AD-A048 906 NAVAL OCEAN SYSTEMS CENTER SAN DIEGO CALIF F/G 20/14
COMMON-MODE NOISE IN SEM LINE DRIVERS AND RECEIVERS.(U)
DEC 77 E KAMM
UNCLASSIFIED NOSC/TR-187 NL

1 OF 1
ADA048906

END
DATE
FILMED
2-78
DDC

NOSC

NOSC / TR 187

Technical Report 187

COMMON-MODE NOISE IN SEM LINE DRIVERS AND RECEIVERS

Edith Kamm

12 Dec[redacted]r [redacted]77

Final Report — 1977

Prepared for
NAVAL ELECTRONIC SYSTEMS COMMAND

NAVAL OCEAN SYSTEMS CENTER
SAN DIEGO, CALIFORNIA 92152

NAVAL OCEAN SYSTEMS CENTER, SAN DIEGO, CA 92152

AN ACTIVITY OF THE NAVAL MATERIAL COMMAND

RR GAVAZZI, CAPT USN
Commander

HL BLOOD
Technical Director

ADMINISTRATIVE INFORMATION

This task was part of the Standard Electronic Module (SEM) Research and Development Program, a program sponsored by the Naval Electronic Systems Command, Support Technology Division, NAVELEX 304, with J Cauffman (originally N Mathis) as responsible individual.

Work was managed and performed at the Naval Ocean Systems Center, Electronics Engineering and Sciences Department, Advanced Applications Division, NOSC Code 923. Management was in the Modular Applications Branch, NOSC Code 9231, by EC Urban, SEM Program Manager. Work was performed in the Power Electronics Branch, NOSC Code 9234, by the author under the technical direction of J Foutz. The NOSC unit number is R228B under program element 62762N and task area XF54584091.

Released by
CE Holland, Head
Advanced Applications Division

Under authority of
CD Pierson, Jr, Head
Electronics Engineering and
Sciences Department

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NOSC Technical Report 187 (TR 187)	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) COMMON-MODE NOISE IN SEM LINE DRIVERS AND RECEIVERS		5. TYPE OF REPORT & PERIOD COVERED Final – 1977
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) E Kamm		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Ocean Systems Center San Diego, California 92152		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62762N XF54584091 NOSC R228B
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Electronic Systems Command Support Technology Division, Code 304 Washington, DC 20360		12. REPORT DATE 12 December 1977
		13. NUMBER OF PAGES 12
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution is unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Electrical grounding
Electromagnetic interference
Modules
Transmission circuits

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

System parameters controlling common-mode noise are identified. Common-mode noise rejection is shown to be specified in very few of the Navy's standard digital interface circuits. It is recommended that common-mode effects can be controlled by (1) establishing a set of performance criteria based upon system requirements and system environments, and (2) developing performance test procedures. Also recommended is the development of new standard interface circuits to meet system/environmental requirements not met by existing standard circuits.

OBJECTIVE

Identify system parameters controlling common-mode noise. Determine whether Standard Electronic Module (SEM) line interface specifications are sufficient to preclude common-mode interference.

RESULTS

1. System parameters controlling common-mode noise were identified. Interference problems may or may not occur depending on the system's balance, shielding, isolation, impedance, grounding, data rate, and signal threshold.

2. Seven SEM interface modules were examined and only two were found to specify common-mode noise rejection. The modules are designed to meet but do not reference interface standards. Six interface standards were examined, and fewer than half specify common-mode noise immunity.

RECOMMENDATIONS

1. To control common-mode effects in digital interface circuits, establish a set of performance criteria based upon system requirements and system environments.

2. Develop procedures which test digital interface circuits against the established performance criteria.

3. Determine which criteria, from the established set, are met by existing SEM modules. Develop new modules to meet system/environmental requirements not now met.

