed in 5.2.1, the store designer needs to consider the implications of aircraft retrofitted with limited AEIS capabilities. In these retrofit applications, the HB signal interfaces are the one area that is typically short-changed. As a result, the store designer must consider the HB support available from the mix of aircraft identified in the system specification.

In general, the use of HB interfaces is viewed as an optional supplement to the communication interface discussed in 5.2.10.3. Any of the four HB ports can be implemented by the store for the functions defined in 5.2.6.1. The use of the HB port for other functions may be permitted in the future, but is currently disallowed by MIL-STD-1760. One potential future application, discussed previously, is to use the port as a high speed data bus interface.

5.2.10.6 Structure ground. As with the interlock signal, the implementation of structure ground is mandatory on the mission store for each of the primary and auxiliary interfaces used by the store. (That is, if the store does not implement the auxiliary interface, then the store is not required to install the auxiliary structure ground interface.)

5.2.11 Reserved functions. The fiber optic interface (contact locations U and Y in the primary signal set connector) are growth provisions for future applications of fiber optics to store interfaces. These contact locations, which accommodate 16 AWG contacts, must not be used for any other function.

Similarly, the 270V DC interface (contact locations N and R in the primary signal set connector and F and H in the auxiliary connector) are growth provisions for future applications of 270V DC power. These contact locations, which accommodate 16 and 10 AWG contacts, must not be used for any other functions.

5.3 Aircraft and store physical design considerations. This section of the report provides supplementary information on MIL-STD-1760 requirements associated with the AEIS physical element. This physical element scope is limited primarily to the intermateability requirements associated with the interface mating connectors and the umbilical cables. Physical design areas such as the mechanical interface between store and aircraft for suspension and release and structural design issues are not addressed by the AEIS standard and, therefore, are not addressed by this report.

5.3.1 Interface commonality and umbilical cables.

5.3.1.1 Carriage of mission stores at ASI or CSSI. As previously discussed, the electrical element of the AEIS standard is defined in a manner that allows mission stores to be carried in two modes. The first and primary mode is for the mission store to be physically connected directly to the aircraft with a parent bomb rack or permanent launch rail. In this primary mode, the MSI is mated to the ASI generally with an umbilical cable.

The second mode is for the mission store to be physically connected to a carriage store with the carriage store connected directly to the aircraft. In this mode, the MSI is mated to a CSSI (generally through an umbilical cable) and the carriage store's CSI is connected to the ASI with an umbilical cable. These two configurations are shown in figure 1.

As with the electrical element, the physical element of the AEIS is defined such that the physical characteristics of the CSSI and ASI can be identical and the physical characteristics of the CSI and MSI can be identical. This provides a common interface at the ASI/CSSI disconnect and at the MSI/CSI disconnect to allow installation of the mission store to either location (assuming of course that other non-AEIS interfacing aspects are compatible). The phrase "can be identical" is used above because MIL-STD-1760 does not define CSI and CSSI electrical or physical requirements. However, the ASI and MSI characteristics are defined in a manner that allows a carriage to be inserted between the aircraft and mission store.

5.3.1.2 Connector pin and socket convention. The general convention in assigning pins or sockets to a particular half of a mated connector pair is to place the socket contact in the connector side which, if unmated, has

electrified contacts. This results in the aircraft ASI receptacle and the umbilical plug (which mates to the store's MSI receptacle) containing sockets. MIL-STD-1760 incorporates part of this convention except at the MSI, the socket contacts are installed in the store receptacle. This reversed convention at the MSI is selected to be in compliance with MIL-HDBK-244, MIL-HDBK-255 and AFR 122-10.

5.3.1.3 Common umbilical cables. As discussed in 5.3.1.1 above, mission stores can be carried directly on aircraft or on aircraft through a carriage store "adapter". In both of these carriage modes a common umbilical cable design can be used. (Note that the only umbilical cable difference in these two carriage modes is the possibility that the umbilical length will vary.) The AEIS standard defines four interface classes (see 5.2.1). However, the interconnection of these interface classes on aircraft and stores only requires two types of umbilical cables:

Type A: An umbilical with the capability of interconnecting all circuits of the primary interface signal set

Type B: An umbilical with the capability of interconnecting all circuits of the auxiliary interface signal set

The Type A cable can be used with both the full primary signal set and the reduced primary signal set of the class II and IIA interfaces. This common usage is available because the class I and II interfaces use interchangeable connectors and all signal circuits required for class II are contained in class I umbilical. In general, there is insufficient differences between the primary umbilicals for class I and class II to justify the impact to logistics if another umbilical type is placed in the field for servicing class II interfaces only.

5.3.1.4 Keyway orientation. The AEIS standard defines the orientation (clocking) of the major keyway for the ASI and MSI connectors on the aircraft and store, respectively. This orientation is compliant with MIL-A-8591 and with the proposed System 2 specification for nuclear weapon interfaces. The keyway orientation needs to be controlled because the axial rotational flexibility of shield overbraided umbilical cables is very limited. Total twist typically available on a shielded (2 foot long) umbilical is less than ±25 degrees. With some cable constructions, the twist available can be significantly less.

5.3.2 Mechanical considerations for electrical interface.

5.3.2.1 Defective lanyard. The store designer should consider the safety implications of a store mechanical separation (ejection) from the aircraft (i.e., S&RE no longer retaining the store) but failure of the umbilical cable to disconnect. The most probable causes of the umbilical failing to

disconnect are: (1) Failure of ground crew to connect lanyard to retention device (such as pylon bail bar), (2) defective lanyard due to corrosion or other mechanical damage, or (3) defective umbilical plug release mechanism (likely due to severe corrosion). While the probability that one of these conditions will occur is low, the safety implications of either a store "dangling" from the aircraft by its umbilical or the store ripping out aircraft wiring due to a lanyard problem warrants some considerations during store design.

One solution to this problem is for the store to use a fail safe receptacle at the MSI. One version of a fail safe receptacle that has been tested contains a shear mechanism in the receptacle shell. This shear point allows part of the receptacle shell to break loose at a preset force (range). Once the shell separates, the umbilical plug with part of the shell will disconnect from the remainder of the store receptacle. The fail safe force can be adjustable over a fairly broad range to optimize the fail safe feature for specific store applications.

5.3.2.2 Blind mate alignment. Applications of the AEIS which require a "blind mating" operation of the store to the aircraft during store uploading introduces a unique set of connector issues.

To begin, the connector coupling mechanism is somewhat different from the MIL-C-38999 Series III coupling. Even with the coupling differences, a store can still use a Series III receptacle at the MSI. The coupling differences will impact the method used by the aircraft (or S&RE device) to assure continued mating between the store MSI receptacle and its mating plug. In general, this can be achieved by providing a mechanical mechanism which pushes the plug onto the receptacle and holds it in place with sufficient force to maintain a moisture seal between the plug and receptacle.

It sould be noted at this point, that store connector physical requirements for rail launched missiles are not currently defined in MIL-STD-1760 (see "limitations" in foreword to the standard). Non-rail launched stores, however, must use a receptacle which complies with the intermateability requirements listed in the standard.

To achieve a blind mate operation requires either: (1) A self-alignment mechanism in the aircraft, or (2) very tight control of connector keyway orientation tolerances on the store receptacle as well as on the mating plug. The store receptacle keyway tolerance is sufficiently loose to allow a self-alignment mechanism to be used.

5.3.2.3 Hung store. A hung store is defined as a store which does not totally separate from the aircraft when jettisoned, released, launched or dispensed. The timely detection of a hung store is required to: (1) Avoid severe asymetrical loading of the aircraft, or (2) avoid launch/ejection of

a store whose path is blocked by the hung store. There may be a large temptation for the aircraft designer to use the interlock interface to achieve a "hung store" detection (e.g., ejection command sent to station but continuity on interlock still exists). While the interlock provides a realistic indication that a store is hung, it does not provide a reliable indication that the store is not hung. This latter condition exists because failure modes in the interlock circuit result in a "not mated" (hence an implied "not hung") indication.

The aircraft designer can use the interlock interface as a first look at probable store separation in an effort to continue logic processing for the next store release. However, prior to releasing the "next critical store", the aircraft should verify separation by a second means such as bomb rack store sensing switches. The term "next critical store" refers to the store which if released would result in unacceptable asymetrical loading or in store collision.

5.3.2.4 Compliance with MIL-A-8591 connector location. The specification MIL-A-8591 was amended in 1985 to move the electrical connector location on the store. The connector was moved from a specific location aft of the store lugs to a specific location forward of the store lugs. New stores are required to locate the MSI in this forward location. As a result, the aircraft may need to service some stores with the connector aft of the lugs and some stores with the connector forward of the lugs. However, no MIL-STD-1760 ejection released stores appear to exist which predate the MIL-A-8591 amendment. Therefore, aircraft can service MIL-STD-1760 stores with a forward located ASI and service non-1760 existing stores through an aft located aircraft-store disconnect. Figure 144 illustrates this configuration in an SMS design which provides separate connectors out of the SSE for implementing the MIL-STD-1760 ASI and the non-1760 mix of discretes, power and analog signals. Figure 145 illustrates an alternate method where an "extension cord" is connected to the aft (or alternately the forward) pylon disconnect to provide the AEIS signals at the forward (or aft) location.

Aircraft designers should not expect stores to contain MSI connectors at both forward and aft locations. In addition, it is generally not practical to achieve the relocation of the ASI by installing a long umbilical between an aft aircraft connector and a forward MSI due to typical installation constraints in the pylon area around the parent bomb rack.

5.3.3 Environmental considerations. Environmental considerations primarily concern the interface connectors which exist on the outside surfaces of the aircraft and store. In many instances, the interface connector is exposed to the environment (temperature extremes, vibration, shock, contaminations, etc.) while unmated. The unmated condition occurs when a store is not loaded at a station or when a store is released from a station. For conditions where the store is not installed, the connector

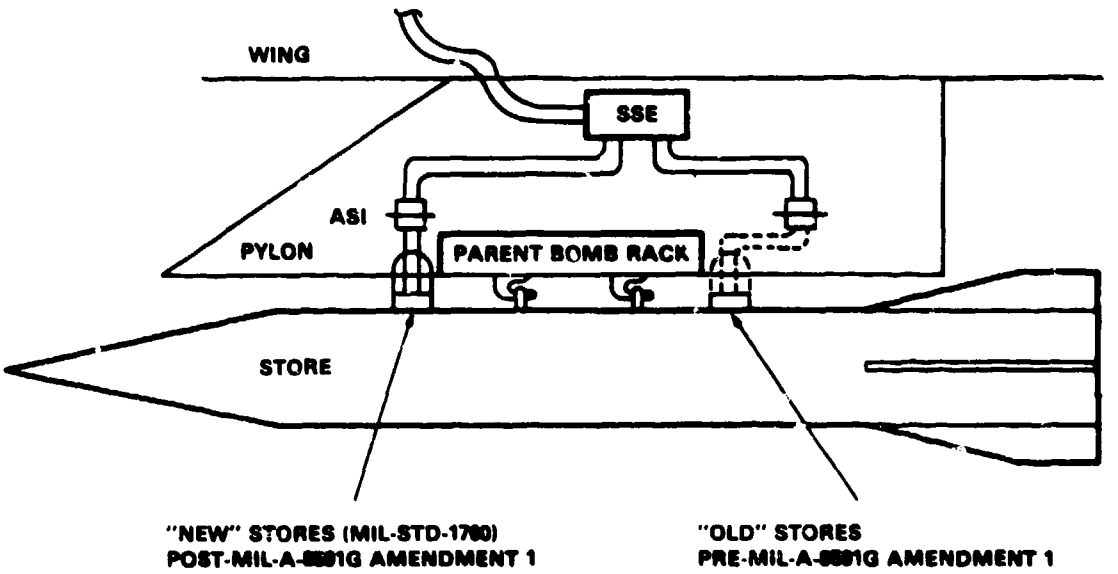


FIGURE 144. Compliance with MIL-A-8591.

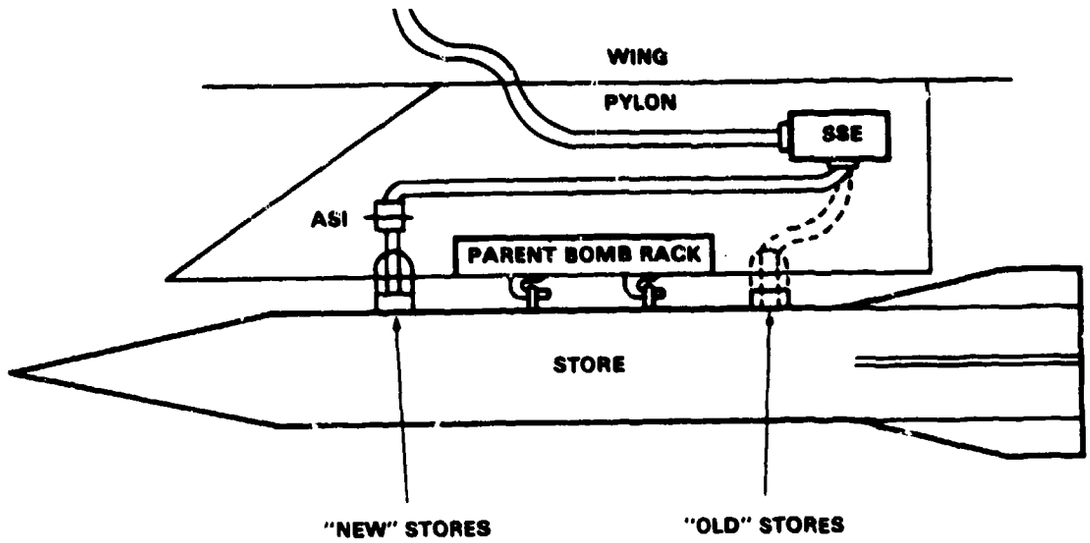


FIGURE 145. Alternate ASI arrangement.

should be covered with a protective cap. For conditions where the store is released, no protection for the unmated connector on the umbilical and on the store is generally available. (Techniques such as umbilical retraction or snap down covers are occassionally considered but seldom used.)

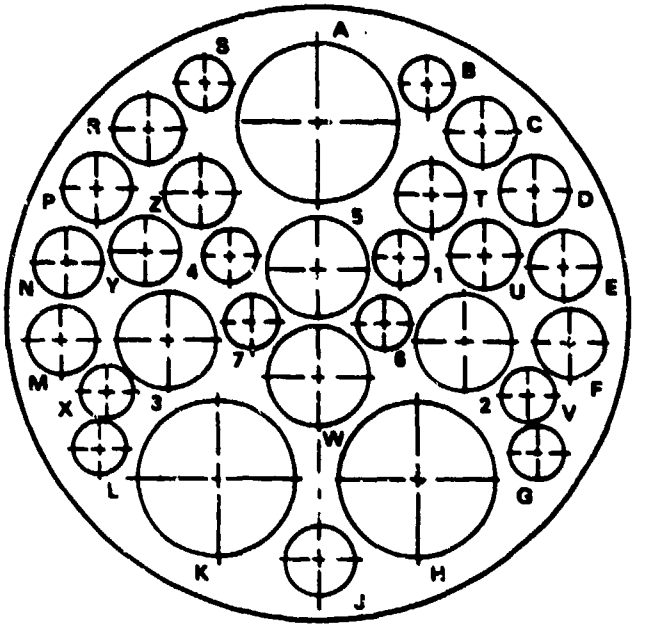
5.3.3.1 Connector location. The location of the ASI in the aircraft and the resulting post separation location of the disconnected end of the umbilical cable influences the environmental performance of the connector. While a great deal of flexibility in connector location is not available, the installation designers should attempt to locate the connector to maximize protection against moisture, ice build-up and exhaust from rocket motors.

5.3.3.2 ASI and MSI environment. The specific environments to which the ASI and MSI are exposed vary considerably with each application and are, therefore, defined in the applicable system specifications. Representative environmental considerations are presented in the aircraft environment and store environment sections of MIL-HDBK-244. Additionally, MIL-STD-1670 establishes guidelines for defining environmental conditions for air-launched stores and includes representative environments for the factory-to-target sequence. Noteworthy environments are: (1) High temperature exposure of the MSI after launch, (2) low temperature exposure during captive carry. (3) high pyrotechnic induced shocks during store ejection, and (4) gas plume impingement on the ASI and umbilical cable.

5.3.4 Connector assembly and installation. This section discusses the wire harness design criteria and hardware required to conform to MIL-STD-1760.

5.3.4.1 Primary signal set. The Primary signal set connector insert arrangement is shown in figure 146. This connector complies with the requirments listed in table XX. The connectors on the umbilical (both ends) are plugs with pin contacts and the connectors on the aircraft, carriage store and mission store are receptacles with socket contacts.

Table XXI is a partial list of components that can be used in harness design. It is noted that table XXI is not a list of parts that must be used. Other parts not listed may be as good or better than those listed. It is only necessary that the components used in the store be compatible with the intermateability dimensions of the connector shell, contacts and insert arrangement defined in table XX. In contrast, the aircraft (as noted in the table) is required to use connectors and contacts which fully comply with MIL-C-38999 and the listed MIL-C-39029 specification sheets.



SHELL SIZE	ARRANGE-MENT NO.	NUMBER OF CONTACTS	SIZE CONTACTS	SERVICE RATING	CONTACT LOCATION
25	-20	3	8	TRIAX	A, H, K
		4	12	COAX	W, 2, 3, 5
		13	16	N	C, D, E, F, J, M N, P, R, T, U, Y, Z
		10	20		B, G, L, S, V, X, 1, 4, 6, 7

FIGURE 146. Primary signal set insert arrangement.

TABLE XX. Primary signal set connector requirements.

ASI connector characteristics:

Connector: The connector shall be in accordance with MIL-C-38999, Series III, Shell Size 25, Polarization Key Identification N

Contacts: The contacts shall be in accordance with the following slash sheets to MIL-C-39029.

Size	Slash Sheet	Abbreviated Title
20	/56	Contact, socket
20	/58	Contact, pin
16	/56	Contact, socket
16	/58	Contact, pin
12	/28	Contact, shielded, pin
12	/75	Contact, shielded, socket
8	/90	Contact, concentric twinax, pin
8	/91	Contact, concentric twinax, socket

Insert Arrangement: The insert arrangements shall be in accordance with MIL-STD-1560, Insert Arrangement No. 25-20.

MSI connector characteristics: The MSI primary signal set connector shall comply with the intermateability dimensions of MIL-C-38999, MIL-C-39029 and MIL-STD-1560 as specified above.

TABLE XXI. MIL-STD-1760 compliant hardware - primary signal set.

Item	Part Number	Nomenclature
1	D38999/26WJ20PN	Plug - Standard
2	D38999/20WJ20SN	Receptacle - Wall Mount
3	D38999/24WJ20SN	Receptacle - Jam Nut
4	D38999/31WJ20PN	Plug - Lanyard Release
5	M39029/56-XXX	Contact, Socket
6	M39029/58-XXX	Contact, Pin
7	M39029/28-XXX	Contact, Shielded, Pin
8	M39029/75-XXX	Contact, Shielded, Socket
9	M39029/90-XXX	Contact, Concentric Twinaxial, Pin
10	M39029/91-XXX	Contact, Concentric Twinaxial, Socket
11	M17/094-RG179	Cable, Coaxial, 75 ohm
12	M17/133-RG316	Cable, Coaxial, 50 ohm
13	M17/152-00001	Cable, Coaxial, 50 ohm (Double Shield)
14	M17/131-RG403	Cable, Triaxial, 50 ohm
15	M17/176-0002	Cable, Twinaxial, 77 ohm
16	M83049/20-25W	Backshell

5.3.4.1.1 Connector assembly. Contact insertion and removal is accomplished with MS27495 (or equivalent) insertion and removal tools. Precaution needs to be taken when assembling the No. 8 twinaxial pin into a plug assembly. The length of the pin contact, the relative stiffness of the twinaxial cable, the location the contact cavities near the O.D. of the insert and the relatively large pin diameter can cause a severe contact skewing problem. This skewing can be especially severe in the D38999/26WJ20PN plug if the wire bundle is clamped down near the rear of the plug's rubber sealing grommet. The skewed pin can cause unequal loading on the contact retention device and result in permanent damage if the load is excessive. Furthermore, the skewed pin can be misaligned sufficiently with the mating socket insert in the receptacle to cause it to strike the closed entry chamber around the socket contact opening. The pin, rigidly confined at the rear by the cable clamp, cannot float within its cavity as intended, as a result, the pin either chips the plastic or begins to wear it away. Once chipped or worn away, it no longer serves its function as a pre-alignment for the entry into the socket contact. Also, pushout of the pin can occur if the pin does not enter the socket and the force exerted by rotating the coupling nut is sufficient to overcome the strength of the retention collet.

The wire harness design must keep the twinaxial pin in proper axial alignment. One design concept uses a spider which supports the twinaxial contacts and has openings to permit the wires to pass through as shown in figure 147. The spider is made from non-conductive material such as teflon and fits inside the connector backshell.

The socket contact does not have the skewing problem due to the relatively long contact cavity in the connector in which the contact is housed. Also, the pin contact skewing problem is not as severe in the D38999/31 lanyard plug due to its longer shell.

5.3.4.1.2 Harness flexibility. To increase harness flexibility, the lay of wires in the harness should form a twist. The lay length should be 8 to 16 times the pitch diameter, i.e., a 0.5 inch diameter cable layer would have one turn every 4 to 8 inches in length. The cable should be twisted with a undirectional lay where all cable layers are twisted in the same direction but with different lay lengths. This produces a cable with maximum flexibility and ruggedness. Cable fillers should be used where necessary to fill large voids between wires in each cable layer. Figure 148 shows a typical twisting arrangement for the primary harness. Other arrangements are also acceptable.

5.3.4.1.3 Cabling. Good cabling design practices must be implemented at the time of initial design. Otherwise, costly additional effort will be expended to locate and attempt to eliminate problems relating to signal

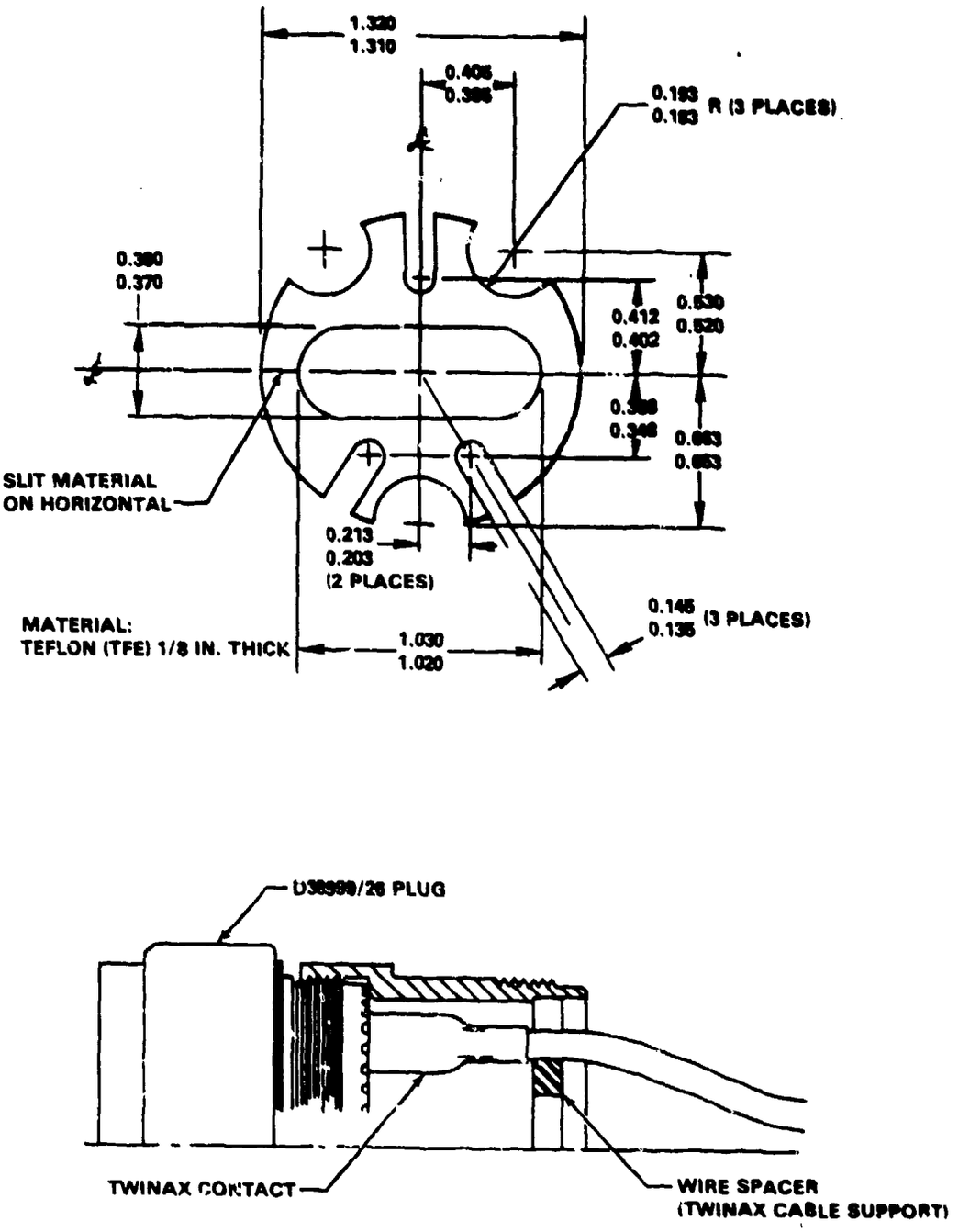
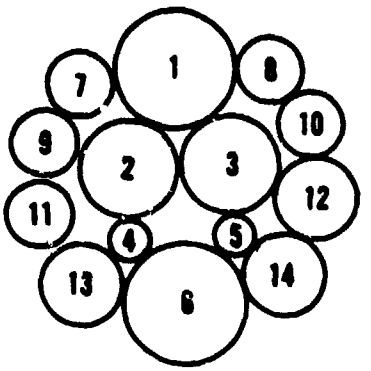


FIGURE 147. Design concept to maintain twinaxial pin in proper axial alignment.



Location	Conductor	Function
1	7-20 AWG twisted	Address discretes
2	2-16 AWG twisted	28V DC power 1
3	2-16 AWG twisted	28V DC power 2
4	1-16 AWG	Structure ground
5	1-20 AWG	Release consent
6	4-16 AWG twisted	115/200V AC
7	Coax/Triax cable	HB4
8	Coax/Triax cable	HB2
9	Coax/Triax cable	HB1
10	Coax/Triax cable	HB3
11	2-20 AWG twisted	Interlock
12	Twinaxial	Mux B
13	Twinaxial	LB
14	Twinaxial	Mux A

FIGURE 148. Typical primary harness conductor arrangement.

degradation and noise pick-up. Wire selection and cabling design must give consideration to signal frequency, voltage and power levels, tolerable signal degradation, reflected signals due to discontinuities and noise pick-up. All low voltage level signals should be transmitted over twisted pairs. Type A and Type B signals should be transmitted over triaxial cable for most applications. Digital multiplex data and Low Bandwidth signals should be transmitted over capacitively balanced twinaxial cable.

5.3.4.1.3.1 High bandwidth. The four high bandwidth ports must be implemented with triaxial or coaxial cable. Selection of specific 50 ohm (HB1 and HB2) and 75 ohm (HB3 and HB4) cables must include consideration of the installed cable length and the resulting impact on signal attenuation at the applicable frequencies. As usual, installation biases for small cable diameters directly conflict with system design preferrences for low signal losses. The use of the subminiature class of cables should generally be restricted to relatively short cable runs to keep overall losses reasonable.

Electrical noise is a problem in both analog and digital systems. Filtering is not desirable since it deteriorates low power level signals. Noise reduction must be accomplished by preventing its entry into the system. This is done by using cables with high noise rejection and applying good isolation and grounding techniques. Noise is usually picked up by wiring through direct contact action of ground loops and common mode returns or by inductive coupling from radiated fields. Also, cables can "crosstalk" the signal they are carrying to other circuits. Noise is also caused by poor cable to equipment impedance matching which can produce signal reflections and high standing wave ratios. Poorly selected and installed cables can act as noise generators or receivers.

Several of these problems can be avoided by using triaxial cables particularly for low frequency (Type A) applications. Triaxial cable is essentially a coaxial cable with a second insulated shield. The use of triaxial cable provides a better grounding option by allowing the center conductor and inner shield to be connected in a single point ground circuit and then electrostatically decoupling this inner shield from the external environment by multi-point grounding the outer shield (see figure 149).

As the signal frequency increases, the ability to maintain an effective single point ground on the inner shield degrades. As a result, high frequency transmission lines end up being grounded at every disconnect for a multiple point shield ground. At these high frequencies, the shielding improvement from triaxial cables is due primarily to a thicker and more thorough coverage shield braid.

As previously discussed in 5.1.9 and 5.2.9, the use of triaxial cables is preferred to coaxial cables. Experience with video systems in existing aircraft illustrates the improvement in video display quality when weapon video is routed through triaxial cables instead of coaxial cables.

The use of triaxial cable with the MIL-STD-1760 connectors' coaxial high bandwidth contacts can be achieved by: (1) terminating the inner shield and center conductor to the coaxial contact, and (2) terminating the outer shield to the connector accessory backshell at the ASI and MSI. Termination of the outer shield to the backshell can be achieved with the use of tag rings or other terminating devices.

5.3.4.1.3.2 Digital multiplex data and low bandwidth. These interface ports are designed to use twinaxial cables to provide good low frequency EMI performance. The twinaxial cable consists of a twisted pair of conductors enclosed by a shield braid (see figure 150). The interface characteristics are designed around the use of MIL-STD-1553 compliant twinaxial cables. The MIL-C-17/176 is an example of such a cable.

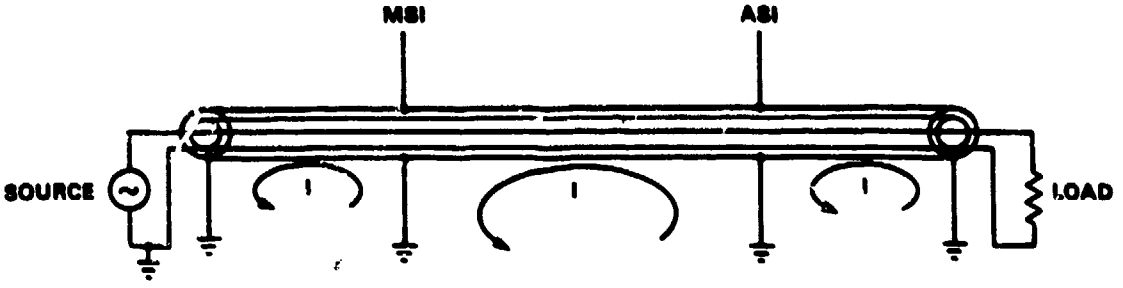
One advantage that the /176 cable has over some other twinaxial cables is a low specified capacitance unbalance of each conductor to shield. A well balanced cable improves the line-line rejection of noise by equally balancing the line-ground (i.e. shield) capacitance in the two conductors.

The MIL-STD-1760 connector contains three twinaxial contacts (MIL-C-39029/90 and 91) for routing the three twinaxial cable signals through the ASI and MSI connectors. These contacts were designed specifically for the MIL-C-17/176 cable.

5.3.4.2 Auxiliary signal set. The Auxiliary power signal set connector insert arrangement is shown in figure 151. This connector complies with the requirements listed in table XXII. The connectors on the umbilical (both ends) are plugs with pin contacts and the connectors on the aircraft, carriage store and mission store are receptacles with socket contacts.

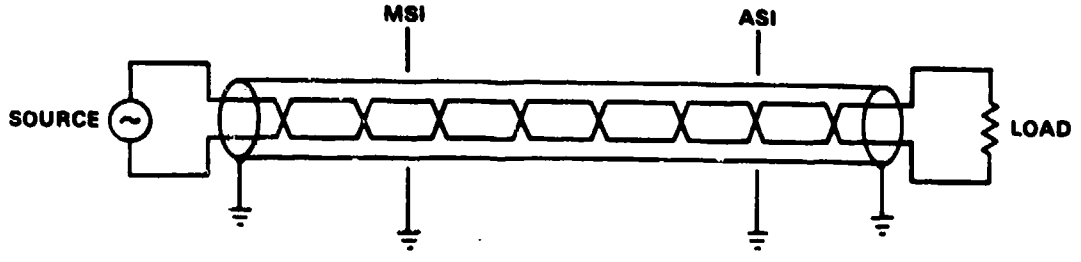
Table XXIII is a partial list of components that can be used in harness design. The aircraft can use other parts providing the ASI requirements in table XXII are met. The store has a broader range of part selection options since the MSI requirements are only oriented toward meeting intermateability characteristics of the specifications and standards listed in the table.

5.3.4.2.1 Connector assembly. Contact insertion and removal is accomplished with MS27495 (or equivalent) insertion and removal tools. Care must be taken when inserting the No. 10 contact. Due to the large contact size, inserting the contact can be relatively difficult. The force necessary to insert the contact through the grommet can result in an overtravel once the initial seal resistance is overcome. This overtravel can result in damage to the interfacial seal and hard dielectric behind the seal. Also, due to the stiffness of Size 10 wire, damage can result to the interfacial seal even after successful contact insertion if the wire is not



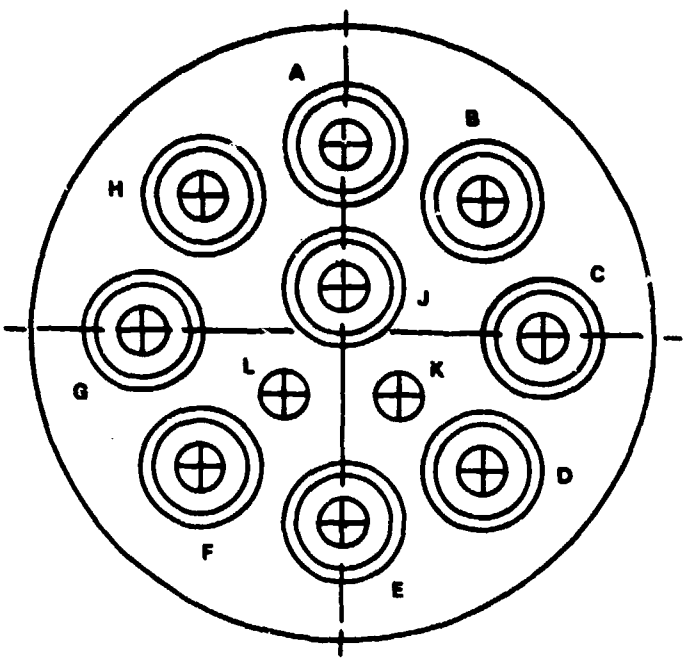
OUTER SHIELD GROUNDED AT ASI AND MSI
(NOISE CURRENTS ISOLATED FROM COAX SHIELD)

FIGURE 149. Triaxial cable installation.



SIGNAL CARRYING CONDUCTORS ISOLATED FROM SHIELD

FIGURE 150. Twinaxial cable installation.



SHELL SIZE	ARRANGE-MENT NO.	NUMBER OF CONTACTS	SIZE CONTACTS	SERVICE RATING	CONTACT LOCATION
25	-11	9	10	N	A, B, C, D, E, F, G, H, J
		2	20		L, K

FIGURE 151. Auxiliary signal set insert arrangement.

TABLE XXII. Auxiliary signal set connector requirements.

ASI connector characteristics:

Connector: The connector shall be in accordance with MIL-C-38999, Series III, Shell Size 25, Polarization Key Identification A.

Contacts: The contacts shall be in accordance with the following slash sheets to MIL-C-39029.

Size	Slash Sheet	Abbreviated Title
20	/56	Contact, socket
20	/58	Contact, pin
10	/56	Contact, socket
10	/58	Contact, pin

Insert Arrangement: The insert arrangements shall be in accordance with MIL-STD-1560, Insert Arrangement 25-11.

MSI connector characteristics: The MSI primary signal set connector shall comply with the intermateability dimensions of MIL-C-38999, MIL-C-39029 and MIL-STD-1560 as specified above.

TABLE XXIII. MIL-STD-1760 compliant hardware - auxiliary signal set.

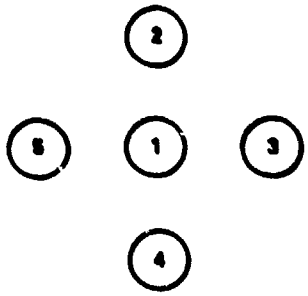
Item	Part Number	Nomenclature
1	D38999/26WJ11PA	Plug - Standard
2	D38999/31WJ11PA	Plug - Lanyard Release
3	D38999/20WJ11SA	Receptacle - Wall Mount
4	D38999/24WJ11SA	Receptacle - Jam Nut
5	M39029/56-XXX	Contact, Socket
6	M39029/58-XXX	Contact, Pin
7	M85045/20-25W	Backshell

handled with care. The wire cable must be properly secured to the connector with backshell hardware, otherwise damage to the interfacial seal can result while handling the harness.

5.3.4.2.2 Harness flexibility. The stiffness of Size 10 wire results in a stiff harness if the wires are laid in a straight line parallel to each other and secured to provide a tight bundle. Laying the wires to form a twist will increase harness flexibility. The lay length should be 8 to 16 times the pitch diameter, i.e., a 0.5 inch diameter cable layer would have one full turn every 4 to 8 inches in length. The umbilical cable should use an undirectional lay for maximum flexibility and ruggedness. Cable fillers should be used where necessary to fill any large voids in each layer of the cable. Figure 152 shows one possible conductor arrangement for the auxiliary harness. Other arrangements are also acceptable.

5.3.5 Reserved functions. The fiber optic contact locations (U and Y in the primary connector) and the 270V DC contact locations (N and R in the primary connector and F and H in the auxiliary connector) are reserved for future use. It is generally recommended that unused contact locations be filled with sealing plugs. The sealing plugs selected must accommodate a mating connector with installed contacts.

5.3.6 Electromagnetic compatibility considerations. The physical aspects of the interface design which impact EMC are primarily limited to cable assembly shielding (and the associated shield termination), EMI shielding



LOCATION	CONDUCTORS	FUNCTION
1	4 NO. 10 TWISTED	115/200V AC POWER
2	1 NO. 10	STRUCTURE GROUND
3	2 NO. 10 TWISTED	28V DC POWER
4	2 NO. 20 TWISTED	INTERLOCK
5	2 NO. 10 TWISTED	270V DC POWER

FIGURE 152. Auxiliary harness conductor arrangement.

effectiveness of the connector, and bonding of receptacles to aircraft and store structures.

