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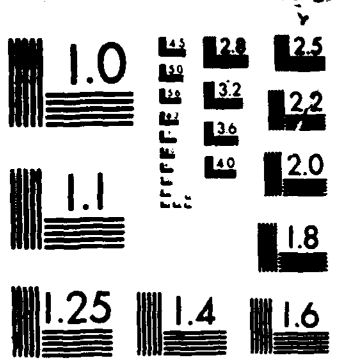

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INSTRUMENTATION AND COMMUNICATION SYSTEMS FOR SOUNDING ROCKETS AND SHUTTLE-BORNE EXPERIMENTS

by

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("Instrumentation and Communication Systems for Sounding Rockets and Shuttle-Borne Experiments")

This report deals with analysis, development and field support of instrumentation and telemetry systems for airborne vehicles. The BERT, ERNIE, EXCEDE and BEAR programs discussed require instrumentation and telemetry which operate under the adverse EMI environments created by electron guns, ion sources or particle beams. The PIIE and POLAR ARC vehicles carried low-modulation-index FM/FM systems. Signal processing, data formatting, encoding, tape recorders and packet telemetry are described for future shuttle flights under the GAS, VIPER and IMPS programs

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1.0 INTRODUCTION

This contract has been concerned with the analysis, development and field support of instrumentation and telemetry systems for sounding rockets and shuttle-borne experiments. Some of the initial work was carried over from the previous contract, F19628-80-C-0050 which covered the period of 4 December 1979 through 3 December 1982.

Section 2.0, which follows, contains discussions of those sounding rocket programs which involved our major efforts from the standpoint of importance, impact, cost or intensity. Most of these programs were successful from a scientific point of view and quality data was obtained. A few programs did not achieve their objectives because of vehicle or system malfunctions. Some programs are still in progress and the actual flights will not take place for one or two years into the future.

The BERT, ERNIE, EXCEDE and BEAR programs discussed in this section all involve instrumentation and telemetry systems which are required to operate under the adverse EMI environments created by electron guns, ion sources or particle beams. The PIIE and POLAR ARC vehicles carried analog FM/FM systems which were constrained to operate with narrower bandwidths than would otherwise be desired. The challenges to communication technology created by this range of adverse operating conditions were solved by the variety of techniques discussed in this section and run the range from remote data acquision units to experimentally determined pre-emphasis tapers.

Section 3.0 contains discussions of contract efforts under the GAS, VIPER and IMPS programs. The systems involved are expected to be flown on future shuttle flights. Signal processing circuits, data formatters, encoders, tape recorders and packet telemetry assignments are described.

Section 4.0 contains discussions of a number of smaller programs under which effort was expended. In some instances the major work was accomplished under the previous contract and efforts were mainly associated with field and launch support. At other times our contribution was merely of an advisory or consultive nature. Other programs in this section were prematurely brought to a close when funding was either terminated or reduced to zero.

Sectiion 5.0 contains a tabulation of field support, launch dates, and travel required to support the programs discussed in prior sections.

Section 6.0 summarized the contract effect devoted to testing components intended for rocket flights and the qualification of certain experiments for future shuttle launches.

2.0 MAJOR ROCKET PROGRAMS

2.1 Ionospheric Modification Study (IMS) (A20.327-1,2)

An experiment to study the effects of releasing sulphur hexaflouride and metalic samarium into the ionosphere was scheduled for flight during the fall of 1983. Two virtually identical payloads were to be carried on Brazilian Sonda III rockets out of the Wallops Flight Facility in Virginia. The primary sensing instrument was a quadrapole mass spectrometer. The chemicals were to be released by ground issued commands, or by an onboard flight timer used for backup. The command uplink utilized standard IRIG tones on a carrier frequency of 412 MHz.

The telemetry antenna selected for this flight was a PSL, 11 inch stripline which was fabricated with a metalic slotted shield normally used for thermal protection. This antenna was selected because PSL thought that the shield would help prevent coating of the antenna by the metalic samarium vapor as it was released from the payload.

Directional couplers were introduced between the transmitter and the antenna to measure the disturbance caused by this release. A five watt transmitter was selected in an attempt to maintain data transmission even under high attenuation conditions.

The telemetry system is shown in Figure 2.1 and consists of a programmable PCM encoder having the following specifications: 9600 Bits/Sec, 24 Words/Minor Frame, 5

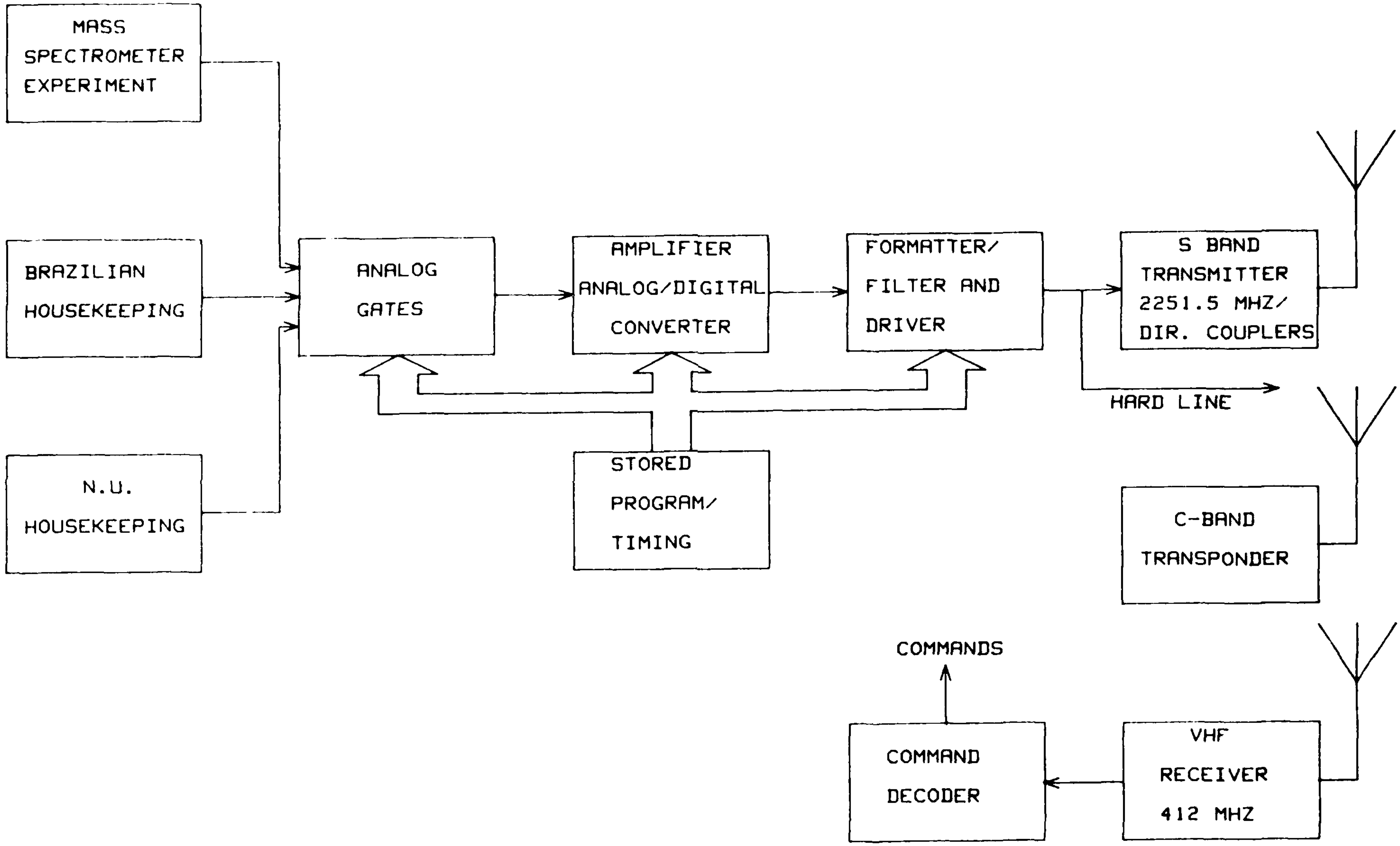


Figure 2.1

IMS TELEMETRY BLOCK DIAGRAM

Minor/Major Frame and 10 Major Frames/Sec. The data consisted of the following:

Mass Spectrometer

4 Channels at 100 samples/sec.

3 Channels at 10 samples/sec.

Brazilian Housekeeping

2 Channels at 100 samples/sec.

3 Channels at 10 samples/sec.

NU Housekeeping

1 Channel at 100 samples/sec.

22 Channels at 10 samples/sec.

The scientist stated that if possible, a change in telemetry format might be desirable on the second flight depending on data analysis of the first flight. An EPROM was programmed to these specifications for insertion into the encoder, if required, between flights.

System integration for the two payloads were conducted at AFGL during the first week of October 1983 and all field equipment was shipped immediately following successful completion of these tests.

The field party arrived at Wallops Island, VA on 19 October 83 and prepared for the first flight on 31 October 83. The second stage of the Sonda III rocket burned for only 5 out of the required 20 seconds, thus yielding no scientific data as the vehicle never reached minimum experimental altitude. The chemicals were released for engineering checks of the system by radio command. Due to weather, NATO activities, and other range commitments, the second round was delayed for two weeks. In this round, the second stage never ignited leading to essentially the same lack of required altitude for scientific purposes. As of this time, no reason for the motor failure has been found. Radar, up link commands and telemetry operated properly during both flights.

During the samarium release a complete RF blackout occurred lasting for from 1 to 2 seconds, followed by a gradual return to normal signals in another two seconds. The VSWR monitored on the directional couplers did not change appreciably after the release, but did change during the powered portion of the flight. At lift-off the VSWR was approximately 1.5 and it reached 2.9 at 250 seconds into the flight. At this point it gradually returned back to 1.5. This effect has tentatively been attributed to dynamic heating of the antenna.

2.2 BERT and ERNIE

The BERT and ERNIE experiments were both carried on the same launch vehicle. The ERNIE payload was located on top (forward) of BERT and separated from it at a specified altitude. It was intended to measure the disturbances caused by the BERT experiment.

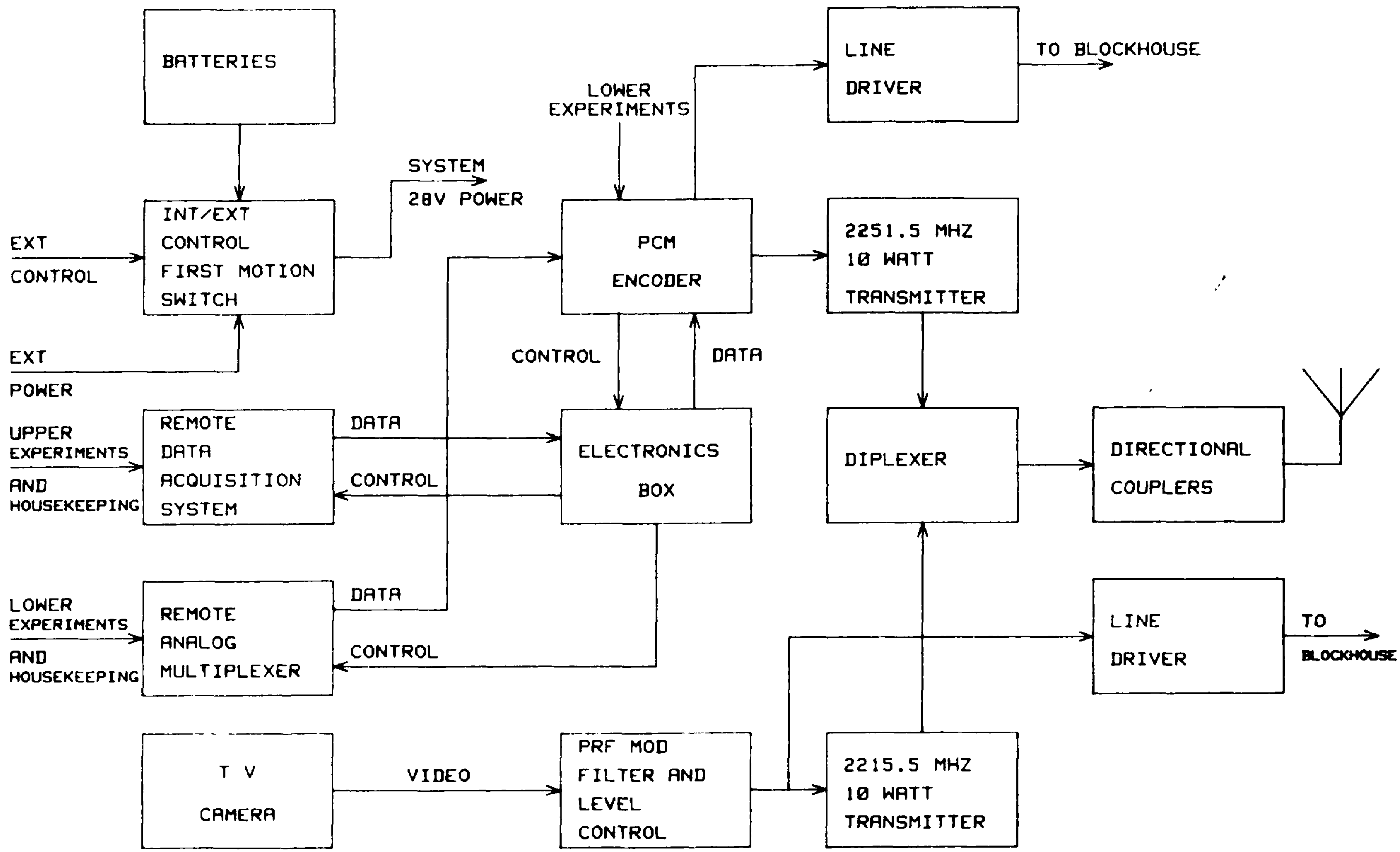
2.2.1 Beam Emission Rocket Technology (BERT-I)

The BERT experiment was developed to eject charge into the ionosphere from a space vehicle and then measure the relationship between this charge and the subsequent charge build-up on the vehicle. In addition, an automatic discharge system for the vehicle was included for evaluation.

Charge producing instruments included an electron gun, a plasma source and source to produce an ion beam. The instruments used to measure the charge, the plasma produced by the charge ejection and the electromagnetic waves produced in the plasma included photometers, spectrometers, electrostatic analyser, mass spectrometer, TV camera and high impedance voltmeters. The payload was to be carried on a NIKE/BLACK BRANT V rocket and launched at night from White Sands Missile Range.

The telemetry system is shown in Figure 2.2.1-1 included a PCM/FM link and a television/FM link. Ranging and location was provided by a C-Band radar transponder. Both the TV and PCM transmitters were multiplexed onto a single circular stripline antenna.