CONTENTS

INTRODUCTION . . . page 3

PROCEDURE . . . 3

RESULTS AND DISCUSSION . . . 3

CONCLUSIONS . . . 7

RECOMMENDATIONS . . . 7

APPENDIX A: COMMON-MODE NOISE REJECTION IN SEM INTERFACE MODULES . . . 9

APPENDIX B: COMMON-MODE NOISE REJECTION IN INTERFACE STANDARDS . . . 11

INTRODUCTION

Electromagnetic energy impinging on signal cables induces common-mode currents into signal lines and returns. The effect on the system depends on the magnitude of the induced signals and the common-mode noise rejection of the signal driver, receiver, cable, and grounding configuration. In a poorly designed system, the common-mode signal is converted to a differential-mode signal and acts as a valid differential signal – resulting in problems. Recent examples include the pegging of indicator meters in shipboard engineering stations and the shutdown of power inverters when a ship's hf transmitter was keyed.

Acting like common-mode noise currents are structure currents feeding into signal lines either capacitively or directly. The structure currents result from either ground voltage differences or electromagnetic energy induced into the hull. Ground voltage differences occur on ships despite the intentional ungrounding of the three-wire power lines. Stray capacitances are significant causes, but the main culprits are line-to-chassis capacitors in equipment emi filters. Thus varying ac voltage grounds are established from equipment to equipment. Hull currents then result, adversely affecting some equipments. These structure currents can also be brought directly into active circuitry by hard-wire connections. In Navy shipboard grounding practices, it is common to connect the signal ground to chassis in each equipment. In fact, MIL-F-18870E makes this mandatory for fire-control systems. It is also mandatory to tie the chassis to the hull. When nonisolated line drivers and receivers are used – also a common practice – structure currents can be brought directly into the interface circuits being used to communicate information between equipments.

The purpose of this work is (1) to identify system parameters controlling common-mode noise, and (2) on the basis of these identified parameters to determine whether Standard Electronic Module (SEM) line driver and receiver specifications are sufficient to preclude interference problems in the presence of common-mode noise.

PROCEDURE

Common-mode noise problems were defined and possible solutions were studied. System parameters controlling common-mode effects were identified.

Seven SEM interface modules were examined for common-mode noise rejection specifications either directly or through a specified interface standard. The seven SEM modules consisted of five line receivers and two line drivers.

Six interface standards were examined for common-mode noise rejection requirements.

RESULTS AND DISCUSSION

Common-mode interference is defined by the IEEE (ref 1) as "Interference that appears between both signal leads and a common reference plane (ground) and causes the potential of both sides of the transmission path to be changed simultaneously and by the same amount relative to the common reference plane (ground)." Differential-mode interference, on the other hand, is defined as "Interference that causes the potential of one side of the signal transmission path to be changed relative to the other side."

---

1. The Institute of Electrical and Electronics Engineers, Inc, Standard Dictionary of Electrical and Electronics Terms – IEEE Std 100-1972

The source of common-mode noise is the induction of currents on signal cables by radiated electromagnetic energy (fig 1).* Adding to common-mode noise signals are unwanted potential differences between grounds (zero-signal reference points and other grounds). Although not, strictly speaking, common-mode voltages, these ground voltage differences contribute to the common-mode contamination of the signal (see fig 2).

To further exacerbate the problem, a common-mode signal can result in not only common-mode interference but also differential-mode interference. Differential-mode voltages appear if unbalance exists in either the driver, cable, receiver, or grounding configurations (see fig 3). V_i represents the resultant common-mode voltage from both radiated and ground voltage sources.

Therefore, to preclude common-mode problems, it may be insufficient to only specify that the receiver reject common-mode noise. For example, figure 4 represents a balanced system in which the common-mode noise is rejected by the receiver and does not become differential-mode noise unless $R_1 \neq R_2$ and/or $Z_1 \neq Z_2$. Figure 5 represents an unbalanced signal source which would cause a common-mode signal to produce a

---

*Figures 1 through 5 are from the Training Notes for a course, EMC – Design and Measurement for Control of RFI/EMI, taught by Don White Consultants, Inc, in Los Angeles, March 7 – 11 1977.