5.3.6.1 Cable assembly shielding. The umbilical cable connecting the ASI to MSI must contain a gross overbraid to minimize injection of external field induced noise into the aircraft and store faraday shields. It is not expected that any tactical or strategic applications of MIL-STD-1760 will occur in environments benign enough to preclude use of a shielded umbilical. In addition, depending on the aircraft and store structural designs, shielded harness assemblies may be required inside the aircraft and store.

A flexible gross shield can be constructed over an umbilical cable by applying a woven wire braid of uninsulated wire. This shield braid can be specified by defining the braid wire gauge, optical coverage and braid angle. Typically, a braid wire of 32 or 34 AWG is used for cables with diameters in the range of the umbilical cable (i.e., approximately 0.5 to 0.75 inches). Shield coverage is generally defined as an "optical coverage" (typically 85 percent for overbraids). Optical coverage is determined by the physical dimensions of the shield construction (e.g. picks per inch, braid angle, etc.). The braid angle generally ranges from 20 to 60 degrees. Smaller angle braids allow a "looser" braid so that the braid can be pushed back on the cable to ease cable termination. The larger angle braids provide tighter and higher coverage. Given that the umbilical shield is one of the paths for lightning currents, the designer should consider beefing up the shield to provide the required 6000 to 40,000 circular mils of conductor.

A covering should be used between the braid and layered wires to reduce the probability that broken wire strands from the braid will penetrate a wire insulation as a result of cable flexing. Additionally, a covering should be placed over the braid to minimize abrasion against adjacent cables and other components and to minimize noise as a result of random touching of the shield to vehicle structure (e.g. during vibration).

5.3.6.2 Shield termination. Unless the shield is properly terminated, RF currents conducted along the shield will be coupled to the system wiring from the point of improper cable termination. This is important in the case of umbilicals. In a properly terminated shield, the entire periphery of the shield is grounded to a low impedance reference (connector shell) minimizing any RF potentials at the surface of the termination. The use of epoxy or other synthetic conducting material for shield termination is not recommended. Use of crimping or magnaforming is preferred. Figure 153 illustrates cable shield-to-connector termination and connector-to-bulkhead termination. The shield should not be pulled back, twisted and then bonded to the connector.

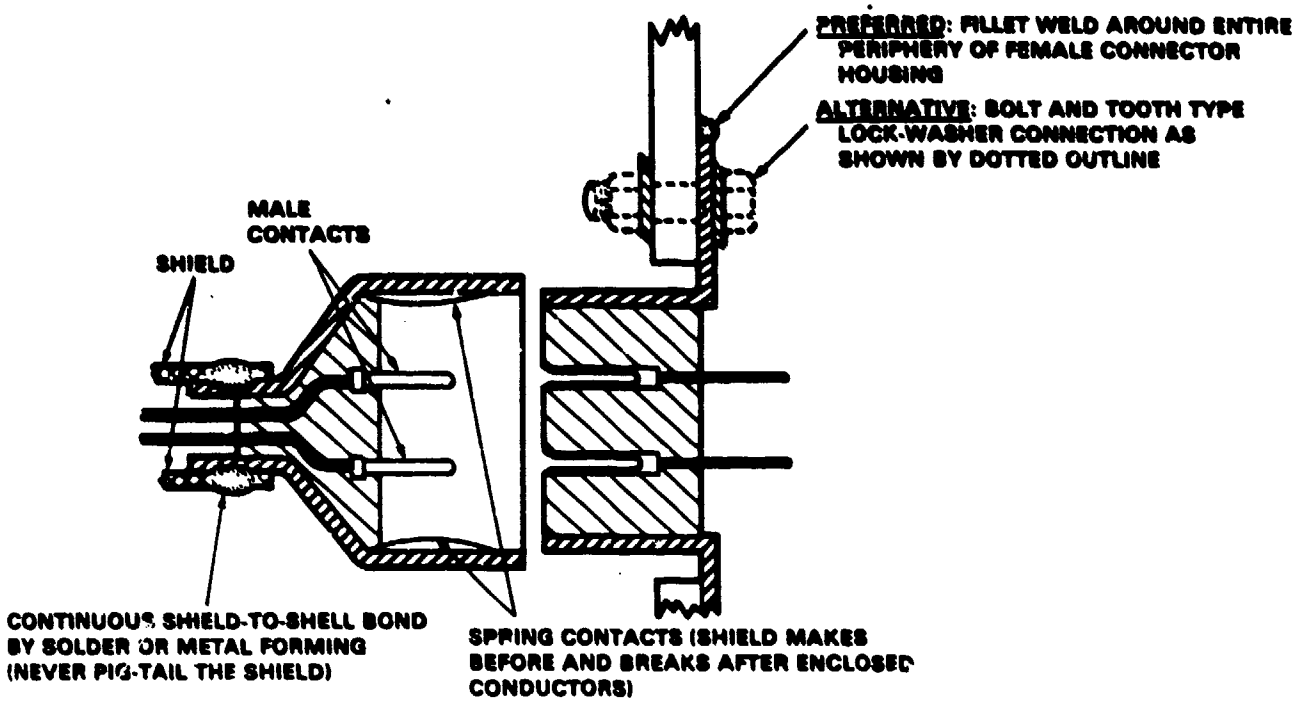


FIGURE 153. Shield termination to connectors.

5.3.6.3 Connector considerations. For a connector to provide high EMI shielding effectiveness, the connector should include the following features:

a. EMI grounding fingers that provide a good shell-to-shell connection prior to mating of individual contacts in the connector.

b. Conductive finishes on the connector shell

c. Provisions for 360 degree braid termination

d. Minimal shield degradation following environmental exposure

The receptacles at the ASI and MSI must be bonded to vehicle structure to minimize potential differences. Also, since the gross overbraid can be one of the paths for lightning currents, the receptacle should be bonded sufficiently to handle the expected current.

5.4 Review and rationale of MIL-STD-1760. This section is a commentary on each paragraph (or sets of paragraphs) of MIL-STD-1760, specifically Revision A of MIL-STD-1760. The commentary includes, where appropriate: (1) An explanation of the requirement; (2) rationale for the requirement; (3) subtleties of the requirement, and (4) a reference to appropriate sections in this report which expand on the design considerations for complying with the requirement. The format of this commentary includes the paragraph(s) from MIL-STD-1760 (as indented text) to be discussed, followed by the appropriate commentary on the paragraph(s).

5.4.1 Introductory information

1. SCOPE

1.1 Coverage. This standard defines implementation requirements for the Aircraft/Store Electrical Interconnection System (AEIS) in aircraft and stores. This interconnection system includes: (1) The electrical (and fiber optic) interfaces at aircraft store stations and the interface on mission stores; (2) interrelationships between aircraft and store interfaces; and (3) interrelationships between the interfaces at different store stations on an aircraft. This interconnection system provides a common interfacing capability for the operation and employment of stores on aircraft.

The AEIS standard defines common interfacing requirements at the electrical disconnect points between aircraft and stores. The interface

characteristics are defined to maximize compatibility while still affording design flexibility and technology advancements in the equipments which implement the interface.

1.2 Purpose. The purpose of this standard is to minimize the proliferation of electrical interfacing variations required in aircraft for operating stores. The implementation of this standard will enhance the interoperability of stores and aircraft by defining specific electrical and physical requirements for the AEIS.

1.3 Application. This standard applies to all aircraft and stores that electrically interface with each other. This coverage encompasses stores and aircraft presently in concept development stages and future aircraft and store development. This standard also applies to existing aircraft which are required to carry MIL-STD-1760 compatible stores.

Due to the number of aircraft and store assets currently in the field and the projected life of these assets, near term application of the AEIS is for new stores carried on "old" (i.e., existing) aircraft. These existing aircraft will be (are being) retrofitted to add AEIS capabilities. The added capabilities will supplement the existing non-AEIS store interface capabilities of these aircraft. While the initial cost for adding more capability (i.e., full AEIS interface) than may currently be needed for operating a specific MIL-STD-1760 store may seem high, longer term benefit for easing the addition of other stores to the aircraft will generally justify the cost difference.

5.4.2 Document references

2. REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents of the issue in effect on date of the invitation for bids or request for proposal, form a part of this standard to the extent specified herein.

(List of specifications, standards and handbooks)

2.2 Other publications. The following documents form a part of this standard to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

(List of industry standards)

This section, typical of all standards, provides a list of documents referenced in the body of MIL-STD-1760. In compliance with DoD policy, the list does not identify specific revisions (i.e., issues) of the listed documents. However, a future revision of one of the referenced documents could result in an impact to interface interoperability. If this occurs, the AEIS standard may be revised to limit or eliminate this impact by referencing a specific issue of the referenced document or by adding qualifications to the appropriate paragraph which cites the document.

5.4.3 AEIS definitions

3. DEFINITIONS

3.1 Aircraft. Any vehicle designed to be supported by air, being borne up either by the dynamic action of the air upon the surfaces of the vehicle, or by its own buoyancy. The term includes fixed and movable wing airplanes, helicopters, gliders, and airships, but excludes air-launched missiles, target drones, and flying bombs.

3.2 Aircraft/Store Electrical Interconnection System (AEIS). The AEIS is a system composed of a collection of electrical (and fiber optic) interfaces on aircraft and stores through which aircraft energize, control and employ stores. The AEIS consists of the electrical interfaces and interrelationships between the interfaces necessary for the transfer of electrical power and data between aircraft and stores and from one store to another store via the aircraft.

3.3 Electrical interface types. Four electrical interface types for the aircraft/store electrical interconnection system are defined as specified herein.

3.3.1 Aircraft Station Interface (ASI). The electrical interface(s) on the aircraft structure where the mission or carriage store(s) is electrically connected. This connection is usually on the aircraft side of an aircraft-to-store umbilical cable. The aircraft station interface locations include, but are not limited to pylons, conformal and fuselage hard points, internal weapon bays, and wing tips. (See 4.1.)

3.3.2 Carriage Store Interface (CSI). The electrical interface on the carriage store structure where the aircraft is electrically connected. This connection is

usually on the store side of an aircraft-to-store umbilical cable. (See 4.1 and 6.8.)

3.3.3 Carriage Store Station Interface (CSSI). The electrical interface(s) on the carriage store structure where the mission store(s) are electrically connected. This connection is usually on the carriage store side of an umbilical cable. (See 4.1 and 6.8.)

3.3.4 Mission Store Interface (MSI). The electrical interface on the mission store external structure where the aircraft or carriage store is electrically connected. This connection is usually on the mission store side of an umbilical cable. (See 4.1).

3.4 Store. Any device intended for internal or external carriage and mounted on an aircraft suspension and release equipment, whether or not the item is intended to be separated in flight from the aircraft. Stores are classified in two categories as specified.

3.4.1 Carriage store. Suspension and release equipment that is mounted on aircraft on a non-permanent basis as a store is classified as a carriage store. Pylons and primary racks (such as a MAU-12 and BRU-10) are not considered carriage stores. (See 6.8.)

A partial list of existing carriage stores include multiple station ejector racks (e.g., BRU-34), multiple station rail launcher (e.g., LAU-88), and single station launchers (e.g., LAU-117). These stores are functionally mechanical and electrical adapters that convert a single store (electrical and mechanical) interface into either a multiple store interface or a single store interface which is electricaly or mechanically different (e.g., adapting a hook/lug suspension mode to a rail/shoe suspension mode). (See 4.1.3.4.)

3.4.2 Mission stores. All stores excluding suspension and release equipment (carriage stores) are classified as mission stores. In general, these stores directly support a specific mission of an aircraft.

A partial list of mission stores include bombs, missiles, rocket launch pods, mines, torpedoes, and electronic pods.

3.5 Stores Management System (SMS). The avionics subsystem which controls and monitors the operational

state of aircraft installed stores and provides and manages the communications between aircraft stores and other aircraft subsystems.

The SMS may be implemented by: (1) one or several dedicated electronic equipments which are formally named SMS; or (2) electronic equipment which is part of another avionic system but which provides the SMS functions, or (3) some combination of (1) and (2). (See 4.1.3.1 and 5.1.1.)

3.6 Suspension and Release Equipment (S&RE). All airborne devices used for carriage suspension, employment, and jettison of stores, such as, but not limited to, racks, adapters, launchers, and pylons.

3.7 Provisions. Space in all feed-through connections and in all wire runs that will allow future incorporation in the aircraft or store without modification other than the addition or changes to connectors, cables and hardware/software necessary to control the added functions.

This definition of provisions is an attempt to clarify what is expected of aircraft manufacturers if they are required to include "provisions for MIL-STD-1760" in designated aircraft models or production blocks.

5.4.4 AEIS general requirements

4. GENERAL REQUIREMENTS

4.1 Aircraft/store configurations. This standard provides for a variety of aircraft/store configurations, as depicted in figure 1, by specifying requirements measurable at the Aircraft Station Interface (ASI) and at the Mission Store Interface (MSI). Although detailed requirements for the Carriage Store Interface (CSI) and the Carriage Store Station Interface (CSSI), as depicted in figure 1b, are not specified in this standard, the requirements on the ASI and MSI allow for possible installation of a carriage store between the ASI and MSI.

Two important introductory issues are presented in this paragraph. First, figure 1 illustrates in a very generic manner, the functional location of the various AEIS interfaces. This block diagram formatted presentation was intentionally selected to distinguish functional location from physical location. This figure, along with paragraphs 3.3.1 through 3.3.4 of the standard is an attempt to emphasize that an AEIS interface (ASI, for example) is the "last" electrical disconnect or break point that is

permanently part of the weapon system (aircraft, for example). Physically, this disconnect point might be in the bottom of a pylon for pylon carriage modes, behind an access panel for conformal carriage modes, part of a blind mate connector mechanism for a bolted-on rail launcher, etc. In general, the actual physical location is of no concern to MIL-STD-1760.

The second important point in this paragraph is that even though figure 1 and paragraphs 3.3.2 and 3.3.3 address AEIS interfaces associated with carriage stores, detail characterization of these interfaces (CSI and CSSI) is not included in MIL-STD-1760. Detail characterization of the CSI and CSSI is excluded due to questions on whether interoperable carriage stores will be developed for future applications. However, even though detail interface definition is not included, the characteristics defined for the ASI and MSI include considerations (signal losses, for example) for inserting carriage stores between the aircraft and mission stores.

> 4.2 Interface classes. All functions of the AEIS shall be allocated between two separate signal sets; the primary interface signal set and the auxiliary power signal set. Separate connectors shall be required for each set. The ASI shall implement, and the MSI shall be compatible with, one of the following interface classes.
>
> | | |
> |---|---|
> | Class I: | The full primary interface. |
> | Class IA: | Class I plus the auxiliary power interface. |
> | Class II: | The full primary interface without high bandwidth 2 and 4, fiber optic channels 1 and 2, 270V DC power and 270V DC return. |
> | Class IIA: | Class II plus the auxiliary power interface. |

The minimum ASI capability required by MIL-STD-1760 is the class II interface. As a current projection, a class II interface capability is expected to be sufficient for most aircraft air-air stations and light weight (1000 pound store class) air-ground stations. Class IA is recommended for most aircraft heavy stations and stations expected to carry electronic pods such as ECM and FLIR. Class I and IIA represent intermediate capabilities which may be appropriate for some aircraft stations.

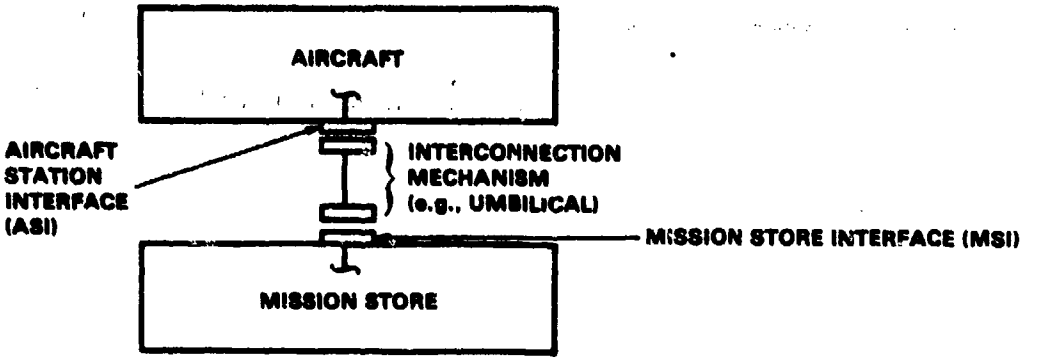


FIGURE 1a. Direct carriage of mission store at aircraft station.

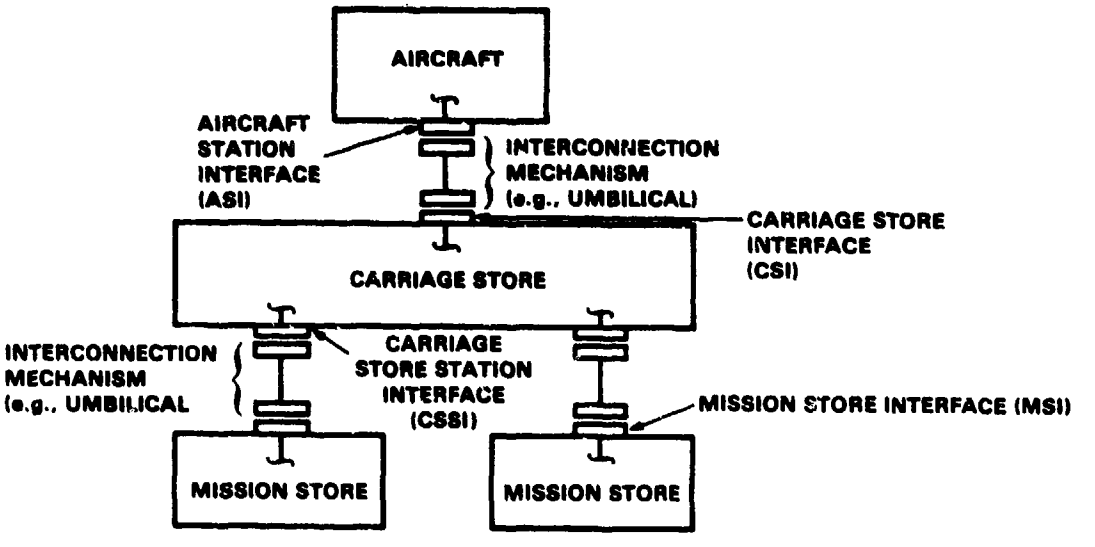


FIGURE 1b. Carriage of multiple mission stores at single aircraft station.

FIGURE 1. Aircraft store configurations.

Mission stores (or specifically, MSIs) are compatible with any of the listed classes provided that the store uses only those signals available in the specific class and complies with MIL-STD-1760 for those signals used. (See 5.1.2, 5.2.1 and 5.3.1.1.)

> 4.3 Primary interface. The primary interface shall include requirements for the primary interface signal set and its connector. The primary interface requirements shall apply to the interface classes defined under 4.2.

Subparagraphs of MIL-STD-1760 Section 4.3 provide an executive summary or overview of the primary interface electrical and physical requirements. Detailed requirements are contained in MIL-STD-1760 Sections 5.1 and 5.2 for the aircraft and mission store, respectively.

> 4.3.1 Primary interface signal set. The primary interface signal set, as shown in figure 2, shall be comprised of interfaces for high bandwidth signals, redundant multiplex data bus signals, low bandwidth signals, fiber optic signals, a specified number of dedicated discrete signals, and aircraft power. Detailed electrical requirements for each of these functions at the ASI and MSI shall comply with the requirements of Section 5 herein.
>
> 4.3.1.1 High Bandwidth (HB) interfaces. Four bi-directional interfaces (HB1, HB2, HB3, and HB4) shall be capable of transferring two general signal types (Type A and Type B) as specified herein. The aircraft shall assign, control, and route these signals to their proper destinations. HB line applications include transfer of video, radio frequency, and time synchronization signals.
>
> 4.3.1.1.1 Type A signal transfer. Four HB interfaces (HB1, HB2, HB3 and HB4) shall be capable of transferring Type A signals (20 Hz to 20 MHz passband) between stores installed at different aircraft stations and between aircraft and attached stores. Type A signals include composite video and time synchronization signals.
>
> 4.3.1.1.2 Type B signal transfer. One HB interface (HB1) shall be capable of transferring Type B signals (20 MHz to 1.6 GHz) between aircraft and attached stores. Type B signals shall include low power level radio frequency signals such as receiver inputs.

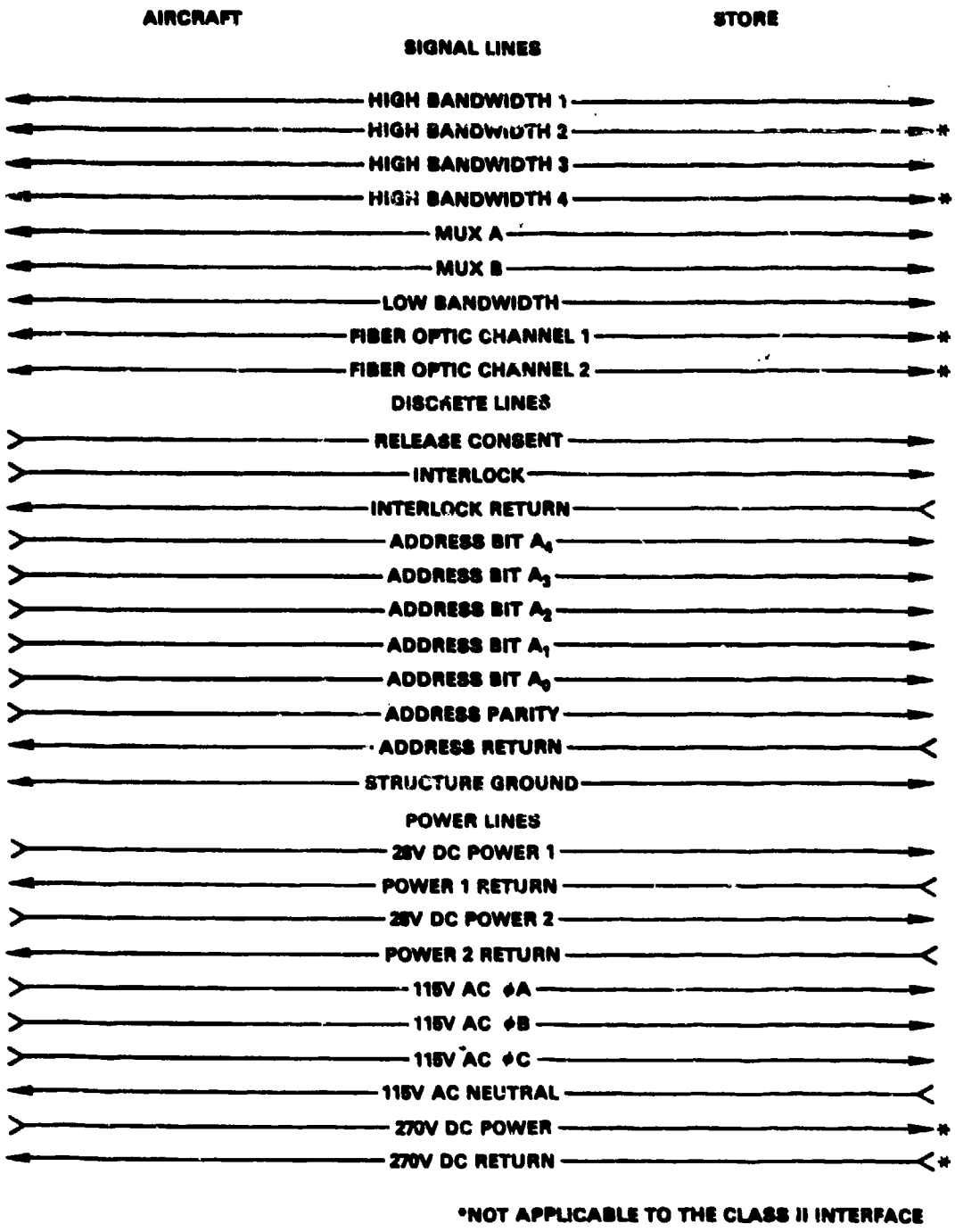


FIGURE 2. Primary interface signal set.

The detailed electrical requirements (in Section 5) for the High Bandwidth interfaces are divided into low frequency band (Type A) and high frequency band (Type B) characteristics to simplify the interface definition. Both Type A and Type B requirement sets apply to the HB1 interface port while only the Type A requirement set applies to the other three ports (HB2, HB3 and HB4).

> 4.3.1.2 Digital multiplex data interface. The digital multiplex data interface shall provide redundant channels (Mux A and Mux B) for transferring digital information, store control and store status data between aircraft and stores. The signals crossing the interface shall comply with the requirements of MIL-STD-1553 as augmented by the requirements of Section 5 herein.

The redundant MIL-STD-1553 compatible serial data port connections at the AEIS interfaces provide the most important service "utility" in the interconnection system. Through this diversified serial time division multiplexed data link, a flexible mechanism is available for primary control of stores and for transferring data between aircraft and stores. Due to peculiarities in the application of MIL-STD-1553 to the aircraft/store interface, several additional requirements are imposed on the data link interface that are not covered in MIL-STD-1553. (See 5.1.3 and 5.2.2.)

> 4.3.1.3 Low Bandwidth (LB) interface. The LB interface shall be capable of transferring bi-directional LB (DC to 50 KHz) signals between the aircraft and stores. Currently, the only LB signals allowed are tones and voice grade audio. (See 6.9.) This interface shall not be used for discrete functions.

The only application currently permitted for this twisted shielded pair Low Bandwidth (LB) interface is to transfer tones (e.g., Sidewinder audio) and voice grade audio (e.g., to recorders in pods or to/from data link pods). The reference to paragraph 6.9 alerts the reader that the LB interface characteristics are established to allow possible future use as a low speed (e.g., 38 kilobaud) point-to-point serial digital data link for applications where the cost of MIL-STD-1553 remote terminals may be high relative to the total cost of a simple store (e.g., an electronically fuzed MK80 series freefall bomb). If it is determined that such low speed serial data applications are appropriate, detail characteristics of the digital data link will be added to MIL-STD-1760 by notice or revision.

Because the LB interface is defined with a DC capability, concerns existed that the LB port will be used as a general purpose discrete. Since such a use would undermine the interoperability enhancement objective of the AEIS, a specific sentence is added disallowing use of this signal as a discrete. (See 4.3.3, 5.1.6 and 5.2.7.)

4.3.1.4 Fiber optic interface. Provisions shall be included in class I interface connectors for two fiber optic communication channels (channel 1 and channel 2). As military fiber optic standards evolve, the fiber optic requirements in this standard will be expanded to incorporate the fiber optic military standard. The fiber optic provisions in the interfaces shall not be utilized until added to this standard.

This paragraphs identifies a dedicated growth provision in the AEIS for future addition of a fiber optic data link capability to the standard. It was considered as premature (at the time of MIL-STD-1760 publication) to establish detail fiber optic interfacing requirements in the AEIS standard. This capability is to remain in reserved status until a standardized set of fiber optic interface characteristics is added to MIL-STD-1760. (See 4.3.2.)

4.3.1.5 Release consent interface. The release consent interface shall be a low power discrete used only to enable, and inhibit, safety critical store functions which are commanded by the aircraft over the digital multiplex data interface (4.3.1.2).

CAUTION

The release consent interface is provided to satisfy an aircraft safety function. Consent is enabled whenever the aircraft determines that safety criteria for store employment sequence has been met.

The name "Release Consent" is a carry over from MIL-STD-1760 (No Revision) dated July 1981. Based on its application, a better name might be "Safety Critical Consent". Two important points are contained in this paragraph. The first point is that the consent signal in and of itself does not result in a store state change but enables or inhibits a store state change that is commanded by the aircraft through the multiplex data interface (Mux A or Mux B).

The second point is that the consent discrete is provided solely as a safety interlock for the aircraft. The intent is that the aircraft can establish the enable state on the discrete at any time prior to the needed employment sequence. As two extreme examples, one aircraft might establish the consent enable state at "wheels up" while another aircraft might establish consent enable only milliseconds before a fire command is sent over the multiplex data bus. In both cases the store is compatible but in the former case the safety of the aircraft may be at risk for a longer time. (See 5.1.4.2 and 5.2.3.2.)

4.3.1.6 Primary interlock interface. The interlock interface shall be available for the aircraft to monitor the electrically mated status of the primary interface connector between stores and aircraft.

CAUTION

The interlock interface shall not be used as the sole criteria for functions which could result in an unsafe condition if the interlock circuit fails open.

Interlock interface is provided as an indicator of whether the eletrical interface between the aircraft and store is electrically connected. The aircraft is not required to use the interlock interface. A single point failure (e.g., broken wire, contaminated contact, etc.) could yield an indication of "interface not mated". Therefore, the aircraft must not use this interface as the only criteria for actions that have safety implications. The primary concern here is the use of the interlock as an indication that a store has physically separated from the aircraft. A false indication could lead to collisions between stores during release, severe asymetrical loading of the aircraft, etc. (See 5.1.4.1 and 5.2.3.1.)

4.3.1.7 Address interface. The address interface shall be used to assign a unique MIL-STD-1553 remote terminal address to the connected store. The address interface shall contain a set of six discretes (five binary weighted address bit discretes A0 through A4 and one parity discrete) and one common address return.

These six address discretes (plus return) allow assigning a unique data bus address from 0 through 30 to the MIL-STD-1553 remote terminal in each store. This address is assigned at the time that the store is installed on a specific aircraft station. The store can then communicate with the aircraft whenever the store receives a command word with a terminal address field which matches its assigned address. A parity signal is included in the address discrete set to provide an error or fault detection capability for single point failure (such as shorted or broken wires) at the interfaces. (See 5.1.4.3 and 5.2.3.3.)

4.3.1.8 Primary structure ground. A dedicated circuit shall be provided between the aircraft and store structure grounds. It shall provide an electrical connection between aircraft and store structures to minimize shock hazards to personnel as required by MIL-B-5087. This circuit shall not be used as a signal or power return path.

Since the last sentence of this paragraph could lead to some confusion, the following comments are presented. The detail requirements of this standard (MIL-STD-1760 Sections 5.1 and 5.3) do not define specific relationships between various grounds in the aircraft or in the store. It is, therefore, possible (likely) that the aircraft will connect 28V DC and 115/200V AC returns to aircraft structure. It is also possible that the store will connect its 28V DC and 115/200V AC load returns to store structure. Under these two legal (i.e., AEIS compliant) design conditions, some power supply currents will flow through the structure ground line. The last sentence does not disallow this condition. It is intended to disallow two other possibilities: (1) An aircraft or store using structure ground as the reference ground for an AEIS signal; and (2) an aircraft or store using structure ground instead of installing dedicated 28V DC return or 115/200V AC neutral lines through the interfaces.

> 4.3.1.9 Primary power. The aircraft shall supply and control all power to stores through the ASI. All ASIs shall provide two 28V DC channels and one channel of three phase, four wire, wye-connected, 400 Hz, 115/200V AC. In addition, provisions shall be included at the ASI for one channel of 270V DC. A dedicated power return shall be provided through the AEIS for each power channel. Mission stores may utilize any combination of 28V DC and 115/200V AC power available at the MSI. The activation of power shall not be used for discrete functions.

Growth provisions are included in the AEIS for future implementation of 270V DC power systems. The current MIL-STD-704 (military standard that defines electrical power characteristics) includes 270V DC as a military standard voltage. However, no aircraft currently distributes this voltage level to utilization equipment. Since 270V DC is not currently implemented in aircraft, MIL-STD-1760 does not require it to be implemented in the AEIS interfaces. However, because 270V DC is included in MIL-STD-704 and may be implemented in the future, growth provisions are included in the AEIS.

As with the comment on MIL-STD-1760 paragraph 4.3.1.3, the last sentence is included in this paragraph to disallow the use of the power lines - particularly the 28V DC lines - as general purpose discretes. (See 5.1.7 and 5.2.8.)

> 4.3.2 Primary signal set connector. The primary signal set connector (Class I or II) shall be in accordance with the requirements specified in 5.1.2.1 and 5.2.2.1.

This requirement establishes (by reference to other paragraphs in the standard) one specific connector and insert arrangement as the standard

primary signal set connector for all ASIs and MSIs with two exceptions. These two exceptions are not highlighted in the main body of the standard but are contained in Items c. and d. of the "Limitations" paragraph of the standard's foreword. The limitation paragraph states that rail launched MSI intermateability characteristics and simple store MSI signal set and intermateability characteristics are not covered in this standard. This limitation results from: (1) An alternate connector being considered for use at the MSI (only) for rail launch stores, and (2) an alternate connector and reduced signal set (subset of class II) being considered for use at the MSI (only) for "simple stores". The nebulous "simple store" label is intended to apply to mission stores which are both low cost and require very small amounts of interface data and power. This label is primarily directed at stores such as electronically fuzed MK80 series free-fall bombs. (See 4.3.3 and 5.3.4.)

> 4.4 Auxiliary power interface. The auxiliary power interface shall include the requirements for the auxiliary power signal set and its connector. The auxiliary power interface requirements shall apply to interface classes IA and IIA defined in 4.2.

Subparagraphs of Section 4.4 provide an overview of the auxiliary power interface electrical and physical requirements. Detailed requirements are contained in Sections 5.1 and 5.2 for the aircraft and mission store, respectively.

> 4.4.1 Auxiliary power signal set. The auxiliary power signal set, as shown in figure 3, shall include interfaces for aircraft power, structure ground, and interlock discrete. Detailed electrical requirements at the ASI and MSI shall be in accordance with Section 5 herein.
>
> 4.4.1.1 Auxiliary power. The aircraft shall supply and control all auxiliary power to stores through the ASI. The auxiliary power interface at an ASI shall include one 28V DC power channel and one channel of three phase, four wire, wye-connected, 400 Hz, 115/200V AC. In addition, provisions shall be included at the ASI for one channel of 270V DC. A dedicated power return shall be provided through the AEIS for each power channel. Mission stores may utilize any combination of 28V DC and 115/200V AC power available at the MSI. The activation of power shall not be used for discrete functions.

The auxiliary power interface is provided to supply additional electrical power to those store applications which require a higher power capacity than is available through the primary interface. Generally, the store types

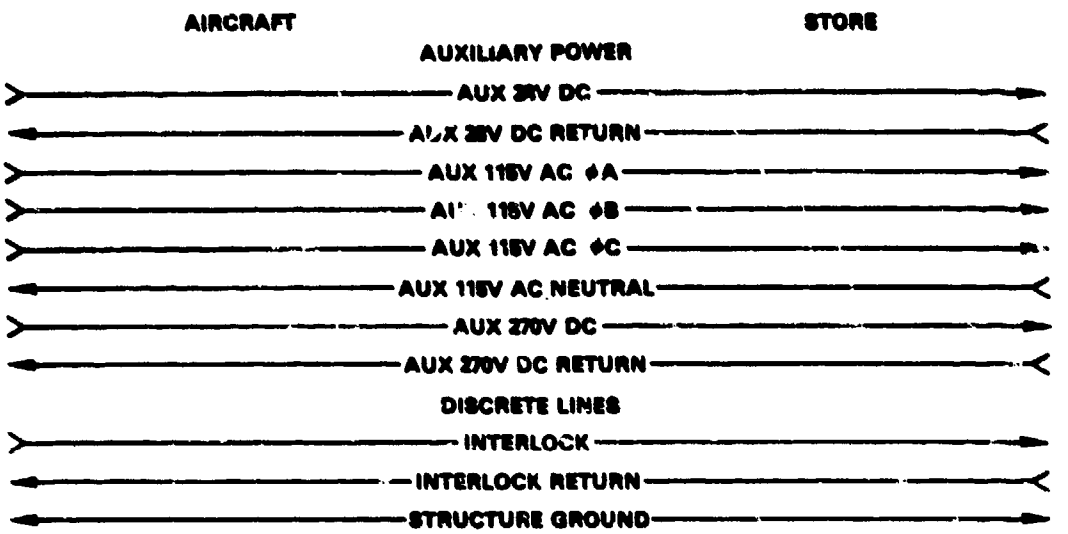


FIGURE 3. Auxiliary power signal set.

which fit this category are electronic pods (such as ECM equipment) or multiple station carriage stores.

Growth provisions are included in the AEIS for future implementation of 270V DC power systems. (See comment on MIL-STD-1760 Paragraph 4.3.1.9.)

As discussed in the comment on paragraph 4.3.1.3, the last sentence is included in this paragraph to disallow the use of the power lines as a general purpose discrete. (See 5.1.2, 5.1.7, 5.2.1 and 5.2.8.)

> 4.4.1.2 Auxiliary interlock interface. An auxiliary interlock interface shall be available for the aircraft to monitor the electrically mated status of the auxiliary power interface connector between stores and aircraft.
>
> CAUTION
>
> The interlock interface shall not be used as the sole criteria for functions which could result in an unsafe condition if the interlock circuit fails open.

Similar to the commentary on MIL-STD-1760 paragraph 4.3.1.6, an interlock interface is also included for the auxiliary power signal set. This interlock provides a capability for the aircraft to monitor the electrically mated status of the auxiliary power connector. The auxiliary connector mated status indication is independent of the interlock interface contained in the primary signal set. (See. 5.1.4.1 and 5.2.3.1.)

> 4.4.1.3 Auxiliary structure ground. A dedicated circuit shall be provided between the aircraft and store structure grounds. It shall provide an electrical connection between aircraft and store structures to minimize shock hazards to personnel as required by MIL-B-5087. This circuit shall not be used as a signal or power return path.

Refer to the commentary on MIL-STD-1760 paragraph 4.3.1.8 above.

> 4.4.2 Auxiliary power signal set connector. The auxiliary power signal set connector shall be in accordance with the requirements specified in 5.1.2.2 and 5.2.2.2.

This paragraph establishes (by reference to other MIL-STD-1760 paragraphs) one specific connector and insert arrangement as the standard connector for the auxiliary interface connector of all ASIs and MSIs.

5.4.5 Detail aircraft requirements

5. DETAIL REQUIREMENTS

5.1 Aircraft requirements (measured at the ASI). The aircraft shall provide the Aircraft Station Interface (ASI) with the characteristics defined herein.

This introduction contains an important point.

The requirements specified for the aircraft and store are defined (and measurable) at the appropriate interface (i.e., ASI or MSI). If the characteristic is not measurable at an AEIS interface or between AEIS interfaces, then it is not included in the standard. The importance of this "interface specification" approach in MIL-STD-1760 is that any technology or design can be used to implement the interface as long as the interface requirements are met. (See 5.1.1.)