The PCM data acquisition system had the following specifications: 108 WORDS/MINOR FRAME, 222.22 MINOR FRAMES/SEC, 192.0 KILOBITS/SEC, 10 MINOR FRAMES/MAJOR FRAME and 8 BITS/WORD. The synchronization word was 24 bits long using a standard IRIG specified code. A remote data



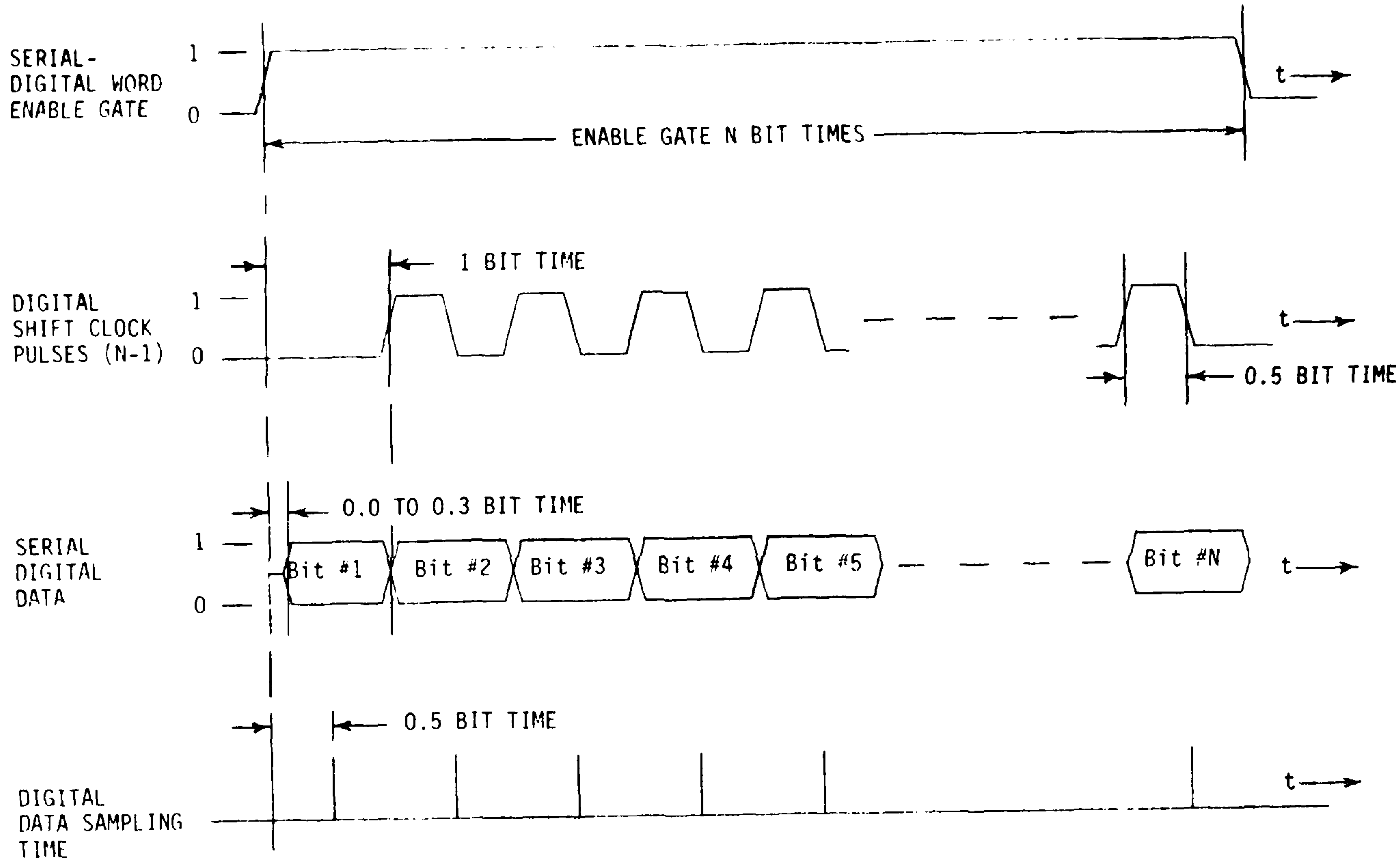
BERT I TELEMETRY SYSTEM

Figure 2.2.1-1

acquisition system (RDAS) was used to interface with the encoder and bring data in an optically-isolated digital format from the instruments in the nose end of the vehicle to the PCM encoder. This RDAS is described in Scientific Report No. 1 of this contract. A remote analog multiplexer was used to prepare data of a primarily housekeeping nature for transmission to the encoder.

A detailed description of the PCM encoders direct digital input and the experimental source interface was presented to all experimenters requiring this type service. This interface consisted of an enable gate and shift clock to the experiment and the serial data to the encoder. The timing details are shown in Figure 2.2.1-2.

Extensive testing was planned for the high vacuum chamber at the NASA facility in Houston. For full simulation, the body of the vehicle had to be allowed to float from ground in order that charging take place. This requirement necessitated that all interfacing for external controls and monitors be electrically isolated from the vehicle. The data was isolated via a fiber optic cable and the television signal was isolated by modulating the video signal onto a Channel 3 carrier and passing the result through a high voltage RF transformer. This technique was employed since direct transmission from the vehicle transmitters was not expected to provide a good signal due to the multipath problems of transmitting and receiving in



All timing is referenced to the 50 percent amplitude point of the leading or trailing edge of the pulse.

Figure 2.2.1-2. Timing Relationships, Serial-Digital Data a metal enclosure. Furthermore, the time duration of the tests in a vacuum would also present a thermal problem if the transmitters were on continuously.

Testing of the lower section instruments began in June 1984. This phase of tests was concluded with a vacuum chamber test at AFGL with all systems functional.

Upper experiments (above the electron gun section) were tested in the fall of 1984. Experiments and system programmers encountered difficulties and trouble shooting, both at AFGL and at the manufacturers facilities, was extensive.

A "full-up" operational test was conducted at the end of the February 1985 including all the isolation controls and monitors designed for the Houston test. Magnetic tapes were recorded to test the ability of the data reduction facilities to process the data. These tests were completed successfully.

The vehicle and the ground support equipment were shipped to Houston early in March 1985. After pre-vacuum operational tests were completed, a full week of the test were conducted in the chamber under various conditions of pressure, plasma and electron gun intensity. All scientific test requirements were successfully completed by the scientists.

After returning to AFGL, the payload was subjected to shock and vibration tests at Acton Testing Laboratories on

16 May 1985. After verifying that all systems were operational, the payload and ground support equipment were shipped to White Sands Missile Range for launch.

The field party arrived on 2 June 85. The flight system was set up in the preflight assembly building for final testing, calibration and integration. After these tests, the ERNIE section was mated with the BERT section and the resultant payload was mounted on a Nike/Black Brant V launch vehicle. After erection in the tower a final vertical checkout and countdown simulation was conducted.

Launch of the BERT-I vehicle took place at 0020 on 14 June 85. All systems (BERT, PCM, TELEVISION and ERNIE) were operating properly and the booms had been extended. Then, 103 seconds into the flight the main experiment programmer was turned on and a malfunction occurred. This happened well after the powered portion of the flight, indicating that the malfunction was not due to vibration, shock, thermal stress or boom extension, but related in some way to charge or plasma produced from the operation of the guns. Problems of this nature were anticipated during the design phase and signal and control lines were isolated and shielded.

Analysis of the flight data indicated two separate anomalies. The first occurred at approximately T + 103 seconds and manifested itself as a loss of word and ID syncronization, although at no time during the entire flight was bit syncronization lost. The probable cause of this malfunction was noise induced on the word address bus which originates at the microcomputer and connects to the combinational logic within the PCM encoder, as well as the combinational logic within the electronics box and the RMUX box. The wiring of this bus was exposed to the outside of the vehicle by two rectangular openings in the TM section skin. The holes were provided to hinge the booms upon which the plasma sheath monitors were mounted. Noise on this bus could produce the following malfunctions:

1) Disruption of combinational logic signals within the PCM encoder resulting in the improper selection on sync words and ID words, and all data inputs.

2) Disruption of combinational logic signals within the electronics box resulting in erroneous major frame sync strobes, word advance strobes and word enable gates. These errors would cause the analog input pointer of the RDAS to be arbitrarily reset or advanced, resulting in improper data selection and the improper selection of experimental digital data.

A second anomily occurred at approximately T + 122 seconds which caused a malfunction in the parity generation circuit. This resulted in the data being shifted one bit toward the LSB, truncating the LSB and inserting a zero in the MSB position. This resulted in halving the digital word. However, a substantial portion of the data has been reconstructed since bit slippage did not take place during the entire flight and certain data and sync words were constant throughout the flight. Since these known words could be located, the algorithm was used to determine the validity of other data. Using this technique, it was found that there were also malfunctions in the main BERT programmer, which resulted in the instruments not being properly exercised.

An important difference between the Houston simulation and the actual flight was that the two rectangular holes in the telemetry section, left when the booms for the Faraday cups were extended, were protected with a copper mesh screen in Houston, but left open during the flight. It is conjuctured that return currents or plasma entered these openings and induced the EMI which resulted in the above symptoms.

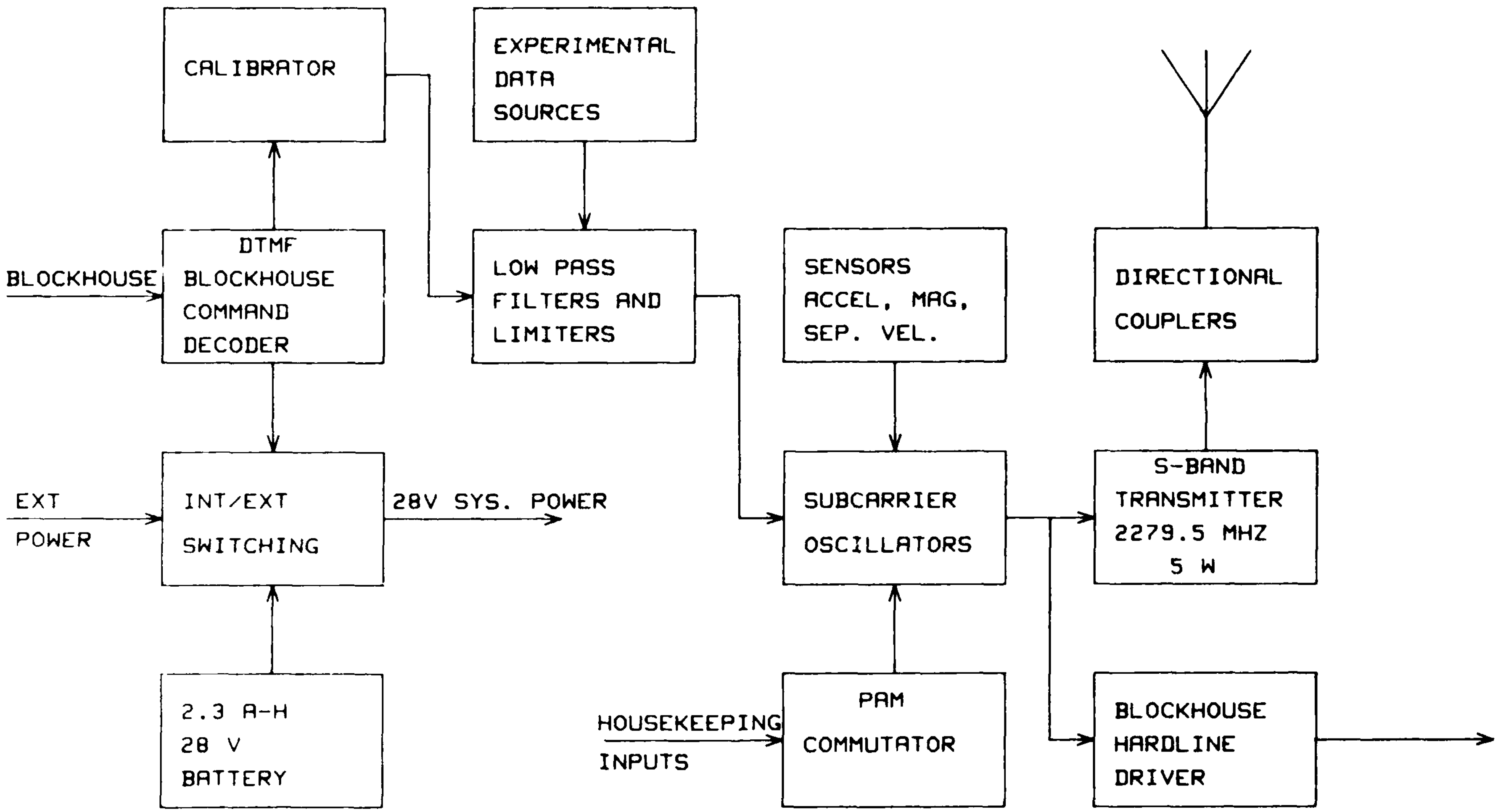
2.2.2 ERNIE (Experiment on BERT-I A19.250)

The ERNIE payload is a self contained system which was designed to make electric and magnetic field measurements on the disturbances caused by the electron gun and plasma sources on the BERT-I payload described in the previous another section of this report. The ERNIE payload sat physically on top of the BERT payload using a common launch vehicle. At specified altitude, the ERNIE payload separated from BERT and made its measurements.

Referring to Figure 2.2.2, the data acquisition and transmission system consisted of a circular stripline antenna, two directional couplers, 5-watt S-Band transmitter, 17 subcarrier oscillators, premodulation filters and limiters, preflight calibrator, PAM commutator and hardline driver. Housekeeping signals monitored temperatures, voltages, relay and boom position sensor outputs. Vehicle diagnostics consisted of accelerators, magnetometers and a separation velocity monitor. The experimental data consists of various electromagnetic field wave analyzers.

Since experimental requirements made it necessary to use very high frequency subcarrier oscillators with low modulation indexes, an analysis was made to determine its effect on the signal-to-noise ratio in these channels. At low modulation indexes the large bandwidth of the individual channels can cause cross modulation into adjacent channels and carrier feedthrough into individual subcarrier discriminators. The extra bandwidth also allows more noise to pass through the discriminator's low-pass filter.

During system development pre-emphasis taper was calculated, using the modulation index of each subcarrier oscillator as one of the factors, to arrive at deviation settings for equal signal-to-noise ratios at the output of each discriminator. A laboratory experiment to make noise measurements on subcarrier oscillators with low modulation



ERNIE DATA ACQUISITION/TRANSMISSION SYSTEM

Figure 2.2.2.

indexes was then instrumented. The experiment used 3 subcarrier oscillators (D,F, and H), and a variety of subcarrier discriminators. Noise levels of up to 5 volts peak-to-peak out of a 10 volt peak-to-peak signal were measured, with an average noise of 2 volts peak-to-peak.

It was also found that the output noise level was a strong function of the quality of the discriminators. The discriminators with single-pole bandpass filters and 2-pole low-pass output filters were significantly noisier than discriminators with higher order filters. E.M.R. Corporation, a manufacturer of discriminators was contacted and suggested discriminators with 7 pole output filters to minimize carrier feedthrough. To lessen interaction between adjacent channels, 4 pole low-pass premodulation filters were placed before the subcarrier osciillators and electronic limiters were placed before the filters to assure that the subcarrier oscillators stayed in band.

The telemetry engineer from Computer Science Corporation who instrumented a similar telemetry system for the project scientist was also contacted. He said that he also encountered high noise levels on the channels, but that the scientists were satisfied with the results, and willing to trade lower signal-to-noise ratios for increased bandwidth.