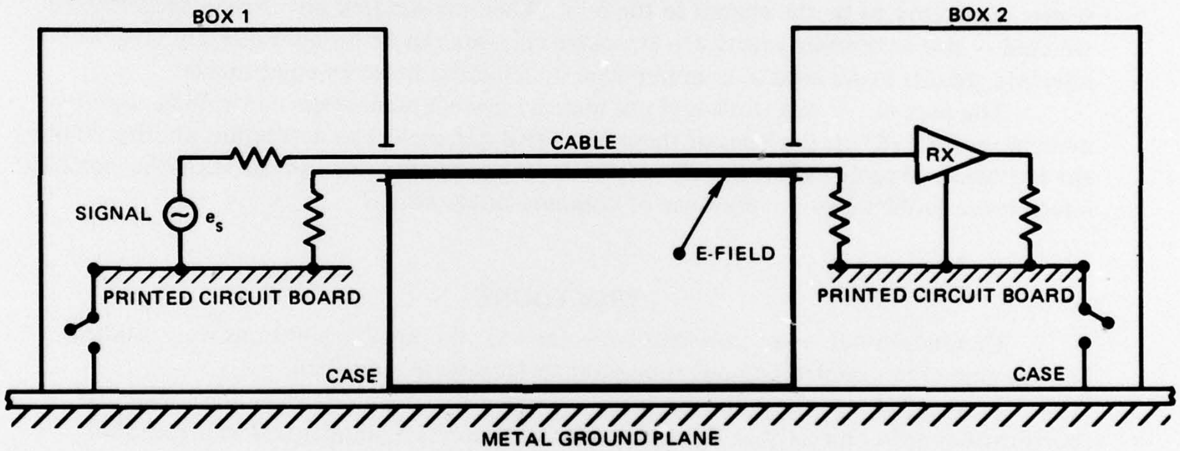

Figure 1. Diagram for field-to-cable coupling.

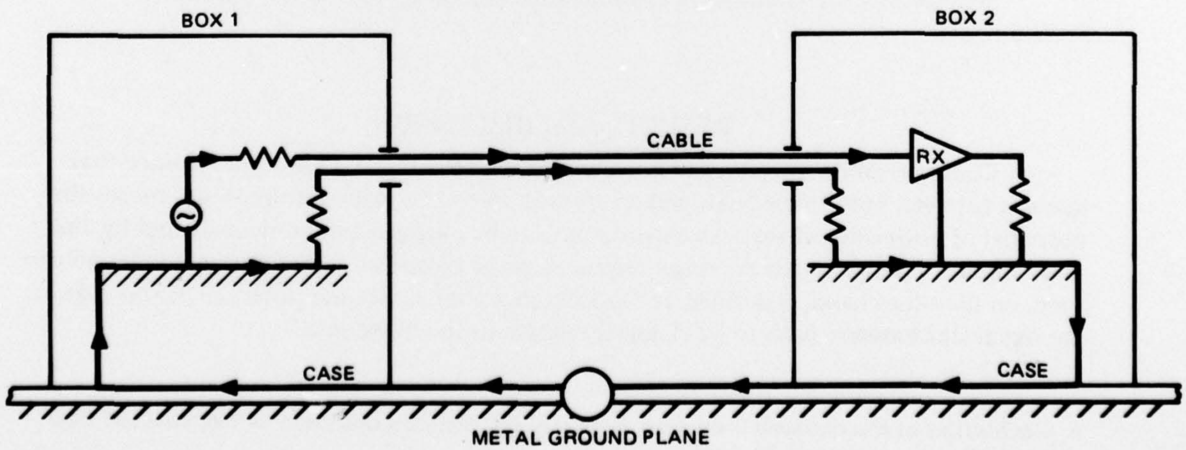

Figure 2. Diagram for ground-loop coupling.