5.1.1 Interface electrical requirements

5.1.1.1 Aircraft HB interfaces. The aircraft shall provide HB interfaces at each primary signal set ASI for bi-directional simplex transfer of Type A and Type B signals in accordance with the requirements herein. Each HB interface shall include a signal connection and a signal return (shield) connection. The requirements specified are based on the ASI containing all four HB interfaces (HB1, HB2, HB3 and HB4) as required by interface classes I and IA. For interface classes II and IIA, requirements associated with HB2 and HB4 shall not apply.

The aircraft is to provide a high frequency signal distribution network with access ports at each ASI and at applicable aircraft avionic equipment areas. The distribution network must support signal transfer through the ASIs in either direction but in a simplex mode. (Bi-directional duplex operation is not required by MIL-STD-1760.) Each HB interface is specified as a coaxial (or two connection) interface consisting of a signal connection and signal return connection. If a coaxial cable is used, then the signal return is the coaxial shield. However, the interface specification also allows a triaxial (or three connection) interface consisting of a signal interface connection, a signal return interface connection and a grounded shield. This grounded shield, however, is not "visible" at the ASI or MSI. Paragraph 6.11 of the standard contains a non-mandatory recommendation to use triaxial cable for the HB network. (Also see 5.1.5 and 5.1.9.)

5.1.1.1.1 Minimum transfer capacity. The aircraft shall support the transfer of one Type B signal or one Type A signal on HB1

simultaneously with the transfer of Type A signals on HB2, HB3, and HB4 through an ASI. (See 6.3.)

This paragraph contains three points. First, two signal types (Type A and Type B) are assigned to specific HB ports. Type A signal requirements are applied to HB1, HB2, HB3 and HB4 while Type B signal requirements are applied to HB1 only.

The second point is that, although HB1 is to be compatible with Type A and Type B signals, it is not required to transfer Type A and Type B signals through the HB1 port at the same time. This means that a specific signal is not permitted to overlap both the Type A and Type B characteristics of Table I - a signal is either Type A or Type B, but not both.

The third point is that the aircraft's high bandwidth signal distributition network must be designed with sufficient capacity to transfer signals through all HB ports at a given ASI. The distribution capacity of the aircraft network for supporting simultaneous operation of more than one ASI is not defined by the standard beyond a non-binding recommendation in paragraph 6.3 and its associated figure 13 in the standard. (See 5.1.5.1.)

5.1.1.1.2 Electrical characteristics. The aircraft shall be capable of transferring Type A and Type B signals through the ASI with the electrical characteristics as specified herein. The Type B requirements shall apply to HB1 only and the Type A requirements shall apply to HB1, HB2, HB3 and HB4. Unless otherwise specified herein, the performance requirements shall apply at the ASI, looking into the aircraft, and shall include the effect of the ASI mating connector.

This paragraph alerts the designer that the interface specifications for the ASI include the effects of the ASI mating connector. Inclusion of the mating connector is important primarily for HB requirements such as Voltage Standing Wave Ratio and attenuation limits. (See 5.1.5.2.1 and 5.1.5.3.)

5.1.1.1.2.1 Signal characteristics. Type A and Type B signals shall comply with the general characteristics of table I. Signals for monochrome raster composite video shall comply with EIA-STD-RS-170, EIA-STD-RS-343A or STANAG 3350 with the following two exceptions: (1) The sync pulse amplitude shall be 28.6 ±5 percent of the composite signal peak-to-peak amplitude; (2) the composite signal peak-to-peak amplitude shall be 1.40 to 3.50 volts at the ASI for aircraft sourced video. The aircraft shall be compatible with

TABLE I. High bandwidth general signal characteristics.

CHARACTERISTIC	SIGNAL TYPE	
	TYPE A	TYPE B
Signal frequency		
Minimum	20 Hz	20 MHz
Maximum	20 MHz	1.60 GHz
Full scale signal voltage		
Minimum	1.0V pp	.01 microvolt pp
Maximum	12.0V pp	1.0 V pp
Signal voltage dynamic range	30 dB	30 dB
Maximum power		
HB1	300 milli-watts 1/	10 dBm 2/
HB2	300 milli-watts 1/	(Not Applicable)
HB3, HB4	200 milli-watts 1/	(Not Applicable)

1/ The average power level shall not exceed the value specified when measured over any 1 second interval.

2/ The instantaneous power level shall not exceed the value specified.

received video (store sourced video) with a composite signal peak-to-peak amplitude of 1.80 to 3.50 volts at the ASI.

The only high bandwidth signals fully specified are video signals which fall within the Type A characteristics envelope. The reference to the two EIA video standards and the one NATO STANAG occurs because ratification of the STANAG by DoD has yet to occur. EIA-RS-170 covers low resolution (525 line) composite raster scan video while EIA-RS-343 covers high resolution (up to 1023 lines) video. The identified exceptions to these standards center around providing a higher signal-to-noise ratio video signal needed for acceptable operation of video in store and SMS application.

Table I identifies the general characteristics with which all Type A and Type B signals must comply. This table defines outer boundaries for characteristics of compliant signals. For example, all frequency components of a Type A signal are contained within a band from 20 Hertz through 20 MegaHertz. A specific Type A signal might actually contain frequencies from 30 Hz to 6 MHz.

The signal amplitude limits are defined by a combination of full scale signal voltage and signal voltage dynamic range limits. Therefore, the maximum (i.e., full scale) voltage of a specific Type A signal can be no less than 1 volt p-p and no more than 12 volts p-p. Likewise, the minimum voltage of a specific Type A signal can be no less than 30 dB below the specific signal's maximum voltage. Using video as an example, a video signal with maximum peak-peak amplitude of 3.0 volts falls within the 1.0 to 12.0 volt p-p limits. As long as the signal doesn't contain necessary information encoded by signal amplitudes less than 0.95 volts p-p (30 dB below 3.0 volts p-p), then the signal complies with the dynamic range requirement.

5.1.1.1.2.2 Signal assignment. The aircraft shall limit the transfer of signals on the HB interfaces to the following:

a. Radio frequency signals which comply with the Type B signal characteristics shall be transferred on HB1.

b. Time correlation (synchronization, clocking and blanking) signals shall be transferred on HB1 or HB2, or both.

c. Raster composite video signals shall be transferred on HB3 or HB4, or both.

This paragraph imposes assignment restrictions for signals on the four HB interfaces for two primary reasons. First, if the use of the HB interfaces

were not restricted, a significant risk would exist that the HB ports would be used for assorted custom functions. Such use would impose direct obstacles to achieving interoperability. While this paragraph restricts the aircraft use of the HB ports, a similar paragraph (5.2.1.1.2.2) applies comparable restrictions to the mission store. It is expected that if viable applications for the HB ports evolve which are not covered by the listed signals, then the standard would be revised to incorporate the new signals.

The second reason for the assignment restrictions is to prevent shuffling of a common set of signals between the four HB ports with each new application. As an example, composite video is a Type A signal. All four HB ports are specified to handle Type A signals. Therefore, without the restrictions of this paragraph, one store could place video on HB1 and some other store could select HB3. The aircraft would then be required to provide signal distribution paths to the cockpit displays from HB1 at each ASI in addition to HB3. Thus, the assignments in the paragraph help limit the aircraft's distribution network complexity.

> 5.1.1.1.2.3 Characteristic impedance. The nominal characteristic impedance at the ASI shall be 50 ohms for HB1 and HB2 and 75 ohms for HB3 and HB4.

The nominal characteristic impedances for the HB ports (as measured at the ASI) are defined in this paragraph. The impedances are defined as "nominal" to establish the impedance reference values around which the VSWR requirements in the next paragraph (5.1.1.1.2.4) are measured. (The nominal characteristic impedance in conjunction with the VSWR defines the actual impedance variations as measured at the ASI.)

> 5.1.1.1.2.4 Voltage Standing Wave Ratio (VSWR). The aircraft shall comply with the VSWR requirements of table II. The VSWR shall include the effects of the mated AEIS connectors shown in figures 4 and 5. The aircraft shall be compatible with the mission stores which impose, at the ASI, a Type A or Type B signal load with a VSWR of 2.0 maximum. When applicable, the aircraft shall be compatible with carriage stores which impose, at the ASI, a Type A or Type B signal load with a VSWR of 3.20 maximum. The VSWR produced at the ASI by the carriage store includes the effect of mission stores connected to the carriage store. (See 5.1.1.1.2.11.)

Limits on VSWR are defined for each ASI interconnect configuration - that is: (1) With and without umbilical cables; (2) into the ASI and out of the ASI; and (3) ASI to aircraft equipment signal paths as well as ASI-ASI signal paths.

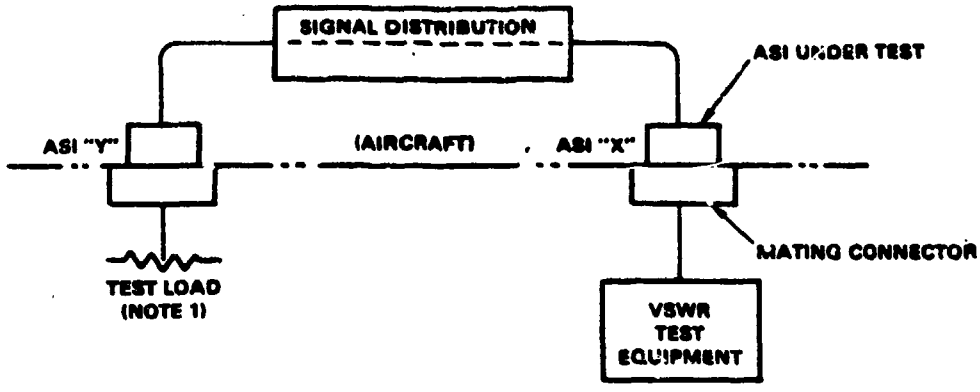
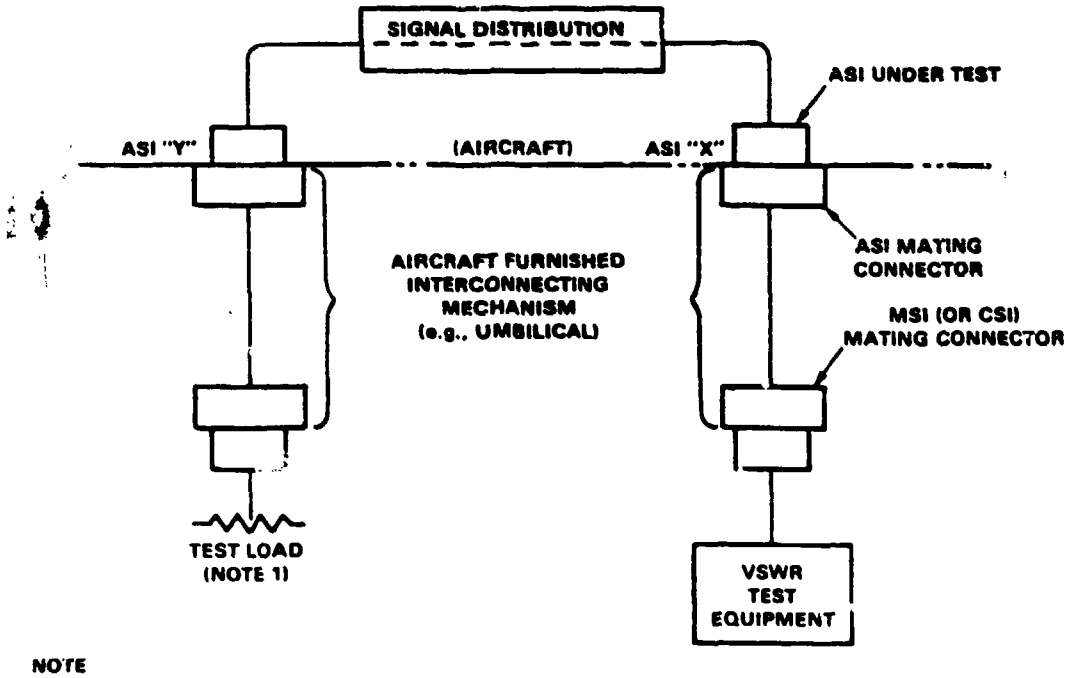


FIGURE 4a. Test at ASI.



NOTE

1. THE TEST LOAD SHALL HAVE A VSWR OF 1.05 MAXIMUM REFERENCED TO 50 OHMS FOR HB1 AND HB2 AND REFERENCED TO 75 OHMS FOR HB3 AND HB4.

FIGURE 4b. Test at store mating connector.

FIGURE 4. VSWR measurements of ASI-to-ASI transfer.

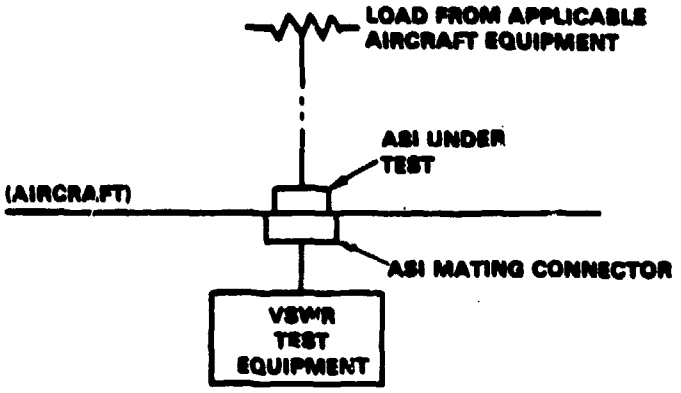


FIGURE 5a. Test at ASI.

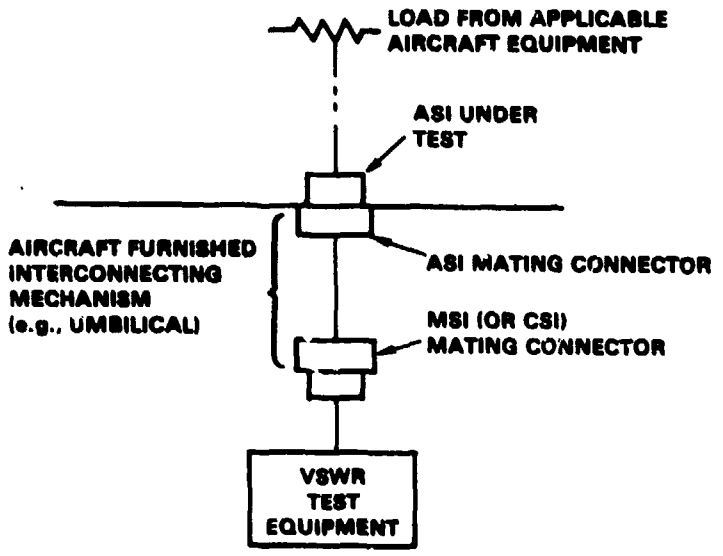


FIGURE 5b. Test at store mating connector.

FIGURE 5. VSWR measurements of ASI-to-aircraft transfer.

Although the Type A signal is defined for frequencies down to 20 Hertz, the VSWR specification only goes down to 5 MHz. The cut-off of VSWR specification at 5 MHz versus continuing down to 20 Hertz was made for two reasons.

First, most VSWR measurement equipment is not capable of measuring VSWR down to these low frequencies (e.g., 20 Hertz). Second, transmission line characteristic impedance is relatively constant until the measurement frequency drops below a critical frequency range. Below this frequency range, the signal no longer propagates through the dielectric waveguide of the transmission line, but now propagates through the conductors. When this transition occurs, the line "impedance" increases toward infinity. (See 5.1.5.2.2.) The frequency range where the transition occurs is dependent on the cable geometry. For typical cables which would be used in the AEIS, this transition starts in the low MegaHertz range. By stopping the lower frequency measurement limit at 5 MHz, accurate and meaningful VSWR measurements can be made.

TABLE II. Aircraft VSWR requirements.

CONDITION	APPLICATION	MAXIMUM VSWR	FREQUENCY RANGE 1/
Figure 4a	2/	1.75	5 MHz to 1.60 GHz
Figure 4b	3/	2.0	5 MHz to 1.60 GHz
Figure 5a	4/	1.75	5/
Figure 5b	6/	2.0	5/

1/ Frequencies from 20 MHz to 1.60 GHz apply to HB1 only.

2/ Applicable to all ASI to ASI signal paths.

3/ Applicable to installations where an ASI to MSI (or ASI to CSI) interconnection mechanism (such as an umbilical cable) is furnished as part of the aircraft equipment.

4/ Applicable to specific systems where the Type A or Type B signal load is located on the aircraft side of the ASI.

5/ The frequency range over which the VSWR is applicable is 5 MHz to 1.6 GHz or, when applicable, a smaller band within this range as determined by the specific Type A or Type B signal load equipment.

6/ Applicable to specific systems where the Type A or Type B signal load is located on the aircraft side of the ASI and where an ASI to MSI (or ASI to CSI) interconnection mechanism (such as an umbilical cable) is furnished as part of the aircraft equipment.

5.1.1.1.2.5 ASI to ASI attenuation. The maximum effective signal attenuation from one ASI to another ASI shall not exceed 6.0 dB for any frequency component over the band from 20 Hz to 20 MHz.

5.1.1.1.2.6 ASI to ASI attenuation flatness. The difference between the minimum and maximum actual attenuation over the frequency band from 20 Hz to 20 MHz for any specific ASI-to-ASI path shall not exceed 5.0 dB.

These two paragraphs define the maximum signal loss and the "fidelity" of the distribution network for ASI to ASI signal paths. An example of compliant path attenuation is shown in figure 154.

These attenuation limits are defined for ASI-ASI paths only because the paths represent the only AEIS end points at which attenuation can be measured. For operation of specific signals on a given aircraft, losses from ASI to the aircraft's end using equipment are also important. However, since the location and performance (gain, for example) of this aircraft end using equipment is not identifiable within the AEIS context, the associated losses are not defined by the standard. A portion of this short-fall is covered by the signal voltage specification in Paragraph 5.1.1.1.2.1 for composite video. (See 5.1.5.2 and 5.1.5.3.)

5.1.1.1.2.7 Propagation delay. All frequency components between 5 and 20 MHz of a signal injected at one ASI shall appear at the associated ASI (of an ASI to ASI transfer path) within 3.0 microseconds maximum.

5.1.1.1.2.8 Signal dispersion. The variation in propagation delay of the different frequency components (between 5 and 20 MHz) of any Type A signal shall not exceed 50.0 nanoseconds when transferred from one ASI to another ASI.

These two paragraphs are conceptually similar to the attenuation and attenuation flatness specifications above. The propagation delay specification defines an absolute limit on the signal delay from one ASI to a second ASI. By limiting the variation in the actual propagation delay of a signal down a specific path between two ASIs, the amount of signal

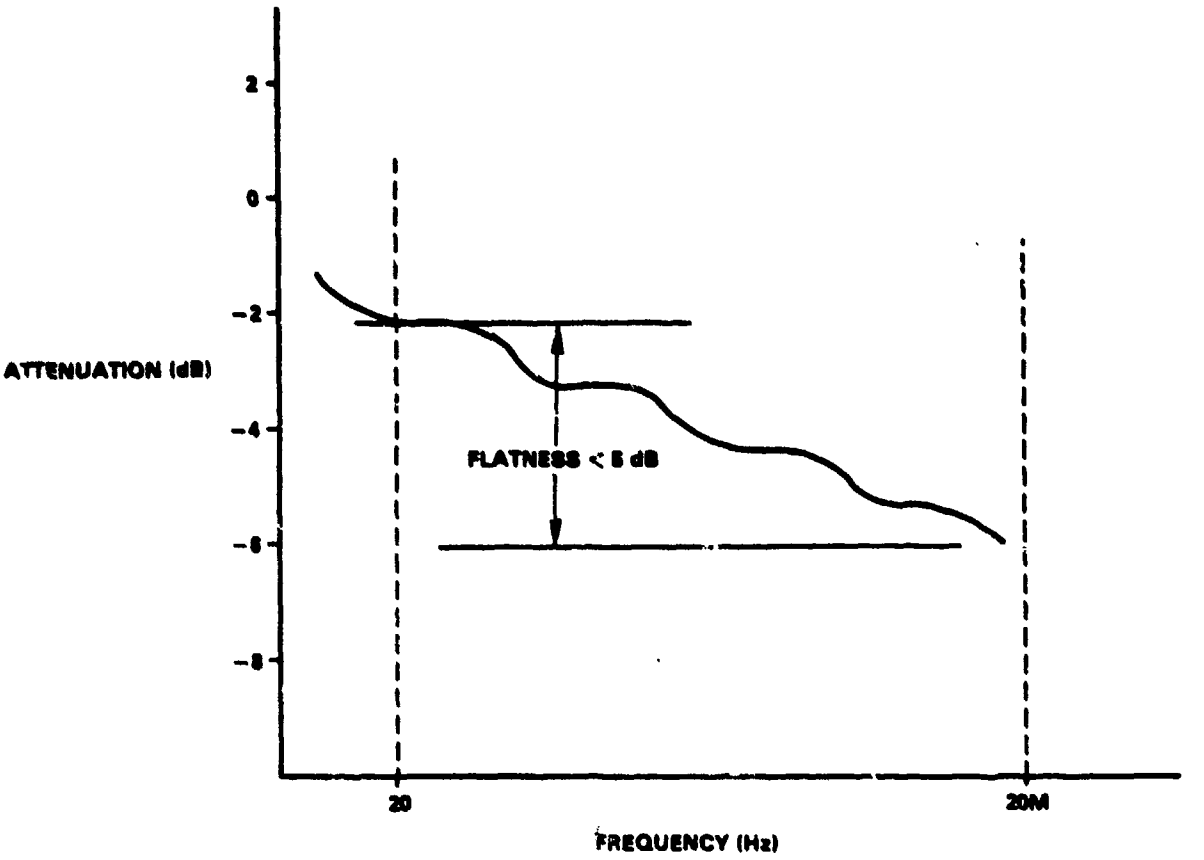


FIGURE 154. Example of ASI-to-ASI attenuation.

dispersion (a form of signal distortion) can be controlled. (See 5.1.5.1 for details on dispersion.) The 3.0 microsecond delay is much longer than that needed for a transmission line based distribution network in any practical aircraft. However, electronic distribution techniques which are viable for this application could require delays longer than those needed by the transmission line implementations. This 3 microsecond limit was set to allow electronic signal distribution. (See 5.1.5.1.1.2 and 5.1.5.3.)

> 5.1.1.1.2.9 Harmonic distortion. When sinusoidal test signals over the Type A frequency range are injected into an ASI, the harmonic distortion (third harmonic) in the signal appearing at an associated ASI (for ASI to ASI transfer) shall be at least 30.0 dB below the input signal level.

A harmonic distortion specification is included based on the possibility that electronic distribution networks or solid state switches will be used in the aircraft for signal routing. These devices contain non-linear components which can induce distortions in the routed signal which would not normally be seen in transmission line based distribution systems. The distortion limit defined assures that the amount of distortion (and the quality of design) is adequate. (See 5.1.5.2 and 5.1.5.3.)

> 5.1.1.1.2.10 Routing control. The aircraft shall be capable of rerouting signals between different AEIS end points (e.g., between ASIs and between ASIs and applicable aircraft equipments).

While this paragraph may seem to be stating the obvious, it is added to make it clear that the aircraft must be capable of actively controlling the signal paths between different stores and between stores and aircraft end using equipments. For example, patch panels of fixed hard-wired paths between fixed end points are not acceptable implementations. (See 5.1.5.2 and 5.1.5.3.)

> 5.1.1.1.2.11 Unterminated HB interface. The aircraft shall not be functionally damaged by the removal of a matched termination (see 5.1.1.1.2.4) on any HB interface in equipment (stores, umbilical cables, etc.) connected to an ASI.

This statement is essentialy a qualification of the VSWR compatibility requirement in paragraph 5.1.1.1.2.4. This paragraph highlights that the controlled impedance termination (as defined by VSWR limits) of an ASI by a store may be removed as part of normal operation (e.g., due to store release, due to path switching in a carriage store, etc.), leaving an unterminated transmission line. While the aircraft equipment is not expected to continue operation under these conditions, the equipment is

expected not to be damaged and to be operational when the matched termination returns.

> 5.1.1.1.2.12 Ground reference. The signal return (shield) (see 6.11) of the HB interfaces shall comply with the following ground requirements when measured at the ASI (looking into the aircraft). The aircraft shall be compatible with stores which connect HB1, HB2, HB3 and HB4 signal returns to applicable store grounds.
>
> a. HB1 and HB2 signal return. The signal return shall be electrically connected to aircraft structure ground.
>
> b. HB3 and HB4 signal return. For ASI to aircraft signal paths, the signal return shall be electrically isolated from aircraft structure ground and from HB3 and HB4 signal returns at all other ASIs. For ASI to ASI signal paths, the signal return shall be electrically isolated from aircraft structure ground (when measured with the associated stores disconnected) and from all other HB3 and HB4 signal returns except the other signal return associated with the connected ASI to ASI signal path.

This paragraph establishes the grounding requirements for the signal returns of the four HB interfaces. The grounding of HB1 and HB2 signal returns is optimized for high frequency applications by use of multiple point grounding. The signal returns for HB1 and HB2 are grounded on the aircraft side of the ASI (this paragraph) and on the mission store side of the MSI (paragraph 5.2.1.1.2.10). The physical location of the grounds or the number of ground connections within the aircraft and within the store are not controlled by MIL-STD-1760. All that MIL-STD-1760 specifies is that a ground connection is detectable on the HB1 and HB2 returns when looking into the ASI.

In contrast, the signal returns of HB3 and HB4 are required to be electrically isolated from aircraft ground when measured looking into the ASI. These two returns are connected to mission store grounds and provide a single point ground system optimized for the lower frequency ranges of the Type A signals. If the aircraft (or store) uses triaxial style (versus coaxial style) cable for these HB applications, the triaxial outer shield can be grounded at multiple points. In fact, since the outer shield of a triaxial cable is not measurable at the ASI/MSI connectors, the aircraft and store designers can ground the outer triaxial shield, however they choose. (See 5.1.9.1.5 and 5.1.9.4.5 for additional shield grounding discussions.) A final point is that subparagraph b requires that the signal return at receiver inputs and at

driver outputs associated with HB3 and HB4 in the aircraft be electrically isolated from aircraft structure ground as detectable at the ASI.

> 5.1.1.2 Aircraft digital multiplex data interface. The aircraft shall provide two digital interfaces (Mux A and Mux B) at each primary signal set ASI for the transfer of digital messages through the ASI to a MIL-STD-1553 compliant remote terminal in the connected store. Each digital interface shall contain a data high connection, a data low connection and a shield connection.
>
> 5.1.1.2.1 Functional characteristics. The aircraft shall transfer data between the aircraft and stores connected to the ASIs. The aircraft shall be responsible for the bus controller function defined in MIL-STD-1553. The Mux A and Mux B interfaces at each ASI shall be operated in a dual standby redundant mode as described in MIL-STD-1553. The aircraft shall also control digital information transfer from a remote terminal below any ASI to a remote terminal below any other ASI. The aircraft shall communicate with the remote terminal (connected to an ASI) with (a) messages whose terminal address corresponds to the address encoded in the address interface (see 5.1.1.6) at the ASI, or (b) MIL-STD-1553 broadcasted messages. Subaddress field of 00111 binary shall only be used for communications with nuclear stores.

The aircraft is assigned the responsibility for controlling the data transfers through each ASI. This control is defined by MIL-STD-1553 as residing in a Bus Controller (BC) terminal. This paragraph, therefore, strongly implies that this bus controller terminal is physically located within the aircraft. The second sentence contains a small hedge in that it requires that the responsibility for the bus controller function resides with the aircraft. It is plausable, however, that the bus controller terminal could be located elsewhere such as in a special fire control system electronic pod. However, even in this special case, the aircraft is still responsible for activating the pod and has in essence delegated its bus controller responsibility to a known, aircraft controlled piece of equipment. The complementary side of this requirement (see 5.2.1.2.1) is that a mission store is only required to provide a MIL-STD-1553 Remote Terminal (RT) capability. This paragraph clearly allocates the MIL-STD-1553 terminal responsibilities between the aircraft and mission store.

Three other major points are contained in this paragraph. First, the aircraft, as bus controller, not only controls BC-RT and RT-BC data transfers as defined by MIL-STD-1553 but also controls transfers between

stores at different ASIs. This store-to-store transfer can be achieved with an RT-RT transfer as defined by MIL-STD-1553. However, MIL-STD-1760 does not require the aircraft to implement RT-RT modes. The intent of the standard is to not disallow any SMS architectures, particularly hierarchical SMS architectures. In a hierarchical SMS, the aircraft could transfer data from one store to another through a two step process of RT-BC followed by BC-RT. Therefore, the requirement in the fourth sentence is for the aircraft to be able to move data from one store to another store - not necessarily by MIL-STD-1553's RT-RT transfer mode.

The second major point is contained in the fifth sentence of the paragraph. This sentence states that communication with a store using the MIL-STD-1553 broadcast command is permitted. Use of broadcasted messages provides only a limited communication capability (i.e., no status response and data cannot be received from the store). It is expected, however, that the Logical Element will either disallow broadcasted messages or restrict the use of broadcasted messages.

The third major point is contained in the last sentence of the paragraph. This sentence requires that the aircraft limit the use of all MIL-STD-1553 command words "visible" at any ASI such that subaddress 7 commands will only be sent to nuclear weapons. This does not imply that nuclear weapons will only use subaddress 7. It does, however, impose limitations on either the bus architecture in the aircraft or the subaddresses used by other equipment connected to an aircraft bus network if command words on that network are transmitted out any ASI. This restriction is included in MIL-STD-1760 to increase overall system safety when nuclear warheads or nuclear bombs are carried on the aircraft. (See 5.1.3.1 and 5.1.3.2. Also see 5.1.3.2.3 on proposed changes to subaddress restrictions.)

> 5.1.1.2.2 Electrical characteristics. The aircraft shall comply with the electrical characteristics defined herein at the ASI. The characteristics defined apply when measured on the data high connection referenced to the data low connection. Data high is that connection which is positive referenced to the data low connection in the first part of a MIL-STD-1553 command or status word sync waveform.
>
> 5.1.1.2.2.1 Output characteristics. The aircraft shall deliver, at each ASI, MIL-STD-1553 compatible digital data waveforms except that the peak-to-peak, line-to-line voltage shall be within the envelope of figure 6. The maximum zero crossing deviation from the ideal (with respect to the previous zero crossing) shall not exceed 150 nanoseconds. (See 6.4.)

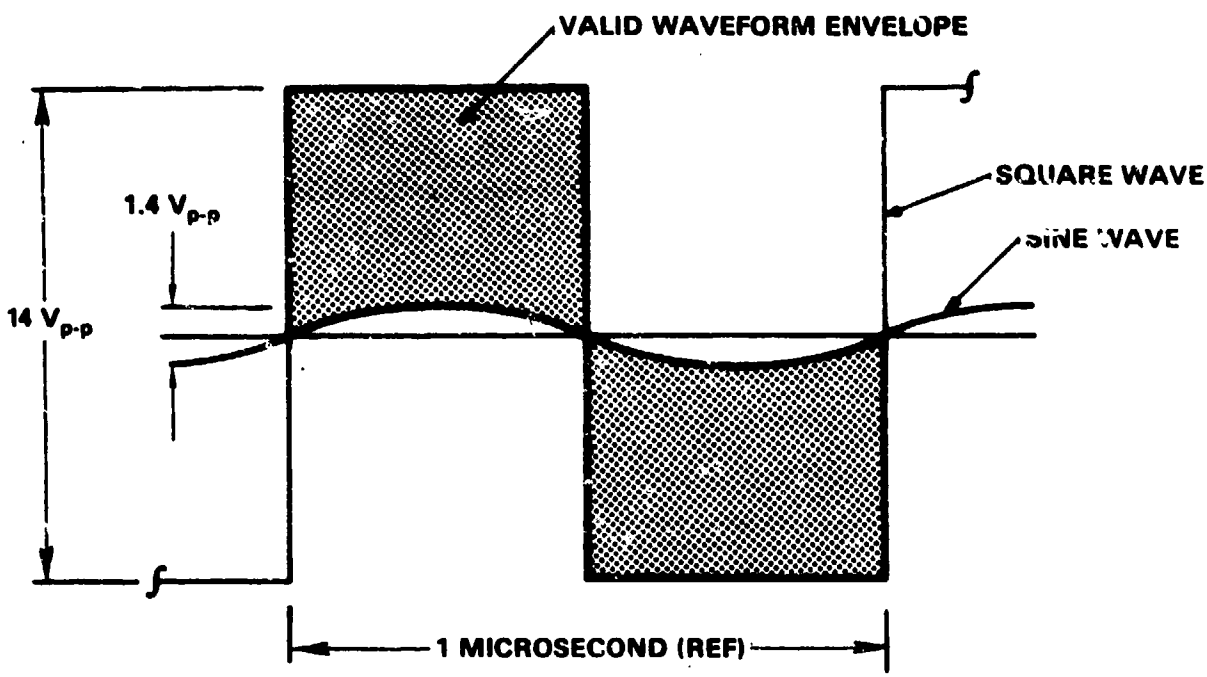


FIGURE 6. ASI output waveform envelope.

5.1.1.2.2.2 Input characteristics. The aircraft shall receive, and operate with, input signal waveforms at any ASI which comply with the output characteristics of a MIL-STD-1553 transformer coupled stub terminal.

5.1.1.2.2.3 Shield grounding. The aircraft shall connect the data bus stub shield of both Mux A and Mux B to aircraft structure ground.

These four paragraphs and the referenced figure identify several clarifications and additions to requirements contained in MIL-STD-1553B. First, data high and data low connections of the multiplex bus stub are defined. This definition assures proper connection of a MIL-STD-1553 RT to the interface connectors (i.e., prevent reversed polarity connections) when taken in conjunction with Note 2 in table IV of the standard.

Second, the point of MIL-STD-1553 waveform characteristics measurement is defined at the ASI which is the interoperable point for the aircraft. In contrast, MIL-STD-1553 defines waveforms at the RT input/output connections.

Third, associated with the interface definition being moved from RT to ASI, the waveform voltage required is defined by the envelope of figure 6. This waveform is basically a conversion of MIL-STD-1553 requirements into a figure with one exception. The minimum allowed output voltage required at an ASI is 1.4 volts p-p. This compares to the 1.0 volts p-p minimum required by MIL-STD-1553 for data buses to deliver to RTs. This additional safety margin is added due to the extra cable length and change in load impedances possible between the ASI point and the store's RT.

Fourth, the paragraph clarifies that the 150 nanosecond zero crossing distortion allowance in MIL-STD-1553 will apply at the ASI.

Fifth, a reference is made to paragraph 6.4 which defines non-mandatory but recommended test conditions (i.e., bus loading) for evaluating suitable input and output waveforms.

Sixth, MIL-STD-1760 paragraph 5.1.1.2.2.2 clarifies that the transformer coupled stub option of MIL-STD-1553 applies to the ASI.

Finally, a requirement is imposed on the aircraft that the shield for each data bus must be connected to aircraft structure ground. This shield grounding is not specifically defined by MIL-STD-1553. The companion requirements in MIL-STD-1760 paragraph 5.2.1.2 (for the mission store) also requires grounding of the shield in the mission store. Between these two sets of requirements, a multiple point shield grounding concept is specified for the multiplexed data link. (See 5.1.3.3, 5.1.3.4 and 5.1.9.)

5.1.1.3 Aircraft LB interface. The aircraft shall provide one LB interface at each primary signal set ASI

for transferring LB signals in accordance with the requirements herein. Each LB interface shall include a non-inverting signal connection, an inverting signal connection, and a shield connection.

5.1.1.3.1 Transfer requirement. The aircraft shall support the transfer of a LB signal between any ASI and applicable aircraft equipment for applications where the signal source is located in either the aircraft or in the connected store. The aircraft shall be capable of rerouting the signals between aircraft equipment and each ASI.

The aircraft is required to install a distribution network for bi-directional LB signals. The network must be capable of switching these LB signals from any ASI to applicable aircraft equipment. The specific equipment that is "applicable" is determined by each specific aircraft based on that aircraft's weapons capability. Generally, as a minimum, the aircraft will provide a network path for the LB signal to the aircraft intercom system. The aircraft designer should consider the implications of paragraph 6.9 of the standard and provide a network path to a SMS unit(s) which contains or could contain (via future modification) an RS485 based, low speed (approximately 38 Kilobaud) point-to-point serial data link interfaced to the SMP, SSE or similar unit. (See 4.3.3 and 5.1.6.)

5.1.1.3.2 Electrical characteristics

5.1.1.3.2.1 Input and output signal. The signal at the ASI (line-to-line and line-to-ground) shall be in the range of -12 volts to +12 volts and shall not exceed 150 milliamperes. The LB signal frequency components shall be contained within a passband of DC to 50 kHz. The LB signals allowed through the interface are tones and voice grade audio (see 6.9). This signal shall not be used for discrete functions.

The general LB signal characteristics are characterized by a low power level and a low bandwidth. Since the defined frequency range includes DC, the last sentence is included in the paragraph. The need for this sentence evolved from concerns that the LB interface might become a general purpose discrete and thereby become an obstacle to interoperability. The last point is that the voltage and current limits are defined for both line-line and line-ground. This requires that the basic aircraft distribution network isolate both the inverting and non-inverting lines from structure ground by at least 80 ohms (12 volts/150 milliamperes). If the aircraft is accepting an input from a store (i.e., the signal load is on the aircraft side of the ASI), then this line-ground isolation level can also apply to the receiver circuitry in addition to the aircraft's distribution network.

Due to the DC specification, the LB distribution network in the aircraft needs to be capable of transferring DC signals. This does not, however, preclude the end using equipment (such as an intercom) from using transformer coupler techniques if the end using equipment does not require DC. The use of transformer coupling is advantageous for isolating the signal grounds in the LB transmitting or receiving equipment, or both. (See 5.1.6.1, 5.1.6.2 and 5.1.9.1.4.)

> 5.1.1.3.2.2 Input impedance. The line-to-line impedance at the ASI (looking into the aircraft) shall be greater than 70 ohms over the frequency range of DC to 50 kHz. This requirement applies when the interface is deactivated and when the aircraft is not sourcing a signal.

> 5.1.1.3.2.3 Load impedance. The aircraft shall comply with the requirements herein when the line-to-line impedance connected to the store side of the ASI is 70 ohms minimum over a frequency range of DC to 50 kHz. This impedance applies when the connected store is deactivated and when the connected store is not sourcing a signal.

The input and load impedances (line-line) are specified by a minimum value only. This allows the impedance to be as high as an "open circuit". This range encompasses typical 600 ohm audio impedances, 120 ohm point-to-point serial data link impedances, etc. The 70 ohm impedance is the absolute minium value. However, the signal voltage and current limits in 5.1.1.3.2.1 impose a slightly higher impedance (80 ohms minimum) which applies to any general purpose LB hardware. An example of this general purpose hardware is an aircraft distributing LB signals through an FDM system. The input impedance of the FDM terminal would need to be greater than 80 ohms. (See 5.1.6.2.)