A preflight calibrator was designed for this payload using DTMF (dual tone multiple frequency) commands from the blockhouse to the payload. (The standard tones used in tone telephone dialing were employed.) The tones were decoded in the payload to digital levels and then applied to the input port of a microcomputer. The calibration levels applied to the inputs of the subcarrier consisted of the following:

1. 0.0 - 5.0V SINE WAVE
2. 0.0 - 5.0V TRIANGULAR WAVE
3. 0.0 - 5.0V 11 POINT STAIRCASE
4. 0.0V CONSTANT
5. 2.5V CONSTANT
6. 5.0V CONSTANT

Power to the calibrator was supplied from the blockhouse which assured that the calibrator would be inactive at liftoff, thus precluding the possibility of latching in a calibrate mode.

System integration was conducted at AFGL during the last week of November 1984. It was found at this time that the Channel J subcarrier oscillators could not respond to input frequencies in excess of 30 KHz. They were supposed to accept up to 45 KHz when a modulation index of unity was used. The modulation preemphasis taper was recalculated to account for the lower information bandwidth and changes were made in hardware to make this modification. All systems performed satisfactorily through shock and vibration. Calibrations were recertified after tests were completed. The flight systems and ground support were then packed for shipment to Houston (Johnson Space Center) for flight simulations with the BERT payload in a large vacuum chamber.

After successful testing in Houston, the payload was shipped back to AFGL for final calibrations. A mixer amplifier which became noisy had to be replaced at this time. Also, a third magnetometer was added to the payload as computer simulations indicated the possibility of end-over-end tumbling after separation from BERT. An additional subcarrier oscillator was added to provide a data channel for this magnetometer.

The flight field party arrived at White Sands Missile Range in New Mexico on 2 June 85. Preflight calibrations and simulated countdowns were conducted. A noisy subcarrier oscillator was replaced during the horizontal checks. The ERNIE payload was connected to the BERT payload, then mounted on the launch vehicle. The vehicle was mounted in the tower for a final verticle checkout. Launch took place at 0020 MDST on 14 June 85. Instrumentation and telemetry performed properly for the entire flight. There was no recovery planned for this payload.

2.3 Beam Experiments Aboard Rockets (BEAR)

At Los Alamos National Laboratories the construction of a neutral beam particle accelerator, fully instrumented to monitor the characteristic of the beam, is in progress.

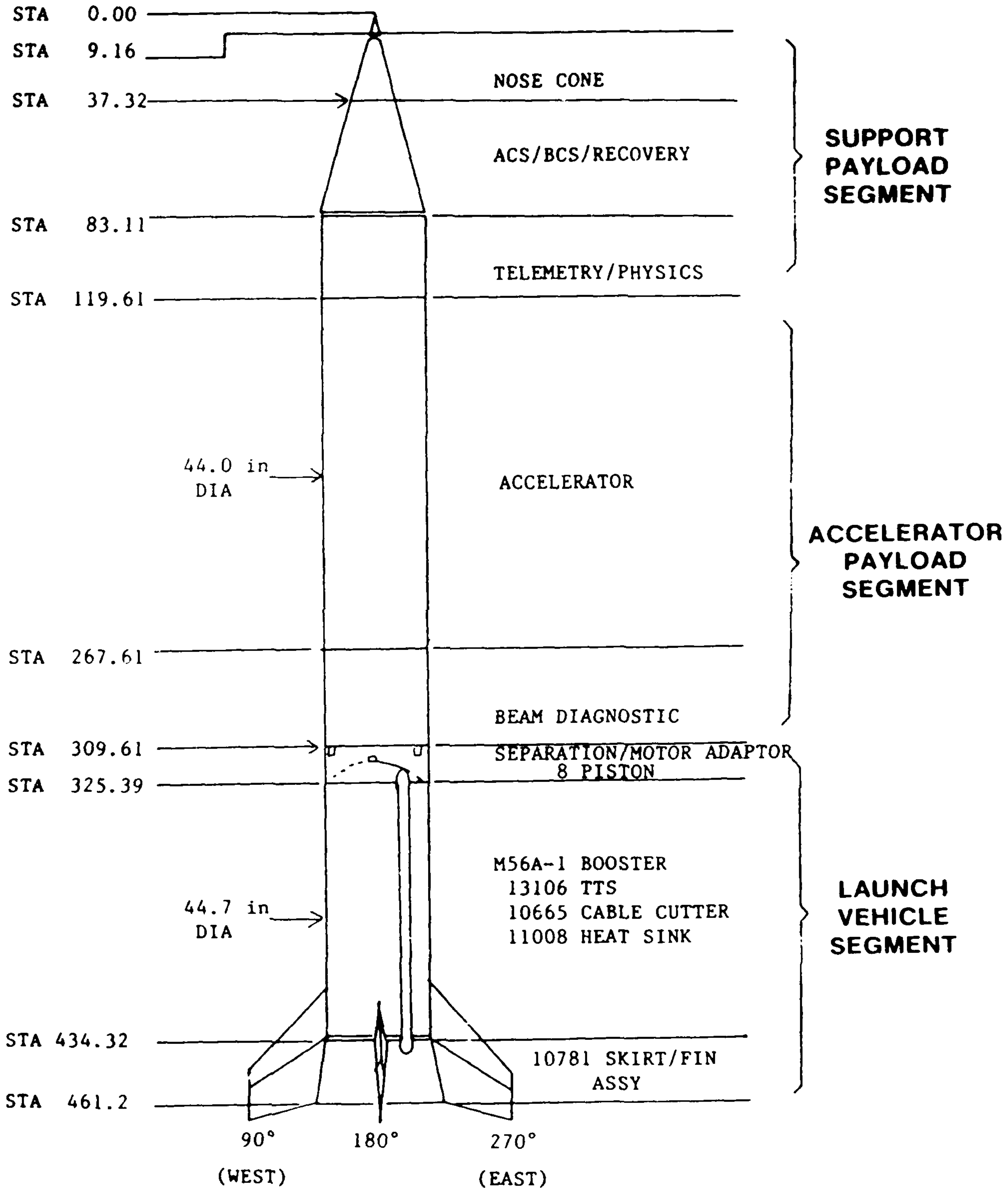
This accelerator is expected to be flown in FY88 on an M56A-1 booster from the White Sands Missile Range. The payload will consist on the following major components:

1. An ion generator (H^+).
2. A R.F. quadrapole accelerator.
3. A beam diagnostic section.
4. A telemetry section.
5. A physics experiment section.
6. An attitude control system.
7. A recovery system.
8. A booster motor.

Figure 2.3-1 shows the relative location of these systems on the vehicle.

The telemetry system will have five r-f links. Two for the accelerator/beam diagnostic PCM data configured for redundant transmission of data, a television link for video data from the beam diagnostic cameras, a housekeeping/physics PCM data link and a wide-band FM link for one of the physics experiments. There will also be on board two magnetic tape recorders for redundancy in case of r.f. failure. One will record the accelerator data, the other the beam diagnostic data. Three transmitters will be triplexed on to a circular stripline antenna mounted on the lower end of the telemetry section, the other two transmitters will be diplexed on another similar antenna located on the top end of the telemetry section. For

BEAR-1 SYSTEM STACK UP



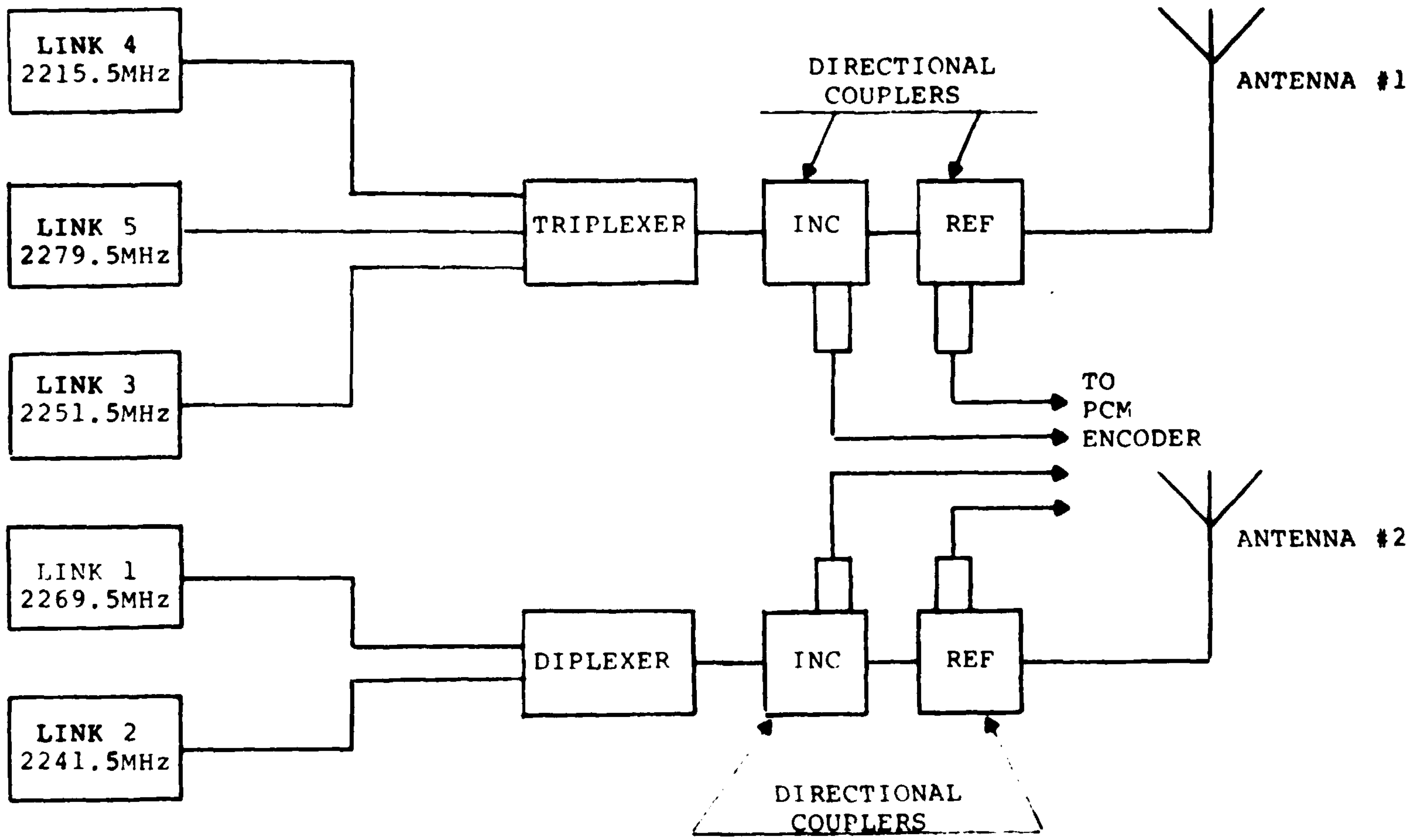
NOTE: Umbilical mast is at 225° as defined above.

Figure 2.3-1.

diagnostics, detected directional couplers will monitor incident and reflected power on both antennas. A C-Band radar transponder will be used for payload tradjectory monitoring. Figure 2.3-2 is a block diagram of the RF system.

The accelerator and beam diagnostics PCM data will be supplied to the telemetry section in a NRZ-L format at 63 Kilobits/second each. They will then be formatted into two combined signals. One signal will contain the accelerator data in a NRZ-S format along with the beam diagnostics data in a 252 Kilobit/second PSK format. The other signal will have reversed roles, the beam diagnostics in a NRZ-S format along with the accelerator data in a 252 Kilobit/second PSK format. Each of the combined signals will modulate a transmitter, thus providing each transmitter with complete sets of redundant data. The transmitters will also be multiplexed onto different antennas for further redundancy.

The tape recorders to be used on this flight are modified computer cartridge types from Digi-Data Corporation. The tapes were modified to record and play back 63 Kilobit/second bi-phase data. The control circuitry was also modified for sounding rocket applications. The recorders will be housed in a pressure vessel and contain their own DC/DC converters. The mechanical structure was ruggedized for meeting the shock and vibration specifications for systems on this motor. Preliminary



BEAR RF TELEMETRY SYSTEMS

Figure 2.3-2.

shock and vibration test at component and system acceptance levels were successfully conducted in mid December 1986. The prototype recorder will also be tested to qualification levels at a later date. Three flight units have been ordered.

The physics section of the payload will house experiments from Naval Research Laboratory (NRL), Hughes, and Science Applications International Corporation (SAIC). The instruments will consist of voltmeters, ion gages, ion sources, electrostatic analysers, langmuir probes and plasma wave receivers. The signals from these experiments, both analog and digital, will be multiplexed with housekeeping and attitude control signals into a PCM bits stream at approximately one megabit/second.

Initial EMI tests were conducted at the accelerator facility at Los Alamos National Laboratory in the first week of October 1985. A simulated data acquisition system consisting of an S-Band transmitter and antenna, a PCM encoder and simulated data sources was placed in proximity to the ion source generator under various conditions of operation. The signals were received by a ground station consisting of a receiver, antenna, PCM bit sync and word decom., strip chart, and oscilloscope. The only noise produced by the ion source that could be detected was small voltage spikes that occurred during high voltage arc over which occurred on initial formation of the source. The data acquisition system used is similar to that proposed for the BEAR payload.

The EMI precautions that will be incorporated on the BEAR payload are summarized in Table 2.3. As noted in the table, a higher level of protection is incorporated in signals which traverse the boundary between the accelerator and telemetry section.

SUMMARY OF EMI PRECAUTIONS

1.) ALL TELEMETRY COMPONENTS HOUSED IN SEALED SECTION.

2.) TELEMETRY/CONTROL FUNDTIONS TO BAND FROM ACCELEROMETER AND BEAM DIAGNOSTIC SECTION OPTICALLY ISOLATED.

3.) TELEMETRY SIGNALS TO AND FROM MOTOR CAP SECTION OPTI CALLY ISOLATED.

4.) ALL LOCALLY PRODUCED ANALOG AND DIGITAL SIGNALS (HOUSE-KEEPING, ATTITUDE CONTROL, PHYSICS) WILL HAVE EMI SURGE ARRESTERS UPON ENTERING TELEMETRY COMPONENTS.

5.) ALL WIRING HARNESSES WILL BE SHIELDED AND GROUNDED.

6.) R.F. TRANSMISSION OF ACCELEROMETER AND BEAM DIAGNOSTIC SIGNALS WILL BE TOTALLY REDUNDANT.

7.) ABOVE DATA WILL ALSO BE RECORDED ON TWO ONBOARD TAPE RECORDERS.

8.) A MECHANICAL TIMER WILL BE USED TO INITIATE FUNDTIONS OCCURRING DURING "BEAM ON" TIME.

9.) A PRESSURE SENSITIVE SWITCH WILL INHIBIT ALL SHUTDOWN TIMING FUNDTIONS FROM INADVERTENTLY OCCURING ABOVE AN ALTITUDE OF 75K FEET.

TABLE 2.3

All baseband signals used to modulate the transmitters will also be brought directly to the blockhouse via line drivers and coaxial cables to allow long term testing without the requirement to radiate. A general block diagram of the BEAR telemetry system is shown in Figure 2.3-3.