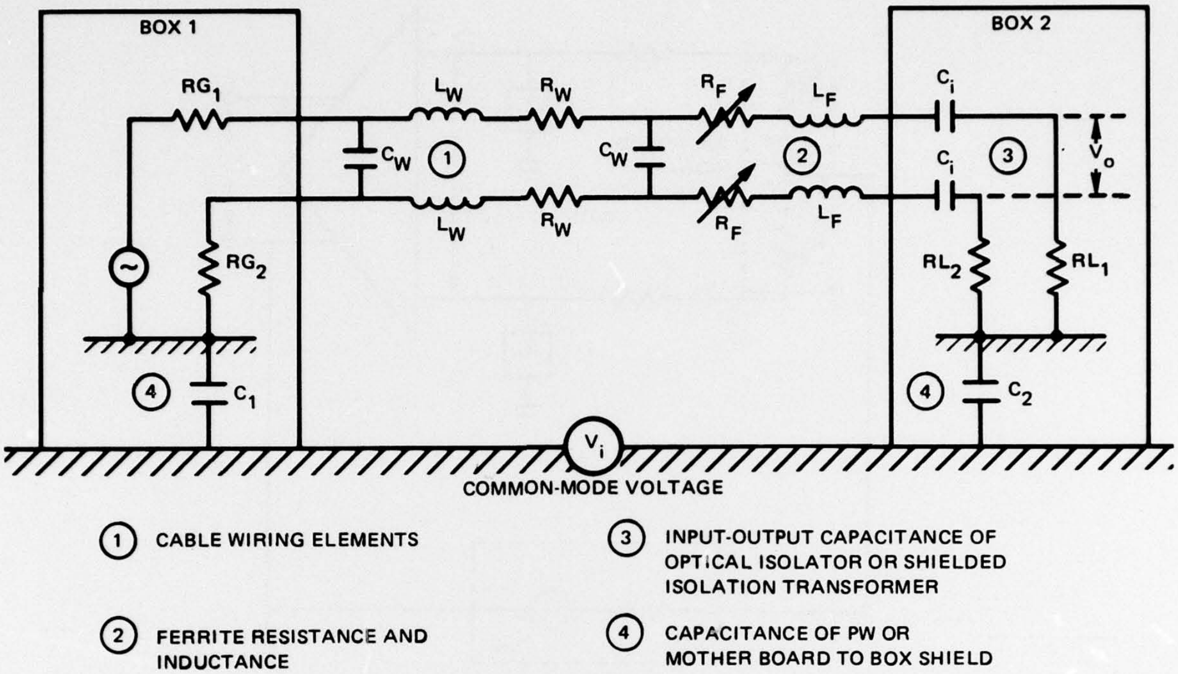

Figure 3. Equivalent circuit of ground-loop coupling.

differential-mode interference signal. Thus, ideally, to preclude problems the entire system must be balanced, including the transmission line.

Common-mode noise problems may also be attacked by:

1. Isolating line drivers and/or receivers
2. Lowering the impedance of the ground system
3. Reducing the system size
4. Ungrounding either the driver or the receiver or both to reduce noise coupling (however, as shown in fig 3, capacitive coupling exists even if the driver or the receiver is ungrounded)
5. Increasing signal thresholds
6. Filtering if data rates are low (more difficult to filter high-speed data)
7. Using higher-voltage drivers and receivers (but higher signal swings generate proportionately more cross talk)

By using the preceding techniques, common-mode noise problems can be prevented. Adequate noise limits (both common and differential mode) should be specified in interface circuits. However, for the seven SEM interface modular circuits which were examined, common-mode noise rejection was specified for only two modules. Although usually designed to meet interface standards, the SEM interface modules do not reference interface standards. However, even if the standards were specified, most of those studied (six) are silent about common-mode noise rejection. Table 1 summarizes the results for seven SEM line drivers and receivers and six interface standards. More details are given in appendices A and B.