> 5.1.1.3.2.4 Shield grounding. When measured at the ASI, the shield shall be electrically connected to aircraft structure ground.

The shield grounding method selected for the LB port is a multi-point shield ground scheme. The shield termination measurable at the interface connector is connected to aircraft structure ground on the aircraft side of the ASI and to store structure ground on the store side of the MSI. This grounding scheme provides optimum shielding for a balanced line twisted pair network. The standard only requires that the shield be grounded somewhere on the aircraft side of the ASI and on the store side of the MSI. The specific physical location of shield connection and the method of termination is not specified by the standard. (See 5.1.9.4.4.)

5.1.1.4 Aircraft release consent interface. The aircraft shall provide a release consent interface at each primary signal set ASI in accordance with the requirements herein for transferring an enable/inhibit signal to the connected store for granting consent to the store to act on safety critical commands over the digital multiplex data interface. (See 4.3.1.5.)

This paragraph requires that the aircraft provide a release consent capability at each ASI. The release consent signal provides an enabling (or inhibiting) function to be used in conjunction with safety critical commands sent to the store over the Mux A/Mux B interface ports. Since release consent is an enable (or inhibit) signal, the application of release enable or removal of release enable (inhibit) is not to be used by itself to command a store into a specific state or to start an irreversible process in a store. The release consent signal is provided to "gate" safety critical data bus commands (such as fire, arm, etc.) into a store's subsystem. The store design documentation or Interface Control Document identifies those commands (if any) which are safety interlocked with release consent. However, the point in time at which release consent is set to the enable state will be determined by the aircraft based on the aircraft's safety criteria - that is, the aircraft will determine when it is willing to remove some of the last safety interlocks to a store. (Also see comment to MIL-STD-1760 Paragraph 4.3.1.5 in 5.4.4 above and additional technical points in 5.1.4.2.)

5.1.1.4.1 Transfer requirement. The aircraft shall be capable of transferring a release consent signal through each ASI. When in the inhibited state, the release consent interface at an ASI shall be electrically isolated from the release consent interface at all other ASIs. The isolation shall be 100 kilohms minimum at DC.

This isolation requirement is included for fail safe purposes. The requirement is directed at preventing a fault (release consent shorted to 28V DC in one store or at one station) from activating the enable state at other ASIs. (See 5.1.4.2 for schematic examples and additional detail.)

5.1.1.4.2 Electrical characteristics

5.1.1.4.2.1 Voltage level. The voltage level measured between the release consent connection and 28V DC power 2 return connection at the ASI shall be:

a. Steady State Conditions:

(1) Enable: Minimum voltage at 19.0V DC
Maximum voltage as defined by MIL-STD-704 for 28V DC

(2) Inhibit: 1.50V DC (maximum)

b. Voltage tansients shall comply with MIL-STD-704 limits for 28V DC applications.

c. Voltage spikes shall comply with MIL-E-6051 limits.

This paragraph introduces two types of design requirements. One deals with voltage levels as indicated by the paragraph title. The second defines the interface line which is to be used as the release consent reference. This reference (28V DC power 2 return) is selected as a compromise between providing an additional line for a dedicated return (with the resulting connector impact) and sharing a 28V DC power return (with resulting EMI considerations). Since the release consent "signal" is defined with MIL-STD-704 voltage levels which are already extremely noisy, sharing the 28V DC return is a reasonable compromise.

The voltage characteristics of the release consent signal are defined over the time domain of spikes to steady state. The voltage spike limits of MIL-E-6051 cover positive and negative voltage spikes of durations up to 50 microseconds. The transient limits of MIL-STD-704 define over- and under-voltage limits from 50 microseconds to several seconds at which point the steady state conditions apply. Within the steady state domain, the aircraft is required to supply at least 19V DC at the ASI for an enable state. The aircraft is also required to limit the voltage into a release consent load (provided by the store) to less than 1.5 volts for a valid inhibit state. This provides a well defined band within which the store's release consent detection circuitry can set enable and inhibit thresholds. (See 5.1.4.2.)

> 5.1.1.4.2.2 Current level. The aircraft shall provide a capacity of 100 milliamperes steady state minimum through the ASI during the enable state. The aircraft shall ensure that the current flow through the release consent interface does not exceed the maximum overcurrent limit of figure 7. The aircraft shall comply with the requirements herein for store imposed load currents of 5.0 milliamperes minimum through the ASI.

The major point of this paragraph is to provide upper and lower bounds for current levels which the aircraft must be capable of supplying while

maintaining the voltage levels of the previous paragraph. A lower limit of 5 milliamperes is selected to assure sufficient current flow to break down films and other contaminants on electrical contact surfaces. This lower limit does not, however, mean that all stores will draw at least 5 milliamperes of current from an enabled release consent discrete. Stores which do not use the release consent signal can provide no load (i.e., open circuit) across the release consent lines. Stores which use release consent will, however, demand at least 5 milliamperes when an enabled release consent is applied.

The 100 milliampere upper limit is established to allow use of solid state drivers or small electromechanical relays in the aircraft for switching the release consent discrete between enable and disable states. The primary driver is electromechanical relays. To ensure low contact resistances (and thus small voltage drops) under the low current conditions, the maximum switched current must be kept within the "intermediate current" rating of relays. This rating is typically 100 milliamperes. (Also see 5.1.4.2.)

> 5.1.1.4.2.3 Stabilization time. With any resistive load between 320 ohms and 3.8 kilohms connected between release consent and 28V DC power 2 return, the voltage at the ASI shall reach steady state levels (see 5.1.1.4.2.1a) within 3 milliseconds during transition between enable and inhibit states.

The primary purpose of this stabilization time specification is to limit the transition time between the two release consent states. This limit defines the duration that a store's release consent detection or buffer circuit operates in the "linear amplifier" region between the two states. The stabilization time is sufficiently long to account for contact bounce phenomena if electromechanical relays are used in the aircraft for release consent switching. The stabilization time is also sufficiently long to allow filtering or other methods of rise/fall time control for compliance with EMC requirements typically imposed on aircraft.

> 5.1.1.4.2.4 Enable lead time. If release consent is required by a store, the release consent signal shall attain the enable state at least 20 milliseconds prior to transferring the safety critical command over the digital mutliplex data interface or prior to the firing signal to the parent S&RE, as applicable.

> 5.1.1.4.2.5 Inhibit delay. If release consent at an ASI has been enabled, the aircraft shall operate under the assumption that the store(s) connected to that ASI may remain in an enable state for up to 20 milliseconds after the release consent signal has been returned to the inhibit state.

5.1.1.4.2.6 Ground reference. The 28V DC power 2 return connection shall be the ground reference for release consent.

The first two paragraphs account for delays between the application (and removal) of an enable signal at an ASI and the actual operation of the enabling (inhibiting) function within the mission store. Part of this delay is the response time of the mission store circuitry. (See 5.2.1.4.2.4 and 5.2.1.4.2.5 of MIL-STD-1760.) Part of the delay is allocated to a carriage store for the case where a carriage store is inserted between the aircraft and mission store. In essence, a 10 millisecond maximum response is required for both of these store types. This response time is sufficiently long to allow significant filtering of the input or output lines or to allow use of electromechanical relays.

The ground reference paragraph simply re-emphasizes which interface line is to be used as the reference for release consent. (See 5.1.4.2.)

5.1.1.5 Aircraft interlock interface. The aircraft shall provide an interlock interface at each primary signal set ASI and auxiliary power signal set ASI for monitoring the mated status of the associated connectors. The interlock interface at each primary and auxiliary ASI consists of an interlock connection and an interlock return connection. (See 6.6.)

This paragraph introduces the interlock interface and points out that separate interlock interfaces are contained in the primary and auxiliary signal sets. The paragraph also references Note 6.6 which re-emphasizes concerns on potential mis-use of this monitor current as a "store gone" signal.

The first sentence of paragraph 5.1.1.5 needs to be interpreted in conjunction with the introductory phrase of paragraph 5.1.1.5.1. That is, the aircraft is not required to use (i.e., monitor) the interlock interface. If the aircraft does monitor the interface, the aircraft must comply with 5.1.1.5.1 of MIL-STD-1760.

5.1.1.5.1 Electrical characteristics. If the aircraft monitors the interlock interface, then the aircraft shall comply with the following requirements. These requirements apply to the interlock connection referenced to the interlock return connection.

a. Open circuit voltage:

(1) Minimum voltage of 4.0V DC.
(2) Maximum voltage as defined by MIL-STD-704 for

28V DC.
(3) Voltage transients shall comply with MIL-STD-704 for 28V DC.
(4) Voltage spikes shall comply with MIL-E-6051.

b. Excitation currents:

(1) Minimum current of 5.0 milliamperes.
(2) Maximum current of 100 milliamperes.

c. Impedance detection threshold. An interface disconnected condition shall be detected for any impedance level of 100 kilohms or greater. An interface connected condition shall be detected for any impedance level of 2.0 ohms or less. These impedance values apply over the frequency range of DC to 4 kHz.

As mentioned in the comment to MIL-STD-1760 paragraph 5.1.1.5, the aircraft is not required to use the interlock interface (i.e., apply an excitation signal to determine mated status). If the aircraft uses the interlock interface, it must comply with the requirements of subparagraphs a, b and c.

Subparagraph a defines limits on the excitation voltage supplied by the aircraft. These voltage limits apply under the condition of an open circuit between interlock and interlock return on the store side of the ASI. The voltage range defined allows MIL-STD-704 28V DC voltage levels and also allows application of "logic circuit level" voltages down to 4.0V DC. Open circuit voltages below this 4 volt level are disallowed to minimize erroneous reading due to contaminated contacts.

For a similar reason, the "closed circuit" current range is bounded between 5 and 100 milliamperes. The 5 milliampere limit would applies if a 2 ohm load is connected across the store side of the ASI. The 100 milliampere limit applies to a short circuit (zero ohms) across the ASI.

Subparagraph c defines the two impedance levels at which the "interface disconnected" and "interface connected" states must be detected. The actual aircraft detection circuit threshold(s) can be set at any point between these two limits. (See 5.1.4.1.1 and 5.1.4.1.2.)

5.1.1.6 Aircraft address interface. The aircraft shall provide an address interface at each primary signal set ASI for assigning a digital multiplex data bus address to the MIL-STD-1553 remote terminal in the store mated to the ASI. Each address interface shall include five binary encoded address bit connections (A0, A1, A2, A3 and A4), one address parity connection and one common address return connection. The address interface shall comply with the requirements specified herein.

5.1.1.6.1 Transfer requirement. **The aircraft shall transfer a remote terminal address through each ASI to the connected store with the address interface. The aircraft shall use this interface only for assigning an address to the remote terminal associated with the directly connected carriage store or mission store, as applicable.**

These two paragraphs introduce the top level requirements on the aircraft for providing a MIL-STD-1553 Remote Terminal (RT) address at the ASI. This address is provided by a set of discretes which allows the connected store's RT address to be uniquely assigned automatically by connecting the store to any specific ASI. These address coding contacts are contained in the ASI since it is not practical to program a store's address during manufacture or during store preload preparation.

5.1.1.6.2 Address assignment. The aircraft shall supply a Logic 0 state or Logic 1 state on each of the five binary weighted address bit connections at each ASI. The remote terminal address assigned to an ASI shall be defined as:

$$\text{Remote terminal address} = (A4)x2^4+(A3)x2^3+(A2)x2^2+(A1)x2^1+(A0)x2^0$$

The aircraft shall supply a Logic 0 state or Logic 1 state on the address parity connection such that an odd number of Logic 1 states exist on the five address bit connections plus the address parity connection. The aircraft shall not modify the address assigned to an ASI whenever any power (see 5.1.1.8, 5.1.1.9, 5.1.1.10) is applied to that ASI.

The rules for assigning addresses with the five address bit lines are defined here by establishing the binary weight of each line. Additionally, an odd parity check is defined allowing detection of single line faults including loss of the common return. (If an even parity check were specified, the check would pass if the address return opened.)

The last sentence clarifies that if an aircraft uses an address interface design in which the assigned address at an ASI is modifiable (e.g., under software control), then the aircraft must not change the assigned address at an ASI as long as that ASI is powered. It is expected that most aircraft applications will simply hardwire the address at an ASI with jumpers directly behind the connector. If, however, the ASI is physically part of a Store Station Equipment (SSE) black box and the SSE is interchangeable at different stations, then some type of address modification system might be

used. A similar condition could exi' if the entire pylon is interchangeable at different stations. (See 5.1.4.3.)

5.1.1.6.3 Electrical characteristics. The address interface electrical characteristics at the ASI shall comply with the following requirements. The characteristics defined apply to the address bit and parity connections referenced to the address return connection.

The electrical characteristics required at an ASI are divided into several parts. The characteristics of the excitation signal sourced by the connected store are defined in 5.1.1.6.3.1 of MIL-STD-1760. Likewise, the voltage and current characteristics of Logic 1 and Logic 0 states are covered in 5.1.1.6.3.2. The aircraft is required to provide these state characteristics when the excitation signals are sourced by the store. The electrical characteristics are then concluded with response and isolation requirements.

5.1.1.6.3.1 Address signal. The aircraft shall comply with the requirements herein when signals with the following characteristics are applied to the address interface at the ASI by the connected store:

a. Open circuit (Logic 1) voltage:

(1) Minimum voltage of 3.5V DC
(2) Maximum voltage of 31.5V DC
(3) Voltage spikes as defined in MIL-E-6051
(4) Rise and fall times of applied voltage less than 10 milliseconds

b. Logic 0 current:

(1) Minimum current of 5.0 milliamperes DC
(2) Maximum current of 100 milliamperes DC through each address bit and parity connection
(3) Maximum current of 600 milliamperes DC through the address return connection
(4) Rise and fall times of applied current less than 10 milliseconds

The characteristics of the store sourced excitation signals are defined to encompass a range of circuit designs from "logic level" signals through higher level MIL-STD-704 28V DC derived excitation. The standard simplifies ASI circuit design requirements by clamping the MIL-STD-704 type 28V DC excitation to a maximum voltage of 31.5V DC. The aircraft address

circuitry is not required, therefore, to withstand the higher (50V DC) power surges defined by MIL-STD-704. This clamping requirement is levied on the mission store by 5.2.1.6.3.1 of MIL-STD-1760.

The current levels that the store is allowed to source and the aircraft is required to support are constrained within the same 5 to 100 milliampere range discussed above for the release consent signal. While the use of electromechanical relays are not necessarily recommended for address modification circuitry, the excitation current and voltage levels allow their use.

The 600 milliampere current flow in the address return line is based on an erroneous address (i.e., 0 with failed parity). The aircraft must still support this current, however, to assure that the store will correctly detect the address as erroneous.

The rise and fall time maximum limits are included to limit the time that an excitation signal is in the "active" region of the aircraft's address modification circuit. This rise/fall time is be more important if particular stores periodically sample the address interface (i.e., pulse the excitation signal) in order to reduce power requirements or internal heat dissipation. (This maximum time is be of no concern to aircraft which hardwire the address with jumper wires behind the ASI.) (See 5.1.4.3 and 5.2.3.3.)

> 5.1.1.6.3.2 Logic thresholds. The aircraft shall provide the following logic states under the voltage and current conditions of 5.1.1.6.3.1:
>
> a. Logic 1 state characteristics. The aircraft shall maintain sufficient open circuit conditions between each Logic 1 set address bit (or parity) connection and the return connection such that when the voltages of 5.1.1.6.3.1 are applied across the connections, the current flow shall not exceed 300 microamperes.
>
> b. Logic 0 state characteristics. The aircraft shall limit the voltage drop between each Logic 0 set address bit (or parity) connection and return connection at the ASI to 1.0 volts maximum when the current levels specified in 5.1.1.6.3.1 are applied. This maximum voltage drop applies when Logic 0 states exist at any or all address bit and parity connections.

Subparagraph (a) defines the Logic 1 states as a function of allowed maximum current flow between each address line and the address return. For aircraft designs which hardwire (open or short) the address lines at the ASI, this requirement can be converted to an impedance requirement. That is, the impedance between a Logic 1 set address line and its return must be at least 105 kilohms looking into the ASI. If the aircraft uses solid state devices

to establish the address states, then the requirement can be interpreted as an "off-state" maximum leakage current over the range of open circuit voltages.

Subparagraph (b) defines the Logic 0 states as a function of maximum allowed voltage drop with the applied excitation current into each address line. For hardwired ASI address designs, this voltage drop (1.0 volts maximum) can be converted to an impedance, but care needs to be exercised in considering the higher current flows in the address return. Knowledge of relative distribution of resistances between an address bit line and the return line is needed before an equivalent impedance can be determined. If solid state (or any non-linear) devices are used to establish the ASI address, then a voltage drop measurement over the excitation current range is the only meaningful specification. (See 5.1.4.3.)

> 5.1.1.6.3.3 Response characteristics. The aircraft shall produce valid address characteristics at the ASI within 10 milliseconds of excitation signal application from the store. The aircraft shall not require continuous application of the excitation signal.

This response time requirement is included to establish limits on any filtering the aircraft might place on the address lines. In addition, the aircraft is not permitted to use the address interface or to establish the address characteristics in any manner that would require continuous sourcing of the excitation signal by the store. Again, for the simple aircraft address implementation of using hardwired jumpers at the ASI, these response characteristics are not significant. Aircraft which use active circuits for establishing the ASI address must consider the constraints of this response requirement. (See 5.1.4.3.)

> 5.1.1.6.3.4 Address isolation. The aircraft shall electrically isolate all address connections (including address return) at each ASI from the address connections at all other ASIs, from power returns and from aircraft structure. The isolation shall be 100 kilohms minimum over the frequency range of DC to 4 kHz.

This isolation is imposed to minimize ground loop induced noise problems in the store's address excitation and detection circuits. The isolation is easily achievable in hardwired ASI address designs. Active ASI address designs could be slightly more complex due to this isolation requirement. (See 5.1.4.3.2.)

> 5.1.1.7 Aircraft structure ground. The aircraft shall provide a connection in each ASI (primary signal set and auxiliary power signal set) which is terminated to

aircraft structure ground and complies with the following requirements.

5.1.1.7.1 Structure ground characteristics. The aircraft shall provide a conductor path from the ASI to aircraft ground capable of carrying 10 amperes (continuous) for the primary signal set, and 30 amperes (continuous) for the auxiliary power signal set. The aircraft structure ground interface shall comply with the class H bonding requirements of MIL-B-5087. The structure ground interface shall not be used as a signal return or power return path.

The structure ground line in both primary and auxiliary AEIS connectors is included to provide a higher level of assurance that the aircraft and store structures are electrically interconnected. As indicated in the paragraph, this ground connection is provided for the hazard protection of MIL-B-5087. Other structure ground paths may exist between the aircraft and store due to mechanical connections, gross shields on interconnecting umbilicals, and possibly power return connections (i.e., 28V DC power 1 return, etc.). These other connections may, however, not exist or be poorly controlled.

The last sentence in 5.1.1.7.1 may lead to confusion. The intent of this sentence is that power and signal circuits through the AEIS interfaces must not rely on the existence of the structure ground line for proper operation. However, it is possible for power and signal currents to flow through structure ground. For example, it is likely that the aircraft will connect its 28V DC power source to aircraft structure. It is also possible that the store will connect the 28V DC return to store structure. (Neither condition is required nor disallowed by MIL-STD-1760.) Under this combination of aircraft and store conditions, 28V DC return currents will, indeed, flow in both the 28V DC power 1 (or 2) return and in the structure ground line. This condition does not violate the intent of the last sentence. (See 5.1.7.2 and 5.1.9.1.6.)

5.1.1.8 Aircraft 28V DC power interface. The aircraft shall provide a set of 28V DC power interfaces at each ASI in accordance with the requirements defined herein. The primary signal set ASI shall contain 28V DC power 1 (and power 1 return) connections and 28V DC power 2 (and power 2 return) connections. The auxiliary power signal set ASI shall contain 28V DC power (and power return) connections.

5.1.1.8.1 Transfer requirements. The aircraft shall be capable of sourcing and independently controlling each 28V DC power interface through each primary signal set ASI and through each auxiliary power signal set ASI.

This set of paragraphs establish the basic requirements for 28V DC power sourcing by the aircraft through each ASI. In addition to sourcing two 28V DC power outputs in the primary ASI and when applicable, one in the auxiliary ASI, the aircraft is required to independently control (turn-on, turn-off) each power output. This independent control is required primarily for safety reasons. (Refer to the power application requirements in MIL-STD-1760 paragraph 5.1.1.8.2.7.)

> 5.1.1.8.2 Electrical characteristics. The 28V DC power interfaces at each ASI shall comply with the electrical characteristic requirements specified herein.
>
> 5.1.1.8.2.1 Voltage level. The voltages at the ASI between each 28V DC power connection and the associated power return connection shall comply with the 28V DC normal and abnormal operation characteristics for utilization equipment defined in MIL-STD-704. The voltage spikes at the ASI shall comply with MIL-E-6051 and voltage transients at the ASI shall comply with MIL-STD-704. These voltage requirements shall apply for all valid load conditions.

This requirement identifies the ASI as the "utilization equipment" input terminals in the context of MIL-STD-704. This definition was required to resolve which point in the AEIS network is considered as the utilization equipment. Possibilities ranged from the input to the aircraft's Stores Management System to the input to equipment installed inside the mission store. The practical choices were narrowed to the ASI or MSI. The ASI was selected primarily because it is the last point in the AEIS network that is directly controlled by the aircraft.

This paragraph defines the voltage levels in both steady state and transient conditions. The voltage transient requirements are divided between MIL-STD-704 and MIL-E-6051. Transients down to 50 microseconds are limited by MIL-STD-704. Transients (spikes) of shorter duration are limited by MIL-E-6051. (See 5.1.7.2.)

> 5.1.1.8.2.2 Current capacity
>
> 5.1.1.8.2.2.1 Primary signal set. The aircraft shall be capable of sourcing the maximum load current levels of figure 7 through the 28V DC power 1 interface and the maximum load current levels of figure 7 through the 28V DC power 2 interface of the ASI. (See 6.10.) The aircraft shall be capable of sourcing a total of 20

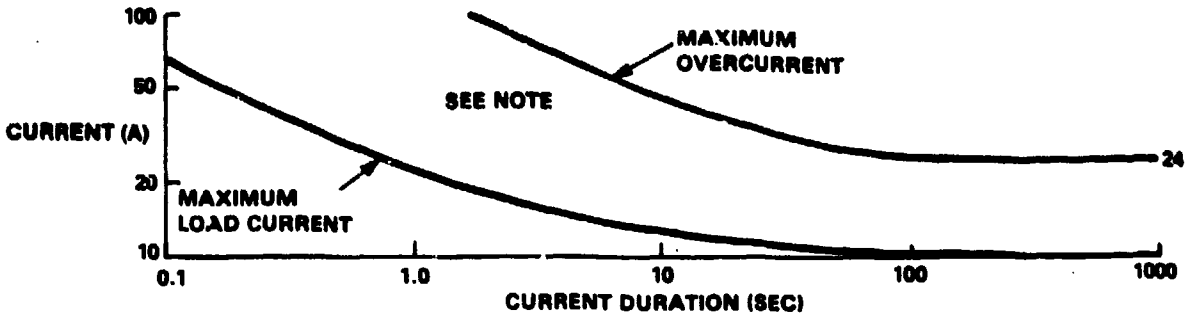
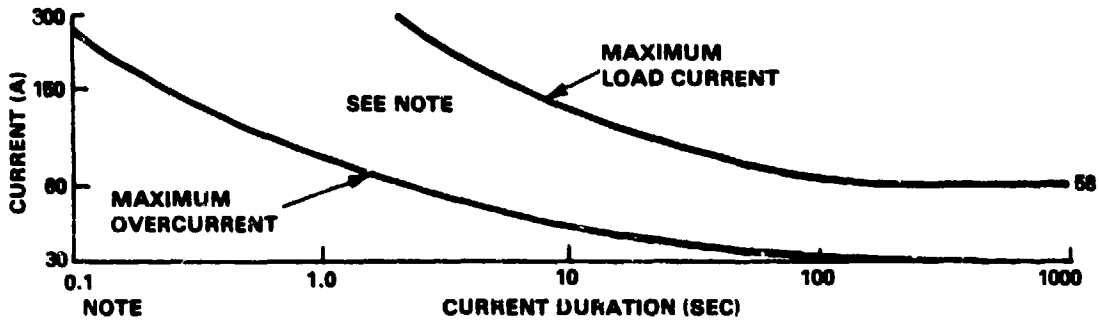


FIGURE 7. Primary interface current level.



THE CURVES OF FIGURES 7 AND 8 DEFINE A LOCUS OF DISCRETE CURRENT-TIME POINTS (e.g., 13 AMPERES FOR 10 SECONDS DURATION) AND ARE NOT INTENDED TO REPRESENT A CONTINUOUS PROFILE OF CURRENT VERSUS TIME. THE MAXIMUM LOAD CURRENT LOCUS DEFINES THE CURRENT-TIME COMBINATIONS OF MAXIMUM ALLOWED FAULT-FREE LOAD CURRENT REQUIRED BY A STORE. THE MAXIMUM OVERCURRENT LOCUS DEFINES THE CURRENT-TIME COMBINATIONS OF MAXIMUM ALLOWED FAULT-INDUCED OVERCURRENT SOURCED BY THE AIRCRAFT. THE AREA BOUNDED BY THE MAXIMUM LOAD CURRENT AND MAXIMUM OVERCURRENT CURVES DEFINES THE CURRENT-TIME BAND WITHIN WHICH AN AIRCRAFT'S CIRCUIT PROTECTIVE DEVICES MUST TRIP (SEE 6.10).

FIGURE 8. Auxiliary interface current level.

amperes, continuously through the combination of 28V DC power 1 and 28V DC power 2 interfaces of the ASI.

5.1.1.8.2.2.2 Auxiliary power signal set. For interface classes IA and IIA, the aircraft shall be capable of sourcing the maximum load current levels of figure 8 through the 28V DC power interface of the auxiliary ASI. (See 6.10.)

This set of paragraphs and the referenced figures define the levels of 28V DC currents that the aircraft is required to be capable of sourcing. The required levels are defined for both continuous and short term conditions. While actual current sourced out the 28V DC power lines is partially dependent on the store's load, the aircraft must be capable of supporting the loads defined by the "maximum load current" curves in the figures. The note below figures 7 and 8 provides additional clarification on the meaning of the load current curves.

This paragraph set also requires the aircraft to be capable of simultaneously sourcing the full 10 amperes (continuous) through both 28V DC power 1 and power 2 interfaces in any ASI. (See 5.1.7.1.)

5.1.1.8.2.2.3 Simultaneous current. The total 28V DC current available simultaneously from all ASIs shall comply with the aircraft system specification. The total 28V DC continuous current provided simultaneously through both the primary and auxiliary interfaces at any class IA or IIA ASI need not exceed 30 amperes.

The total power which can be sourced simultaneously through all ASIs is dependent on the aircraft's power generation (plus conversion) and distribution capacity. While it might be desirable that the aircraft be capable of supporting the full rated load at each ASI simultaneously, store loadout limitations, carriage configurations and the number and location of ASIs on each aircraft may result in this full loading being unnecessary. The standard recognizes this condition and, to avoid potential misinterpretation, clarifies that total power capacity through all ASIs is determined uniquely by each aircraft system specification.

The paragraph also clarifies that aircraft stations which implement the auxiliary ASI are not required to source 50 amperes (i.e., 10 plus 10 plus 30) as might be interpreted by the combination of MIL-STD-1760 paragraphs 5.1.1.8.2.2.1 and 5.1.1.8.2.2.2. (See 5.1.7.1.)

5.1.1.8.2.3 Overcurrent protection. The aircraft shall ensure that the current flow through any 28V DC power connection does not exceed the maximum overcurrent limits of figures 7 and 8 for the primary and auxiliary

ASIs, respectively. The aircraft may achieve this current limit operation by the deactivation of the appropriate power interface and any other power interface at the associated ASI. (See 6.10.)

The aircraft is required to provide protection against excessive current flow out each power line. The overcurrent limits are defined in the referenced figures by the "maximum overcurrent" curves. In addition, a note is included below the figures to clarify interpretation of the curve.

To some extent, this requirement is the first known case where a standard (or specification) requires an aircraft to provide some level of fault protection for its connected utilization equipment. The general mode is for the aircraft to protect its distribution wiring from faults to prevent total loss of aircraft electrical power, to prevent aircraft fires and to limit the extent of damage to other subsystems. The utilization equipment is generally left to protect itself - if it is to be protected at all. The AEIS standard goes against this general mode by requiring a specific overcurrent protection level at the ASI primarily to help protect the connected store. This protection assistance is imposed because of the potential destructive capability of the store - i.e., many contain explosive warheads, rocket motors, etc., which have significant safety impact on the aircraft and its crew. Without some limitations on the amount of fault induced energy which can be dumped into the store, it is considered not practical for the store to always protect itself. Given that the aircraft already provides protection for its distribution wiring (i.e., compliance with MIL-W-5088 is required by aircraft system specifications) and given that safe operation of explosive stores is in the best interest of the aircraft and crew, MIL-STD-1760 imposes an overcurrent protection requirement at the ASI.

In designing the aircraft's overcurrent protection mechanism, devices may be selected that remove power (i.e., trip) at any point within the current-time band bounded by the "Maximum Load Current" and "Maximum Overcurrent" curves. In essence, the "Maximum Load Current" curve defines the "no-trip" limit while the "Maximum Overcurrent" curve defines the "must-trip" limit. (See 5.1.7.4.)

> 5.1.1.8.2.4 Off-state leakage current. The off-state leakage current at the ASI between each 28V DC power and its respective return shall not exceed 1.0 milliampere DC with any valid load impedance. The off-state leakage current at the ASI between auxiliary 28V DC power and auxiliary power return shall not exceed 2.50 milliamperes DC with any valid load impedance.

Requirements on the quality of power turn-off are defined in this paragraph through an off-state leakage current maximum limit. The requirement is directed primarily at aircraft designs which use solid state switching

devices for controlling the 28V DC power interfaces. The requirement is primarily a benefit to the aircraft designer in that it prevents extremely low leakage current conditions from being required by store designers. (A companion requirement is contained in 5.2.1.8.2.5 of MIL-STD-1760.) The leakage level is sufficiently low to avoid shock hazards but high enough to allow practical solid state switch designs. (See 5.1.7.2.)

> 5.1.1.8.2.5 Stabilization time. When tested with any valid resistive load connected to the ASI, the voltage at the ASI shall reach steady state levels (see 5.1.1.8.2.1) within 3.0 milliseconds of power turn-on and turn-off. (See figure 9.)

This paragraph and the referenced figure define the maximum rise and fall time permitted for the 28V DC power interfaces. This limit addresses stabilization delay sources such as filters, relay contact bounce, and solid state switch controlled (ramp) turn-on. Excessive slow rise (and fall) times complicate store power supply designs or designs of other active solid state devices in the store which can be connected to the power interfaces.

> 5.1.1.8.2.6 Ground reference. The 28V DC power return connections at the primary and auxiliary ASIs shall be the reference for each associated 28V DC power connection.

This paragraph simply states that a power return must be provided for each 28V DC power output.

> 5.1.1.8.2.7 Power application. The aircraft shall only energize 28V DC power 2 and auxiliary 28V DC when the aircraft has determined that it is safe to do so. The aircraft operation shall consider that some stores may utilize 28V DC power 2 or auxiliary 28V DC for powering safety critical functions such that store safety may be degraded with activation of these power interfaces. The aircraft may energize 28V DC power 1 at any time under the assumption that all store functions so powered are either not safety critical or that multiple safety interlocks exist within the store such that store safety is not significantly degraded by activation of 28V DC power 1.

This paragraph allocates 28V DC power 2 and auxiliary 28V DC to potential safety critical functions. It alerts the aircraft designer that activation of either of these power interfaces could degrade the safety of the connected store. This safety degradation results not from the store using power application as a command for some safety critical action (e.g., arm) but from the store using 28V DC power 2 (or auxiliary 28V DC power) as the

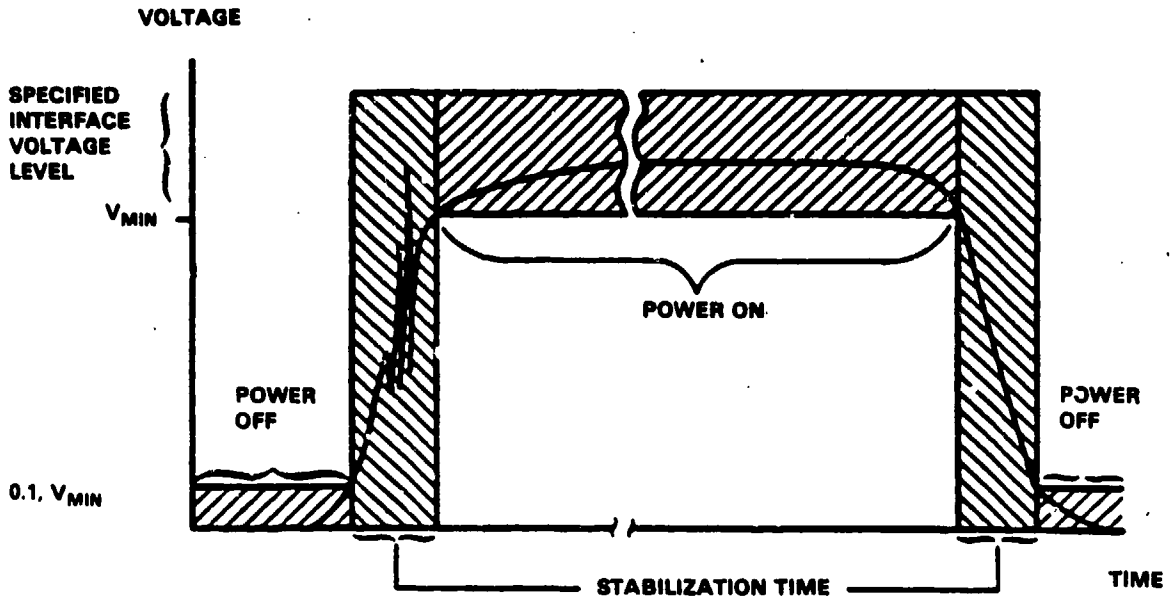


FIGURE 9. Stabilization time.

energy source for carrying out safety functions commanded over the MIL-STD-1553 data bus.

> 5.1.1.9 Aircraft 115/200V AC power interface. The aircraft shall provide a set of three phase, four wire, wye-connected, 115/200V AC power interfaces at each ASI in accordance with the requirements defined herein. The primary signal set ASI shall contain 115V AC Phase A, Phase B, Phase C, and neutral connections. The auxiliary power signal set ASI shall contain 115V AC Phase A, Phase B, Phase C, and neutral connections.
>
> 5.1.1.9.1 Transfer requirements. The aircraft shall be capable of sourcing and independently controlling the 115/200V AC power interface through each primary interface signal set ASI and through each auxiliary power signal set ASI.

This set of paragraphs introduces the requirement for the aircraft to provide three phase AC power at each ASI. The AC power is further divided into primary and auxiliary interface requirements which are expanded in the associated subparagraphs of the standard. The aircraft is also required to provide independent control of the primary and auxiliary AC power sets. The standard does not, however, require that each AC phase also be independently controlled (i.e., ganged 3 phase switching is permitted). Since some stores may not rquire all three phases of AC power for store operation, aircraft designers should consider the safety advantages of providing separate phase switching. There could, however, be some reliability and space disadvantages in the aircraft equipment for providing separate switching of each phase. (See 5.1.7.2 and 5.1.7.5.)

> 5.1.1.9.2 Electrical characteristics
>
> 5.1.1.9.2.1 Voltage level. The voltage at the ASI between each 115V AC phase connection and the associated 115V AC neutral connection shall comply with the 115V AC normal and abnormal operation characteristics for utilization equipment defined in MIL-STD-704. The voltage spikes at the ASI shall comply with MIL-E-6051 and voltage transients at the ASI shall comply with MIL-STD-704. These voltage requirements apply for all valid load conditions.

The commentary on MIL-STD-1760 paragraph 5.1.1.8.2.1 applies equally to the 115/200V AC power interface voltage level requirements. (See 5.1.7.2.)

5.1.1.9.2.2 Current capacity.

5.1.1.9.2.2.1 Primary signal set. The aircraft shall be capable of sourcing the maximum load current levels of figure 7 simultaneously through each of the three 115V AC phases of the primary signal set ASI. (See 6.10.)

5.1.1.9.2.2.2 Auxiliary power signal set. For interface classes IA and IIA, the aircraft shall be capable of sourcing the maximum load current levels of figure 8 simultaneously through each of the three 115V AC power phases of the auxiliary ASI. (See 6.10.)

This set of paragraphs and the referenced figures define the level of currents that the aircraft must be capable of simultaneously sourcing out each phase connection. The referenced figures (one for the primary ASI and one for the auxiliary ASI) specify the current capacity for short term loads as well as continuous loads. The aircraft must be capable of sourcing at least the current levels defined by the "Maximum Load Current" curve in the figures.

5.1.1.9.2.2.3 Simultaneous current. The total 115V AC current available simultaneously from all ASIs shall comply with the aircraft system specification. The total 115V AC continuous current provided simultaneously through both primary and auxiliary interfaces at any class IA or IIA ASI need not exceed 30 amperes per phase.

Similar to the commentary on 28V DC simultaneous current requirements, this paragraph is included to clarify two points. First, the total power simultaneously sourced out all ASIs is not controlled by MIL-STD-1760, but is aircraft dependent and controlled by the system specification for each aircraft model. Secondly, the aircraft stations which include an auxiliary ASI are only required to source a total simultaneous current of 30 amperes per phase through the combination of the primary and auxiliary ASIs. (See 5.1.7.1.)

5.1.1.9.2.3 Overcurrent protection. The aircraft shall ensure that the current flow through any 115V AC power phase connection does not exceed the maximum overcurrent limits of figures 7 and 8 for the primary and auxiliary ASIs, respectively. The aircraft may achieve this current limit operation by the deactivation of the appropriate power interface and any other power interface at the associated ASI. (See 6.10.)

This paragraph imposes an overcurrent protection requirement on the AC power outputs of the ASI similar to that discussed for the 28V DC power outputs. (See commentary on MIL-STD-1760 paragraph 5.1.1.8.2.4.).

5.1.1.9.2.4 Off-state leakage current. The off-state leakage current at the ASI between any 115V AC phase and the associated 115V AC neutral shall be less than 2.0 milliamperes for the primary signal set ASI and shall be less than 5.0 milliamperes for the auxiliary power signal set ASI with any valid load impedance.