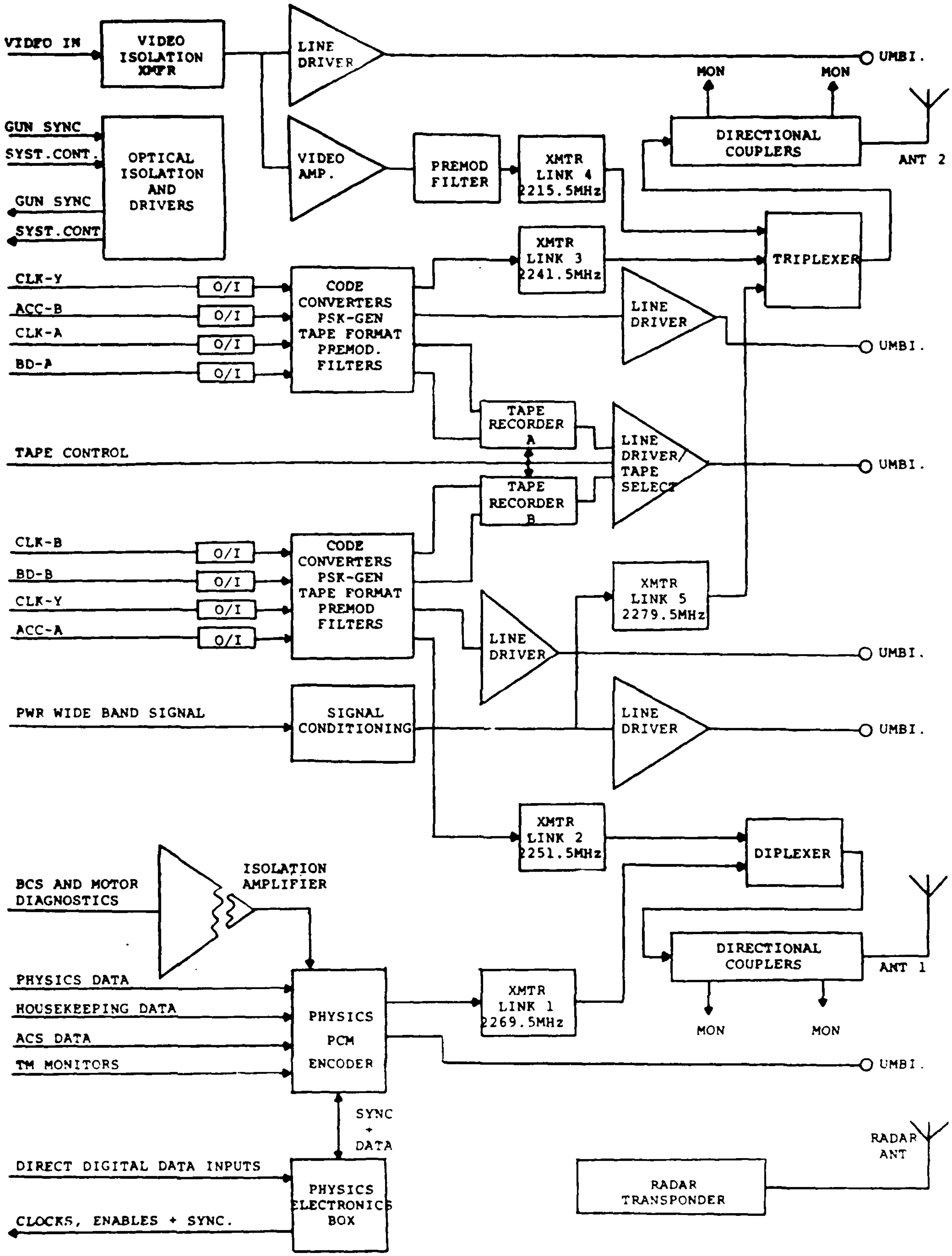
The PDR was held on 7 January 1986 and the CDR was held on 23 June 1986.

Technical Interchange Meetings (TIM) have been held on a monthly or bimonthly schedule since the program began.

Before the flight of this payload, extensive testing will be conducted in a vacuum chamber at a location to be determined at a later date. These tests will verify the characteristics of the beam as well as the operation and reliability of all support systems.

2.4 EXCEDE III

This program is a DNA supported project by AFGL. It will use an Aries launched vehicle carrying two payloads to 130 kilometers at the White Sands Missile Range. One payload, the gun module, will carry a group of four electron guns, each operating at 3 kilovolts and with a maximum current of about 10 amperes each. The gun module will also carry cameras, an electrostatic analyzer, and other diagnostic instrumentation. The second payload, the sensor module, will carry a variety of sensors which will cover the spectral range from 0.15 to 24 micrometers. These instruments will include an infrared interferometer, an



BEAR TELEMETRY BLOCK DIAGRAM

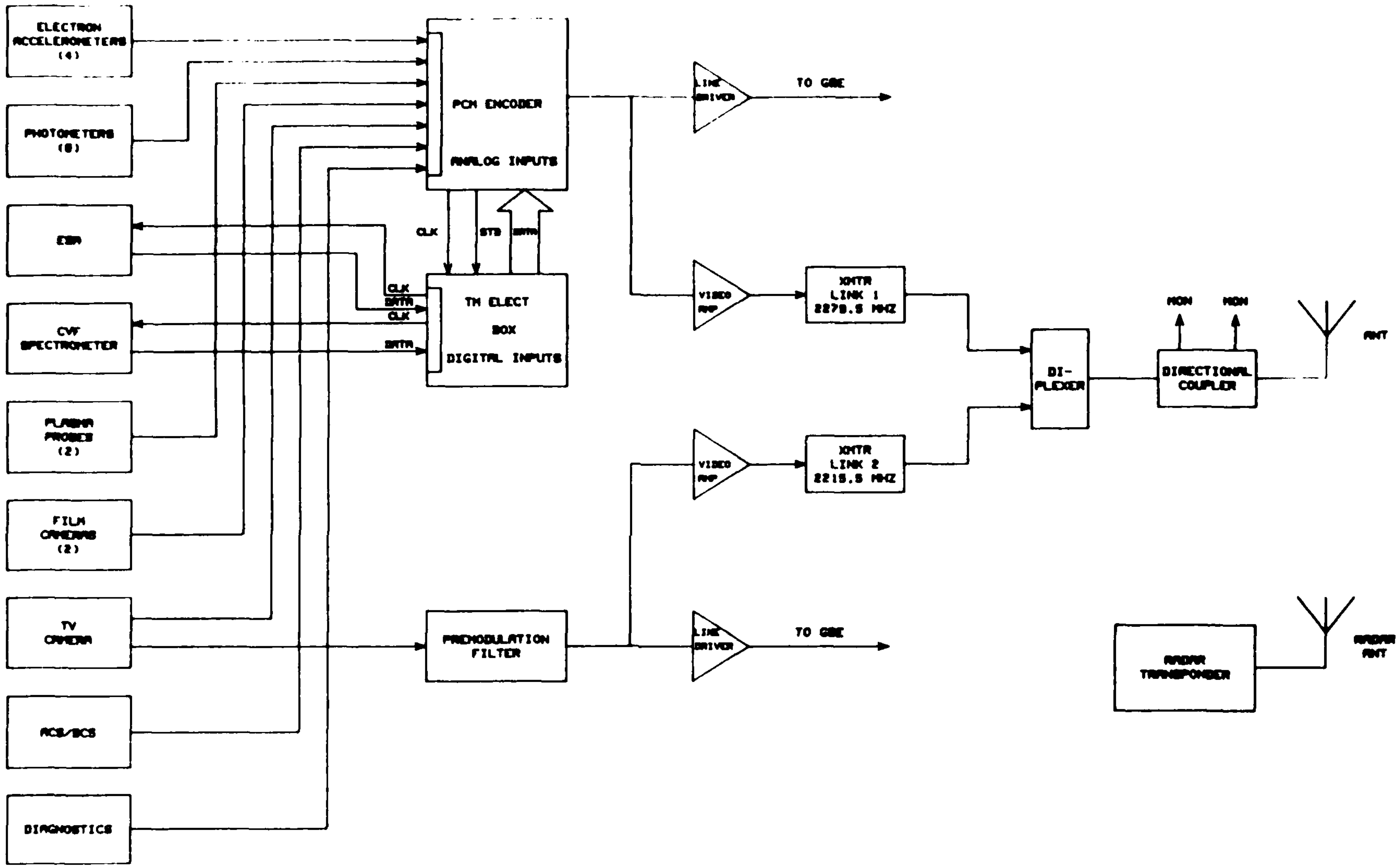
Figure 2.3-3.

infrared spatial circularly variable filter spectrometer, an infrared spatial radiometer, ultraviolet and visible spectrometers, scanning filter photometers, cameras and an atomic oxygen resonance flourescence experiment.

The prime objective for the EXCEDE III flight is to determine spatial/temporal measurements of the infrared radiance produced in the upper atmosphere by controlled dosing without interference from degassants or beam-plasma interactions. This will be accomplished by sealing the gun module so that only the external surface can degas. By using a separate sensor module the instruments can be located to the side of the beam rather than at the base of the beam. This will allow a better perspective and an unambiguous relation of the angular displacement between the lines-of-sight and the beam, and the time after excitation.

Northeastern University commenced work on the EXCEDE program during FY85. Once the early planning was over, ERL (Electronic Research Laboratory) was given responsibility for the telemetry on the gun module and the television systems on both the gun and sensor modules. Oklahoma State University undertook the sensor module telemetry as well as the gound-to-air and inter-vehicle ranging systems. Unfortunately funding was not carried into FY87 so that work on this program has been brought to a stop.

A block diagram of the proposed gun module system is shown in Figure 2.4. The PCM/FM system shown will use a



EXCEDE III GUN MODULE BLOCK DIAGRAM

Figure 2.4.

standard Northeastern programmable encoder. Optical isolators will be used between data sources and the encoder where possible.

The television system for the sensor module will consist of an image intensified solid state camera capable of very low light level sensitivity and wide dynamic range. The exact requirements have not yet been defined by the project scientists, thus the specific make and model of camera have not been selected. The cameras will output an RS 330 format (a relaxed RS 170 format) which will allow viewing on standard video monitors. Ten watt transmitters with preemphasis deviation in accordance with CCIR-405 will be required.

2.5 Polar Ionospheric Irregularities Experiment (PIIE)

A mission to measure polar cap disturbances in the ionosphere with a rocket borne payload from Stromfjord, Greenland was scheduled for early 1985. The instrumentation included a mass spectrometer, plasma probes, electron spectrometer and electric field probes. The telemetry system utilized both an FM/FM and PCM links, C-Band beacon and a TRADAT ranging system. There was also an attitude control system to maintain the front of the payload in the direction of the flight path.

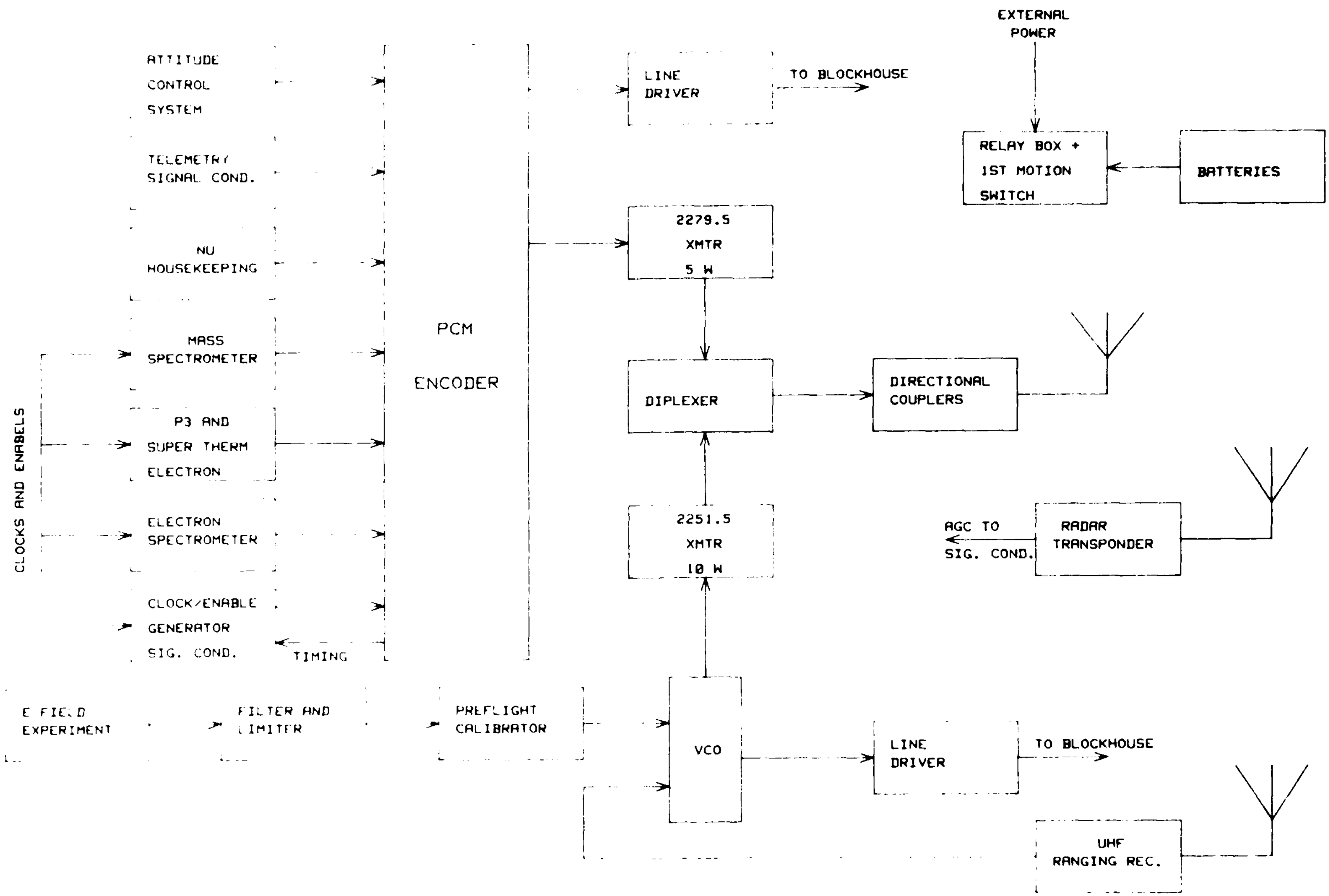
The FM/FM link used a 10 watt transmitter at a frequency of 2251.5 MHz. Like the FM/FM link described in the ERNIE section of this report, high-frequency subcarrier oscillators using low-modulation indexes were utilized. The discussion on noise and modulation pre-emphasis tapers in the ERNIE section of this report applies directly to the PIIE FM/FM system. The PCM/FM link utilized a 5 watt transmitter at a frequency of 2279.5 MHz. Figure 2.5 is a block diagram of the data acquisition telemetry system. Line drivers provided the blockhouse with the base band signals from both links. The PCM system operated at 258.048K bits/sec.

This payload used a preflight calibrator identical to the one described in the ERNIE section of this report.

System integration was completed during the second week of November 1984 at AFGL with shock and vibration test being made at Acton Laboratories on the next weekend.

As in the ERNIE payload, it was found that the Channel J subcarrier oscillator could not respond to the 45 KHz information frequency that it was rated for. The data frequency was then reduced to 30 KHz and a new premodulation taper was calculated and implemented in hardware. After final post shock and vibration calibrations were completed, the flight systems and ground support equipment were shipped to Greenland.

The field party arrived on 22 February 1985. Preflight checks were completed and the vehicle was placed in the tower on the 7th of March. The vehicle was launched on 15 March 1985 with all systems performing satisfactorily.