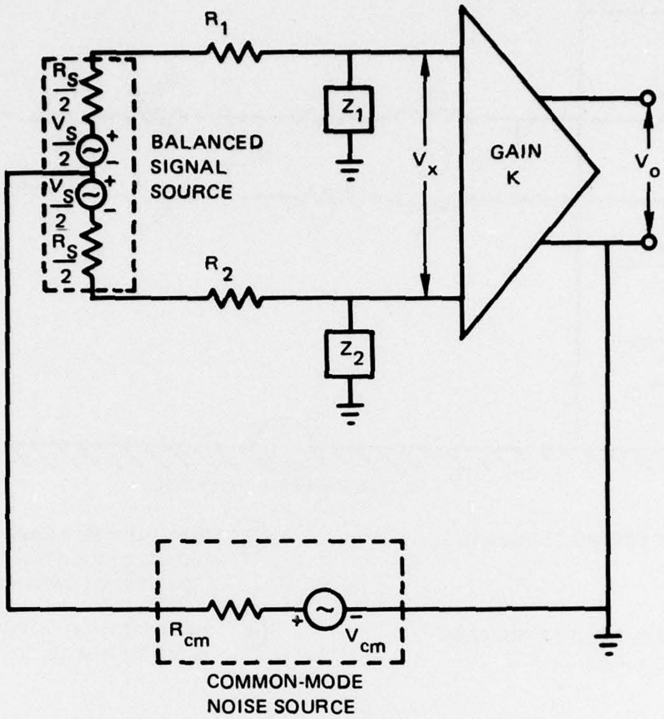

Figure 4. Common-mode noise in balanced systems.

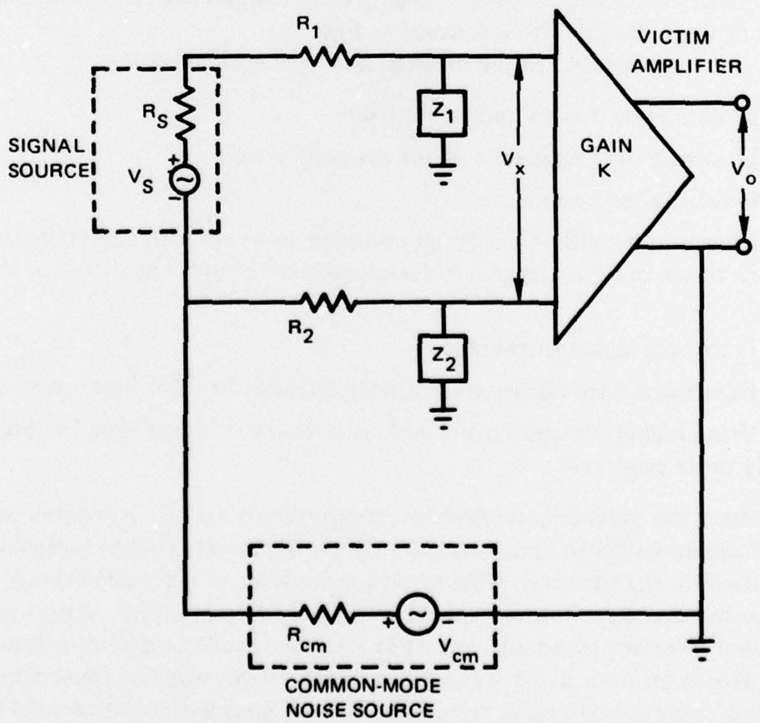

Figure 5. Common-mode noise in unbalanced systems.

TABLE 1. COMMON-MODE NOISE REJECTION IN INTERFACE STANDARDS AND SPECIFICATIONS.