The quality of power turn-off is defined in this paragraph for the 115V AC interfaces. The allowed leakage currents are higher than those permitted for the lower voltage 28V DC interfaces due to solid state switch design considerations.

5.1.1.9.2.5 Stabilization time. When tested with any valid resistive load connected to the ASI, the voltage at the ASI shall reach steady state levels within 3.0 milliseconds of power turn-on and turn-off. (See figure 9.)

This requirement is identical to the 28V DC stabilization time. Therefore, the commentary forparagraph 5.1.1.8.2.5 also applies to this paragraph.

5.1.1.9.2.6 Phase rotation. The three 115V AC, 400 Hz, power phases at the ASI shall comply with the phase sequence and voltage phase difference requirements of MIL-STD-704. The power phase assigned to contact location A in the auxiliary ASI connector shall be the identical phase as assigned to contact location P in the primary ASI connector at the same ASI location.

The aircraft is required to furnish AC power at the ASI contacts for each phase with the phase sequence defined by MIL-STD-704. Although the sequence A-B-C is defined, the specific line or ASI contact that is defined as Phase A is relative. For example, the Phase A (contact) at one ASI may not be synchronized (i.e., zero phase difference) with Phase A (contact) at another ASI. (These two ASIs might be powered by two different unsynchronized AC generators.) The second sentence of this paragraph establishes a relationship between the power phase at the primary and auxiliary ASIs which are located at the same aircraft station. That is, the voltage on the contact designated as Phase A (contact A) in the auxiliary connector and the voltage on the contact designated as Phase A (contact P) in the primary connector must have a nominal zero phase difference. This, in turn, synchronizes Phases B and C in the two connectors at a specific ASI. Beyond this local ASI phase synchronization, MIL-STD-1760 does not define phase synchronization requirements between different aircraft stations. This then allows the aircraft to "rotate" phases at the different ASIs as an aid in improving the total power system phase balance. (See 5.1.7.6.)

5.1.1.9.2.7 Load power factor. The electrical characteristics at the ASI shall comply with the requirements herein when loads with a power factor within the limits of figure 10 are applied to the ASI. The power factor is

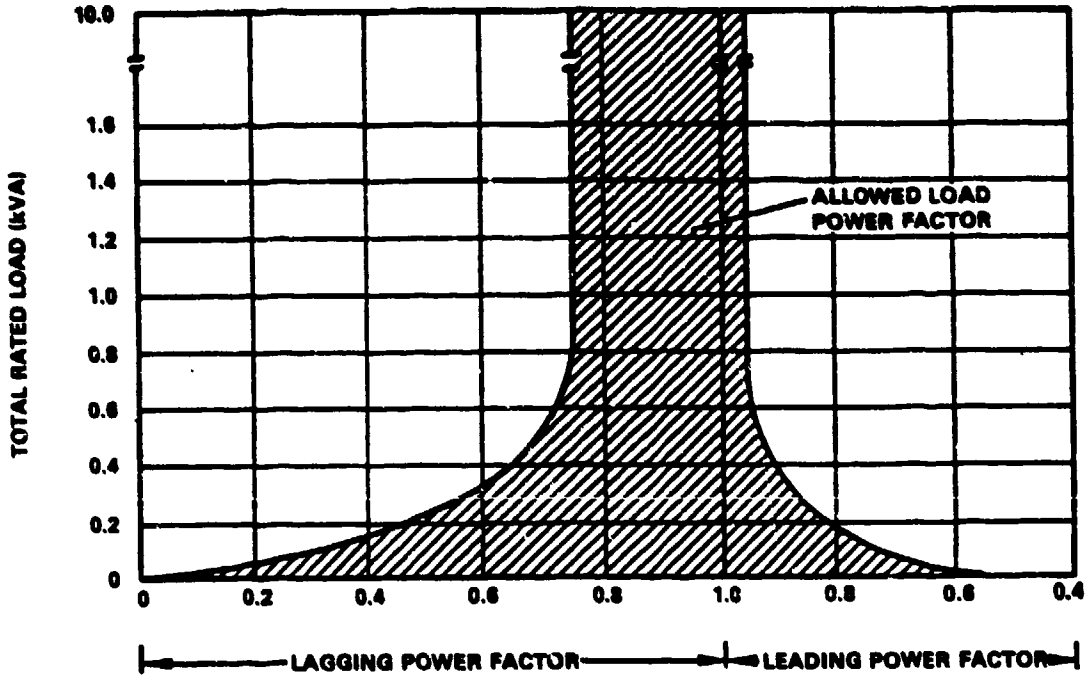


FIGURE 10. Power factor limits.

defined as the ratio of true RMS input power to the true RMS input volt-amperes.

This power factor requirement is included in MIL-STD-1760 because recent revisions of MIL-STD-704 removed the utilization equipment power factor limits. Some control of a load's power factor is necessary to minimize disturbances to power generators and conversion equipment and to assist the aircraft designer in controlling the total (system level) connected load power factor. The power factor curve shown is extracted from earlier revisions of MIL-STD-704.

5.1.1.9.2.8 Phase power unbalance. The electrical characteristics at the ASI shall comply with the requirements herein when loads with a phase power unbalance within the limits of MIL-STD-704 are applied to the ASI.

The aircraft is required to support phase unbalanced loads within the limits of MIL-STD-704. Phase rotation (see commentary on MIL-STD-1760 5.1.1.9.2.6) permitted by MIL-STD-1760 provides a method by which an aircraft designer can cancel some of the phase unbalance at the aircraft power system level. (See 5.1.7.6.)

5.1.1.9.2.9 Ground reference. Each 115V AC neutral connection in the primary signal set ASI and auxiliary power signal set ASI shall be the reference for its respective 115V AC power phase.

This paragraph requires that a separate power return or neutral to be provided by the aircraft as the reference for the primary and auxiliary 115/200V AC interfaces.

5.1.1.9.2.10 Power application. The aircraft may energize the 115/200V AC power interface (primary and auxiliary) at any time under the assumption that all store functions so powered are either not safety critical or that multiple safety interlocks exist within the store such that store safety is not significantly degraded by activation of 115/200V AC power.

This paragraph clarifies that the 115/200V AC power interfaces can be activated (to MIL-STD-1760 stores) without significant safety degradation. This paragraph, when used in combination with 5.1.1.8.2.7, establishes a top level allocation between safety and non-safety critical functions for the different AC and DC ASI power outputs. (See 5.1.7.2.)

5.1.1.10 Aircraft 270V DC power interface. The 270V DC power interface is a growth provision for future applications of 270V DC. The 270V DC power interfaces shall not be activated at an ASI until characteristics

and performance details are added to this standard. All class I interface connectors at all ASIs shall include contacts (or plugged cavities) for 270V DC power and 270V DC power return. The general 270V DC electrical characteristics include voltage levels as defined in MIL-STD-704 for 270V DC and continuous current levels of 10 amperes for the primary ASI and 30 amperes for the auxiliary ASI. (See 5.1.2.)

This requirement identifies top level electrical characteristics for a 270V DC power interface. The characteristics are defined only in sufficient detail to allow selection of appropriate ASI connector hardware. The current revision of MIL-STD-704 defines 270V DC electrical characteristics as if operational 270V DC systems exist or will be used in the near term. However, since current aircraft do not contain 270V DC systems, stores are not permitted (by MIL-STD-1760) to require a 270V DC power input. Likewise, to avoid potential compatibility problems or fault modes, the aircraft is prohibited from applying 270V DC to the ASI. (See 4.3.1 and 5.1.8.2.)

5.1.1.11 Aircraft fiber optic interface. The two fiber optic interfaces are growth provisions for future applications. The fiber optic interfaces shall not be activated at an ASI until characteristics and performance details are added to this standard. All class I interface connectors at all ASIs shall include two 16 AWG size contact provisions (plugged cavities) for fiber optic channel 1 and channel 2. (See 5.1.2.)

Similar to the 270V DC case, aircraft with class I ASIs are required to install ASI connectors which include contact provisions for two 16 gage (cavity size) fiber optic contacts. The aircraft is not required to include fiber optic cables as part of the AEIS wiring.

Activities are underway to standardize fiber optic multiplex data buses. Once these fiber optic standards are completed and store application of the fiber optic bus (through the AEIS interfaces) is required, additional fiber optic details will be added to the AEIS standard.

5.1.2 ASI connector characteristics

5.1.2.1 Primary signal set connector. The primary signal set connector and insert arrangement shall be in accordance with table III. The contact assignments shall be in accordance with table IV.

5.1.2.2 Auxiliary power signal set connector. The auxiliary power signal set connector and insert

TABLE III. Primary signal set connector requirements.

ASI connector characteristics:

Connector: The connector shall be in accordance with MIL-C-38999, Series III, Shell Size 25, Polarization Key Identification N

Contacts: The contacts shall be in accordance with the following slash sheets to MIL-C-39029.

Size	Slash Sheet	Abbreviated Title
20	/56	Contact, socket
20	/58	Contact, pin
16	/56	Contact, socket
16	/58	Contact, pin
12	/28	Contact, shielded, pin
12	/75	Contact, shielded, socket
8	/90	Contact, concentric twinax, pin
8	/91	Contact, concentric twinax, socket

Insert Arrangement: The insert arrangement shall be in accordance with MIL-STD-1560, Insert Arrangement No. 25-20.

MSI connector characteristics: The MSI primary signal set connector shall comply with the intermateability dimensions of MIL-C-38999, MIL-C-39029 and MIL-STD-1560 as specified above.

TABLE IV. Primary signal set contact functional assignment.

CONTACT LOCATION	SIZE	NOMENCLATURE
A	8	LB 1/
B	20	Interlock
C	16	28V DC Power 1
D	16	28V DC Power 1 Return
E	16	28V DC Power 2 Return
F	16	28V DC Power 2
G	20	Address Parity
H	8	Mux B 2/
J	16	115V AC, Phase C 4/
K	8	Mux A 2/
L	20	Address Bit A0
M	16	115V AC, Phase B 4/
N (Reserved)	16	270V DC Return
P	16	115V AC, Phase A 4/
R (Reserved)	16	270V DC Power
S	20	Interlock Return
T	16	Structure Ground
U (Reserved)	16	Fiber Optics Channel 2
V	20	Address Bit A4
W	12	HB 2 3/
X	20	Address Bit A1
Y (Reserved)	16	Fiber Optics Channel 1
Z	16	115V AC Neutral
1	20	Release Consent
2	12	HB 4 3/
3	12	HB 3 3/
4	20	Address Bit A3
5	12	HB 1 3/
6	20	Address Return
7	20	Address Bit A2

1/ The LB contact is a twinaxial style contact. LB signal assignments within the contact are:
Center contact: Non-inverting
Intermediate contact: Inverting
Outer contact: Shield

2/ The Mux A and B contacts are a twinaxial style contact. Mux A and B signal assignments within the contact are:
Center contact: Mux data high
Intermediate contact: Mux data low
Outer contact: Mux shield

TABLE IV. Primary signal set contact functional assignment. - Continued

3/ The HB contacts are a coaxial style contact. Signal assignments within the contact are:
Center contact: Signal
Outer contact: Signal return (shield)

4/ Phase rotation shall comply with the requirements of 5.1.1.9.2.6.

TABLE V. Auxiliary power signal set connector requirements.

ASI connector characteristics:

Connector: The connector shall be in accordance with MIL-C-38999, Series III, Shell Size 25, Polarization Key Identification A.

Contacts: The contacts shall be in accordance with the following slash sheets to MIL-C-39029.

Size	Slash Sheet	Abbreviated Title
20	/56	Contact, socket
20	/58	Contact, pin
10	/56	Contact, socket
10	/58	Contact, pin

Insert Arrangement: The insert arrangement shall be in accordance with MIL-STD-1560, Insert Arrangement No. 25-11.

MSI connector characteristics: The MSI primary signal set connector shall comply with the intermateability dimensions of MIL-C-38999, MIL-C-39029 and MIL-STD-1560 as specified above.

TABLE VI. Auxiliary power signal set contact functional assignment.

CONTACT LOCATION	SIZE	NOMENCLATURE
A	10	115V AC, Phase A 1/
B	10	28V DC
C	10	115V AC, Phase B 1/
D	10	28V DC Return
E	10	115V AC, Phase C 1/
F (Reserved)	10	270V DC
G	10	115V AC Neutral
H (Reserved)	10	270V DC Return
J	10	Structure Ground
K	20	Interlock
L	20	Interlock Return

1/ Phase rotation shall comply with the requirements of 5.1.1.9.2.6.

arrangement shall be in accordance with table V. The contact assignments shall be in accordance with table VI.

These two paragraphs and the referenced tables require the aircraft to use MIL-C-38999 compliant connectors at the primary and auxiliary ASIs. The primary connector is required to be a MIL-C-38999 Series III, Shell Size 25, N Polarization connector with a 25-20 insert arrangement and a mix of contacts defined by reference to specific specification slash sheets. (See MIL-STD-1760 table III). The primary signal set signals are assigned to specific contacts (MIL-STD-1760 table IV) in the 25-20 insert. The table also designates inter-contact signal assignments for the coaxial and twinaxial contacts to avoid polarity reversals at the MIL-STD-1553, Low Bandwidth and High Bandwidth contacts. The /28 and /75 shielded contacts listed in table III and IV for HB1 through HB4 do not provide a controlled contact impedance. As a result, the VSWR performance could be marginal, particularly if the aircraft uses several series connections of these shielded contacts in the ASI-to-SMS harnessing. Controlled impedance contacts are available and are intermateable with the /28 and /75 contacts. These contacts are not, however, currently QPL'd (1986) but can be procured for better VSWR performance - specifically at the high end of the Type B signal frequencies.

The auxiliary ASI connector must be a MIL-C-38999 Series III, Shell Size 25, A Polarization connector with a 25-11 insert arrangement and a mix of contacts defined by reference to specific contact specification slash sheets. (See MIL-STD-1760 table V.) The auxiliary power signal set signals are assigned to specific contacts in the insert by table VI. (See 5.1.5.2.1 and 5.3.4.)

5.1.2.3 Connector receptable. The connector on the aircraft side of the ASI mated connector pair shall be a receptacle with socket contacts or with plugged cavities.

This paragraph defines the gender of the aircraft's ASI connector. To minimize exposed contacts and maximize ruggedness of the "permanently attached" connector, a receptacle style connector with socket style contacts is required. (See 5.3.1.2.)

5.1.2.4 Connector orientation. The ASI connector location on the aircraft shall be compatible with store connector locations. The connector keyway orientation shall conform to the following:

a. With the interface connector positioned such that the longitudinal axis of the connector (the axis that traverses from the back of the connector through the

center to the front of the connector) is in the horizontal plane of the aircraft and the connector face is facing forward on the aircraft, the major (large) keyway shall be located in the up position. (See figure 11a.)

b. With the interface connector positioned such that the longitudinal axis of the connector is in the vertical plane of the aircraft and the connector face is facing down on the aircraft, the major (large) keyway shall be located in the forward position. (See figure 11b.)

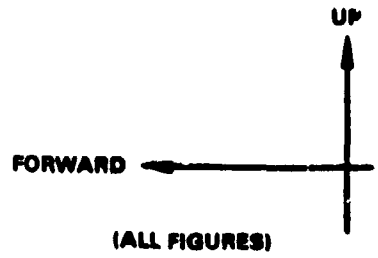
c. With the interface connector positioned such that the longitudinal axis of the connector is in the horizontal plane of the aircraft and the connector face is facing aft of the aircraft, the major (large) keyway shall be located in the down position. (See figure 11c.)

d. With the interface connector positioned such that the longitudinal axis of the connector is in the horizontal plane of the aircraft and the connector face is facing inboard or outboard of the aircraft, the major (large) keyway shall be located in the forward position. (See figure 11d.)

This set of orientation requirements (also see referenced figure) is included for compatibility with MIL-A-8591. This specification defines the connector (keyway) orientation for the store's MSI. Due to the general lack of rotational flexibility in umbilical cables - particularly gross shielded cables - the orientation of the ASI major keyway needs to be defined. The keyway locations shown for each connector orientation helps insure "mechanical" compatibility of umbilical cables. (See 5.3.1.4 and 5.3.2.4.)

5.1.3 Electromagnetic Compatibility (EMC). The aircraft shall comply with the EMC requirements of MIL-E-6051 and applicable sections of MIL-HDBK-235 when loaded with stores which comply with 5.2 and after store release.

The paragraph simply emphasizes that the aircraft must provide electromagnetic compatibility when stores (which meet the AEIS standard) are installed on the aircraft and after these stores are released. The released store condition is included because the ASI (or ASI connected umbilical) connector is unmated (exposed to electromagnetic environment) after store separation. (See 5.1.9 and 5.3.6.)



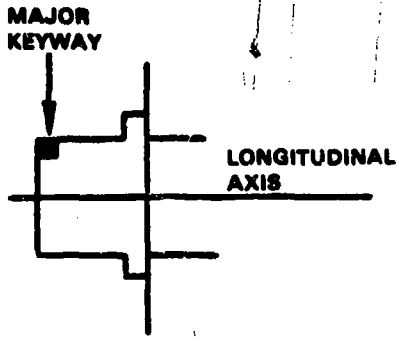


FIGURE 11a. Facing forward.

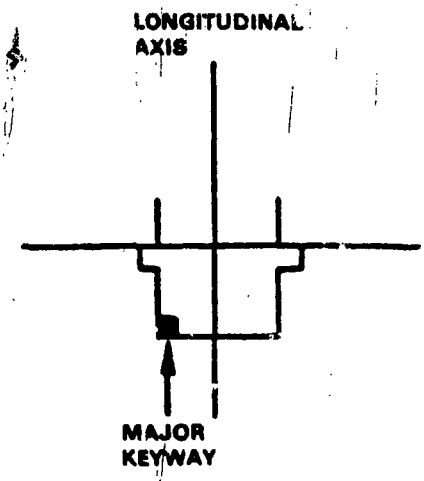


FIGURE 11b. Facing down.

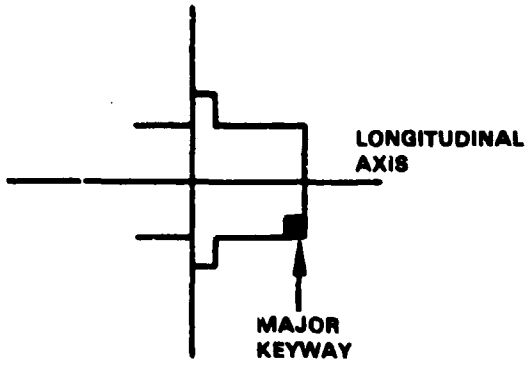


FIGURE 11c. Facing aft.

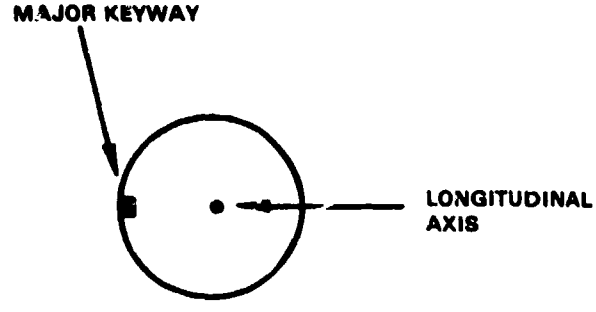


FIGURE 11d. Facing outboard/inboard.

FIGURE 11. Connector orientation.

5.4.6 Detail mission store requirements

> 5.2 Mission store requirements (measured at the MSI). Mission stores shall provide Mission Store Interfaces (MSIs) with the characteristics defined herein.

This introduction to requirements imposed on the mission store emphasizes (in the title) that the requirements apply to the MSI and are measurable at the MSI. Within this constraint, the internal store subsystems can be designed using a multitude of technologies and internal subsystem architectures. All MIL-STD-1760 requires is that certain characteristics be supplied at the mission store interface. (See 5.2.)

> 5.2.1 Interface electrical requirements
>
> 5.2.1.1 Mission store HB interfaces. Mission stores with a class I MSI shall provide connections for four HB interfaces (HB1, HB2, HB3 and HB4) at the primary signal set MSI. Mission stores with a class II MSI shall provide connections for HB1 and HB3 interfaces at the primary signal set MSI. Each HB interface shall include a signal connection and a signal return (shield) connection at the MSI. The mission store is not required, however, to use any HB interface. If a HB interface is used, the mission store shall comply with the requirements below. If a HB interface is not used, the impedance between the signal and signal return connection at the MSI shall be greater than 45 ohms for HB1 and HB2 and greater than 68 ohms for HB3 and HB4.

This paragraph is packed with a number of requirements and introductory points on the High Bandwidth (HB) interface in the MSI. The first two sentences provide a reinforcement of the interface class definitions of MIL-STD-1760 paragraph 4.2. Class I MSIs contain connections (i.e., connector contacts or cavities) for four HB ports (HB1, HB2, HB3 and HB4) while class II MSIs are limited to HB1 and HB3 high bandwidth ports only. The paragraphs then establish that each HB port consists of two connections - a signal connection and a signal return connection. For implementations using coaxial cable for the HB lines, the signal return is also the shield. For triaxial cable implementations, the signal return is the inner shield of the concentric double shielded triaxial cable.

The next couple of sentences clarifies that the mission store is not required to actually use any of the HB ports in the interface, but if any port is used, then the requirements of MIL-STD-1760 5.2.1.1 subparagraphs apply. The only HB electrical requirement imposed on stores which do not use one or more of the HB ports is a simple impedance requirement. All unused ports must provide a signal-to-signal return impedance of at least 45

ohms (HB1 and HB2) and 68 ohms (HB3 and HB4). An open circuit meets this requirement. The unused ports do not, therefore, need to be physically terminated into any load. In fact, paragraph 5.2.2.3 of MIL-STD-1760 states that the connector cavities of unused signals may be plugged - i.e., insertion of a contact into the cavity is not required. (See 5.2.6.)

> 5.2.1.1.1 Transfer requirements. The MSI shall include a maximum of two HB interfaces (HB1 and HB2) for 50 ohm applications and a maximum of two HB interfaces (HB3 and HB4) for 75 ohm applications. (See 6.5.)

This requirement clarifies that only two 50 ohm (nominal) impedance ports and two 75 ohm impedance ports are available for the mission store. The reader is also referenced to Note 6.5 of MIL-STD-1760 which cautions the designer if more than one 50 ohm (HB1) and one 75 ohm (HB3) port is required. (See 5.4.7 for additional commentary on Note 6.5 and also see 5.2.1, 5.2.6 and 5.2.10.5 for general comments on the high bandwidth interface and subsetting.)

> 5.2.1.1.2 Electrical characteristics. The mission store shall source or sink Type A and Type B signals through the MSI with the following electrical characteristics. Type A signal requirements apply to HB1, HB2, HB3 and HB4. Type B signal requirements apply to HB1 only. Unless otherwise specified, the performance requirements apply at the MSI, looking into the mission store and include the effect of the MSI mating connector.

The signal types (A and B) are allocated to the various HB ports with Type B permitted on HB1 only. The last sentence clarifies that the characteristics specified in the subparagraphs include the effects of the MSI mating connector. This clarification is most important when specifying and measuring the VSWR - particularly at the high end of the Type B signal frequency range. With some test equipment or test methods it is possible to exclude or eliminate the effects of the MSI mated connector pair from the VSWR measurements. This exclusion is not permitted because the MSI connector performance can be the weak link in the RF signal path.

> 5.2.1.1.2.1 Signal characteristics. Type A and Type B signals shall comply with the general characteristics of table I. Signals for monochrome raster composite video shall comply with EIA-STD-RS-170, EIA-STD-RS-343A, or STANAG 3350 with the following two exceptions: (1) The sync pulse amplitude shall be 28.6 percent ±5 percent of the composite signal peak-to-peak amplitude; and (2) the composite signal peak-to-peak amplitude shall be 3.0 ±0.5 volts at the MSI for store sourced video and 1.0 to

3.5 volts at the MSI for store received video (aircraft sourced video).

The signal characteristics are divided into general characteristics and specific characteristics. The general characteristics, listed in MIL-STD-1760 table I, define limits for any signal applied to the HB ports by the aircraft or store. These general characteristics are mainly of interest to the aircraft designer in establishing requirements for the HB signal distribution network. Store interest in the general characteristics is for visibility of the aircraft's signal distribution capability. The general characteristics also define signal limits for new HB signals not currently defined by MIL-STD-1760.

The only specific signals defined with detailed characteristics are the several types (i.e., resolutions) of composite, raster scan video. The video requirements are defined by reference to specific video standards with several defined exceptions. The primary exception is raising the video signal amplitude from 1.0 volt p-p to 3.0 volt p-p for sourced video. This higher source amplitude is required in MIL-STD-1760 applications due to the relatively long cable runs (i.e., high losses) and due to the high electromagnetic noise level in the aircraft/store environment. (See 5.2.6.2 and 5.2.9.1.7.)

5.2.1.1.2.2 Signal assignment. The store shall limit the transfer of signals on the HB interfaces to the following:

a. Radio frequency signals which comply with the Type B signal characteristics shall be transferred on HB1.

b. Time correlation (synchronization, clocking and blanking) signals shall be transferred on HB1 or HB2, or both.

c. Raster composite video signals shall be transferred on HB3 or HB4, or both.

This set of requirements restricts the mission store to applying only specific signals to each of the four HB ports. As discussed in the commentary to paragraph 5.1.1.1.2.2 in Section 5.4.5 of this report, these assignment restrictions are imposed to: (1) Limit proliferation of different signals on the HB ports (proliferation would generate new interoperability obstacles), and (2) direct specific signal types into specific ports (simplify the aircraft's HB signal distribution network). As indicated in 5.4.5, additional signals or modified assignments will be included in this paragraph as other viable applications for the HB ports evolve. The intent is to control these new applications as they arise to avoid loss of interface standardization due to HB loopholes. (See 5.2.6.1.)

5.2.1.1.2.3 Characteristic impedance. The nominal characteristic impedance at the MSI shall be 50 ohms for HB1 and HB2 and shall be 75 ohms for HB3 and HB4.

This paragraph defines the reference impedance for the four HB ports. This reference impedance is particularly important for high frequency RF measurements such as VSWR.

5.2.1.1.2.4 VSWR. The mission store shall comply with the VSWR requirements of table VII for applications where the signal load is on the mission store side of the MSI. The VSWR shall include the effects of the mated connectors shown on figure 12. The mission store shall be compatible with aircraft which impose at the MSI, a Type A or Type B signal load with a VSWR of 2.0 maximum. When applicable, the mission store shall be compatible with carriage stores which impose at the MSI, a Type A or Type B signal load with a VSWR of 3.20 maximum. The VSWR produced at the MSI by the carriage store includes the effect of the aircraft to which the carriage store is connected. (See 5.2.1.1.2.9.)

This paragraph defines VSWR requirements for cases when the mission store is either the signal load (first two sentences) or the signal source (last three sentences). For the condition when the mission store provides a signal load, the VSWR limits of table VII must be met by the store. These requirements are clarified by the measurement configurations shown in the accompanying figure 12. For those applications where the mission store is sourcing signals, the store must be compatible with the defined VSWR levels. Designers should recognize that the VSWR seen at the MSI when the mission store is connected to an aircraft through a carriage store is relatively high (i.e., 3.20). The high VSWR is primarily due to the large number of series connected coaxial (or shielded) contacts in circular, general purpose connectors (as opposed to dedicated RF connectors) that exist in this carriage store configured loadout.

The final important point is given in Note 3 of table VII. This note clarifies that the store VSWR requirements only apply over the specific frequency range of interest to the store as opposed to the broader range defined for the Type A and Type B signals. (See 5.2.6.3 and 5.2.6.4.)

5.2.1.1.2.5 MSI to MSI attenuation and attenuation flatness. Mission stores which require a HB interconnection (Type A signal) with another mission store shall be compatible with the applicable attenuation and attenuation flatness requirements of Table VIII.

TABLE VII. Mission store VSWR load requirements.

CONDITION	APPLICATION	MAXIMUM VSWR 3/
Figure 12a	1/	1.75
Figure 12b	2/	2.0

1/ Applicable at all MSIs where the Type A or Type B signal load is located in the mission store.

2/ Applicable to installations where the MSI to ASI (or MSI to CSSI) interconnection mechanism (such as a umbilical cable) is furnished with the mission store and the Type A or Type B signal load is located in the mission store.

3/ These VSWR requirements apply over the frequency range applicable to the specific Type A or Type B signal load in the mission store.

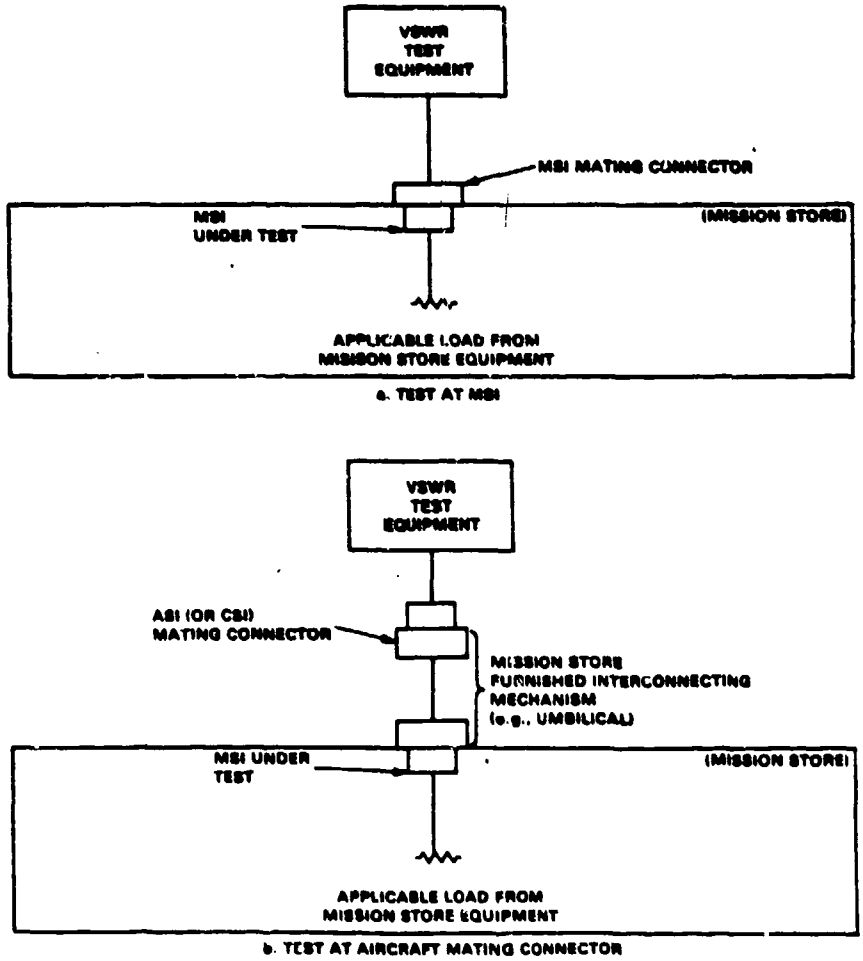


FIGURE 12. VSWR measurement of MSI load.

TABLE VIII. Mission store attenuation compatibility.

MEASUREMENT POINTS 1/	INTERVENING CARRIAGE STORE	ATTENUATION (dB)	ATTENUATION FLATNESS (dB) 2/
ASI to ASI	No	6.0	5.0
MSI to MSI	No	7.0	5.5
MSI to MSI	Yes	9.5	7.5

1/ Includes the effect of associated mating connectors.

2/ Attenuation flatness is the difference between minimum and maximum actual measured attenuation over the frequency band (20 Hz to 20 MHz) for any specific signal path.

This paragraph and the associated table define the signal loss and fidelity that the mission store should expect for store-to-store HB signal transfers. The losses and fidelity (attenuation flatness) are defined for three sets of end points.

The ASI-to-ASI requirement is simply a repeat of the aircraft requirements in MIL-STD-1760 paragraphs 5.1.1.1.2.5 and 5.1.1.1.2.6. The MSI-to-MSI requirements (no intervening carriage store) reflect the ASI-to-ASI path performance as degraded by a set of umbilical cables connected between the two ASIs and MSIs. Finally, the MSI-to-MSI attenuation and flatness values with a carriage store inserted between the ASI and MSI represents the worst case performance.

The Note 2 definition of attenuation flatness in table VIII is clarified in figure 154 contained in Section 5.4.5 of this report. It should also be noted that the attenuation flatness defined affects the effective port bandwidth available to the mission store due to the relatively high losses. (See 5.2.6.2 and 5.2.6.4.)

5.2.1.1.2.6 Propagation delay. Mission stores requiring a HB interconnection with another mission store shall be compatible with networks which have a propagation delay of up to 3.0 microseconds for the different frequency components (between 5 MHz and 20 MHz) of the Type A signal transferred from one MSI to another MSI.

5.2.1.1.2.7 Signal dispersion. Mission stores requiring a HB interconnection with another mission store shall be compatible with networks which produce a variation in propagation delay up to 55 nanoseconds. This variation is the change in propagation delay of the different frequency components (between 5 MHz and 20 MHz) of the Type A signal transferred from one MSI to another MSI.

These two paragraphs represent the signal time delay equivalent of attenuation and attenuation flatness. The propagation delay maximum specifies the worst case delay that any signal frequency component can encounter in passing from one MSI to another. The allowed 3 microseconds delay is established not for compatibility with very large aircraft but to allow the use of electronic based signal distribution networks such as those used in frequency division multiplex systems.

The signal dispersion requirement limits the maximum variation in actual propagation delay of the various frequency components. This delay variation results in signal distortion because the arrival of various signal frequencies (e.g., from a pulse) are "dispersed" over time. The delay and dispersion requirements are defined only down to 5 MHz due to the change in propagation mode that occurs at low frequencies in the Type A signal band. The delay and delay variation can be determined with test equipment that measures "group delay". (See 5.2.6.4.)

5.2.1.1.2.8 Harmonic distortion. The mission store shall be compatible with networks which produce third harmonic distortions up to 25 dB below the power level of the intentional Type A signal.

Inclusion of a distortion specification recognizes the possibility that electronic based signal distribution networks may be used in future aircraft. Harmonic distortion normally results from unwanted signals being generated by the non-linearities in solid state devices which would be used in the electronic based distribution networks. Under certain conditions, harmonics can also be generated by ferromagnetic material in passive cable, connector and switching hardware. Generally, however, these passive component generated harmonics only occur in systems operating at higher power levels than permitted for the AEIS application.

5.2.1.1.2.9 Unterminated HB interface. The mission store shall not be functionally damaged by the removal of a matched termination (see 5.2.1.1.2.4) on any HB interface in equipment (aircraft, carriage stores, etc.) connected to the MSI.

This paragraph reminds the store designer that the high bandwidth port looking into the aircraft may occasionally be an open circuit due to switching operations in the aircraft. The store signal sources are required to survive, without damage, transmission into an open circuit. Due to transmission line effects, the reflected wave will change the voltage/current characteristics seen by the store from those characteristics expected with the VSWR levels defined by paragraph 5.2.1.1.2.4. (See 5.2.6.2 and 5.2.6.4.)

> 5.2.1.1.2.10 Ground reference. When measured at the MSI, the signal return of all implemented HB interfaces shall be electrically connected to a suitable mission store ground. (See 6.11.) The mission store shall be compatible with aircraft which connect HB1 and HB2 signal returns to aircraft structure ground and which isolate HB3 and HB4 signal returns from aircraft grounds. For applications requiring ASI to ASI transfers, the mission store shall be compatible with other mission stores which connect HB3 and HB4 signal returns to mission store ground.

This paragraph in conjunction with paragraph 5.1.1.1.2.12 establishes the HB signal grounding approach visible at the AEIS interfaces. The mission store is required to connect the signal return of all used HB ports to mission store ground. The aircraft is also required to ground HB1 and HB2 returns and float HB3 and HB4 returns. As a result, a multi-point shield grounding approach is used for HB1 and HB2 ports and a single point shield ground is used for HB3 and HB4 ports. This grounding approach is selected to EMC optimize HB1 and HB2 networks for high frequency operations and HB3 and HB4 for low frequency operations. The AEIS standard does not actually control the physical location or termination method of the shield ground in the store nor does it prohibit use of triaxial cable. It simply requires that measurements at the MSI indicate that the signal return connections are connected to ground.

The last sentence in the paragraph highlights that MSI-to-MSI transfers on HB3 or HB4 occurs on a double grounded return path. This results because, even though the aircraft floats the HB3 and HB4 returns from internal aircraft grounds, the two mission stores ground the returns. The aircraft is not required to electrically isolate these two MSI return grounds from each other. Therefore, once the MSI-to-MSI path is established through the aircraft, both the source and load ends of the path are grounded. (See 5.2.6.4 and 5.2.9.1.7.)

> 5.2.1.2 Mission store digital multiplex data interface. The mission store shall provide connections for the digital multiplex data interface (Mux A and Mux B) in the primary signal set MSI. Each of the Mux A and Mux B connections shall include a data high, a data low, and a

shield connection. The mission store is not required to use the interface. However, if the interface is used, the mission store shall comply with the MSI requirements below. If the interface is not used, the impedance between the data high and data low connections at the MSI shall be greater than 1000 ohms from 75 kHz to 1.0 MHz.

5.2.1.2.1 Functional characteristics. The mission store shall provide a remote terminal function defined in MIL-STD-1553. This remote terminal shall be accessible through the digital interface (Mux A and Mux B) at the MSI for a dual standby redundant, half duplex MIL-STD-1553 communication link with the aircraft or carriage store. The mission store shall respond in accordance with MIL-STD-1553 to those messages whose MIL-STD-1553 command word terminal address corresponds to: (1) The address encoded on the address interface (see 5.2.1.6) monitored at the MSI; and (b) the broadcast address if implemented by the mission store. Subaddress field of 00111 binary shall only be used for communications with nuclear stores.

These two paragraphs establish the top level requirements for a MIL-STD-1553 remote terminal interface in the store. The lead-in paragraph identifies the "digital multiplex data interface" as consisting of a Mux A and Mux B port. Each port is further defined as containing a Data High, a Data Low, and a Data Shield connection. The lead-in paragraph also emphasizes that if the mission store uses this data interface then it must comply with the subparagraph requirements. If the mission store does not use the interface then the input impedance must be above 1000 ohms. An open circuit meets this requirement.