PIIE TM BLOCK DIAGRAM

Figure 2.5.

Apogee was 428.8 Km with impact 232 Km down range. There were no RF dropouts from liftoff to LOS just before impact.

2.6 POLAR ARCS

2.6.1 Introduction

A telemetry system was designed and constructed for a payload to be flown on a Black Brant rocket in the POLAR ARCS program at Sondrestrom Air Base, Greenland. The vehicle A21.428 consisted of two instrumented sections: a mother and daughter. The daughter section with its own telemetry link was designed to be ejected during the flight. Only the data from the instruments on the mother vehicle were handled by the system described in this section of the report.

The instruments carried on the mother vehicle included a Soft Particle Spectrometer and a Top Hat Analyzer by Southwest Research Institute, Ac Magnetometer by Danish Space Research Institute and a Quadrupole Ion Mass Spectrometer by Air Force Geophysics Laboratory. Electric Field instruments were supplied by Systems Unlimitted, while the Navy Research Laboratory flew the Pulsed Plasma Probes. The payload also contained an Attitude Control System by Space Vector Corp. Two data links were employed to transmit a total of 14 analog data channels and 128 digitized signals generated by the instruments and payload monitors. A 10 watt S-band transmitter operating at 2251.5 MHz carried the

FM/FM signals. The PCM/FM link of 307.2 kbps employed a 5 watt transmitter at 2279.5 MHz. Both links were diplexed on a single wrap-around microstrip antenna.

2.6.2 FM/FM System

The clasical modified 3/2 power taper design for the POLAR ARCS FM/FM system could not be implemented. The number o high frequency data signals confined within a single link of limited power, restricted transmitter deviation and the available IF bandwidth of the receivers could not be accommodated by the classical design requiring a 40 db S/N ratio at the threshold. Designs for relaxed, but equal S/N ratios in all channels also met with disasterous results when tested. The intermodulation products of the highest subcarrier oscillators generated by system nonlinearities introduced unacceptable amounts of noise in the lower channels. The final design sacrificed the S/N ratios of the highest channels in favor of the lower subcarrier channels. This approach reduced the noise caused by the intermodulation products. Although somewhat degraded, the projected S/N ratios curing the flight in the highest channels were aceptable to the users.

The design parameters and the expected performance of the FM/FM system are presented in Figure 2.6.2. Worst case parameters were used in the calculations. Notably, a -8 db gain was assumed for the flight antenna. This figure represents the antenna gain at the two rather sharp nulls.

FM/FM SYSTEM FOR: POLAR ARCS DATE:11/25/86

X-MTR. FREQ.:	2251.50 MHz
X-MTR. POWER:	10.00 W.
X-MTR.ANT.GAIN:	-8.00 DB
RECV.ANT.GAIN:	34.53 DB
RANGE:	450.00 km
POLARIZATION LOSS:	3.00 DB
OTHER LOSSES:	3.00 DB
NOISE TEMP.:	250.00 DEG.K
IF BW:	3300.00 kHz
CALCULATED IF BW:	2844.00 kHZ
X-MTR PEAK DEVIATION	862.00 kHz
CARRIER S/N:	17.41 DB

UNLESS O.N.:FREQUENCY IN kHz;S/N IN DB;RESISTORS IN kOhms.

NO.	CH.	FREQ.	MOD.I	DATA FREQ.	X-MTR.DEV.	DATA S/N	THRSHLD	TAPER R(K)
1	25	560.000	1.40	30.000	220	31.4	24.0	10.0
2	24	400.000	2.00	15.000	116	34.9	27.4	61.1
3	23	300.000	1.50	15.000	116	34.9	27.4	61.1
4	22	225.000	1.69	10.000	100	38.8	31.4	78.4
5	21	165.000	1.24	10.000	100	38.8	31.4	78.4
6	20	124.000	1.86	5.000	56	42.8	35.4	176.9
7	19	93.000	1.40	5.000	56	42.8	35.4	176.9
8	18	70.000	1.35	3.900	43	43.8	36.4	244.6
9	17	52.500	2.46	1.600	18	47.8	40.4	649.7
10	16	40.000	3.00	1.000	11	49.7	42.3	1093.0
11	15	30.000	2.25	1.000	11	49.7	42.3	1093.0
12	13	14.500	4.94	.220	5	62.6	55.1	2461.0
13	12	10.500	4.92	.160	5	66.7	59.3	2461.0
14	11	7.350	5.01	.110	5	71.6	64.2	2461.0

Figure 2.6.2. Design Parameters for FM/FM

These nulls occur in the antenna pattern when looking into the front or the aft end of the vehicle. Duringthe data gathering phase of the flight, the payload will be placed on its node. Therefore, the receiving antennas will see that portion of the vehicle antenna pattern which exhibits 1 to 3 db gain. Thus, an improvement of 9 to 10 db in the projected S/N ratios may be expected if the vehicle follows the prescribed flight plan.

Standard commercial components were used to implement the FM/FM system. Microminiature subcarrier oscillators, mixer amplifier and mount (Vector MMO-11, MMA-11 and MMM655-16 respectively) formed the frequency multiplexer. The output of the transmitter (Vector T110S) was combined in a diplexer (Wavecom S-201-18A) with the PCM/FM transmitter signal to drive the microstrip antenna (PSL 55.805). The analog signals were routed through an Electronics Box before entering the subcarrier oscillators. In the Electronics Box the signals could be inteerrupted to inject internally generated calibration signals into the subcarrier oscillators. The calibrator is deactivated during lift-off and the solid state signal switches automatically return into the default mode connecting the data signals to the subcarrier oscillators. Further description of the calibrator is given in the section on the Electronics Box.

2.6.3 PCM/FM System

A total of 128 data and monitor signals were transmitted at 307.2 kbps through the PCM/FM system. Bulk of the data transmitted over the link required conversion into a digital form. Although few of the monitor signals were bi-level in nature, they too wer converted into the digital words to fill the available channels. Over 60 kbps data were received by the encoder already in the digital form and required only an insertion into the PCM bit stream.

The digital data were transmitted to the encoder from the electronics box over a parallel interface. The electronics box received the data over four serial digital links. The control of the transmission rested with the electronics box which supplied the ENABLE signals to each of the four links as needed. The CLOCK, MINOR FRAME SYNC and the MAJOR FRAME SYNC were common to all four data channels. The 8 bit NRZ data words were transmitted at the PCM bit rate just prior to the insertion into the PCM data train. Thus, the data were requested from the four channels at different times during the minor frame.

A twisted shielded pairs of wires were used to transmit data and the control signals. Single ended drivers supplied current to the diodes of optically isolated receivers. The data link circuits and the timings diagram for the transfer of a single word are shown in Figure 2.6.3-1.

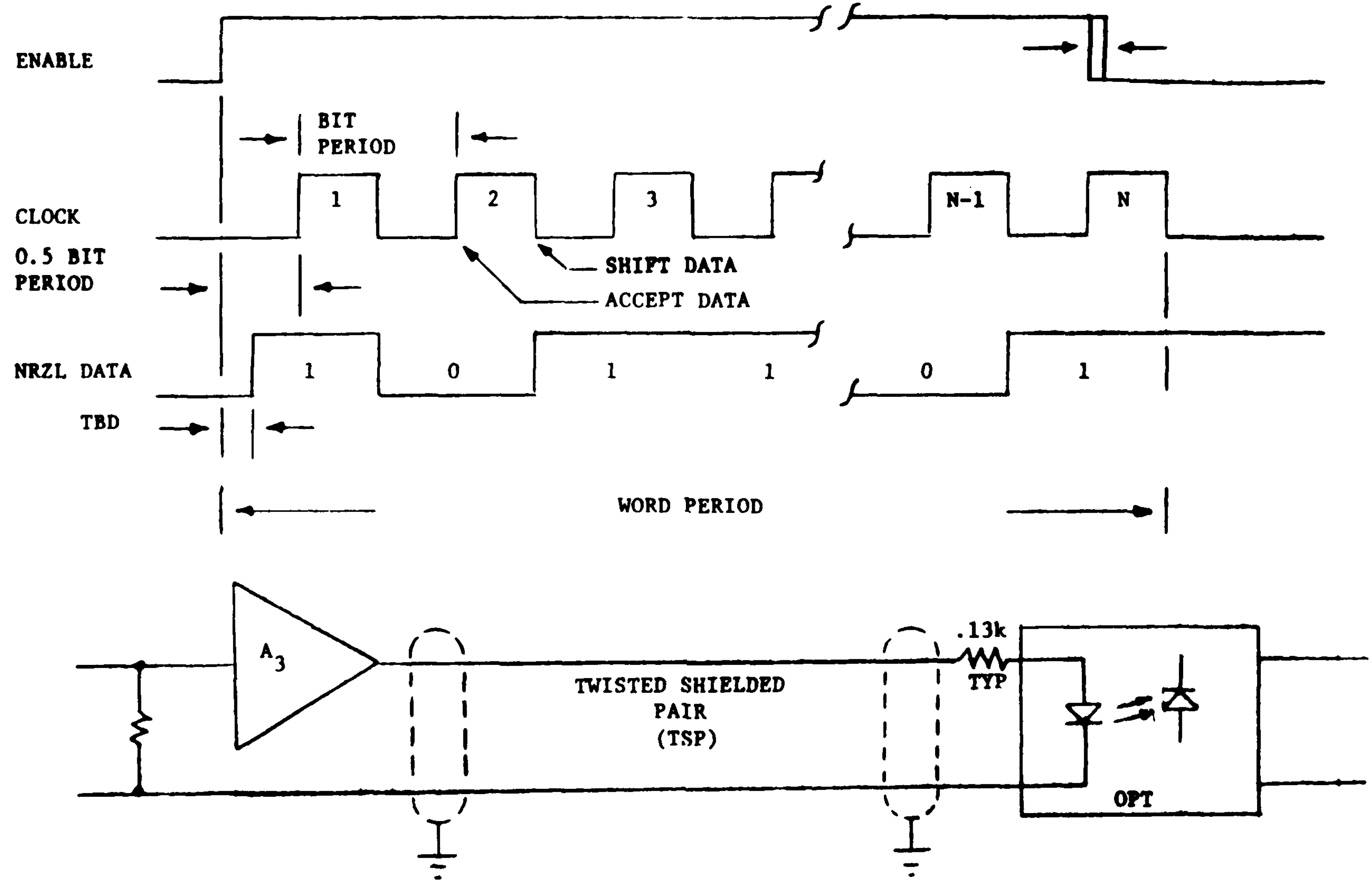


Figure 2,6.3-1. Serial Digital Interface

The analog signals were received and processed by the encoder. Most of the data were converted and transmitted with a 10 bit resolution and accuracy. Where 8 bit resolutions were requested, the two least significant bits of the 10 bit data word were set to ZERO. The sampling rates for the analog signals ranged from 2048 S/S for the pulsed plasma probe data to a minimum of 32 S/S for some of the housekeeping monitor signals. To synchronize the data gathering process with the PCM data stream, some at the instruments required clock signals. The pulsed plasma probes were provided with 1024 and 64 Hz clocks. Their data were sampled and converted not earlier than 125 us after the transistions of the 1024 Hz signal. The quadrupole mass spectrometer required only a 64 Hz clock and did not impose any restrictions on the sampling times. Sixteen of the monitor signals originating in the instruments of the Southwest Research Institute were multiplexed onto a single pair of wires before being sent to the encoder. A clock pulse generated in the electronics box was sent and advanced the multiplexer to a new channel as needed. The already available major frame sync pulse was utilized to maintain synchronization between the PCM frame and the multiplexer.

The minor frame consisted of 120 ten-bit words. A 30 bit (3EBCCDOOH) frame synchronization pattern was employed to help maintain synchronization of the lengthy frame during decommutation. Fourteen words within the frame, including the subframe counter were used to sub-commutate selected data. One major frame of the PCM data consisted of 8 minor frames. Thus, 256 minor frames within 32 major frames were transmitted every second. The design data for the PCM/FM data link and the PCM data format are shown in Figures 2.6.3-2 and 2.6.3-3 respectively.

2.6.4 Electronics Box

The encoder used in this PCM/FM system was very similar to the one described in Scientific Report No. 3. The electronics box supplemented the encoder by providing signals and functions specific to this application. Also, included within the box were circuits to serve the needs of the FM/FM system.

Figure 2.6.4 shows the circuits of the electronics box. The analog switches used to inject calibration signals into the FM/FM system occupy the lower center portion of the drawing. Upon command the CAL #1 and CAL #2 signals reverse polarity and force the solid state analog switches to connect the CAL.SIGNAL to the subcarrier oscillators. When the command to calibrate is removed, the analog switches once again connect the data signals to the FM/FM system. The CALIBRATOR is shown in the lower right hand corner of the drawing. The CALIBRATOR receives its commands from the GSE. A two-tone command is received and decoded by U7. The output of the decoder selects a calibration program within the uC (U6), which generates the appropriate sequence of

PCM/FM SYSTEM FOR: POLAR ARCS

X-MTR. FREQ.:	2279.50 MHz
X-MTR. POWER:	5.00 W.
X-MTR.ANT.GAIN:	-8.00 DB
RECV.ANT.GAIN:	34.53 DB
RANGE:	450.00 km
POLARIZATION LOSS:	3.00 DB
OTHER LOSSES:	3.00 DB
NOISE TEMP.:	250.00 DEG.K
IF BW:	500.00 kHz
CALCULATED IF BW:	0.00 kHZ
X-MTR PEAK DEVIATION	109.00 kHz
CARRIER S/N:	22.49 DB

PCM TYPE:	NRZ-S
BIT RATE:	307200.00 Bps
BITS/WORD:	10.00
MSB	FIRST
WORDS/FRAME:	120.00
WORDS/MAJOR FRAME:	960.00
FRAMES/MAJOR FRAME:	8.00
FRAMES PER SECOND:	256.00
MAJOR FRAMES PER SECOND:	32.00

Figure 2.6.3-2.