Standard		Comment
RS-232 (EIA)*		Silent
RS-422 (EIA)*		Immunity specified
RS-423 (EIA)*		Silent
MIL-STD-1397 (SHIPS)		Silent
MIL-STD-188-100		*Immunity partially specified*
MIL-STD-1553A		Immunity specified
Specification		
MIL-M-28787 (NAVY)	Modules, electronic, standard hardware program (for seven slash sheet interface modules – 5 receivers and 2 drivers)	Silent for five interface modules – immunity specified for two interface receivers

*Electronics Industries Association

CONCLUSIONS

Common-mode noise rejection is specified in very few of the Navy's standard digital interface circuits. The requirement is seldom stated in detailed specifications. MIL-STD-461 presently contains no common-mode testing, although common-mode tests are being developed for future issues. Better control of common-mode noise effects is required now and is essential in future EMP environments. At present, the Navy depends almost entirely on the contractor's knowledge and good intentions for any common-mode noise rejection it gets in its systems.

RECOMMENDATIONS

1. To control common-mode noise effects in digital interface circuits, establish a set of performance criteria based upon system requirements (eg, data rate, signal threshold) and system environments (eg, shielding, grounding, EMP). Update the criteria when new threat or system requirements occur.

2. Develop quality assurance (QA) test procedures for digital interface circuits to measure the performance criteria established in the preceding paragraph.

3. Determine which criteria, from the established set, are met by the existing SEM modules. Demonstrate their performance by the tests developed in paragraph 2.

4. For SEM modules meeting the criteria, incorporate performance specifications and testing procedures into MIL-M-28787 slash sheets.

5. Develop SEM digital interface modules meeting system/environmental requirements not now met by existing SEM modules.

APPENDIX A: COMMON-MODE NOISE REJECTION IN SEM INTERFACE MODULES

Table A1 comments on common-mode noise specifications for seven qualified SEM interface modules. As noted, only two modules specify common-mode noise rejection. None of the modules reference interface standards.

However, discussion with NAFI personnel* indicated that the NTDS modules are intended to meet the NTDS interface standard, MIL-STD-1397. Although MIL-STD-1397 is not specified for the NTDS modules, they are tested to 1397 requirements by NWSC personnel at Crane, Indiana. Table A2 lists the SEM modules (qualified or in process) planned to be compatible with MIL-STD-1397.

The telephone discussion with NAFI personnel also revealed that modules are currently being developed to be compatible with two other interface standards, RS-232 and *MIL-STD-1553. Interface modules are being designed for the UYK-30 (a bit slice micro-*processor) to meet RS-232 requirements, but it is not yet determined whether the modules will reference RS-232. As indicated in appendix B, however, RS-232 does not specify common-mode noise requirements. Interface modules are being developed (also for the UYK-30) to meet MIL-STD-1553, but it is not yet determined whether the modules will reference MIL-STD-1553. As indicated in appendix B, MIL-STD-1553 does specify common-mode noise requirements.

---

*Telecon between Ray Malphy/Dean Demeyer (both with NAFI 924) and Edith Kamm, NOSC 9234, 4 May 1977

TABLE A1. COMMON-MODE NOISE REJECTION IN MIL-M-28787 (NAVY) MODULES, ELECTRONIC, STANDARD HARDWARE PROGRAM (FOR SEVEN SLASH SHEET INTERFACE MODULES).

SEM Slash Sheet	SEM Key	Description	Comments
16[1]	JDK	Receiver, 18 TTL	Silent
23[2]	SBT	Receiver, 28 V to 5 V	Silent
48[2]	MDP	Driver, Translate to Negative V, TTL	Silent
51[2]	MDQ	Receiver, Translate to Negative V, TTL	Specifies ±7-V common-mode rejection
54	QDH	Receiver, Slow NTDS	Silent
109	MDL	Driver	Silent
110	MDM	Receiver	Specifies 0.5-V-μs differential noise immunity and ±200-V common-mode noise immunity with less than ±50% overshoot, and a rise time of 10 ns or less

[1]Specified threshold voltages will not reject noise
[2]Input threshold voltages are specified

TABLE A2. SEM INTERFACE MODULES DESIGNED TO BE COMPATIBLE WITH MIL-STD-1397 (NTDS).