The second paragraph defines top level functional characteristics which apply if the store uses the data interface. (It is expected that nearly all MIL-STD-1760 stores will use this data interface.) A dual standby redundant MIL-STD-1553 compliant remote terminal is required in the store. This terminal is required to respond to commands addressed to it under the rules of MIL-STD-1553. The store is required to use as its terminal address, the address decoded by the address discretes defined in MIL-STD-1760 paragraph 5.2.1.6. This allows assignment of the store address at the time of operation on a given aircraft station. This permits optimum flexibility in allowing different bus architectures in the aircraft. The issue of whether the store responds (within the restrictions of MIL-STD-1553) to broadcasted (i.e., Address = 31) messages is left open by MIL-STD-1760. It is expected that the logical element will either ban broadcasts or will attempt to limit the types of commands which are broadcasted. Unrestricted broadcasted messages is seen as overly complicating compatibility of stores mixed with other stores and equipment on different aircraft. (See 5.2.2.1.)

5.2.1.2.2 Electrical characteristics. The mission store shall comply with the electrical characteristics defined herein at the MSI. The characteristics defined apply when measured on the data high connection referenced to the data low connection. Data high is that connection that is positive referenced to the data low connection in the first part of a MIL-STD-1553 command or status sync waveform.

The electrical characteristics for the data interface are introduced at this point. The paragraph emphasizes that the characteristics addressed apply (i.e., are measured) at the MSI. This contrasts with MIL-STD-1553 which defines characteristics at the input to the remote terminal hardware. The main differences then between MIL-STD-1553 and MIL-STD-1760 is that the AEIS standard addresses characteristics which is seen at the end of a piece of MIL-STD-1553 cable conn to a MIL-STD-1553 remote terminal. This length of cable, between the MSI and the actual remote terminal transceiver buried within the mission store, changes some characteristics as defined by MIL-STD-1553. It is highly desirable to allow use of existing remote terminal hardware in the store. Without clarifying the effects of the cable on these characteristics, some stores would be forced into using special remote terminals simply to meet RT requirements at the MSI.

The second point in the introduction to electrical characteristics in the standard is to define the polarity of the data interface connections (data high referenced to low data). This avoids reverse polarity connections between the aircraft and the store. This polarity definition, in combination with Note 2 of MIL-STD-1760 table IV, avoids this connection problem which has occurred in past MIL-STD-1553 systems.

5.2.1.2.2.1 Output characteristics. The mission store shall provide output characteristics at the MSI which comply with the output characteristics of a MIL-STD-1553 transformer coupled stub terminal except the terminal output voltage shall be 20.0V to 27.0V p-p, line-to-line.

Two main points are made in this paragraph. The MIL-STD-1553 standard defines two types of remote terminals based on the method of coupling the terminal's stub to the main bus. These two methods are direct coupled and transformer coupled. This paragraph requires the store to contain a transformer coupled style remote terminal. Transformer coupled stubs are selected because the stub length from the bus coupler in the aircraft to the remote terminal in the store is nearly always too long to use direct coupled stubs.

This paragraph also imposes a requirement on the mission store data interface over what is required by MIL-STD-1553. MIL-STD-1553 requires the terminal output voltage of transformer coupled remote terminals to be in the range of 18 to 27 volts p-p, line-to-line when connected to a 70 ohm ±2 percent load. In contrast, MIL-STD-1760 requires the store to output at the MSI a line-to-line voltage of 20 to 27 volts p-p into the same test load. This higher minimum output voltage is required for two reasons. First, the possible load impedance seen by the store at the MSI can be lower than the 70 ohm test load referenced in MIL-STD-1553. Increasing the minimum output voltage raises the design margin. Second, a higher minimum voltage is defined because (1) the losses in the AEIS bus network of some aircraft are expected to be higher than losses for typical MIL-STD-1553 avionic applications, and (2) the electromagnetic noise environment at the aircraft/store interface areas is expected to be higher than typical noise levels. Raising the minimum voltage is seen as necessary to maintain reasonable signal-to-noise ratios. (See 5.2.2.2.2.)

> 5.2.1.2.2.2 Input characteristics. The mission store shall be capable of receiving and operating with input signals at the MSI which comply with the input waveform compatibility, common mode rejection and noise rejection requirements of MIL-STD-1553 for transformer coupled stub terminals. The magnitude of the line-to-line input impedance at the MSI, when the mission store terminal is not transmitting or has power removed, shall be a minimum of 300 ohms within the frequency range of 75 kHz to 1.0 MHz. The remote terminal contained within the mission store shall comply with the 1000 ohm minimum terminal input impedance required by MIL-STD-1553.

This paragraph requires the store to accept MIL-STD-1553 compliant input signals when applied at the MSI. As with the output characteristics, the input parameters of transformer coupled stubs are designated for the MSI. In addition, this requirement expands on the remote terminal input impedance requirement of MIL-STD-1553. The paragraph clarifies that the MIL-STD-1553 requirement still applies at the input to the remote terminal contained in the store. However, due to the effects of the cable connected between the MSI and remote terminal, measurements at the MSI will indicate a lower (below 1000 ohms) impedance even though a MIL-STD-1553 compliant terminal is installed in the store. To avoid custom designed remote terminals, the MSI measured impedance is lowered to compensate for the interconnecting cable. (See 5.2.2.2.1.)

> 5.2.1.2.2.3 Shield grounding. The mission store shall connect the data bus stub shields of both Mux A and Mux B to a mission store structure ground.

This paragraph addresses an interface detail implied by MIL-STD-1553 but not specifically required. Mission stores are required to connect the data shield to the store structure ground at some point on the store side of the MSI. Since the aircraft is also required to ground the data shield on the aircraft side of the ASI, a multiple point shield grounding scheme is imposed for the data interface. (See 5.2.9.1.1.)

> 5.2.1.3 Mission store LB interface. The mission store shall provide connections for an LB interface in the primary signal set MSI. The LB interface shall include a non-inverting, an inverting, and a shield connection. The mission store is not required to use the LB interface. However, if the LB interface is used, the mission store shall comply with the MSI requirements below. If the LB interface is not used, the impedance between the non-inverting and the inverting connections at the MSI shall be greater than 70 ohms.
>
> 5.2.1.3.1 Transfer requirements. The MSI shall include an LB interface for transferring an LB signal between the mission store and the connected aircraft. The mission store shall provide the signal source or signal load as applicable.

These two paragraphs introduce the Low Bandwidth (LB) interface requirements on the mission store. Similar to the digital multiplex data interface, the LB interface contains three connections - a non-inverting connection, an inverting connection and a shield connection. Likewise, the mission store is not required to use the LB interface port but if it does use the port, the store must comply with the requirements in the associated subparagraphs. If the store does not use the LB interface, it is required to maintain at least 70 ohms between the non-inverting and inverting connections on the store side of the MSI. As with the store's HB and Mux A/B interfaces, an open circuit meets the intent of this unused interface "termination" impedance.

The transfer requirement paragraph applies to the mission store if it uses the LB interface. This paragraph clarifies that the store can be a signal source, a signal load, or both as applicable. The second sentence of 5.2.1.3.1 is not clear that "or both" is a legal option. However, paragraph 4.3.1.3 refers to bi-directional signals in the General Requirements section of the AEIS standard which infers this option.

> 5.2.1.3.2 Electrical characteristics. The LB interface electrical characteristics at the MSI shall comply with the following requirements. (See 6.9.)
>
> 5.2.1.3.2.1 Signal characteristics. The LB signal at the MSI (line-to-line and line-to-ground) shall be in

the range of -12 volts to +12 volts. The LB signal frequency components shall be contained within a passband from DC to 50 kHz. The LB signals allowed through the interface are tones and voice grade audio. (See 6.9.) This signal shall not be used for discrete functions.

The general LB signal characteristics are specified as a low power level, low bandwidth signal. The signal voltage characteristics are defined for both line-to-line and line-to-ground to accommodate different types of line drivers and receivers. The standard requires the store to limit the signal to a DC to 50 kiloHertz frequency band. A specific signal generated by a store is not, however, required to span this entire range. For example, an audio tone is generally constrained to a tighter band. The defined frequency range should be interpreted as the passband within which signals can be transferred. Any frequency components outside of this band (such as harmonics) may or may not be transferred. The store must not, therefore, rely on the transfer of any higher frequencies (beyond 50 kHz) for system operation.

The standard currently restricts signals on the LB interface to tones and voice grade audio. However, the network distribution requirements imposed on the aircraft are defined to allow possible future uses of this interface for low speed, point-to-point, serial data links using the EIA-STD-RS-485 transceiver or for other possible applications. However, these alternate uses must not be implemented by a store (or aircraft) without government approval. (See 5.2.7.)

5.2.1.3.2.2 Load impedance. The mission store shall comply with the requirements herein when the line-to-line load impedance applied to the MSI by the aircraft is a minimum of 70 ohms over the frequency range of DC to 50 kHz.

5.2.1.3.2.3 Input impedance. Mission stores which sink a LB signal shall provide a line-to-line impedance of 70 ohms minimum over the frequency range of DC to 50 kHz.

The load and input impedances are specified as a minimum value only. This allows the impedance to be as high as an "open circuit". This range also encompasses the typical 600 ohm audio impedances and 120 ohm serial data link impedances. The 70 ohm impedances are absolute minimum values. However, paragraph 5.1.1.3.2.1 identifies a 150 milliampere maximum current limit. (This current limit was unintentially removed from the mission store requirements but will be reinserted in a future notice to the standard.) This 150 milliampere limit, in conjunction with the ±12 volt maximum signal voltage, results in an 80 ohm minimum impedance if maximum voltage level signals are transmitted. (See 5.2.7.)

5.2.1.3.2.4 Shield grounding. The mission store shall connect the LB shield to mission store structure ground.

The shield grounding method selected for the LB interface is a multiple point shield grounding scheme. The shield termination, as measured at the MSI locking into the store, is connected to mission store ground. Likewise, the LB shield is connected to aircraft ground on the aircraft side of the ASI. This grounding scheme provides optimum shielding for a balanced line twisted shielded pair signal path. As with all other characteristics, the standard only requires that the shield "appear" to be grounded when measured at the MSI. The standard does not define the actual internal store circuitry or shield termination location and procedures. (See 5.2.9.1.6.)

5.2.1.4 Mission store release consent interface. The mission store shall provide connections for a release consent interface in the primary signal set MSI. The release consent interface shall include a release consent signal connection referenced to the 28V DC power 2 return connection (see 5.2.1.8). The mission store is not required to use the release consent interface. However, if the release consent interface is used, the mission store shall comply with the MSI requirements below. If the release consent interface is not used, the impedance between the release consent connection and the 28V DC power 2 return connection shall be greater than 100 kilohms (at DC).

This paragraph provides a lead-in for the mission store's release consent interface. The several points made are: (1) A release consent interface is included in the MSI connector; (2) this interface contains the signal (release consent) and its return (28V DC power 2 return); and (3) the store is not required to use the interface (in which case the store will provide at least 100 kilohms impedance between the signal and return lines) but if it uses the interface, the store must comply with the requirements in the associated subparagraphs. These requirements allow stores which do not use release consent to leave the connector contact assigned to release consent open circuited or even to plug the contact cavity in the MSI connector with a sealing plug, i.e. not even install a contact.

5.2.1.4.1 Transfer requirements. The MSI shall include a release consent interface for receiving an enable/inhibit signal for granting consent to the store to act upon safety critical commands over the digital multiplex data interface. (See 4.3.1.5.)

CAUTION

The release consent interface is provided to satisfy an aircraft safety function. Consent is enabled whenever the aircraft determines that safety criteria for store employment sequence has been met.

This paragraph clarifies that, functionally, the release consent signal is an enabling or inhibiting signal used in conjunction with the digital multiplex data interface (MIL-STD-1553). The actual command to achieve a safety critical function is sent over the data interface. In contrast, release consent, if high, allows any interlocked MIL-STD-1553 commands to be acted on and, if low, to be ignored. The activation of release consent, i.e., transition to the enable state, must not by itself result in any safety critical action or irreversible action. It is expected that an aircraft may grant consent and then later remove consent. Therefore, the store must be able to return to the inhibited state with release consent removal (provided that some irreversible command was not sent to the store while the enable condition existed).

The caution note is included to alert the store designer that release consent is not a general purpose discrete but an aircraft safety interlock signal. This signal may be applied early in a flight time line or late in the time line depending on specific aircraft safety criteria. The only requirement expected of the aircraft is that consent will at least be granted shortly before the aircraft issues an interlocked command. The specific commands that are interlocked with release consent must be identified in the store design documentation or ICD. (See 4.1.2.4.1 and 5.2.3.2.)

5.2.1.4.2 Electrical characteristics. The release consent interface electrical characteristics at the MSI shall comply with the following requirements.

5.2.1.4.2.1 Voltage level. The mission store shall establish the appropriate enable or inhibit state when the following voltage levels are applied to the release consent connection (referenced to the 28V DC power 2 return connection) at the MSI:

a. Steady-state voltages:

Enable:	Minimum voltage at 15.0V DC Maximum voltage as defined in MIL-STD-704 for 28V DC
Inhibit:	1.50V DC (maximum applied)

b. Voltage transients up to the limits of MIL-STD-704 for 28V DC.

c. Voltage spikes up to the limits of MIL-E-6051.

The voltage levels are defined for both release consent signal states - enable and inhibit. The enable signal is basically voltage levels which can be expected from a MIL-STD-704 compliant power source with one exception. The minimum steady state voltage seen at the ASI (for a valid enable signal) is 15V DC. The inhibit signal is basically the lack of an enable signal but is defined as a 1.50V DC maximum steady state voltage between the release consent connection and the 28V DC power 2 return connection at the MSI. While it has been suggested (see 5.1.4.2) that the aircraft should tie the release consent line to power 2 return during the inhibit state, some aircraft may simply provide an open circuit to achieve the inhibit state. In extremely high electromagnetic environments, the resulting noise induced voltage may be above the 1.50V level if the line is not tied to ground in the inhibit state.

The store is required to set its detection threshold(s) for the enable/inhibit states at a voltage level(s) such that an enable state will be assured if the applied voltage is 15 volts or greater and an inhibit state will be assured if the applied voltage is less than 1.5V DC.

The voltage spikes defined by MIL-E-6051 can last for durations up to 50 microseconds and can best be handled by judicous use of filtering and transient suppression. (See 5.2.3.2 and 5.2.9.1.4.)

5.2.1.4.2.2 Current level. The mission store shall limit the load current to a range of 5.0 to 100 milliamperes when the steady state enable voltages (see 5.2.1.4.2.1) are applied to the MSI.

The current level imposed by the store's load must be constrained within the limits of 5 milliamperes to 100 milliamperes based on applied steady state enable voltages (15V DC to 31.5V DC). This requires that the effective steady-state impedance applied by the store at the MSI must range between 315 and 3000 ohms. This current range was selected to allow the aircraft to use electromechanical relays for the release consent switching function. If the relay contact switching exceeds 100 milliamperes, then contact arcing will damage the low current switching capability of the relay. This 100 milliampere level is sometimes referred to as the "intermediate current" rating of a relay. The 5 milliampere lower level was set to ensure sufficient current flow to operate with partially contaminated contacts. The lower current level also reduces the minimum power dissipation a missile release consent monitor circuit must provide. (See 5.2.3.2.)

5.2.1.4.2.3 Stabilization time. The mission store shall be compatible with aircraft and carriage stores which deliver a signal to the MSI with a transition time (between enable and inhibit states) of up to 6.0 milliseconds when measured with a resistive load.

This stabilization time covers state transition duration due to filtering, contact bounce and other factors. The mission store circuitry needs to be capable of operating within the (potential) linear region of its release consent monitor circuit for the stabilization time duration.

The 6 milliseconds listed is twice as long as the aircraft's 3 millisecond stabilization requirement. This additional delay or instability is based on potential insertion of a carriage store between the aircraft and the mission store. (See 5.2.3.2)

5.2.1.4.2.4 Enable response. The mission store shall be capable of accepting safety critical commands over the digital multiplex data interface within 10 milliseconds after a valid enable signal is applied to the MSI.

5.2.1.4.2.5 Inhibit response. The mission store shall functionally reject any safety critical commands over the digital multiplex data interface within 10 milliseconds after a valid inhibit signal is applied to the MSI.

5.2.1.4.2.6 Ground reference. The 28V DC power 2 return connection at the MSI shall be the ground reference for the release consent signal.

The first two paragraphs establish limits on the response time of the store's enable/inhibit circuit. A limit is defined in order for the aircraft to know how early (in advance of transmitting a critical command) release consent must be placed in the enable (or inhibit) state for the critical command to be accepted (or rejected). The response time does not, however, imply that critical commands must be carried out by the store within the 10 millisecond limit.

The response time selected allows use of: (1) Electromechanical devices in the store, (2) filtered inputs, (3) signal sampling, or (4) other techniques in the store's release consent circuit.

5.2.1.5 Mission store interlock interface. The mission store shall provide connections for an interlock interface in the primary [illegible]al set MSI (primary MSI) and in the auxiliary power signal set MSI (auxiliary MSI) which comply with the requirements below. The

interlock interface at both the primary and auxiliary MSI shall include an interlock connection and an interlock return connection. (See 6.6.)

5.2.1.5.1 Transfer requirements. The primary MSI and, when implemented, the auxiliary MSI shall provide continuity between the interlock connection and the interlock return connection which complies with the requirements herein.

The introductory paragraph to the interlock interface requirements has one significant difference from the introduction to other mission store interface lines. The other lines are identified with an option for the mission store to use or not use the signal. The interlock interface does not provide the store with this option. If a store requires any MIL-STD-1760 interface (i.e., the store contains an MSI), then the store must include the interlock interface in the implemented MSI. If both primary and auxiliary MSIs are required by the store, then two sets of interlock interfaces are required - one set for each MSI connector.

The interlock interface consists of an interlock connection and an interlock return connection. The mission store is required to provide continuity between these two connections and must meet the defined electrical requirements. Normally, the mission store will contain a wire jumper behind the MSI connector to provide this continuity.

5.2.1.5.2 Electrical characteristics. The mission store shall provide a continuity path between the interlock and interlock return connections with an impedance of 500 milliohms maximum over the frequency range of DC to 4 kHz when measured at the MSI. This impedance applies for excitation current within the range of 5.0 to 100 milliamperes. The excitation current from the connected aircraft (see 5.1.1.5.1) may be continuously applied or periodically pulsed. The mission store shall comply with the requirements herein when the excitation signal open circuit voltage applied to the MSI by the aircraft is between 3.50V DC and MIL-STD-704 28V DC upper voltage limits. The mission store shall electrically isolate both the interlock and interlock return connections at the MSI from all mission store circuits and grounds. The isolation shall be 100 kilohms minimum over the frequency range of DC to 4 kHz.

This paragraph defines the effective impedance that the store must provide through the interlock "jumper". This effective impedance must be supplied with the listed excitation voltage and current ranges and at frequencies up

to 4 kHz. The impedance value defined essentially prohibits the insertion of any component in the continuity loop between interlock and interlock return. Furthermore, the electrical isolation requirement and the fact that the store can not be assured that the aircraft is even applying an excitation signal, precludes the store using this interface for any internal store function. For example, the store must not monitor the interlock interface to determine if it is connected to an aircraft. (The store can achieve this "aircraft mated" monitor function by using the address discretes.) (See 5.2.3.1.)

> 5.2.1.6 Mission store address interface. The mission store shall include connections for an address interface in the primary signal set MSI for detecting the assigned store digital multiplex data bus address. If the mission store needs to determine the mated status of the MSI, it shall use the address interface. (See 6.6.) The address interface shall include five binary encoded address bit connections (A0, A1, A2, A3 and A4), one address parity connection and one common address return connection. Mission stores which implement the digital multiplex data interface (5.2.1.2) shall comply with the address interface requirements below. Mission stores which do not implement the digital multiplex data interface are not required to use the address interface.
>
> 5.2.1.6.1 Transfer requirement. The mission store shall energize the address interface at the MSI to monitor the digital multiplex data bus address assigned to the mission store by the connected aircraft.

These introductory paragraphs to the address interface include the following parts: (1) The address discretes are to be used primarily for assigning the store its remote terminal address; (2) the address interface can also be used to determine the mated status of the mission store's connection with either an aircraft or a carriage store; (3) the address interface contains seven specific connections; and (4) stores which use the digital multiplex data interface in the MSI must also use the address interface. As with other interfaces, if the store uses the address interface then it must comply with the requirements in the associated subparagraphs.

> 5.2.1.6.2 Address assignment. The mission store shall monitor the five binary encoded address bit connections at the MSI for Logic 0 and Logic 1 states. The remote terminal address assigned to the MSI shall be defined as:

Remote terminal address = $(A4)x2^4+(A3)x2^3+(A2)x2^2+(A1)x2^1+(A0)x2^0$

The mission store shall monitor the address parity connection at the MSI for Logic 0 and Logic 1 states. The mission store shall accept the assigned address as a valid remote terminal address if the address parity connection logic state indicates odd parity. Odd parity is defined as an odd number of Logic 1 states on the six-bit set composed of the five address bit connections plus the address parity connection.

The rules for assigning addresses with the five address bit lines are defined here by establishing the binary weight for each line. In addition, the store is required to check the parity connection for proper parity and accept the address (only) if the parity check passes. This parity check operation may be conducted with dedicated circuitry or can be determined by using address decode circuitry in some of the available MIL-STD-1553 protocol chip sets. Some chip sets load the remote terminal address through a software interface between the chip set and a host processor. For these systems, a separate address read circuit is required in the store. However, even if the store's remote terminal hardware contains a discrete address decode capability, the noise environment and required address signal characteristics (and detection thresholds) must be considered prior to directly connecting these on-chip decoding circuits to the external world address discretes. (See 5.2.3.3.)

5.2.1.6.3 Electrical characteristics. The characteristics defined below shall apply to the address bit and parity connections when referenced to the address return connection.

The electrical characteristics are divided into excitation signal limits, required detection thresholds and a response time requirement.

5.2.1.6.3.1 Address signal. The mission store shall provide excitation signals with the following characteristics:

a. Open circuit (Logic 1) voltage:

(1) Minimum voltage of 4.0V DC
(2) Maximum voltage of 31.5V DC
(3) Voltage spikes shall comply with MIL-E-6051
(4) Rise and fall times of applied voltage shall not exceed 10 milliseconds when measured with a resistive load

b. Logic 0 current:

(1) Minimum current of 5.0 milliamperes DC
(2) Maximum current of 100 milliamperes through each address bit and parity connection
(3) Maximum current of 600 milliamperes through the address return connection
(4) Rise and fall times of applied current shall not exceed 10 milliseconds when measured with a resistive load

The characteristics of store sourced excitation signals are defined to encompass a range of potential circuit designs. This range runs from "logic level" signals through higher level MIL-STD-704 28V DC derived excitation. The mission store, however, is required to clamp the maximum open circuit excitation voltage to 31.5V by subparagraph a.(2) above. For example, the store can use 28V DC power 1 input (MIL-STD-704) to source the address excitation signal. However, since MIL-STD-704 allows this input voltage to rise to 50 volts during power system transients, the store must clamp this voltage to 31.5V to meet the maximum voltage requirement.

The store is required to meet the rise and fall times on the excitation signals to minimize the power dissipation in any potential aircraft circuitry used to establish the address states. This power dissipation can be high as the aircraft's circuitry is transitioned through an active region of a device such as a transistor in a line driver. This rise/fall time limit is of particular importance if the store is periodically pulsing the address interface to sample the address and thereby minimize store circuitry power dissipation. (For example, continuously exciting all address lines at the maximum allowed power requires the store to source over 16 watts out the address interface.)

The closed circuit or Logic 0 current levels sourced by the store are constrained to the same 5 to 100 milliampere range used for other interface discretes. Since the store circuitry determines the excitation voltage, the short circuit (Logic 0) current can be controlled through pull-up resistors in the store or by other means. The store must also be capable of sourcing enough power to properly operate the address detection circuitry even under conditions of erroneous addresses. For example, address zero with a failed parity would be an invalid address but the store's circuitry must be capable of determining that the address is invalid. Therefore, the store must be capable of sourcing Logic 0 currents into all six address lines.

5.2.1.6.3.2 Logic threshold. The mission store shall detect Logic 0 and Logic 1 states under the following conditions. The logic state detection conditions apply to all valid and invalid address assignment combinations.

a. Logic 1: Any current level of 300 microamperes or less into any address bit or address parity connection when the excitation voltage of 5.2.1.6.3.1 is applied shall be interpreted as a Logic 1 state.

b. Logic 0: Any voltage level of 1.50V or less between any address bit (or parity) connection and the address return connection when the excitation current of 5.2.1.6.3.1 is applied shall be interpreted as a Logic 0 state.

Subparagraph (a) specifies the Logic 1 state by a maximum current flow between each address line and the address return. Since the store circuitry's open circuit voltage and pull-up resistance value is known by the store designer, this maximum "leakage" current can be converted into an address line Logic 1 voltage. Setting the Logic 1 detection threshold below this voltage assures detection of a valid Logic 1 state.

The Logic 0 voltage is directly specified and determines the maximum voltage value for the threshold of a Logic 0 state.

As an example then, a store which uses an address monitor circuit with a 5 volt open circuit voltage and a 500 ohm pull-up resistor expects to see a Logic 1 voltage of 4.85 volts or greater and a Logic 0 voltage of 1.50 volts or less. Therefore, the Logic 1 threshold of the circuit is set below 4.85 volts and above the Logic 0 threshold (assuming a detector with hysterises). Likewise, the Logic 0 threshold is set above 1.5 volts and below the Logic 1 threshold. (See 5.2.3.3.2.)

5.2.1.6.3.3 Response characteristics. The store shall allow 10 milliseconds minimum for logic state stabilization after application of the excitation signal.

The response time is specified to require the store to wait 10 milliseconds after application of the excitation signal to allow the aircraft circuitry and interconnecting cabling to stabilize. This is particularly important if the aircraft contains filters on the address lines at the ASI or in some other aircraft equipment. For cases where the aircraft simply provides jumpers at the ASI for coding the address, signal filtering by the aircraft is not expected. In general, however, the store designer does not know if an aircraft (on which his store is to be installed) uses jumper wires or some other design for address assignment. (See 5.2.3.3.)

5.2.1.7 Mission store structure ground. The mission store shall provide a connection in the primary signal set MSI and in the auxiliary power signal set MSI which

is terminated to mission store structure and complies with the following requirements.

5.2.1.7.1 Structure ground characteristics. The mission store shall provide a conductive path from the MSI to mission store ground capable of carrying the overcurrent levels defined in figures 7 and 8 for the primary MSI and auxiliary MSI, respectively. The mission store structure ground interface shall comply with the class H bonding requirements of MIL-B-5087. The structure ground interface shall not be used as a signal return or power return path.

The structure ground connection in both primary and auxiliary connectors is included to provide a higher level of assurance that the store structure is electrically connected to the aircraft structure. The connection is provided for shock hazard protection of personnel (e.g., during electrical faults) and to reduce low frequency noise voltages between the aircraft and store structures. Other electrical paths may also exist between the store and aircraft structure (for example, umbilical cable shield or store mechanical attachment points) but these paths are poorly controlled.

The intent of the last sentence is to highlight that power and signal circuits through the AEIS must not rely on the structure ground line for proper operation. Each power or signal line must have a return exclusive of structure ground. Due to grounding approaches used in the aircraft and store, it is highly probable (and acceptable) that some power or signal current will flow through the structure ground connections. (See 5.2.8 and 5.2.9.1.8.)

5.2.1.8 Mission store 28V DC power interface. The mission store shall provide connections for the 28V DC power interface in the primary signal set MSI (primary MSI) and in the auxiliary power signal set MSI (auxiliary MSI). The primary MSI shall contain 28V DC power 1 and power 1 return connections and 28V DC power 2 and power 2 return connections. The auxiliary MSI shall contain a 28V DC power connection and a 28V DC power return connection. The mission store is not required to use any of the 28V DC power interfaces. However, if any 28V DC power interface is used, the mission store shall comply with the MSI requirements below. If any 28V DC power interface is not used, the impedance between the unused power connection and the associated return connection at the MSI shall be greater than 100 kilohms (at DC).

5.2.1.8.1 Transfer requirements. The mission store shall restrict its 28V DC power requirements (from the connected aircraft or carriage store) to characteristics as defined in 5.2.1.8.2 herein.

This set of pargraphs introduces the 28V DC power interface requirements for the mission store. The introduction begins by defining the lines included in the power interface. These lines include 28V DC power 1 and power 2 in the primary MSI and auxiliary 28V DC power in the auxiliary MSI. Each of the three power lines requires a dedicated return. As typical with other interfaces for the mission store, the paragraph clarifies that the mission store is not required to use any of these power interfaces - but if used, the store shall comply with the associated subparagraphs. Stores which do not use any 28V DC power interface must maintain at least 100 kilohms (e.g., an open circuit) between the power line and its associated return. (See 5.2.8.)

5.2.1.8.2 Electrical characteristics. The 28V DC power interfaces at the MSI shall comply with the following electrical characteristics.

5.2.1.8.2.1 Voltage level. The mission store shall be compatible with MSI voltages which comply with the 28V DC normal and abnormal characteristics and voltage transients for utilization equipment defined in MIL-STD-704 with the following additions. The mission store shall be compatible with applied voltages which are 0.0 to 2.0V DC less than the MIL-STD-704 characteristics defined for utilization equipment. The mission store shall comply with the voltage spike requirements of MIL-E-6051 at the MSI.

This paragraph relates the MSI voltages (to which the store must be compatible) to MIL-STD-704 utilization equipment terminal voltage characteristics with one exception. This exception is that the voltage can be up to 2.0 volts DC below the MIL-STD-704 levels. For example, given the MIL-STD-704 normal characteristics for steady state voltage of 22 to 29 volts DC, this paragraph requires the store to be capable of operating with 20 to 29V DC applied. (Two volts are subtracted from the low voltage end and nothing is subtracted from the high end.)

The reference to normal, abnormal and transient characteristics of MIL-STD-704 covers the entire time domain for non-steady state voltages down to 50 microseconds. The reference to MIL-E-6051 pulls in the last 50 microsecond window. (See 5.2.8.1.)

5.2.1.8.2.2 Load current. The mission store shall comply with the following load current requirements when

the MSI voltage is within the range of 20.0V DC to 29.0V DC.

5.2.1.8.2.2.1 Primary signal set. Under fault free conditions, the mission store load applied at the primary MSI to each of the 28V DC power 1 and 28V DC power 2 connections shall not exceed the maximum load current level of figure 7. (See 6.10.)

5.2.1.8.2.2.2 Auxiliary power signal set. Under fault free conditions, the mission store load applied at the auxiliary MSI shall not exceed the maximum load current level of figure 8. (See 6.7 and 6.10.)

This set of paragraphs and the referenced figures 7 and 8 (see 5.4.5 for reproductions of the figures) define limits on fault free current that a store is permitted to draw from the aircraft. These current limits are applicable when the MSI voltage is between 20 and 29V DC.

For stores with linear loads, the 10 ampere steady state limit of figure 7 in conjunction with the 29V DC upper voltage limit requires that the store load not exceed 2.9 ohms on power 1 and 2.9 ohms on power 2. At 20V DC, the store draws less than 7 amperes or 140 watts from the 28V DC power 1 or power 2 circuits. Since the store may be supplied voltages anywhere in the 20 to 29V DC range, the (linear load type) store can not fully utilize the available 10 amperes defined by the figure. Likewise, linear load type stores can only rely on approximately 20 amperes or 400 watts from the auxiliary MSI connections to the aircraft.

Even with these relatively small power ratings from the auxiliary 28V DC interface, only a small percentage of aircraft stations are expected to contain the auxiliary power connector. The bottom line is that stores which require relatively large amounts of power should use the 115/200V AC interface as the power source rather than 28V DC.

Th maximum load current curves of figures 7 and 8 allow the store to apply higher short term loads to the ASI than permitted by the 10 and 30 ampere continuous ratings for primary and auxiliary MSIs, respectively. These higher short term loads allow the store to draw higher currents for load in-rush, firing Electro-Explosive Devices (EEDs), driving seeker head motors, or other short power burst applications. (See 5.2.8.2 and 5.2.8.3).

5.2.1.8.2.2.3 Simultaneous load. Under fault free conditions, mission stores with a class IA or IIA MSI shall limit the total simultaneous current on all 28V DC power interfaces in the primary and auxiliary MSI to the maximum load current level of figure 8. (See 6.7.)

Mission stores which use the 28V DC interfaces in both primary and auxiliary MSIs must limit the total 28V DC power currents in these three interfaces (28V DC power 1, power 2 and auxiliary power) to the maximum load current curve of figure 8. This limit is required because aircraft do not generally contain very much DC power. (It is not unusual that the total DC power available on a tactical aircraft for all systems is less than 200 amperes.) Without the simultaneous power limit, the standard could significantly drive the total power conversion capacity of the carrier aircraft. (See 5.2.8.3.)

> 5.2.1.8.2.3 Load isolation. The mission store shall provide a minimum isolation of 100 kilohms (at DC) between the primary MSI 28V DC power 1 connection, the primary MSI 28V DC power 2 connection and the auxiliary MSI 28V DC power connection. The mission store may provide continuity between the associated 28V DC power return connections.

This requirement is included to ensure that a store does not connect the 28V DC power inputs together inside the store in a manner that: (1) Allows current into one power input to exit a second power input, or (2) allows current to divide unequally between the various inputs such that overload of one of the power interfaces could occur. Isolation between the power inputs is required because voltage differences can easily exist between 28V DC power interfaces due to: (1) Power being sourced from different generators or converters, or (2) differences in voltage drops in power distribution wiring and switching devices. (See 5.2.8.4.)

> 5.2.1.8.2.4 Overcurrent compatibility. The mission store shall not become unsafe if fault currents up to the maximum overcurrent levels of figures 7 and 8 are sourced into the primary and auxiliary MSIs, respectively. (See 6.10.)

The maximum overcurrent curves in figures 7 and 8 define the maximum current-time limits at which the aircraft disconnects (e.g., trip) the power source from the faulted load. The store must be capable of sinking fault currents up to these trip out levels. (The fault current level is determined by the source and distribution impedance plus the actual impedance of the fault.) If the fault is in the store, the fault currents will flow into store and - by some path - back out. This paragraph requires the store to withstand these potential fault currents without becoming unsafe. The standard does not define the specific methods that a store must use to "not become unsafe". (See 5.2.8.5.)

> 5.2.1.8.2.5 Off-state leakage current. The mission store shall be compatible with off-state leakage currents supplied to the primary MSI up to 1.0

milliampere DC between each 28V DC power and its respective return. The mission store shall be compatible with off-state leakage currents applied to the auxiliary MSI up to 2.50 milliamperes DC between auxiliary 28V DC power and the associated 28V DC power return.

An off-state leakage current compatibility requirement is imposed on the store in anticipation that solid state switching devices may be used for 28V DC power switching. The leakage currents listed assume a very low impedance connection between 28V DC and its associated return. As the load impedance increases, the leakage current will drop. The main point of this paragraph is that stores should not connect current sensitive devices such as EEDs directly across the 28V DC power interfaces. Additional isolation of these devices from the power input is required. For example, it is not assured that the 28V DC power inputs on all aircraft will meet the requirements of MIL-STD-1512 for EED firing circuits.

5.2.1.8.2.6 Stabilization time. The mission store shall be compatible with MSI voltages which are below the levels of 5.2.1.8.2.1 herein for up to 6.0 milliseconds during power turn-on and turn-off. (See figure 9.)

This paragraph and the referenced figure 9 (see 5.4.5 for figure) define the maximum time for the MSI voltage to rise (or fall) to its final value. This rise/fall time is due to circuit aspects such as power line filters in the aircraft and contact bounce of electromechanical relays. The stabilization time is twice as long as that required at the ASI (see MIL-STD-1760 paragraph 5.1.1.8.2.5) due to additional delays that could be caused by a carriage store connected between the aircraft and mission store.

The store designer should also recognize that MIL-STD-704 allows voltage drop-out of up to 50 milliseconds during power transfers within the power generation, conversion and distribution systems. (See 5.2.8.1.)

5.2.1.8.2.7 Power utilization. Mission stores shall utilize 28V DC power 2 or auxiliary 28V DC to power those safety critical functions for which insufficient interlocks exist in the store for assuring that the required level of store safety can be achieved once the associated power interface is activated. The store shall not arm or employ solely as a result of the activation of 28V DC power 2 or auxiliary 28V DC power. Mission stores may utilize 28V DC power 2 or auxiliary 28V DC for powering non-safety critical store functions with the understanding that the aircraft will not energize these power interfaces until the aircraft has

determined that it is safe to do so. Mission stores shall utilize 28V DC power 1 only for powering those store functions which are not safety critical or which have sufficient safety interlocks such that store safety is not significantly degraded with the activation of 28V DC power 1. Mission stores shall withstand without functional damage, the activation of any 28V DC power interfaces prior to needed activation.

This requirement on mission stores is the store side equivalent of the aircraft power application requirement in 5.1.1.8.2.7 of MIL-STD-1760 (see 5.4.5). Any safety critical store function for which the store needs additional safety interlocks (over those available through MIL-STD-1553 commands, release consent or other methods), can be powered from 28V DC power 2 and auxiliary 28V DC. In contrast, the store can expect the aircraft to activate 28V DC power 1 on the assumption that the store functions powered are not safety critical or are adequately interlocked such that store safety degradation does not result. However, even with these safety qualifications, the store must withstand without functional damage the application of any or all power interfaces at the MSI. This set of requirements is established with two concepts in mind. First, 28V DC power 1 is expected to be applied as part of store initialization while 28V DC power 2 and auxiliary power remain off until store identity (and possibly status) is determined. Second, the application of power must not directly result in the store executing any actions other than power-up. (Recall that paragraph 4.3.1.9 of MIL-STD-1760 stated that the 28V DC power interface shall not be used as a discrete.) As a result, the activation of any 28V DC power interface must not result in store functional damage.

5.2.1.8.2.8 Ground reference. The 28V DC power return connections at the primary and auxiliary MSIs shall be the reference for each associated 28V DC power connection. The mission store shall be compatible with aircraft which connect the 28V DC returns to aircraft structure grounds. The mission store shall also be compatible with aircraft which isolate the 28V DC returns from aircraft structure grounds.

This paragraph re-emphasizes that power return connections are provided in the two MSI connectors for each 28V DC power line (i.e., power 1, power 2 and auxiliary power). MIL-STD-1760 does not specifically require the aircraft or the store to connect the 28V DC returns to vehicle structure. As a result, the store is required to be compatible with aircraft which isolate the returns from structure and with aircraft which connect the returns to structure. (See 5.2.9.1.5.)