Design Parameters for PCM/FM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
E1	E2	E3	E4	P1	P2	P3	P4	E5	E6	E7	E8	S1	S2	S3	S4	M1	M2	SF ID	P1	P2	P3	P4	SF 1	SF 2	SF 3	SF 4	S5	S6	S7

31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
E1	E2	E3	E4	P1	P2	P3	P4	E5	E6	E7	E8	S8	S9	S10	S11	M1	M2	SF 5	P1	P2	P3	P4	SF 6	SF 7	SF 8	SF 9	S12	S13	S14

61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
E1	E2	E3	E4	P1	P2	P3	P4	E5	E6	E7	E8	S15	S16	S17	S18	M1	M2	SF 10	P1	P2	P3	P4	SF 11	SF 12	SF 13	SPARE	S19	S20	S21

91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
E1	E2	E3	E4	P1	P2	P3	P4	E5	E6	E7	E8	S22	S23	S24	S25	M1	M2	S26	P1	P2	P3	P4	S27	S28	S29	S30	FS1	FS2	FS3

FRAME

SOURCE DATA	SYM	MINOR WORDS	MAJOR WORDS
NU	H	0	47
NU	v	0	3x4 + 1x2
NRL	P	4x8	3
AF&L	M	2x4	1x4 +3x2 +2
SU	E	8x4	0
SV	A	0	2x2 + 5
DSRI	D	0	1x2
SWRI	S	30	16

SUMMARY

	SF 1	2	3	4	5	6	7	8	9	10	11	12	13
1	v1	v2	S31	v3	S32	v4	M3	M4	M5	M6	A1	A2	D1
2	H1	H5	S33	H9	S34	H13	H19	H23	H29	H35	H39	H45	P5
3	v1	v2	S35	v3	S36	H14	M3	SPARE	H30	H36	H40	H46	P6
4	H2	H6	S37	H10	S38	H15	H20	H25	H31	H37	H41	H47	P7
5	v1	v2	S39	v3	S40	v4	M3	M4	M5	M6	A1	A2	D2
6	H3	H7	S41	H11	S42	H16	H21	H26	H32	M7	H42	A3	A6
7	v1	v2	S43	v3	S44	H17	M3	H27	H33	M8	H43	A4	A7
8	H4	H8	S45	H12	S46	H18	H22	H28	H34	H38	H44	A5	SPARE

SUBFRAME

Figure 2.6.3-3. PCM Data Format

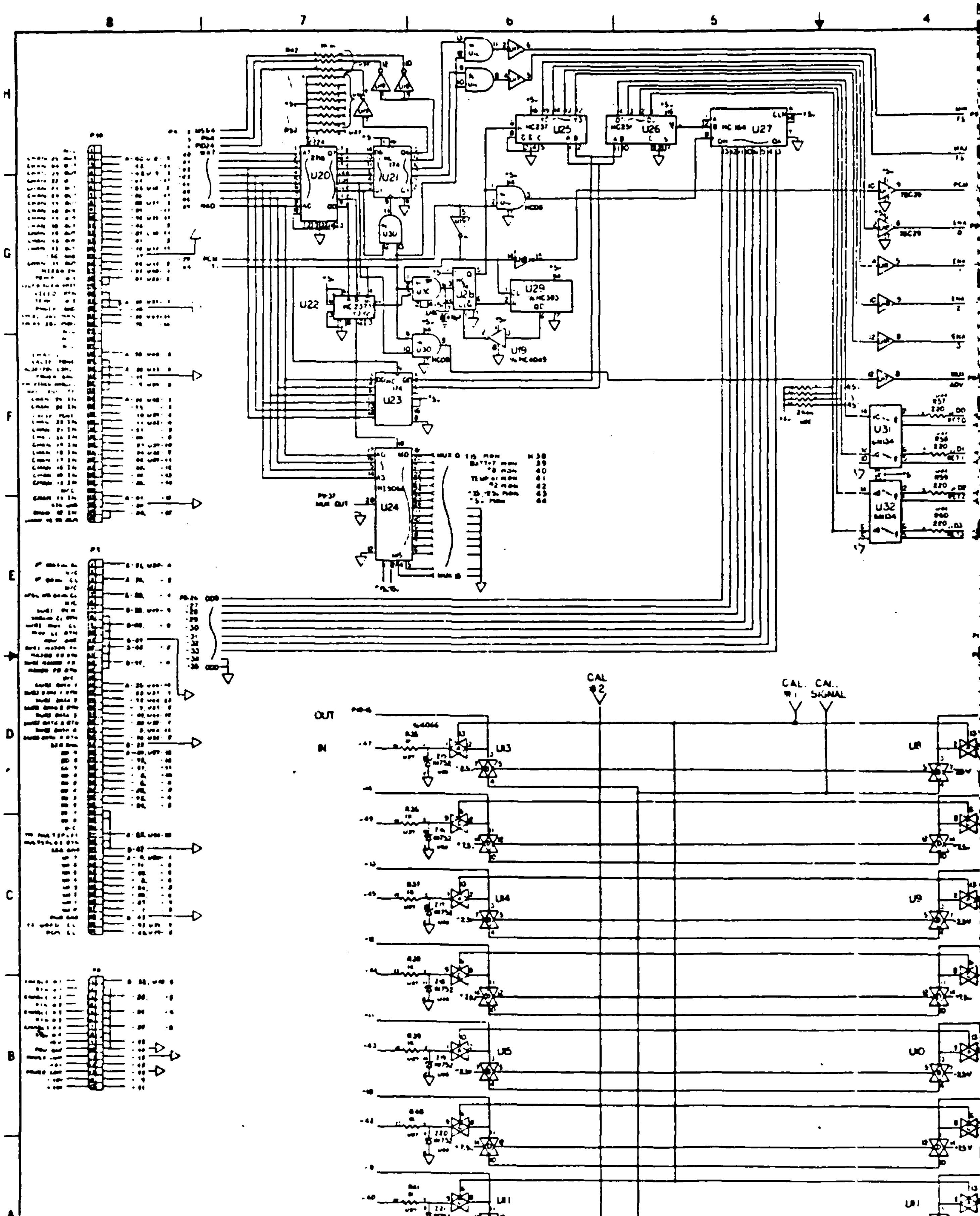
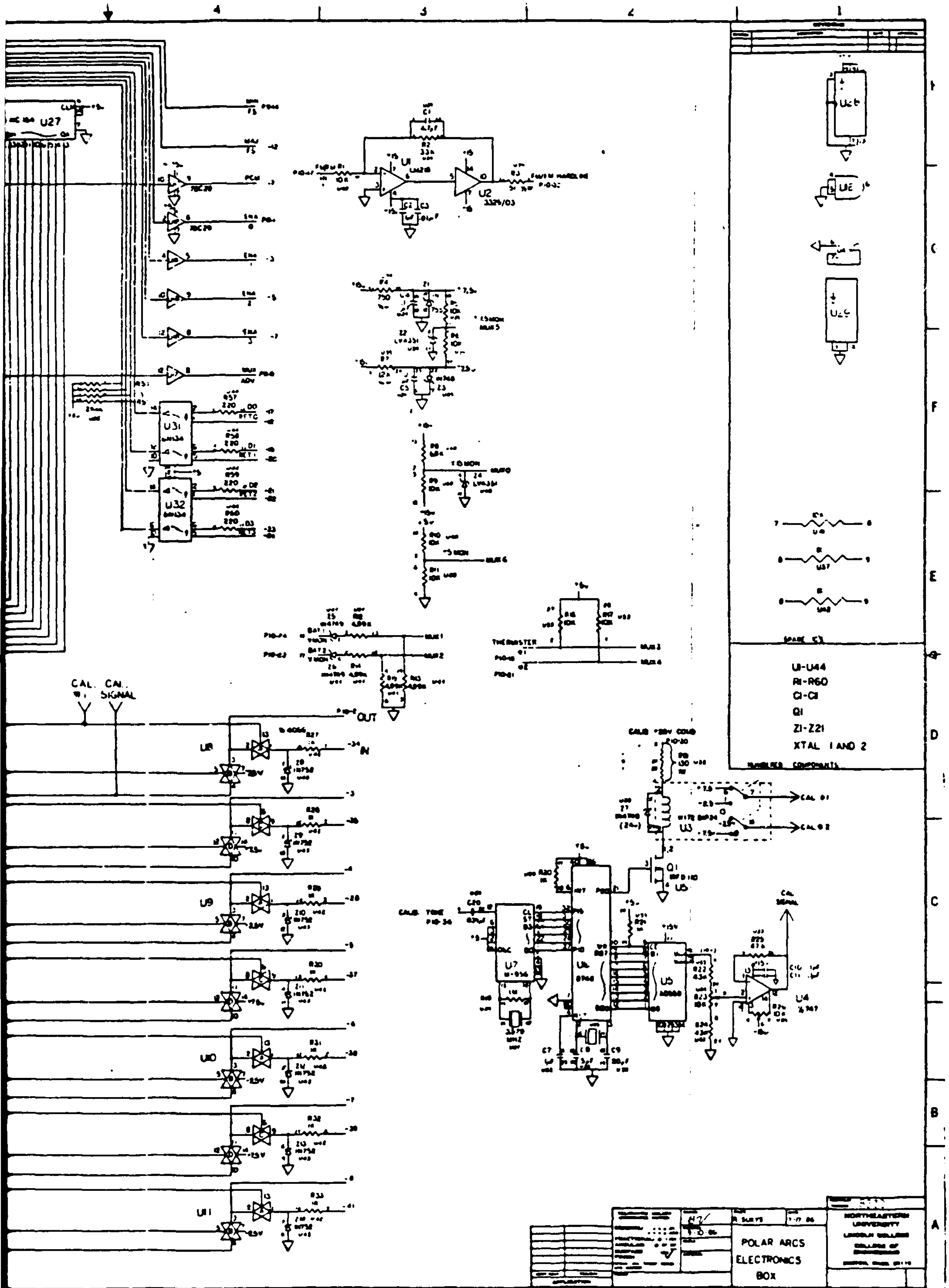


Figure 2.6.4. Electronics Box



U27
U1
U2
U31
U32
CAL. CAL.
SIGNAL
OUT
IN
U8
U9
U10
U11
U3
U4
U5
U6
U7
Q1
THERMISTER
CAL SIGNAL
SPARE
UI-U44
RI-R60
CI-CII
QI
ZI-Z21
XTAL 1 AND 2
POLAR ARCS
ELECTRONICS
BOX
NORTHEASTERN UNIVERSITY

digital codes for the digital to analog converter U5. The output of the D/A unit is conditioned by the amplifier to produce the calibration signal. It should be noted that the +28 volts necessary to drive the calibrate command relay and thus to switch the analog transmission gates into the calibrate modes are supplied by the GSE. Therefore, once umbilical connection is broken, the calibrator becomes disabled and the analog switches remain in the signal transmission mode. Other miscellaneous circuits associated with the analog signal processing are shown on the right side of the drawing. They include, from the top, the amplifier/line driver to transmit the output of the subcarrier mixer amplifier over a cable to the ground station, the +7.5 and -2.5 volt generator/monitor for V_{DD} and V_{SS} of analog switches, and finally, the $\pm$15V, 5V, battery voltage and temperature monitors.

The serial digital data control circuits and clock generators for the instruments are located in the upper left portion ofthe drawing. During each PCM word an address selection code (WAO-WA7) is provided by the encoder to the EPROM (U20). When bit 3 of U20 is SET, the selected bits of the EPROM are latched into U21 by the PCM word clock signal T1. By sequential selection of appropriate codes stored in the EPROM, the output of the latch can be forced to generate the 1024 Hz and the 64 Hz clocks for the instruments (P1024, P64 and MS64). The minor and the major frame synch pulses are also generated by the same process. Since their duration is one PCM bit period, the outputs of the latch (U21) are gated through U16 by the clock T1.

The pulses to advance the analog multiplexer in the instruments of SWRI and the clock for the serial digital data are generated more directly. The digital clock is an inverted PCM clock originating in the encoder. The multiplexer advance pulse is produced by an AND gate driven by the output of the EPROM and T1.

A 3 to 8 decoder (U22) driven by the EPROM generates select signals for the internal analog multiplexer (U24) and for the control of the digital data transfer circuits. The multiplexer address code is determined directly by the status of the address word WAO-WAT. The selection of the channel for the serial digital data is also accomplished by the address word latched into U23. The output of that latch selects the channel. The ENABLE signal for the selected channel is generated by the 3 to 8 line decoder U25 provided it is enabled by U28. The output Q of U28 is triggered high by the combination of the PCM clock, word clock and the output of U22 forcing a positive transition at the output of U30. Once the channel selection is completed, the incoming data from that channel are directed through the selector U26 into the shift register U27. PCM clock shifts the data in.

After 8 clock pulses, the counter U29 resets U28 and disables the channel selector U25. At that time the data becomes available to the encoder on the parallel bus DD_0-DD_9.

2.7 CWAMI/HIRAM

The CWAMI payload, A30.276, was a baffled version of the Field Widened Interferometer and HIRAM, A30.579, is a refurbished refly of CWAMI.

2.7.1 CWAMI

Northeastern University was responsible for a dual link telemetry system at 2251.5MHz and 2279.5MHz multicoupled onto a stripline antenna. The system was similar to that previously launched at PFRR and consisted of a PCM/FM link of an NRZ-L signal at 420kbps. Link 2 was a PAM/FM/FM system consisting of seventeen subcarrier oscillators. Northeastern also had the responsibility of pre-launch and launch operation of a band radar transponder, an FM receiver at 550MHz for the Tradat ranging system and a recovery location beacon at 242MHz.

The telemetry system of the CWAMI had been refurbished and final assembly and testing was accomplished during December 1982 leading to integration testing at AFGL and vibration testing at Acton Laboratories during January 1983.

Personnel arrived at PFRR, Alaska on February 22, 1983, to begin field operations leading to a launch. The payload was placed on Pad 3 on Thursday, March 3, 1983, to begin its countdown process.

The baffled version of the Field Widened Interferometer conducted its first countdown at Poker Flat Research Range, Alaska on March 4, 1983. The moon up period affected the launch window so that on March 24, 1983, the payload was taken down from the launcher and the field party returned home to await the April moon down launch window.

The field party returned to PFRR on April 2, 1983, and successfully launched the payload on April 12, 1983, at 11:06 p.m. local time. The payload reached an apogee of 139.5km at T + 185 seconds with all support and telemetry systems performing as expected. Recovery was accomplished with the payload being returned in excellant condition.

2.7.2 HIRAM

HIRAM was reburbished from the CWAMI payload and was originally scheduled to be launched from Poker Flat Research Range, Alaska in October 1985.

The integration and field testing for the Field Widened Interferometer payload (HIRAM) was delayed however, leading to a proposed launch in the January/February 1986 window at the Poker Flat Research Range, Alaska. After all preliminary testing of the telemetry and tracking systems was completed, integration of the payload systems with Utah State University experiment took place at AFGL during the period of 9 to 20 December 1985. Vibration and shock testing was completed on 16 Demember 1985 at Acton National Laboratory. Personnel arrived at the Poker Flat Research Range, Alaska on 2 January 1986 to open a launch window on 10 January 1986.

The HIRAM was counted for 7 consecutive days before the moon-up period closed the launch window on 16 January 1986. The window reopened on 23 January 1986 for 15 consecutive nights and closed again on 7 February 1986. The third window reopened on 14 February and closed again on 10 March 1986 after another 24 consecutive "hot" counts. The field party returned to the launch site for the opening of the fourth launch window period on 18 March 1986. The countdown continued nightly for 25 days until the window was closed again on 13 April 1986. Due to the fact that the launch windows were getting too narrow during the moon down periods the decision was made to cease the operation until the next fiscal year. The payload was taken down, shipped back to AFGL and the field party returned to their home bases. The HIRAM payload was counted 71 nights during this field operation at PFRR.

The HIRAM payload has been rescheduled for launch at the Poker Flat Research Range, Alaska during the second quarter of FY87. The field party will be arriving at the launch site on February 4, 1987, leading to a window opening on February 16, 1987.

3.0 ORBITING VEHICLE PROGRAMS

3.1 GAS (Shuttle Borne Get Away Special)

The Get Away Special is a shuttle borne experiment container which will house a standardized data acquisition system. The AFGL model has its own power supply (batteries), PCM encoder, magnetic tape storage and time clock. There is a minimal interaction between the shuttle and the experiment with the possible expection of on/off type controls.

In concept, an experimenter can mount his data gathering device inside the container with as little as 6 months preflight notice.

A block diagram of the GAS Payload Support System (PSS) is shown in Figure 3.1.