	DRIVER		RECEIVER	
	Slash Sheet	Key Code	Slash Sheet	Key Code
NTDS Slow (Receiver is qualified as standard) (Driver *is in process)*	239	QBQ	54	QDH
NTDS Fast (Qualified)	48	MDP	51	MDQ
NTDS ANEW (Being qualified at NWSC, Crane)	241	QDR	242	QDF

Note: None of the qualified modules (54, 48, and 51) reference MIL-STD-1397 and only module 54 references NTDS.

APPENDIX B: COMMON-MODE NOISE REJECTION IN INTERFACE STANDARDS

Table B1 lists interface standards and comments on their common-mode noise specifications.

RS-232 (EIA) is a data interface standard often specified for Navy interfaces. (EIA is Electronic Industries Association, 200 Eye Street, Washington, DC 20006.) Common-mode rejection is not specified. Some noise rejection is provided by the switching threshold. Paragraph 6.3 of RS-232 states that the electrical specifications are intended to provide a 2-volt margin in rejecting noise introduced either on interchange circuits or by a difference in reference ground potential across the interface.

RS-422 (EIA) and RS-423 (EIA) are new data interface standards permitting faster data rates and longer cables than the older EIA standard RS-232. A recent paper (ref 2) states that these two interface standards have emerged because RS-232 cannot handle the longer lines and higher data rates. Also, industrial applications often demand system

2. Morris, D, Revised Data-Interface Standards, Electronic Design, v 18, p 138–141, 1 September 1977

TABLE B1. COMMON-MODE NOISE REJECTION IN INTERFACE STANDARDS.

Standard		Comment
RS-232 (EIA)	– Interface between Data Terminal Equipment and Data Communications Equipment – serial binary data	Silent
RS-422 (EIA)	– Electrical Characteristics of Balanced Voltage Digital Interface Circuits	Specifies ±7-V common-mode rejection
RS-423 (EIA)	– Electrical Characteristics of Unbalanced Voltage Digital Interface Circuits	Silent
MIL-STD-1397 (SHIPS)	– Input/Output Interfaces, Standard Digital Data, Navy Systems	Silent
MIL-STD-188-100	– Common Long Haul and Tactical Communication System Technical Standards	
	– Low Level Balanced Interface	Specifies ±4-V common-mode rejection
	– High Level Interface	Silent
	– Low Level Unbalanced Interface	Silent
MIL-STD-1553A	– Aircraft Internal Time Division Command/Response Multiplex Data Bus	
	– Remote Terminal/Data Bus Interface	Specifies ±10-V common-mode rejection
	– Terminal/Subsystem Interface	Silent (but specifies ±0.5-V maximum common-mode output voltage)

performance in a high-electrical-noise environment. In such cases, a balanced line (RS-422) reduces interference, but the RS-423 interface only provides asymmetrical links. An adapter standard (RS-XYZ) covers the interconnection between the old and new standards.

MIL-STD-1397 is the NTDS interface standard. Four interfaces are specified: NTDS Slow, NTDS Fast, ANEW, and Serial. No common-mode rejection is specified. Switching thresholds are specified, providing some noise rejection. Also, NTDS Fast and ANEW specify differential receivers. Paragraph 5.2 requires that a plan for the hardware implementation and system utilization of the intended interface be submitted to the procuring agency for review prior to implementation.

MIL-STD-188-100 specifies common-mode rejection for low-level balanced digital interfaces only. Both balanced and unbalanced interfaces are specified with the choice left to designer, depending on transmission distances. For high-level interfaces, no common-mode rejection is specified.

MIL-STD-1553 specifies common-mode rejection for a remote terminal/data bus interface. No common-mode rejection is specified for an interface between an external device and a remote terminal, but a maximum common-mode output voltage is specified.