5.2.1.9 Mission store 115/200V AC power interface. The mission store shall provide connections for the 115/200V

AC power interface in the primary signal set MSI (primary MSI) and in the auxiliary power signal set MSI (auxiliary MSI). Both the primary MSI and auxiliary MSI shall contain 115V AC Phase A, Phase B, Phase C and neutral connections. The mission store is not required to use any of the 115V AC phases. However, if any 115V AC phase is used, the mission store shall comply with the MSI requirements below. If any 115V AC phase is not used, the impedance between the unused phase connection and the associated neutral connection at MSI shall be greater than 100 kilohms (at 400 Hz).

5.2.1.9.1 Transfer requirements. The mission store shall restrict its 115/200V AC power requirements to characteristics as defined in 5.2.1.9.2 herein.

This set of paragraphs introduces the 115/200V AC power interface requirements imposed on the mission store. The introduction begins by defining the lines included in the primary and auxiliary MSI. (Each MSI contains three power phases and a neutral.)

The paragraph also clarifies that the mission store is not required to use any of these power interfaces - but if used, the store shall comply with the requirements in the associated subparagraphs. Stores which do not use specific 115V AC interfaces must maintain at least 100 kilohms (e.g., an open circuit) between the power phase connection and the neutral connection.

5.2.1.9.2 Electrical characteristics. The 115/200V AC power interface at the MSI shall comply with the following electrical characteristics.

5.2.1.9.2.1 Voltage level. The mission store shall be compatible with MSI voltages which comply with the 115V AC normal and abnormal characteristics and voltage transients for utilization equipment defined in MIL-STD-704 with the following additions. The mission store shall be compatible with applied voltages which are 0.0 to 3.0V rms less than the MIL-STD-704 characteristics defined for utilization equipment. The mission store shall comply with the voltage spike requirements of MIL-E-6051 at the MSI.

This paragraph requires that the store be compatible with MSI voltages which are defined by the utilization equipment terminal voltage characteristics of MIL-STD-704 with one exception. This exception is that the applied voltage can be up to 3.0V rms below the MIL-STD-704 levels. For example, given the MIL-STD-704 steady state "normal" characteristics of 108 to 118 volts rms, the store must be compatible with 105 to 118 volts rms.

The reference to normal, abnormal and transient characteristics of MIL-STD-704 covers the entire time domain for non-steady state voltages down to 50 microseconds. The 50 microseconds window, in turn, is covered by MIL-E-6051. (See 5.2.8.1.)

> 5.2.1.9.2.2 Load current. The mission store shall comply with the following load current requirements when the MSI voltage is within the range of 105 and 118 volts rms.
>
> 5.2.1.9.2.2.1 Primary signal set. Under fault free conditions, the mission store load applied at the MSI to each 115V AC phase connection shall not exceed the maximum load current level of figure 7. Mission stores designed for operation through carriage stores shall limit the phase load at the MSI to 90 percent of the maximum load current level of figure 7. (See 6.7 and 6.10.)
>
> 5.2.1.9.2.2.2 Auxiliary power signal set. Under fault free conditions, the mission store load applied at the MSI to each 115V AC phase connection shall not exceed the maximum load current level of figure 8. (See 6.7 and 6.10.)

This set of paragraphs and the referenced figures 7 and 8 define limits on fault free current that a store is permitted to draw from the aircraft. These current limits are applicable with the MSI voltage between 105 to 118 volts rms.

As with the 28V DC MSI power interfaces, less current is actually available (i.e., can be relied on) than implied by the figures. If one assumes that the store contains a linear load such that current is directly proportional to applied voltage, then the assured continuous per phase current and power available to the store is approximately 9 amperes and 900+ volt-amperes for the primary MSI and 26+ amperes and 2800 volt-amperes for the auxiliary.

Since only a small number of aircraft stations will contain the auxiliary interface, the store designer should attempt to limit the power needs to the 2700 volt-ampere level (i.e., 900 v-a per phase). Generally, this level is sufficient for most stores.

The maximum load current curves of figures 7 and 8 allow the store to apply higher short term loads to the ASI than permitted by the 10 and 30 ampere/phase continuous rating for the primary and auxiliary MSI, respectively. These higher short term loads allow supporting actuator

drives, power supplies and other equipment requiring large in-rush currents or current pulses.

In order to allocate some power for operating carriage store internal loads, ten percent of the AC current that is normally available at the primary ASI is taken away from the mission store. This reduction applies only to mission stores designed for operation from carriage stores. In many cases, a mission store can be operated from a carriage store (given availability of the carriage store) but whether it will be is generally not known during mission store design. As a result, the store designer should assume that his store is a candidate for carriage store operation unless good rationale exists to the contrary. As a result of this carriage store power allocation, the per phase current available at the primary MSI of a linear load type store is further reduced to 8 amperes (840 volt-amperes). (See 5.2.8.2 and 5.2.8.3.)

> 5.2.1.9.2.2.3 Simultaneous load. Under fault free conditions, mission stores with a class IA or IIA MSI shall limit the total simultaneous per phase current on all 115V AC phase connections in the primary MSI and auxiliary MSI to the maximum load current level of figure 8. Mission stores designed for operation through carriage stores shall not exceed a 29 ampere continuous per phase load.

Mission stores which use the 115/200V AC interfaces in both primary and auxiliary MSIs must limit the total 115V AC power currents for each of the three phases to the maximum load current curve of figure 8. Even with this limitation, over 8400 volt-amperes total AC power is available to mission store (again assuming linear loads). If the mission store is expected to be carried on a carriage store and uses the auxiliary interface (an unlikely combination), the total AC power available at the MSI is reduced to over 8100 volt-amperes for the linear loads. (See 5.2.8.3.)

> 5.2.1.9.2.3 Load isolation. The mission store shall provide a minimum isolation of 100 kilohms (at 400 Hz) between the primary MSI 115V AC phase connections and the auxiliary MSI 115V AC phase connections. The mission store may provide continuity between the associated 115V AC neutral connections.

As with the commentary on 5.2.1.8.2.3 above, busing together the primary and auxiliary AC power interfaces is not permitted because the two power sources may be electrically isolated and unsynchronized. The store may either divide its loads among the two AC power sources available at the aircraft side of the MSI or switch the loads between the two sources. (See 5.2.8.4.)

5.2.1.9.2.4 Overcurrent compatibility. The mission store shall not become unsafe if fault currents up to the maximum overcurrent levels of figures 7 and 8 are sourced into the primary and auxiliary MSI, respectively. (See 6.10.)

The maximum overcurrent curves in figures 7 and 8 define the maximum current-time limits at which the aircraft will disconnect (e.g., trip) the power source from the faulted load. This paragraph requires the store to withstand these potential fault currents without becoming unsafe. The method(s) that the store uses to remain safe during these faults is not specified by MIL-STD-1760. (See 5.2.8.5.)

5.2.1.9.2.5 Off-state leakage current. The mission store shall be compatible with off-state leakage currents applied to the primary MSI up to 2.0 milliamperes between each 115V AC power phase and the 115V AC neutral. The mission store shall be compatible with off-state leakage currents supplied to the auxiliary MSI up to 5.0 milliamperes between each auxiliary 115V AC power phase and the associated 115 VAC neutral.

These off-state leakage current compatibility requirements are imposed on the store to allow use of solid state switching devices in the aircraft. The 2 and 5 milliampere leakage currents listed assume a very low connected impedance between the power phase and the neutral. As the connected load impedance increases the leakage current will drop.

5.2.1.9.2.6 Stabilization time. The mission store shall be compatible with MSI voltages which are below the levels of 5.2.1.9.2.1 herein for up to 6.0 milliseconds during power turn-on and turn-off. (See figure 9.)

This paragraph and the referenced figure 9 defines the maximum time for the MSI voltage to rise (or fall) to its final value. This rise/fall time is due to aircraft components such as power line filters and contact bounce of electromechanical relays. The 6 millisecond stabilization time is twice as long as the stabilization time required at the ASI. This doubling is due to additional delays that can be introduced if a carriage store is inserted between the mission store and aircraft.

In addition to this turn-on delay, the store designer is reminded that MIL-STD-704 allows total loss of voltage for up to 50 milliseconds during power transfers within the power generation, conversion and distribution systems. (See 5.2.8.1.)

5.2.1.9.2.7 Load power factor. The mission store load for each phase at the MSI shall have a power factor within the limits of figure 10.

This requirement is included in MIL-STD-1760 because control of load power factor is necessary to minimize disturbances to generators and conversion equipment. This requirement (figure 10) is extracted from earlier revisions of MIL-STD-704. The current release of MIL-STD-704 no longer includes power factor limits. (See 5.2.8.7.)

5.2.1.9.2.8 Phase unbalance. The mission store load at the MSI shall comply with the AC phase power utilization requirements of MIL-STD-704.

Similar to load power factor, excessive phase unbalance causes power generator or inverter operational problems. As a result, MIL-STD-704 includes limits on the amount of current unbalance permitted between the power phases. These unbalance limits are imposed on the mission store. (See 5.2.8.7.)

5.2.1.9.2.9 Power utilization. Mission stores shall utilize 115/200V AC power (primary and auxiliary) only for powering those store functions which are not safety critical or which have sufficient safety interlocks such that store safety is not significantly degraded with the activation of 115/200V AC. The mission store shall withstand without damage, the activation or loss of any 115V AC power phase at any time.

This requirement on mission stores is the store side equivalent of the aircraft power application requirement in 5.1.1.9.2.10 of MIL-STD-1760 (see 5.4.5). The store can expect the aircraft to activate the 115/200V AC power interfaces on the assumption that the store functions powered are not safety critical or are adequately interlocked such that store safety degradation does not result. This requirement is included to set power use groundrules for the later addition of an interface initialization process with which all future AEIS stores must be compatible. This initialization process is expected to begin with the application of 115/200V AC power along with 28V DC power 1. As a result, the aircraft crew needs some assurance that 115/200V AC power (and 28V DC power 1) can be applied without an undesirable surprise.

The last sentence of 5.2.1.9.2.9 is directed at stores which use multiple power phases for energizing specific equipments within the store (e.g., three phase power converters, two or three phase actuators, heaters, etc.). Since the aircraft provides three power phases through three sets of wiring, connector contacts, relay contacts, circuit breakers, etc., the loss of one (or more) power phase(s) at the MSI while the other(s) is still energized

is not an unusual occurrence. This partial power "loss" can occur after the store has been powered for some time. This partial power "loss" can also occur during the initial activation of three phase power such that only one or two phases is ever powered.

The store designer should not assume that the aircraft SMS contains sufficient monitor circuits to detect this power loss. It follows then, that partial phase power can remain at the MSI for an indefinite time. From a safety perspective, this partial power loss must not result in damage to the store including the store transitioning into an unsafe condition. In addition, this "withstand without damage" requirement is desirable from a logistics viewpoint to avoid "wasting" a store due to a somewhat common aircraft failure.

Particular areas that the store designer should consider in surviving (this does not mean operating during) partial phase loss is three phase power converters and electromechanical actuators. The power converter, depending on the design, might produce: (1) No output (safe) if one phase is lost, (2) out of tolerance voltage magnitude, or (3) out of tolerance ripple. Items (2) and (3) can be devastating to processor or other digital logic operation. The primary problem with the actuators is overheating due to long duration of applied stall or near-stall currents. (See 5.2.8.6.)

> 5.2.1.9.2.10 Ground reference. The 115V AC neutral connections in the primary and auxiliary MSIs shall be the reference for each associated 115V AC phase connection. The mission store may connect any or all of the 115V AC neutrals routed through the MSI to mission store structure. The mission store shall be compatible with aircraft which connect (or isolate) the 115V AC neutrals to (or from) aircraft structure grounds.

The store is required to provide a separate neutral connection at the MSIs for the primary and for the auxiliary 115/200V AC power interfaces. This separate neutral provides different current return paths so that the aircraft and store can use grounding and current return techniques that minimize EMI.

In addition, MIL-STD-1760 does not specifically require the aircraft or the store to connect the 115/200V AC neutrals to vehicle structure. As a result, this paragraph requires that the store be compatible with aircraft which isolate the neutrals from structure and with aircraft which connect neutrals to structure. (See 5.2.9.1.5.)

> 5.2.1.10 Mission store 270V DC power interface. The 270V DC power interface is a growth provision for future application of 270V DC. The 270V DC power interfaces

shall not be utilized at the MSI until characteristics and performance details are added to this standard. All class I interface connectors at all MSIs shall include contacts (or plugged cavities) for 270V DC power and 270V DC power return. The general 270V DC electrical characteristics include voltage levels as defined in MIL-STD-704 for 270V DC and continuous current levels of 10 amperes for the primary MSI and 30 amperes for the auxiliary MSI. (See 5.2.2)

Top level requirements are identified for the store to include growth provisions for 270V DC power. These provisions are included in the form of contact cavities in the class I MSI primary connector and class IA MSI auxiliary connector for a 270V DC power contact and a 270V DC power return contact. These contacts and the connector must be compatible with carrying MIL-STD-704 270V DC power voltages at continuous current ratings of 10 and 30 amperes for the primary and auxiliary MSIs, respectively. (In reality, the class II connectors defined in MIL-STD-1760 paragraph 5.2.2 also contain this contact cavity provision, except that the store is only required to be intermateable with the designated connectors and could conceivably use a special insert which did not include the 270V DC cavities.)

Although 270 VDC is defined in MIL-STD-704 as a "legal"power voltage standard, mission stores are required by MIL-STD-1760 to not utilize this power interface. The intent of this requirement is that the mission store must not require the aircraft to furnish 270V DC in order for the store to operate. It was not intended to strictly forbid a store from including an internal power conversion capability by which the store could be powered from either 270V DC or one of the other power interfaces. (See 5.2.11.)

5.2.1.11 Mission store fiber optic interface. The two fiber optic interfaces are growth provisions for future applications. The fiber optic interfaces shall not be utilized at a MSI until characteristics and performance details are added to this standard. All class I primary signal set interface connectors at all MSIs shall include two 16 AWG size contact provisions (plugged cavities) for fiber optic channel 1 and channel 2. (See 5.2.2.)

This paragraph is a fiber optic equivalent of the 270V DC provisions defined in the commentary on 5.2.1.10. The same comments apply on the class I and class II MSI connectors and on the intent that the store not require the aircraft to send data over the fiber optic channels in order for the store to operate. Since a fiber optic multiplex military standard is not yet available, a store designer who includes a fiber optic multiplex terminal in his store must accept the risk that his fiber optic terminal may be incompatible with any future fiber optic system included in this standard.

5.2.2 MSI connector characteristics

5.2.2.1 Primary signal set connector. The primary signal set connector and insert arrangement shall be in accordance with table III. The contact assignments shall be in accordance with table IV.

5.2.2.2 Auxiliary power signal set connector. The auxiliary power signal set connector and insert arrangement shall be in accordance with Table V. The contact assignments shall be in accordance with Table VI.

These two paragraphs and the referenced tables III through VI define intermateability requirements that the store's MSI connector must meet. Table III and V (reproduced in the Section 5.4.5 commentary on MIL-STD-1760 5.1.2) specify requirements on the MSI connector different than the ASI connector. While the aircraft is required to use MIL-C-38999 compliant connectors with specific insert arrangements and military specification contacts, the MSI is only required to provide a connector (with insert and contacts) that meets the intermateability dimensions of the listed specifications. The intent is that since the aircraft's connectors will be in the field over a longer time, standard military piece parts should be used to facilitate logistics support.

In contrast, the store is generally a one shot device with possibly unique or more critical connector design requirements. It was therefore decided to allow the store to use other connector designs as long as the connector "front end" is intermateable with the designated specifications of tables III and V. Two examples of unique MSI connector considerations are: (1) Fail safe (shear mechanism) receptacle that allows aircraft-store separation even if the umbilical cable's lanyard mechanism fails (e.g., ground crew forgot to connect the lanyard to the bail bar); and (2) special low profile accessary area on the back of the receptacle to minimize penetration of the receptacle into the store warhead, rocket motor or other subsystems.

This intermateability concept applies to the contacts as well as the connector shell. The MIL-C-39029 contacts listed are rear insert/removable crimp contacts. A store designer might choose to use a connector with fixed contacts that are soldered (such as used with hermetically sealed connectors). (The commentary in Section 5.4.5 on paragraph 5.1.2 of MIL-STD-1760 concerning the coaxial/shielded high bandwidth contacts also applies to the mission store connector.)

The final point on these two connector paragraphs is that the foreword of MIL-STD-1760 includes a limitations paragraph which states that requirements

for "rail launched MSI" connectors and "simple store MSI" connectors are not currently addressed by the ABIS standard. It is expected that these connectors will be addressed in a future revision or notice to MIL-STD-1760. The connector currently used on the rail launched AIM-120A (AMRAAM) contains contacts for the class II signal set. This connector is not, however, intermateable with the table III connector. Since AIM-120 compatible connectors are currently being installed on a number of tactical aircraft and is, in some respects, becoming a de facto standard, consideration is being given to adopting the intermateability details of this connector and multiple sourcing the connector. Currently, however, a standard rail launch MSI connector is still an open issue. Similarly, studies have been conducted on the need and configuration of a MSI subset for supporting "simple stores". (This subset has informally been referred to as a MIL-STD-1760 class III interface.) Simple stores are grossly defined as mission stores which are sufficiently low cost and require low data quantities/rates and low power levels such that the installation of MIL-STD-1553 compliant remote terminals in the expendable store may not be cost effective. Some study results suggest using a MIL-C-38999 Series III, Insert 13-98 or similar size connector for the simple store MSI. These studies also suggested subsetting the class I interface down to the Low Bandwidth interface, DC power and interlock. The inclusion of release consent, structure ground and some form of aircraft mated status monitor using the address interface have also been studied. The Low Bandwidth interface could be used to support bi-directional EIA-STD-RS-485 serial data transfers in a point-to-point mode. Currently, the inclusion of a simple store MSI class (subset and connector) is being studied to determine need and cost effectiveness. As a result, the simple store MSI is still an open issue. (See 4.3.3, 5.3.1, 5.3.2 and 5.3.4.)

> 5.2.2.3 Connector receptacle. The mission store connector shall be a receptacle with socket contacts or with plugged cavities for those interface signals not used by the mission store. The major keyway shall be located forward on a connector mounted on the store top surface and shall be located up on any aft vertical surface.
>
> 5.2.2.4 Connector location and orientation. The MSI connector location and orientation shall conform to MIL-A-8591 for ejection launched mission stores.

The first paragraph defines the gender of the mission store's MSI connector, i.e., the connector mating half that is "permanently" attached to the store. To minimize exposed contacts and maximize ruggedness of this permanently attached connector, a receptacle style connector shell with socket contacts is specified. This first paragraph also reminds store designers that contact cavities for unused interface signals can be plugged as well as installing the contacts. This plugging is of particular advantage for the

twinaxial and coaxial contact cavities. (In order to install an unused twinaxial or coaxial contact into a connector, the contacts must be assembled onto a twinaxial or coaxial cable stub. Plugging the cavities is therefore allowed for manufacturing cost reasons.

If the store contains plugged cavities, sealing plugs must be used that allow the coupling of a mating plug that has pin contacts installed opposite to the plugged cavities. (A "hole" needs to be provided in the receptacle's interfacial plate to allow the plug's pin contacts to pass through the plate when mated.)

The last sentence in the first paragraph orients the MSI connector major keyway for compatibility with the ASI connector orientation requirements in paragraph 5.1.2.4 of MIL-STD-1760 (see 5.4.5 commentary). This last sentence is also compatible with MIL-A-8591 which defines the "mechanical" interface between the aircraft and stores. This MIL-A-8591 orientation is also repeated in the second paragraph (5.2.2.4) in addition to designating the physical location of the connector for ejected mission stores. The last sentence of 5.2.2.3 is nearly redundant with 5.2.2.4 except for rail launched stores. By including the last sentence of 5.2.2.3 the keyway orientation of rail launched MSIs is also controlled. (See 5.3.1.2, 5.3.1.4 and 5.3.2.4.)

> 5.2.3 Electromagnetic Interference (EMI). When required by the system specification to be tested in accordance with MIL-STD-462 to determine compliance with the applicable requirements of MIL-STD-461 and MIL-HDBK-235, mission stores shall be tested using the cables defined in the appendix herein. (Reference 6.13.)

The purpose of this paragraph is to define a standard test cable configuration that is to be used for conducting MIL-STD-462 tests on mission stores. This test cable requirement is not activated unless the store system specification requires MIL-STD-462 tests. It must be clear that MIL-STD-1760 is not imposing MIL-STD-462 tests nor MIL-STD-461 and MIL-HDBK-235 compliance on the mission store. For stores required to be tested in accordance with MIL-STD-462, the test cables defined in the appendix provide a consistent and repeatable interconnect to the mission store that is not dependent on a specific aircraft configuration. (Each aircraft will have different harness configurations. As a result, a common test baseline is not available without the defined test cables.) The store's system specification may also require that MIL-STD-462 tests be run with other test configuration(s) representative of specific aircraft. This paragraph only requires that the standard test cables be used for a set of tests - not that tests be run only with the standard cables.

5.4.7 Notes supporting the AEIS standard

6. NOTES

6.1 International standardization agreement. Certain provisions of this standard are subject to international standardization agreements: NATO STANAG and ASCC Air Standard. When change notice, revision or cancellation of this standard is proposed that will affect or violate the international agreement concerned, the preparing activity will take appropriate reconciliation action through international standardization channels, including departmental offices, if required. It is intended that MIL-STD-1760 will be compatible with the following documents: Digital Interface Requirements, Aircraft Monitor and Control (System 2); STANAG 3350AVS, Monochrome Video Standard for Aircraft System Applications; STANAG 3837AA, Standard Aircraft/Store Electrical Interface; and STANAG 3838AVS, Digital Time Division Command/Response Data Bus.

This note is a reminder to the preparing activity and custodians of the standard that MIL-STD-1760 includes requirements that are also defined in NATO and ASCC standards that have been approved by the DoD. Due to these international agreements, changes to the standard can not be made arbitrarily.

6.2 Video signals. The NATO STANAG 3350 Monochrome Video Standard for Aircraft System Applications has been proposed for NATO video applications. This STANAG is currently undergoing revision and is expected to be ratified in the near term. Since it is not presently ratified by the U.S., the video signal requirements in Section 5 herein allow the use of video signals similar to EIA-RS-170 and RS-343. The revised and ratified STANAG is expected to include a Class C video which is very similar to the RS-170 video characteristics. As a result, the intent is that upon ratification of STANAG 3350, the EIA video references in Section 5 will be removed and STANAG 3350 Class C added.

This note establishes the general intent that MIL-STD-1760 and a ratified (i.e., approved by DoD) STANAG 3350 will be compatible. The STANAG 3350 has yet to be ratified and is still undergoing changes. Therefore, the final extent of compatibility and any resultant changes to MIL-STD-1760 are still open issues.

6.3 HB network capacity. The network transfer capacity requirement imposed on the aircraft in 5.1.1.1.1 establishes the minimum required capacity. It is

expected that for any aircraft to meet its mission requirements, a higher level of HB network capacity than required by this standard may be needed. The actual network capacity required (i.e., the number of simultaneous HB signals flowing through the aircraft stores management system) will tend to vary with each aircraft and with each store loadout on a given aircraft. As a goal, the aircraft should support the following minimum HB network capacity:

a. Simutaneous transfer through the 50 ohm network of one Type B signal (on HB1) and two Type A signals (on HB1 and HB2) between ASIs and internal aircraft equipments plus one Type A signal (on HB1 and HB2) between any two ASIs.

b. Simultaneous transfer through the 75 ohm network of two Type A signals between ASIs and internal aircraft equipments plus one Type A signal between any two ASIs.

Figure 13a illustrates this minimum aircraft capacity as a collection of HB channels which is transparent to the various technologies which could be used to implement the aircraft network. Figure 13b illustrates the same network capacity when implemented with a centralized "crosspoint" style switching matrix. It is not intended that figure 13b be interpreted as a required (or acceptable) design for the network but simply as an illustration of the recommended network capacity.

This note establishes guidelines on the level of aircraft HB signal distribution network capacity which should be adequate for most tactical aircraft. As indicated in the note, some aircraft may require a more extensive network capacity than shown in order to support the aircraft's designated mission(s) and store loadouts.

The referenced figure 13a is drawn in an implementation vague manner to avoid implying specific signal distribution technology. Technologies ranging from electromechanical relays to Frequency Division Multiplex systems can be used to construct an aircraft distribution network.

Figure 13b is more representative of a specific distribution technique -- i.e., centralized switching matrix. This figure, however, is a simplified schematic of a switching matrix. The switching elements designated on the figure with an "X" can be relatively complex devices - particular to meet Type B band (20 MHz to 1.6 GHz) switching requirements - e.g., low VSWR. (See 5.1.5.1.)

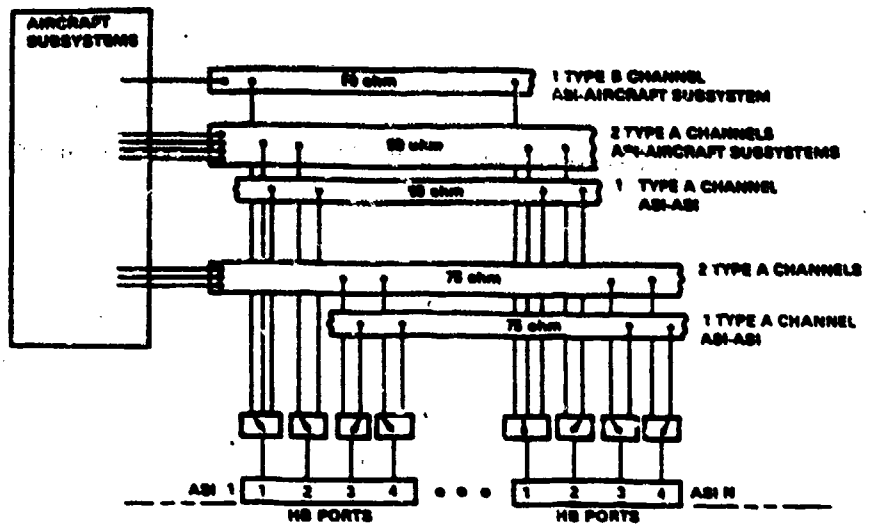


FIGURE 13a. Recommended channel capacity.

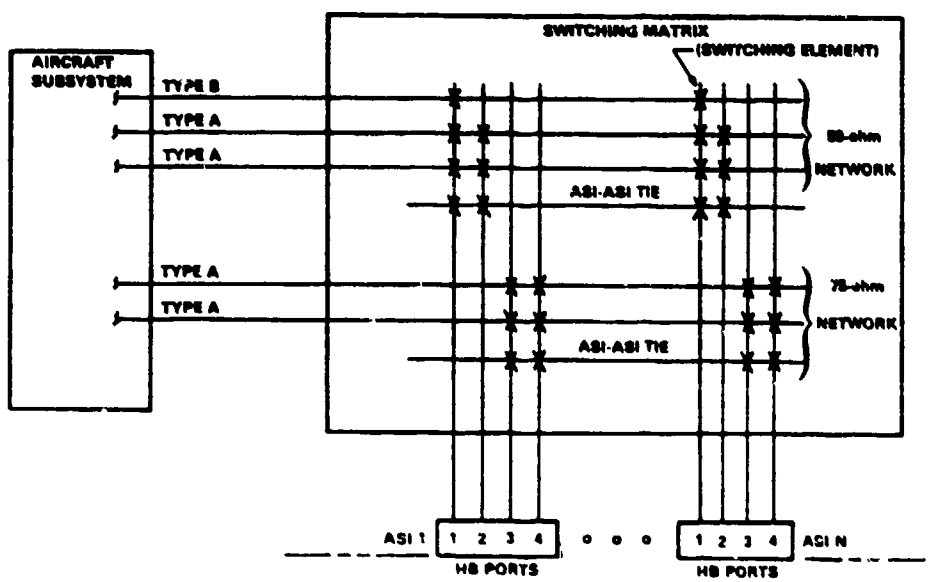


FIGURE 13b. Centralized switching matrix example.

FIGURE 13. Suggested aircraft high bandwidth network capacity.

6.4 ASI test conditions for Mux A and Mux B. The following termination conditions are recommended for evaluating compliance with the output characteristics (5.1.1.2.2.1) and input characteristics (5.1.1.2.2.2) requirements for the Mux A and Mux B ASI interfaces:

a. All ASIs terminated with a 1000 ohm ±5 percent resistive load at the end of a 20 foot long MIL-STD-1553 compliant cable;

b. All ASIs (except ASI under test) disconnected (i.e., Mux A and Mux B open circuited); and

c. All ASIs in the terminated conditions expected (such as opened or shorted) during aircraft operation including stores release.

This paragraph provides guidelines for evaluating the aircraft's digital multiplex data interface performance. Several configurations are listed for connecting test cables to the store side of the ASI. These configurations attempt to represent the worst case termination conditions. The 20 foot cable test of subparagraph (a) is selected to represent the longest cable run from ASI to mission store remote terminal that could be projected. This length includes not only the internal store cable but also any ASI-MSI interconnecting umbilicals. To achieve this length in an actual application probably requires a large (long) store connected to the aircraft through an intermediate carriage store or adapter.

Subparagraph (b) represents the opposite extreme - i.e., no cables connected to the ASI. This configuration results from missions which do not include AEIS stores at some (or all) stations. Subparagraph (c) represents a more aircraft dependent case where specific termination conditions may need to be tested. Included in this is recognition that umbilical cables can become damaged as a result of store release or a cable/connector failure and result in a shorted multiplex interface. (See 5.1.3.3.)

6.5 Mission store use of HB interfaces. It is highly recommended that mission stores which require HB services limit their HB interface requirements to HB1 and HB3. This suggestion is presented because some aircraft will implement class II or IIA interfaces at some ASIs and class II and IIA interfaces do not contain HB2 and HB4 connections. Therefore, a mission store which requires HB2 or HB4 interfaces will not be able to operate from class II or IIA ASIs.

This note is included to alert store designers that class II interfaces will be more typical on aircraft than class I. As a result, the designer should

avoid use of HB2 or HB4 when viable design options permit. (See 5.2.1 and 5.2.10.5.)

6.6 Use of interlock and address for mated status. Figure 14 presents an example of one possible mated status monitor implementation for both aircraft and mission stores. Mission store designers who choose to monitor the electrical interface for mated status (with the aircraft) should include logic in the store that indicates a valid mated condition whenever continuity is seen on any of the address discretes. All valid addresses sent to the store will always have continuity between at least one of the address bit or parity connections and the address return connection. As with the interlock interface, the address interface could indicate a non-mated condition if a line breaks or a faulty connection exists in the interface. As a result, the store and aircraft must not rely solely on these mating status signals for activating any safety critical functions - i.e., the store and aircraft must fail safe with respect to the mating indication.

This note is included to provide suggestions and to re-enforce cautions on the use and misuse of the interlock and address discretes. (See 5.1.4.1, 5.2.3.1, 5.2.3.3 and 5.3.2.3.)

6.7 Mission store power utilization. It is highly recommended that mission stores be designed to (1) minimize the power required from the aircraft, and (2) avoid requiring the use of the auxiliary power signal set. This latter recommendation is made because the auxiliary power signal set is an option for both class I and class II ASIs. As a result, it is expected that the auxiliary power will only be available at a limited number of ASIs. For maximum installation flexibility, therefore, the mission store designer should attempt to stay within the power rating available through the primary signal set.

This note is included to remind the store designer that the auxiliary interface will be available at a limited number of aircraft stations. In addition, even though MIL-STD-1760 requires availability of two 10 ampere 28V DC and three 10 ampere 115V AC phase power interfaces at each ASI, the total power available from the aircraft is limited to the extent that very few aircraft are expected to be able to supply full ASI power ratings simultaneously to all ASIs. Therefore, for maximum store utilization flexibility, the designer should minimize the actual power required by the store. (See 5.2.8.2 and 5.2.8.3.)

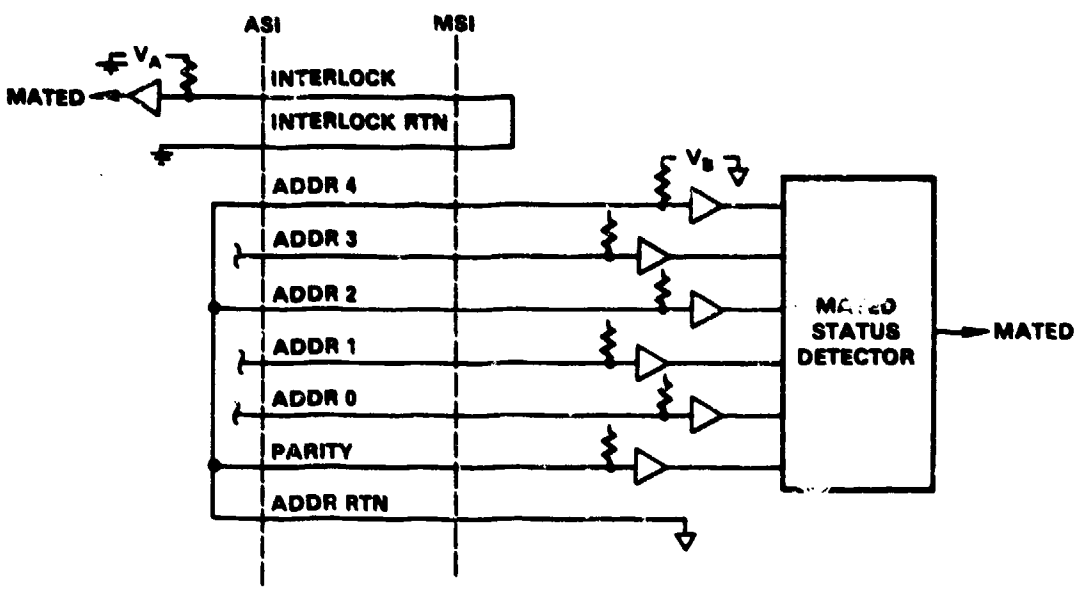


FIGURE 14. Mated status monitor example.

6.8 Carriage store interfaces. Detail interface requirements for the CSI and CSSI are not included in MIL-STD-1760. However, the detail requirements for the ASI and MSI contained herein include signal loss allocations for the carriage store (and any associated umbilical cables). Any carriage store which is required to carry a MIL-STD-1760 compliant mission store on a MIL-STD-1760 compliant aircraft station would be designed such that the CSI is compatible with ASI characteristics and the CSSI is compatible with MSI characteristics.

This note is a reminder that carriage stores (devices such as multiple station ejector racks, rail launchers that connect to bomb racks, etc.) may be developed in the future with MIL-STD-1760 interfaces (see figure 1 of MIL-STD-1760). The current MIL-STD-1760 does not include detailed specification of the carriage store interface characteristics. The current standard does, however, include allocations in the defined ASI and MSI characteristics to allow future insertion of carriage stores.

6.9 LB interface utilization. The LB interface is provided to transfer low frequency, low power level signals which for various reasons are inappropriate for transfer over the Mux A or Mux B interface. Tones and voice grade audio currently represent the only allowed signals on the LB interface. The LB interface characteristics have, however, been defined to accommodate the potential future application of the LB interface for transferring low speed serial digital data using balanced line differential receivers and drivers such as those defined by EIA Standard RS-485.

This note is included for guidance on potential future uses for the Low Bandwidth interface. The note also includes an explanation on why the LB characteristics contain certain parameters or parameter values. (See 4.3.3, 5.1.6, 5.1.9.1.4, 5.2.7 and 5.2.10.4.)

6.10 28V DC and 115/200V AC power interface current limits. The maximum overcurrent and maximum load current curves of figures 7 and 8 were derived from the trip and no-trip calibration data for MIL-STD-1498 circuit protection devices. These curves represent a locus of time-current points (e.g., a 23 ampere current for 1 second duration, a 13 ampere current for 10 seconds duration, etc.). The curves are not intended to be a continuous profile of current versus time.

Under fault free conditions, a store must limit its

applied load (as measured at the MSI) such that the maximum load current locus is not exceeded. A conservative indication of this compliance would occur if the maximum true RMS of the load current profile averaged over all time intervals does not exceed the current associated with the same time intervals as defined by the maximum load current locus. Under conditions of internal store power interface faults, the store must be capable of safely withstanding (operational impairment expected) overcurrents for the duration defined by the maximum overcurrent locus of figures 7 or 8, as applicable.

The aircraft must be capable of sourcing through an ASI any current for the duration defined by the locus of points designated by the maximum load current curve in figure 7 or 8, as applicable. The aircraft may remove power from an ASI (by tripping a circuit breaker, for example) whenever the ASI load current exceeds any point defined by the maximum load current locus. The aircraft must remove power from any ASI before the current exceeds the maximum overcurrent locus in figure 7 or 8, as applicable. The maximum load current curve and maximum overcurrent curve, therefore, define the area of a current-time band within which an aircraft's circuit protection devices must trip.

This note is included in the standard to clarify interpretation of the current curves of MIL-STD-1760 figures 7 and 8 and paragraphs 5.1.1.8.2.2, 5.1.1.8.2.3, 5.1.1.9.2.2, 5.1.1.9.2.3, 5.2.1.8.2.2, 5.2.1.8.2.4, 5.2.1.9.2.2 and 5.2.1.9.2.4. (See 5.1.7.4 and 5.2.8.5 of this report.)

6.11 Cable selection for HB interfaces. The use of concentric triaxial cable in aircraft and stores for implementing the HB interfaces is highly recommended. Recent aircraft implementations have shown improved signal quality when triaxial cable is used instead of coaxial cable. These improvements are due to the protection afforded by the triaxial cable from both magnetic field and electric field interference to which low frequency signals are particularly susceptible. The interface definition in this standard allows use of triaxial cable even though only coaxial style contacts are contained within the interface connector. This apparent connector limitation can be overcome by electrically terminating the outer shield of the triaxial cable to the conductive backshells of the interface connectors. This termination can be made by

means of a multishield terminating device such as an inverted-cone contact ring or tag ring (or other techniques). The inner shield of the triaxial cable is used for signal return for the high bandwidth signal.

This note is included to strongly recommend use of triaxial cable for the HB interface transmission lines. The ASI and MSI connectors selected coaxial contacts for the HB functions due to space limitations in the interface connectors. However, from an EMC perspective, triaxial cable should be used in most applications for the transmission lines. The coaxial contacts in the ASI and MSI connectors do not prohibit use of triaxial cables in the aircraft, store and interconnecting umbilical cable. (See 5.1.9.1.5, 5.1.9.4.5, 5.2.9.1.7, and 5.3.4.1.3.)

6.12 Power deadfacing. The aircraft should ensure that unmated ASI connectors are not powered. As a minimum, the aircraft should ensure that no power is applied to a store until store presence is assured. As soon as is practical, power deadfacing should be carried out on receipt of store gone signals.