NU was assigned the responsibilities of providing a PCM encoder and purchasing the magnetic tape recorder.

3.1.1 GAS PCM Encoder

The NU Programmable PCM Encoder described in the final report of contract F19628-80-C-0050 was modified as indicated below:

1. Reduced Power Consumption - The power was reduced by using an 80C31 CMOS (Complementary Metal Oxide Semiconductor) microcontroller, CMOS microprocessor peripherals, high-speed CMOS logic and a low power pro-

PAYLOAD SUPPORT SYSTEM BLOCK DIAGRAM

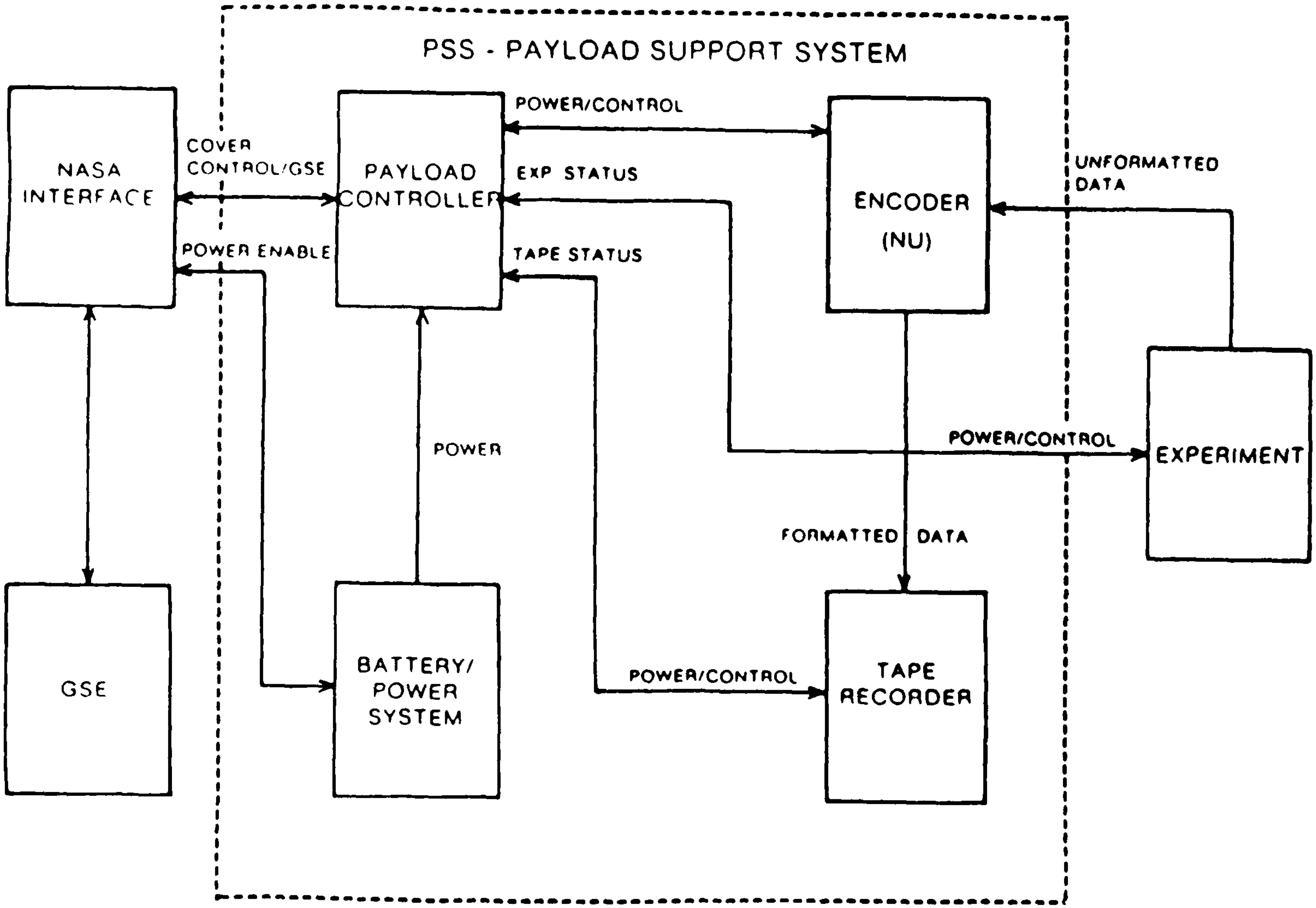


Figure 3.1.

grammable gain amplifier, sample to hold, and analog-to-digital converter. The overall power consumption was reduced to 1.50 watts.

2. Encoder Command Interface - The PCM encoder's interrupt system was expanded to accommodate up to 8 different commands. Upon receipt of a new command from the controller, the encoder sends an acknowledge signal back and selects a new operational format. By providing multiple formats, the data storage capacity of the magnetic tape recorder can be maximized, i.e. one format for housekeeping during non-data intervals and one format for data taking intervals.

3. Encoder Output Circuits - The PCM encoder's output data signal from the parallel-to-serial converter is an NRZ-L serial bit stream and was converted to an 8 bit parallel signal to accomodate the requirements of the tape recorder input circuitry and to a Bi0-L which is transmitted to the GSE (Ground Support Equipment) via an RS-422 compatible differential driver. The 8 bits transmitted to the recorder also via RS422 compatible differential drivers are accepted by the recorder upon receipt of a Data Strobe (DSTS) signal from the encoder. When the recorder is ready for more data, it sends a Data Buffer Ready (DRDY) signal to the encoder. For performance verification, the encoder counts the number of DRDY pulses per major frame and reads this out as a data point.

4. Word Length Circuit - The encoder's word length circuit was modified to accommodate variable word length of 8, 12 or 16 bits. These can be mixed within a particular format. This helps maximize the data storage capacity of the tape recorder.

5. Temperature Sensor - A linear temperature sensor was mounted to the encoder's enclosure to aid in the construction of a thermal profile of the GAS payload.

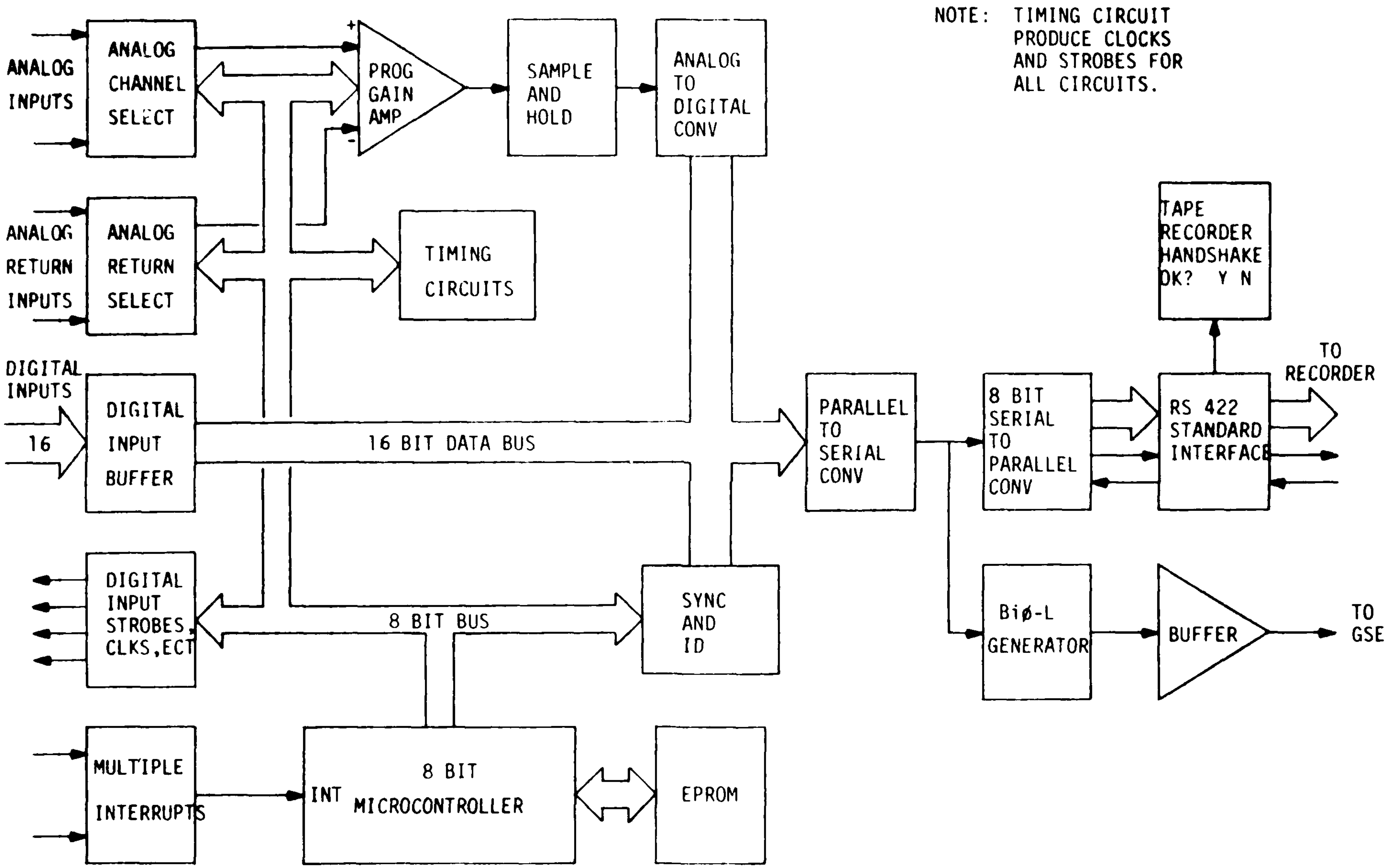
6. EMI Filters - EMI filters were added to the power input circuitry. This provides a two fold function: they keep external EMI out while keeping internal EMI contained.

A table of the GAS PCM encoder's characteristics is presented in Table 3.1.1-1 and a block diagram is presented in Figure 3.1.1-2.

GAS PROGRAMMABLE PCM ENCODER CHARACTERISTICS

ANALOG INPUT CHANNELS:	96 (QUASI-DIFFERENTIAL).8 RETURNS
DIGITAL INPUT CHANNELS:	(TRISTATE BUS STRUCTURE) ENABLES AND CLOCK SIGNALS AVAILABLE AS REQUIRED.
BIT RATE:	2 BITS/SECOND TO 230K BITS/SECOND (LIMITED BY TAPE RECORDER).
WORD LENGTH:	8, 12, AND 16 BITS (CAN BE MIXED WITHIN A PARTICULAR FORMAT).
ANALOG LEVELS: (FULL SCALE)	0 TO + 1.0V, 0 TO + 2.5V, 0 TO + 5.0V, 0 TO + 10.0V. (CAN BE MIXED WITHIN A PARTICULAR OPERATING FORMAT).
FORMAT:	FULL SUPER AND SUB COMMUTATION CAPABILITY, UP TO 256 MINOR/MAJOR FRAMES.
PROGRAMMING:	ALL OPERATING PARAMETERS ARE STORED IN EPROM AND CAN BE CHANGED BY REPROGRAMMING. MULTIPLE FORMATS CAN BE ACCESSED VIA INTERRUPT SIGNALS.
SIZE:	9 X 6.5 X 3 INCHES.
WEIGHT:	3 LBS. 10 OZS.
POWER REQUIREMENTS: (APPROXIMATE)	47mA AT 5.0V. 42mA AT +15V. 42mA AT -15V. APPROXIMATELY 1.5 WATTS.

TABLE 3.1.1-1



GAS PAYLOAD PCM ENCODER

Figure 3.1.1-2.

The PCM encoder was constructed using wire wrap techniques for the first application. This allowed for quick modifications of the prototype model as was required during the interfacing with the controller and tape recorder.

Check-out of the GAS PCM encoder was completed using a circuit to simulate the tape recorder's and controller's interface. Preliminary environmental testing was conducted which consisted of 6 temperature cycles of $-20^{o}C$ to $+50^{o}C$ with a 30 minute soak at each of the extremes. The encoder was delivered to AFGL during the 3rd. week of April 1986.

A successful Thermal Cycling Test was performed in June 1986 and the encoder was also successfully tested for mechanical environmental stresses in December 1986.

3.1.2 GAS Tape Recorder

The magnetic tape recorder used was purchased from Sundstrand Data Control, Inc. It is designated as the Data Logger and is a miniature high-environment digital data recorder. This recorder was ordered in February 1985 and finally received in February 1986, after promises of delivery in August 85.

A complete operational checkout of the GAS tape recorder has not been possible due to the fact that a Tape Cartridge Reproducer (TCR) has not been available to playback the Tape Cartridge (TC). A partial checkout was performed at AFGL by monitoring the status port, currents drawn by the three power supplies, and by listening to the Tape Cartridge for operation of the tape drive servo motor.

A table of the GAS tape recorder's characteristics is presented in Table 3.1.2 and a block diagram is presented in Figure 3.1.2.

GAS TAPE RECORDER CHARACTERISTICS

OPERATIONAL MODES	
Automatic Record	-Recording takes place automatically any time a 32K buffer becomes filled with input data.
Demand Record	-The contents of a partially filled buffer are written to tape when commanded.
Self-Test	-Causes a full self-test of RCU electronics.
Tape Inhibit	-Tape movement is inhibited, otherwise unit responds normally.
CONTROL INTERFACE	
Input Characteristics	-RS-422 differential line.
Commands	-Normal record; Self Test; Tape Inhibit; Demand Record.
Recorder On	-Application of power.
STATUS INTERFACE	
Output Characteristics	-RS-422 driver, differential line.
Status Indications	-BOT; EOT; Record Ready; Self Test Active; BIT Status; Tape Inhibit Active;Record Active.

TABLE 3.1.2

TABLE 3.1.2 (Continued)

DATA SIGNAL INTERFACE

Input Characteristics	-RS-422 receiver, differential line.
Data Input	-8 bit parallel bytes.
Data Strobe	-Strobe issued while data word is stable.
Data Acknowledge	-Indication that byte has been processed and that data may be altered.
Data Transfer Rate	-Variable up to 36,000 bytes/ sec. average transfer rate.

CAPACITY

Total Capacity	->300 M bits.

POWER REQUIREMENTS

Standby Power	-15 watts
Power During Tape Motion	-30 watts
Operating Power Sources	- +28 VDC ± 4.0 VDC +5 VDC + 0.24 - 0.1 VDC +15 VDC ± 1.0 VDC -15 VDC ± 1.0 VDC

SYSTEM ENVIRONMENT CONDITIONS

Temperature, Operating	- -40°C to +55°C.
Temperature, Storage	- -65°C to +85°C.
Vibration, Operating	- 6g RMS
Acceleration, operating	- 15g
Shock, Non-operating	- 60g at 10m Sec.