This note is included as a recommendation to the aircraft SMS designer. It is not included in the main body of the standard as a requirement because it addresses what happens at an ASI while it is not functioning as an operational interface - i.e., a store is not mated. From a personnel hazard and system vulnerability perspective, the power to the interface should be turned-off when no store is connected. In addition, the power should be turned-off prior to store separation to avoid breaking power current flow with the connector during umbilical disconnect.

6.13 HB radiated emissions. Table I defines the maximum allowed signal power levels for HB signals as part of the HB general signal characteristics. Specific HB signals currently defined for the HB interfaces have power levels significantly lower than these maximum ratings. The maximum allowed signal power levels in this standard are relatively high when electromagnetic interference radiated emissions are considered. Aircraft, stores and the associated umbilicals may require additional cable shielding to maintain radiated emissions within required limits when signals near these maximum allowed power levels are used.

This note is included to advise aircraft and store designers on future HB applications. Applications which use relatively high power levels on the HB lines need shielding techniques more extensive than available from typical coaxial cables in order to meet MIL-STD-461 radiated emission limits. (See 5.1.9.4.5 and 5.2.9.1.7. Also see commentary above on Note 6.11.)

5.4.8 EMI test cable appendix.

APPENDIX

CABLES FOR ELECTROMAGNETIC INTERFERENCE (EMI) TESTING OF MISSION STORES

10. GENERAL

10.1 Scope. This appendix covers the requirements for the test cables to be used for EMI testing of mission stores.

10.2 Purpose. This appendix shall be contractual implemented when mission stores are tested in accordance with MIL-STD-462.

20. REFERENCED DOCUMENTS

20.1 Government documents. The following documents form a part of this appendix to the extent specified:

SPECIFICATIONS

MILITARY

MIL-C-17/94	Cables, Radio Frequency, Flexible, Coaxial, 75 ohms
MIL-C-17/113	Cables, Radio Frequency, Flexible, Coaxial, 50 ohms
MIL-C-17/176	Cables, Radio Frequency, Flexible, Twinaxial
MIL-W-22759/16	Wire, Electric, Fluoropolymer Insulated, Extruded Etfe, Medium Weight, Tin Coated Copper Conductor, 600 Volt, 150 Deg. C

STANDARDS

MILITARY

MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of

(Copies of specifications, standards and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

30. DEFINITIONS

Not applicable.

40. REQUIREMENTS

40.1 Mission store testing. If tested in accordance with the requirements of MIL-STD-462, mission stores shall use cables which comply with the requirements of table IX. These test cables shall be used to interconnect the MSI to the simulated (or actual) aircraft loads and sources. For MIL-STD-462 RS03 tests, the mission store shall be tested at 200 volts/meter with shielded test cables 1 and 1A (see table IX) and at 20 volts/meter with unshielded test cables 2 and 2A (see table IX). Test cables 2 and 2A shall be used for all other MIL-STD-462 EMI tests.

This appendix defines standard configuration test cable requirements for supporting MIL-STD-462 tests on mission stores (when required by the store's system specification). This testing issue is discussed in Section 5.4.6 commentary on MIL-STD-1760 paragraph 5.2.3.

Paragraph 40.1 of this appendix covers two general test cable configurations (1 and 2). Test cable 1 contains gross shielding and is used for MIL-STD-462 RS03 tests run at 200 volts/meter. Test cable 2 is an unshielded cable that represents internal aircraft harnessing. This second cable is used for MIL-STD-462 RS03 tests at 20 volts/meter and also for all of the other MIL-STD-462 tests. Use of the unshielded cable assembly is selected to represent a worst case aircraft harness configuration and to insert design margin into the EMI requirements. (See 5.2.9.)

TABLE IX. EMI test cable requirements.

SIGNAL NAME	CABLE REQUIREMENTS		
	WIRE SPECIFICATION SHEET AND SIZE	WIRE TWISTS/METER	TEST CABLE 1/
Primary signal set			1 and 2
HB1 & 2	MIL-C-17/113 (RG315)	-	
HB3 & 4	MIL-C-17/94 (RG179)	-	
Mux A, Mux B, LB	MIL-C-17/176	-	
Fiber Optic Channel 1 & 2	(No line required)	-	
Release consent	MIL-W-22759/16-20	-	
Interlock and interlock return	MIL-W-22759/16-20	Pair: 15±3	
Address bit A4 Address bit A3 Address bit A2 Address bit A1 Address bit A0 Address parity Address return	MIL-W-22759/16-20	Set: 15±3	
Structure ground	MIL-W-22759/16-16	-	
28V DC power 1 and 28V DC power 1 return	MIL-W-22759/16-16	Pair: 15±3	
28V DC power 2 and 28V DC power 2 return	MIL-W-22759/16-16	Pair: 15±3	
115V AC Phase A, B, C and neutral	MIL-W-22759/16-16	Quad: 15±3	
270V DC power and 270V DC power return	(No line required)		

TABLE IX. EMI test cable requirements. (Cont'd)

SIGNAL NAME	CABLE REQUIREMENTS		
	WIRE SPECIFICATION SHEET AND SIZE	WIRE TWISTS/METER	TEST CABLE 1/
Auxiliary power signal set			1A and 2A
Interlock and interlock return	MIL-W-22759/16-20	Pair: 15±3	
28V DC power and 28V DC power return	MIL-W-22759/16-10	Pair: 15±3	
115V AC Phase A, B, C and neutral	MIL-W-22759/16-10	Quad: 15±3	
270V DC power and 270V DC power return	(No line required)		
Structure ground	MIL-W-22759/16-10		

1/ The test cables shall comply with the following requirements:

a. 1 and 1A: The cable assembly shall be enclosed by a braided wire shield with 80 to 95 percent optical coverage. The shield shall have a 360 degree connection to the connector assembly at each end of the cable. The cable length, measured between the front faces of the two connectors, shall be 2 meters ±2 percent. The "aircraft end" cable connector shall be a D38999/26WJ20PN plug for test cable 1 and a D38999/26WJ11PA plug for test cable 1A.

b. 2 and 2A: The cable assembly shall provide no gross shielding other than that provided by the connector assembly. The cable length measured between the front faces of the two connectors shall be 2 meters ±2 percent. The "aircraft end" cable connector shall be a D38999/26WJ20PN plug for test cable 2 and a D38999/26WJ11PA plug for test cable 2A.

6. NOTES

6.1 Intended use. The primary intended use of this report is to increase aircraft and store designers' awareness of available methods for improving aircraft/store inoperability to recommend specific design and fabrication practices and to provide sufficient engineering data to implement MIL-STD-1760 requirements. The secondary intention is to better inform the aircraft/store designer on the requirements imposed by MIL-STD-1760 and to provide rationale adopting the requirements.

6.2 Subject term (key word) listing.

Addressing
Attenuation
Cable, umbilical
Commentary
Discrete
Digital multiplex
Electromagnetic compatibility
Fiber optics
High bandwidth
Interface, aircraft
Interface, carriage store
Interface, carriage store station
Interface, electrical
Interface, mission store
Interface, power
Interoperability
Low bandwidth
Low cost store
MIL-STD-1760
Release consent
Shielding
Stores management system
Structure ground

APPENDIX A

AEIS TEST NETWORKS

A.10 INTRODUCTION

Test data presented in this report was obtained during a test program which was conducted primarily to formalize the requirements specified in MIL-STD-1760. The test program was conducted on AEIS networks that typify two aircraft/store applications. One application consists of a network that interfaces the mission store to the aircraft via an umbilical as shown in figure A-1. The other application consists of a network that interfaces the mission store to the aircraft via a carriage store and two umbilicals as shown in figure A-2. To provide realistic information, data was obtained on "new" harnesses and harnesses that have been environmentally fatigued to show possible signal degradation resulting from contaminates and wear that could accumulate during aircraft service life. (The switching hardware was not environmentally fatigued.)

The wire harnesses include MIL-STD-1760 compliant connectors (unqualified MIL-C-38999 connectors), twinaxial pins/sockets and cable for the Mux bus and low bandwidth lines, coax pins/sockets and cable for the high bandwidth lines, and military standard hardware for the remaining wire, contacts, backshells, etc. as shown in figure A-3. Military grade hardware was used to simulate typical aircraft and carriage store switching functions. The enclosure for the carriage store and test panel were designed to accommodate testing rather than to meet aircraft/store installation requirements. However, the switching circuits provided a good simulation of switching functions encountered in aircraft and stores. Also, the design allowed the desired EMI shielding effectiveness to be obtained during testing.

A.20 TESTING

Testing consisted of electrical performance tests and EMI characterization tests. The configuration depicted in figure A-1 provided data on the simplest and most common implementation of MIL-STD-1760 requirements. The configuration depicted in figure A-2 provided the maximum levels of circuit resistance, voltage drop, signal attenuation, VSWR and EMI. All tests were run on hardware before and after environmental exposure.

A.20.1 Low level circuit resistance. Low level circuit resistance tests were run on the address and interlock lines. These tests were conducted in accordance with MIL-STD-1344A, Method 3002.1 both prior to and after environment exposure.

A.20.2 Voltage drop. Voltage drop tests were run on each of the power interfaces and on the release consent interfaces. These tests were conducted with methods similar to MIL-STD-1344 Method 3004.1 both before and after environmental exposure.

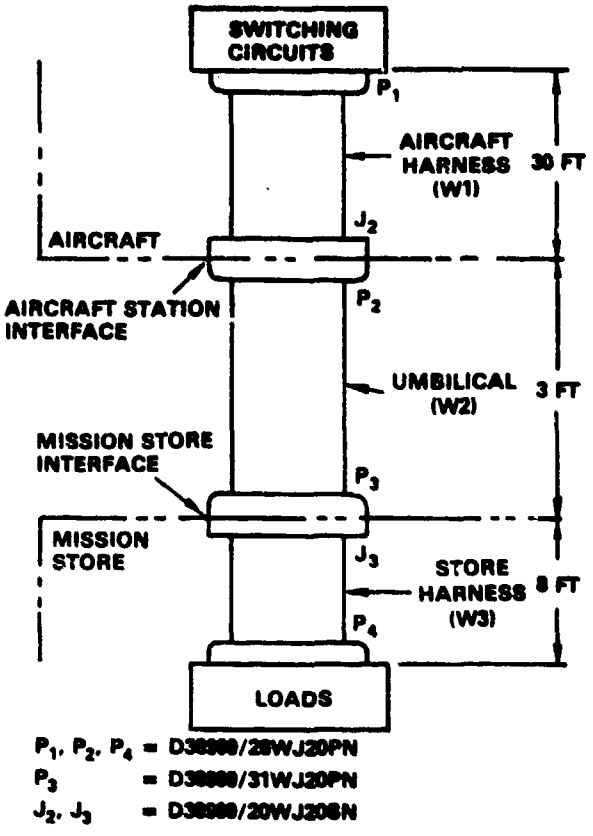


FIGURE A-1a. Harness configuration.

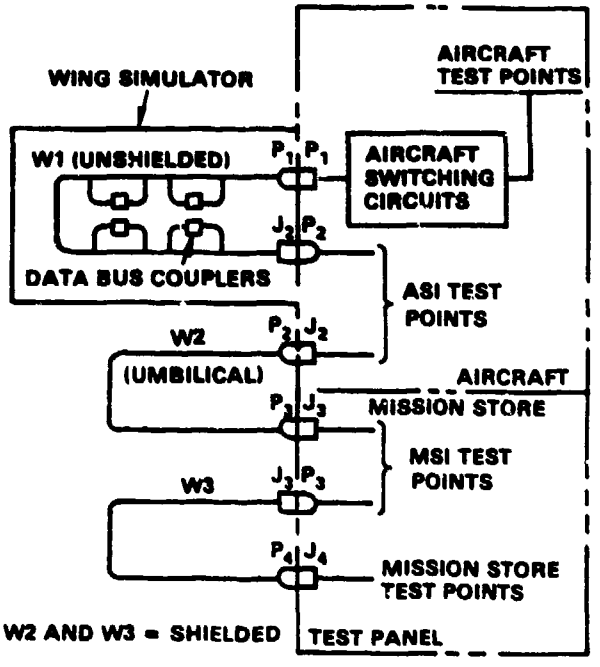


FIGURE A-1b. Harness test set-up.

FIGURE A-1. Direct carriage of mission store at aircraft station.

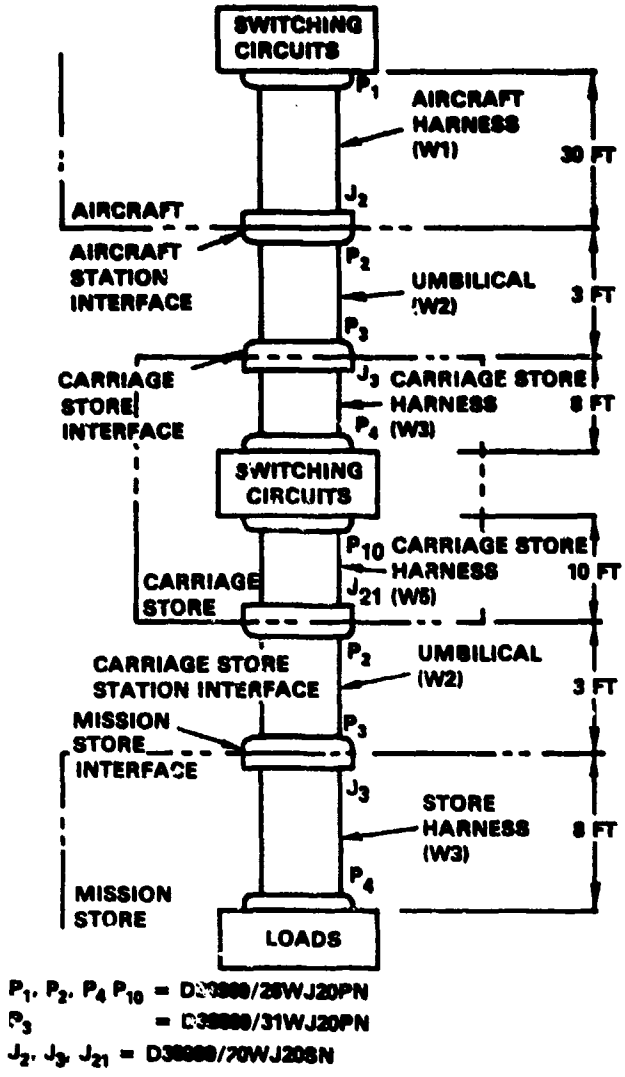


FIGURE A-2a. Harness configuration.

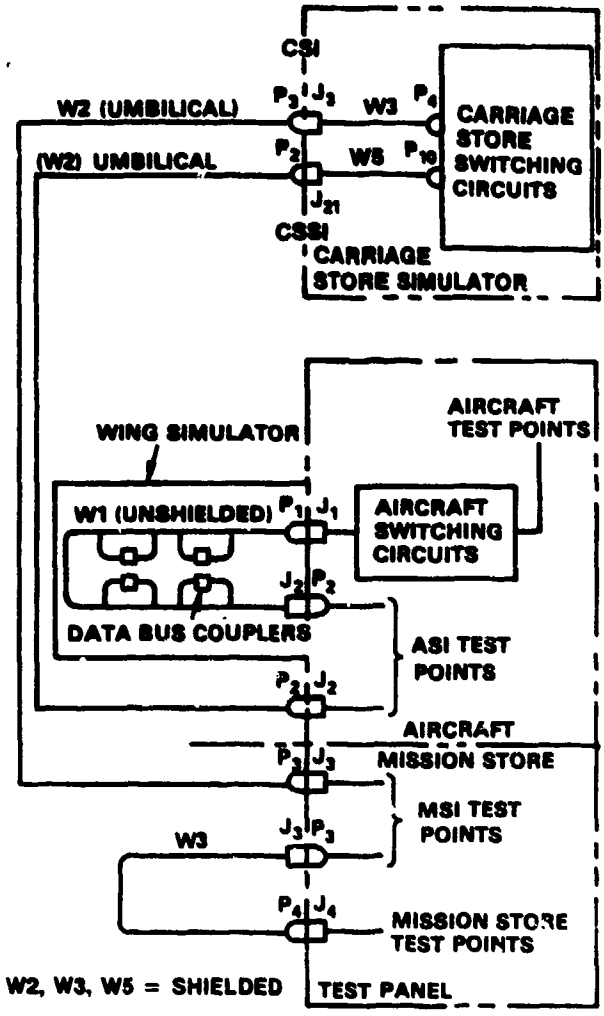


FIGURE A-2b. Harness test set up.

FIGURE A-2. Carriage of multiple mission stores at aircraft station.

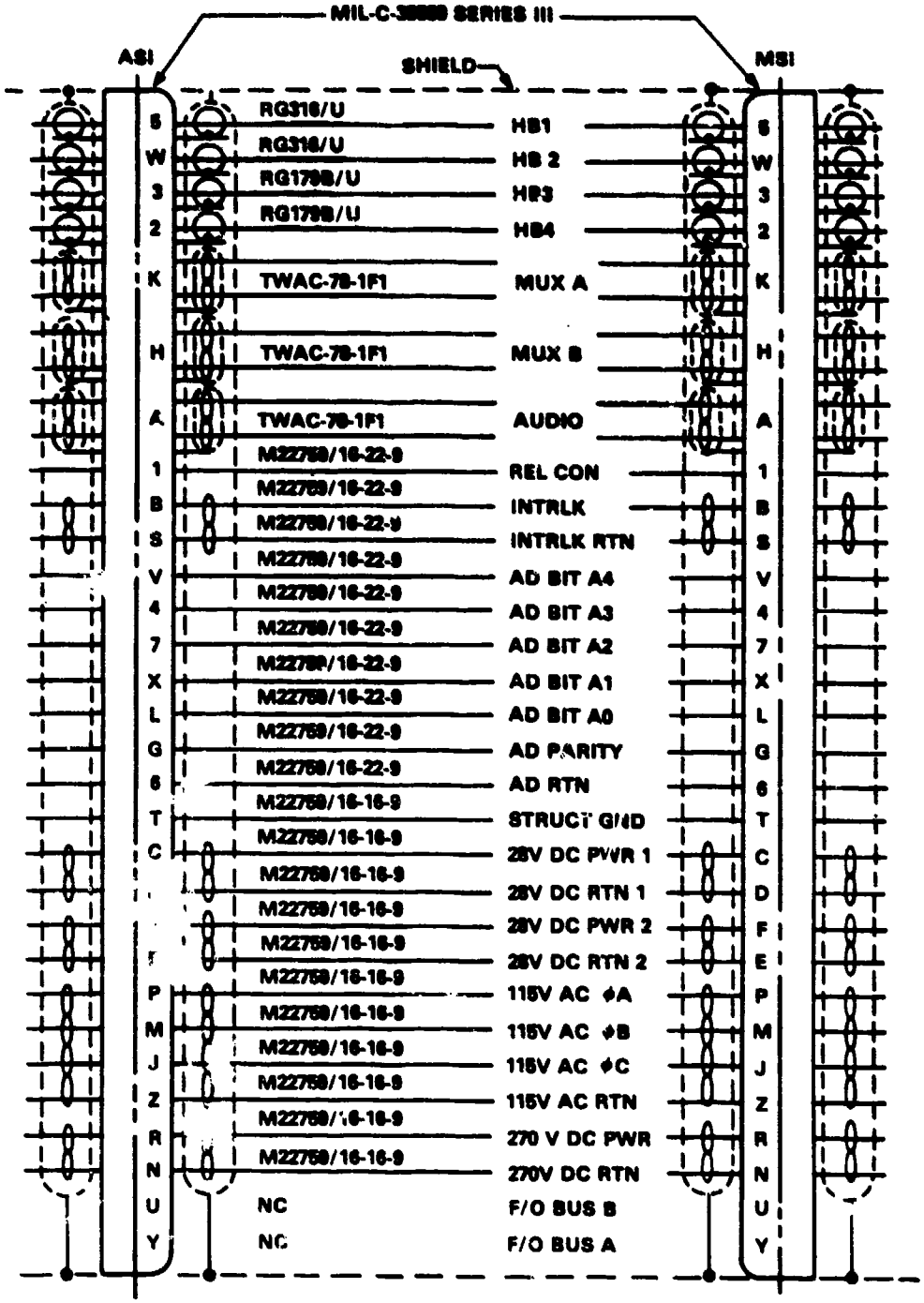


FIGURE A-3. Typical primary signal set harness design.

A.20.3 Signal attenuation. The signal attenuation test set-up for the High Bandwidth interface is shown in figure A-4. The frequency was swept from 1.0 MHz to 31 MHz for HB3 and HB4, between 1.0 MHz to 76 MHz for HB1 and HB2 and between 50 MHz to 3.0 GHz for HB1.

A.20.4 VSWR. The VSWR test set-up for the High Bandwidth interface is shown in figure A-5. The frequency was swept between 1.0 MHz and 20.0 MHz for the HB3 and HB4 lines, and between 1.0 MHz and 3.0 GHz for the HB1 and HB2 lines.

A.20.5 Electromagnetic interference (EMI). EMI tests were performed on harness configurations with and without the carriage store. The tests consisted of three catagories: (1) Field-to-wire coupling (radiated), (2) wire-to-wire coupling (crosstalk) and (3) radiated emissions. The test set-up for crosstalk tests is shown in figure A-6. Voltage measurements on each wire were made at frequencies from 100 Hz to 10 kHz. Measurements on all High Bandwidth lines were taken in the 50 ohm input impedance mode. A 75 ohm to 50 ohm pad was used on HB3 and HB4. All other voltage measurements were taken in the 100 kilohm input impedance mode. Tests were also made using one wire harness containing conventional 20 gauge contacts in lieu of twinaxial contacts for Mux A and Mux B.

The test set-up for measuring crosstalk for MIL-STD-1760 induced signal levels and "power-on" transients is shown in figure A-7 for frequency domain and figure A-8 for time domain. A series of measurements were taken on each line when both Mux Bus controller and the video camera were in simultaneous operation. Although the control panel and harness breakout was located outside the shield room, aluminum covers and conductive tape were used to make the area RF tight. A worst case address signal was simulated by a series of pulses generated by MOSFET switching circuits. Power-on switching transients were generated by electromechanical contactors.

Crosstalk for discrete microwave was measured at 1.6 GHz for the maximum allowable MIL-STD-1760 signal of 117 dB microvolt (10 dBm). The signal was injected on the aircraft side of the test harness and monitored at the store end.

Field-to-wire coupling was evaluated in the presence of a 200 volt/meter field. Tests were also made with the umbilical connector (P3) disconnected (figure A-1) to simulate a store release condition. The wing simulator was set for 40 dB of shielding. Probable measurement errors associated with the tests are given in table A-I.

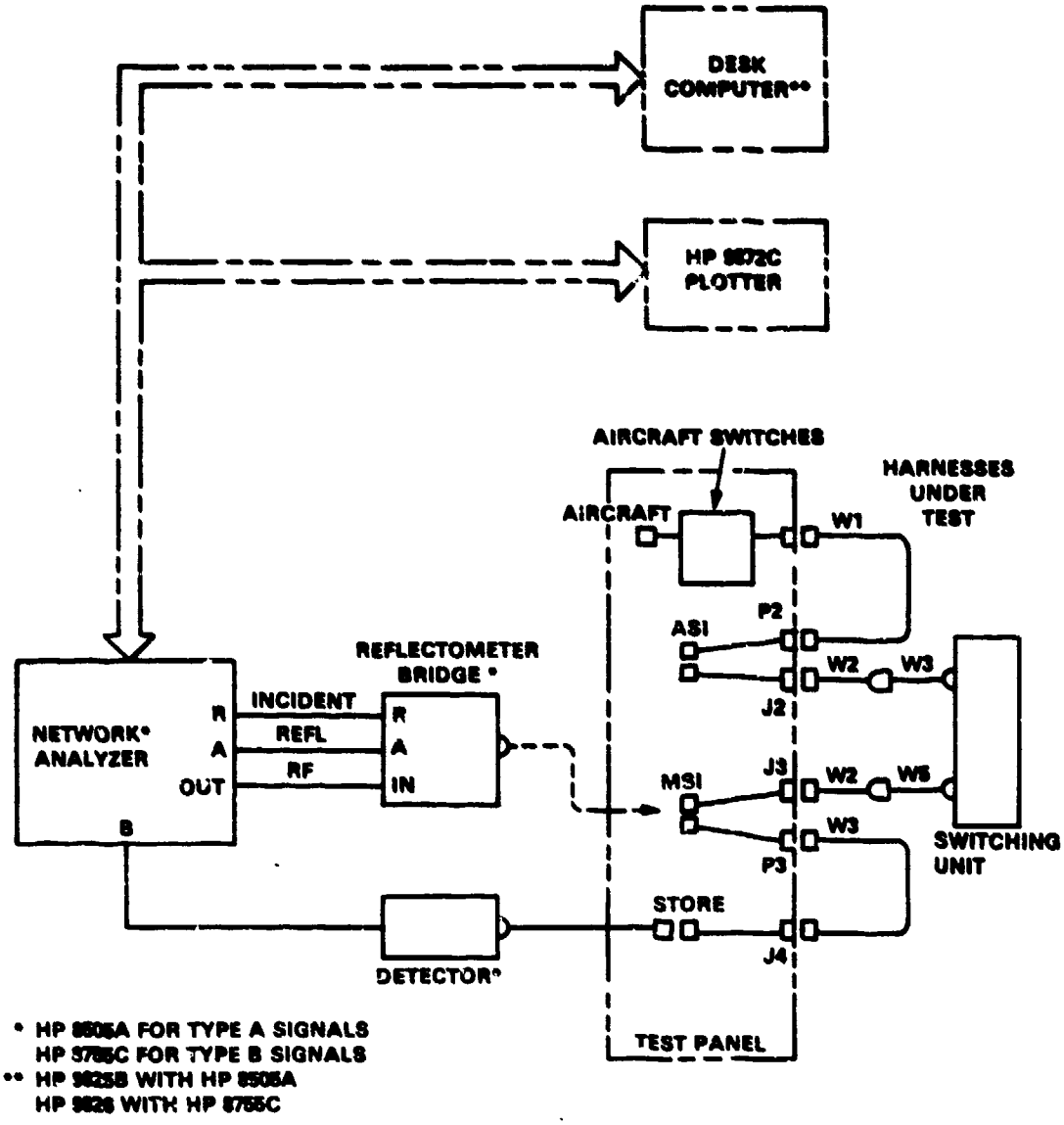


FIGURE A-4. Coaxial line signal attenuation test set-up.

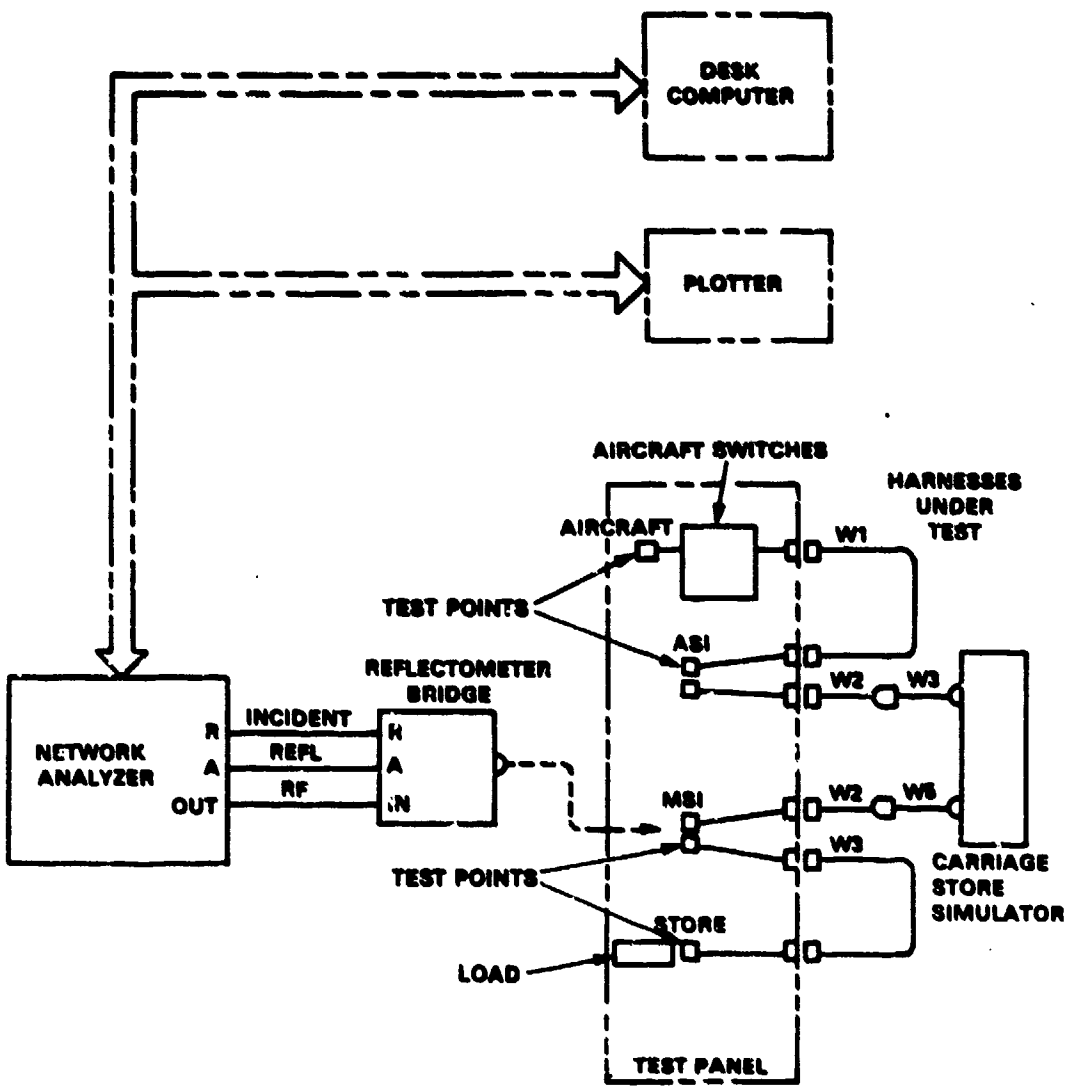
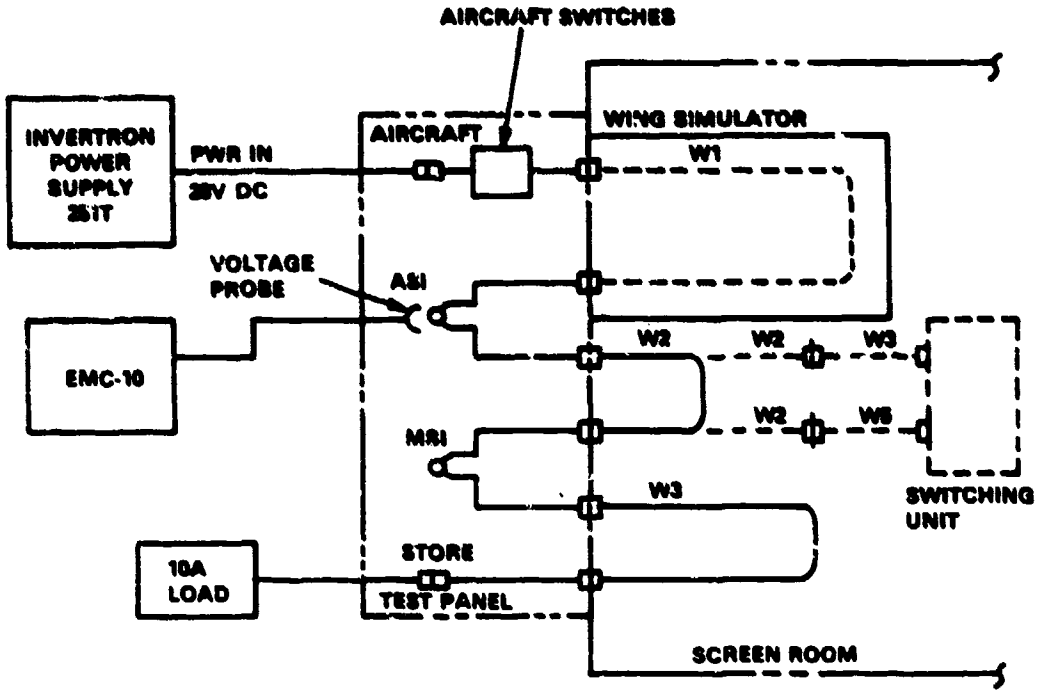


FIGURE A-5. VSWR test set-up.



NOTE: SWITCHING UNIT (CARRIAGE STORE SIMULATOR)

FIGURE A-6. Crosstalk test set-up for injected power line noise.

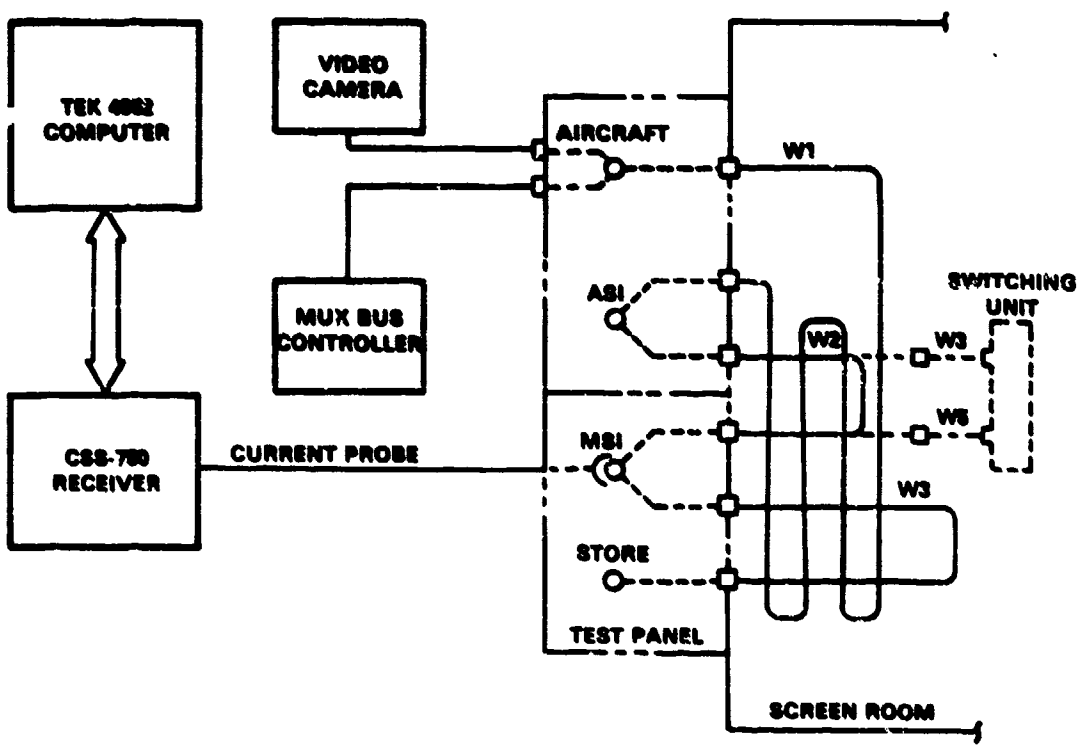


FIGURE A-7. Test set-up for frequency domain crosstalk measurement.

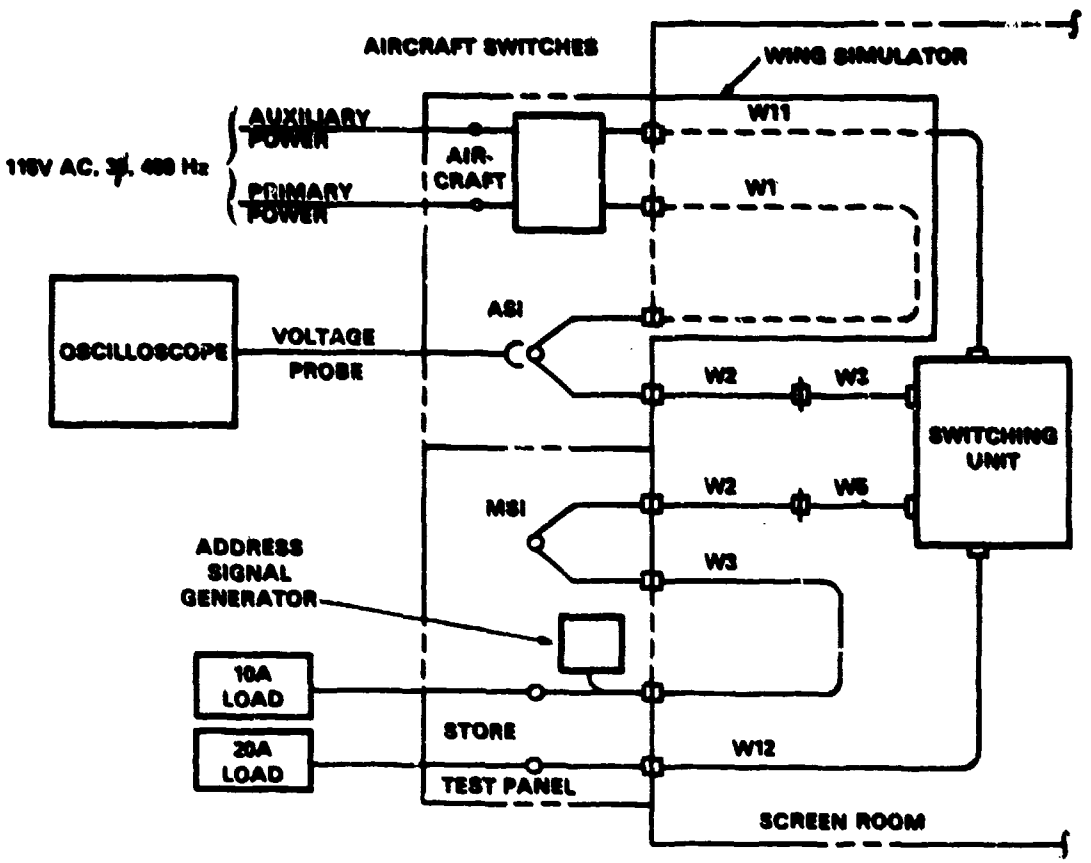


FIGURE A-8. Test set-up for time domain crosstalk measurement.

TABLE A-1. Summary of EMI measurement errors.

Type	Probable error
Calibration	2.0 dB
Probe	.5 dB
Enclosure	
f <39 MHz	2.0 dB
f >39 MHz	5.0 dB
Wing Simulator	
f <235 MHz	2.0 dB
235<f<500 MHz	Data Invalid
500 MHz <f<10 GHz	7.0 dB
Total RMS Errors	
f<39 MHz	4/6 dB
39<f<235 MHz	5.8 dB
235<f<500 MHz	Data Invalid
500<f<10 GHz	8.9 dB

Where f is the frequency

INDEX

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