DATA RECORDER PHYSICAL PARAMETERS

Weight: Total System	- <9.0 pounds
Size	- 4"H x 7.0"W x 7.5"L

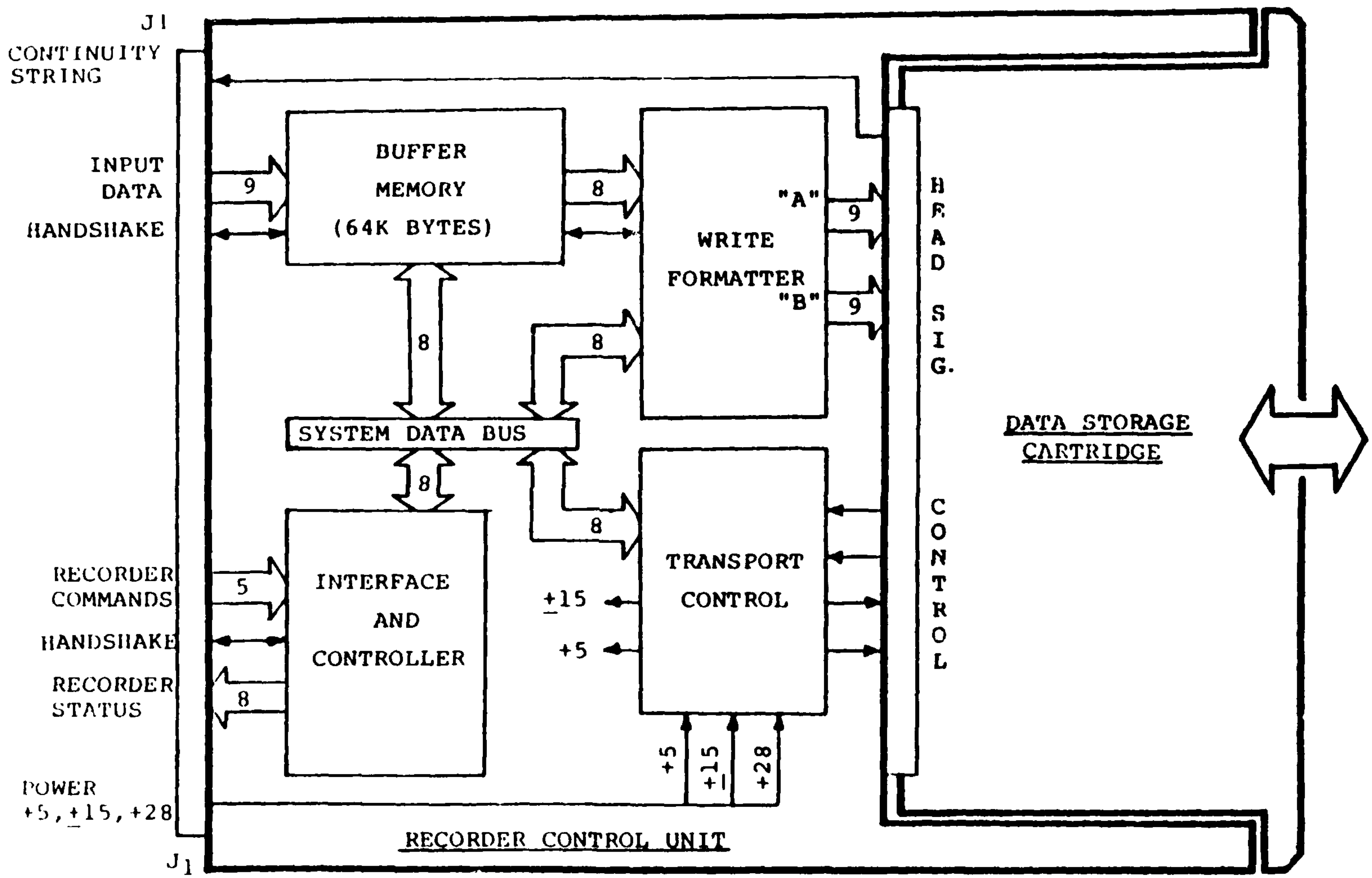


Figure 3.1.2. System Block Diagram, Data Logger

3.1.3 GAS PCM Encoder Interface

The recorder provides a simple byte wide (8 bits) data input interface. The recorder employs a high speed parallel input buffered data channel which includes a 64 byte F1F0 (first-in-first-out) buffer at the PCM encoder's interface, a dedicated data bus, and two 32K byte alternating buffer fields. As a result, burst transfers may be accomplished at a very high rate: greater than 250K bytes per second. The decoupling provided by the buffer memory, allows the PCM encoder to be independent from the tape interface, as the recorder will automatically record each time a buffer is full.

The PCM encoder enters data bytes by first setting up the data value and then setting the DSTB (DATA STROBE) true. The DSTB operates in a full handshake in conjunction with the DRDY (DATA BUFFER READY) output of the recorder. Both the data value and the strobe may change when DRDY goes false, indicating that the new data value has been loaded into the FIFO. DRDY returns true when FIFO is ready to accept another data value (not full). New data cannot be entered unless DRDY is true. If the average transfer rate is below 36K bytes per second, the FIFO will typically be empty and DRDY will return true within one-microsecond. The purpose of the FIFO is to allow data entry to continue while the buffer fields are being toggled (once every 32K bytes). All data inputs are RS-422 differential line receivers.

DSTB and DRDY are also RS-422 devices. Although the recorder is equipped to automatically record full buffers (32752 bytes) it is also equipped to allow the PCM encoder to demand records of a smaller size. This is accomplished on a record-by-record basis by setting a WRITE FLAG during entry of the last data byte for the desired record. The WRITE FLAG is entered into the FIFO along with the data value using the data handshake function. The FIFO carries 9-bit words allowing the flag to remain sychronous with the last data byte until that byte propogates through to the FIFO output. The byte is then stored in buffer memory and the WRITE FLAG causes a buffer toggle (write) request to the recorder's microprocessor. Although the WRITE FLAG allows generation of any sized record up to 32752 bytes it is recommended that records be written at the maximum size practical. Smaller record sizes degrade capacity, through put rate, and record time. One of the primary uses of the WRITE FLAG is to force a partially filled buffer to be emptied.

3.1.4 GAS Recorder Command Interface

The recorder includes a five-bit command interface to support premission operational verification and shop testing. Commands may be entered by setting up the command value, then providing a pulse at the COMMAND STROBE (CSTB) input. The pulse must be a minimum of one-microsecond or may be operated as a full handshake in conjunction with

COMMAND PORT READY (CRDY) output from the recorder. In the latter case, both the command value and the strobe may be removed when CRDY goes false indicating that the new command has been entered and an interrupt requested. The two commands that are used are commands 0 and 4. The remaining commands (Command 1,2 and 3) are reserved and used for bench test functions. Command 0 input, when true, causes the recorder to operate in a tape motion inhibited mode. This command is valuable during pre-mission system testing to conserve tape usage. In this mode, the recorder operates normally in all respects except that tape motion is inhibited. As a result, the host system and all functions through the recorder interfaces may be validated without actually writing on tape. A status bit is provided from the recorder indicating whether or not the recorder is operating in a tape inhibit mode. The mode may be exited by entering a command with CMD 0 set false or by cycling power. COMMAND 4 input, when true, causes the recorder built-in-test (BIT) to go through an extended memory test mode in addition to normal BIT functions. This mode has been provided to support applications which requires a fast start-up during normal operation. These applications cannot afford the added time required for BIT to perform a full test of the buffer memory and other functions. Under normal startup conditions, an abbreviated test is performed on all recorder functions including buffer memory. The controller may then request the extended test when time allows. When the recorder performs an extended test of the buffer memory, previous data content will not be saved. The recorder returns to the normal operating mode upon completion and may be terminated by receipt of a new command with the Self Test bit false.

3.1.5 GAS Recorder Status Interface

The recorder includes an 8-bit status output port to provide the controller with basic recorder status. One of the status bits, STATUS 0, is used as a status update attention flag. This line is pulsed by the recorder whenever the status value changes. All status outputs are interfaced through RS-422 differential line drivers.

STATUS 1 output, when true, indicates that the recorder is in a tape inhibited mode. The recorder will accept data and operate normally except that the tape will not move and data will not actually be recorded. This is provided as a tape saving feature during host system checkout. The recorder remains in the tape inhibited mode until power is cycled or a non-tape inhibit command is issued.

STATUS 2 output, when true, indicates that the recorder's built-in-test (BIT) has detected a fault. Detection of a fault does not inhibit further operation. The fault status remains set until power is cycled, a self test command is issued, or a buffer becomes full and initiates a write operation. If the failure reoccurs, the status will again be set.

STATUS 3 output, when true, indicates that the recorder is in a tape motion mode. The status bit is set at the beginning of the ramp up to speed sequence and is reset once the tape speed has ramped down to stop. For example, if a 32K byte record is being written, the status would be true for the 0.9 seconds required to write the buffer to tape. Note that during a tape inhibited mode, the record active status is still set and reset to simulate a record operation to the host system interface.

STATUS 4 output, when true, indicates that the recorder is currently executing an extended self test operation. Once the test sequence is complete, the recorder returns to the normal operating mode and the status is reset. A self test command causes the status to be set true.

STATUS 5 output, when true, indicates that the recorder is in a normal operating mode, the buffer memories are available for data input, and a cartridge is present. The status is set following power-on initialize sequence. If a cartridge is not installed, the ready status will not be issued. If a self test is commanded, the ready status will be reset for the duration of the self test sequence. In effect, a ready indication implies that the recorder is in an auto-logging mode ready to begin accepting data from the host.

STATUS 6 output, when true, indicates that the cartridge has been filled to capacity.

STATUS 7 output, when true, indicates that the cartridge is at the beginning of the recording media. In effect, it is empty.

3.1.6 GAS PDR and CDR

The PDR was attended on 2 April 1985 at AFGL where NU presented the preliminary PCM encoder characteristics. Except for the addition of another 32 analog inputs, the characteristics remained unchanged for the CDR on 25 September 1985.

3.1.7 Proposed Modifications for Tape Recorder Power Reduction

The flight tape recorder described in section 3.1.2 was designed for naval torpedo performance monitoring. The design used TTL logic, which at the time was the logic family of choice due to its speed capability and proven reliability. Power consumption, while certainly a design consideration, was not a driver for the overall system. Torpedo runs are, by nature, not long-term operations. In the long run, AFGL applications would be better served if the overall power requirements could be reduced.

After receiving some circuit component documentation from the Navy sources, it was found that the logic circuitry would be the most productive area for initial investigation aimed at reducing power consumption. The manufacturers published power consumption (in a data recording mode) is as follows:

+ 28V ± 4V - 25 Watts

+ 15V ± 1V - 5 Watts

- 15V ± 1V - 5 Watts

5.0V ± .25V - 15 Watts

The logic integrated circuits consist of an HMOS microprocessor and memory, TTL RS422A differential interfaces, TTL programmable logic arrays and LSTTL low and medium scale general logic (54 LSXX series).

While most of the 54LSXX have direct low-power replacements with the 54HCXX series, the logic arrays and interfaces will require detailed specification matching to insure complete compatibility with low power replacements. The following circuits were investigated for direct low power component replacement:

1. Write Format Driver
2. Memory Buffer
3. Transport Control

The write format driver consists of analog write head drivers (LM118), analog gates (HI5045) and TTL logic. The array logic and TTL logic can be replaced with C-MOS logic at a savings of 3.15 watts typical, 5.5 watts maximum on the 5 volt supply. The typical and maximum values are from manufacturers specification sheets and could vary depending on specific application. The drivers are not replaceable directly and the analog gates are already C-MOS technology.

The memory buffer consists of 512K bits of N-MOS memory, TTL logic, programmable logic array and RS-422 interface logic. If the memory, programmable logic arrays and TTL logic were replaced with their C-MOS equivalent, a savings of up to approximately 5 watts could be achieved. The actual savings would be very dependant on the clock rate of the memories.

The transport control is mostly analog in nature and as such, power reduction is not a simple part for part replacement. Total redesign of the servo controls could possibly reduce power, but the servo is already a pulsed proportional system which is active only when the tape is in motion. It is doubtful that any significant saving could be achieved in this circuit.

To summarize, possibly 10 watts could be saved with part-for-part replacement. This is predicated on the availability of obtaining programming information to program the array logic. This information may be proprietary. The largest savings would be in memory replacement.

3.2 VIPER (Visual Photometric Experiment)

The VIPER payload will be the first user of the Get Away Special support system. This experiment will contain a visual radiometer, two television cameras, a video recorder and supporting hardware and power. The objective is to measura+6He the diffuse zodiacal and galactic emission at standard B, V, R astronomical wavelengths as a precursor to the large aperture infrared experiments which will fly in the early 1990's. This data will be used to upgrade and extend the zodiacal light models into the visual spectral region with newer data more contemporary with the IR data bases. Long term variation of the zodiacal light will be explicitly quantified.

The diffuse zodiacal light and galactic emission provide the fundamental limiting brightness against which surveillance systems must operate. These measurements will provide the first systematic data in these spectral regions since the early 1970's (OSO, Pioneer 11). These older measurements are not in close agreement with the limited ELC-1 visual data nor do they fit well with the interplanetary dust's chemical composition inferred from the ZIP data base.

The telemetry requirements of this experiment are 2-100 sample/sec. channels at 12 bit accuracy, 11-10 sample/sec. channels at both 8 and 12 bit accuracy, 28-1 sample/sec. channels at 8 bit accuracy and a 12 bit digital word at 1 sample/sec. Housekeeping requirements adds another 28 digital inputs at various slow sampling rates.

The software program for the 80C31 microcontroller which accommodates the above requirements was flowcharted, written and debugged. The encoder was delivered during the third week of April 1986. The encoder was successfully integrated into the system and tested for environmental stresses, i.e. shock, vibration, and thermal cycling.

A Preliminary Design Review (PDR) held at AFGL on 13 August 1985 was attended by NU personnel where a presentation about the GAS PCM encoder was made. A Critical Design Review was held on 18 September 1985 at AFGL.

Components have been purchased so that a second encoder similar to that described above can be fabricated in the future. Documentation has been completed and components received.

3.3 EIM Interface System (EIS) for IMPS

3.3.1 Introduction

This chapter describes the preliminary design of a system intended to provide a single set of electrical interfaces between the Environmental Interactions Monitors (EIM) and the avionics of the Shuttle Pallet Satellite (SPAS). The EIM instruments are supported by EIS with power and command distribution, data transmission and time reference.

The directly supported EIM instruments include: Suprathermal Electron Spectrometer (SES), Pressure Gauge (PG), Electron and Ion Electrostatic Analyzers (ESA-E and ESA-I), Differential Ion Flux Probe (DIFP), Quadrapole Ion/Neutral Mass Spectrometer (QMS) and a cluster of instruments designated as Plasmas and Fields (PAF) connected to EIS through a single interface PFI. Control functions and circuits are also provided to deploy, retract and monitor up to six E-Field Antennas (EFA) flown as a part of PAF. A simplified EIM-EIS block diagram is shown in Figure 3.3.1.

3.3.2 Overview

The EIS system receives, generates and processes a total of 99 kbps of data. These data are transmitted over two data links. Ninety-eight (98) kbps are processed for transmission to the onboard tape storage system, while the rest are channeled into the real time data link of SPAS. The data from the instruments are received in digital, bi-level and analog forms. Only an equivalent of 4.5 kbps of analog data from two instruments are processed. The bulk are received as a serial digital data. Some monitor data are also generated internally to EIS. The system also receives Mission Elapsed Time updates from SPAS avionics and time tags the instrument data. A total of 27 ground based commands received through the SPAS avionics are processed and redistributed to the instruments in bi-level or serial digital form. Over 100 such commands are generated. Also, approximately 90 watts of SPAS power are fused, switched and distributed to the EIM system.

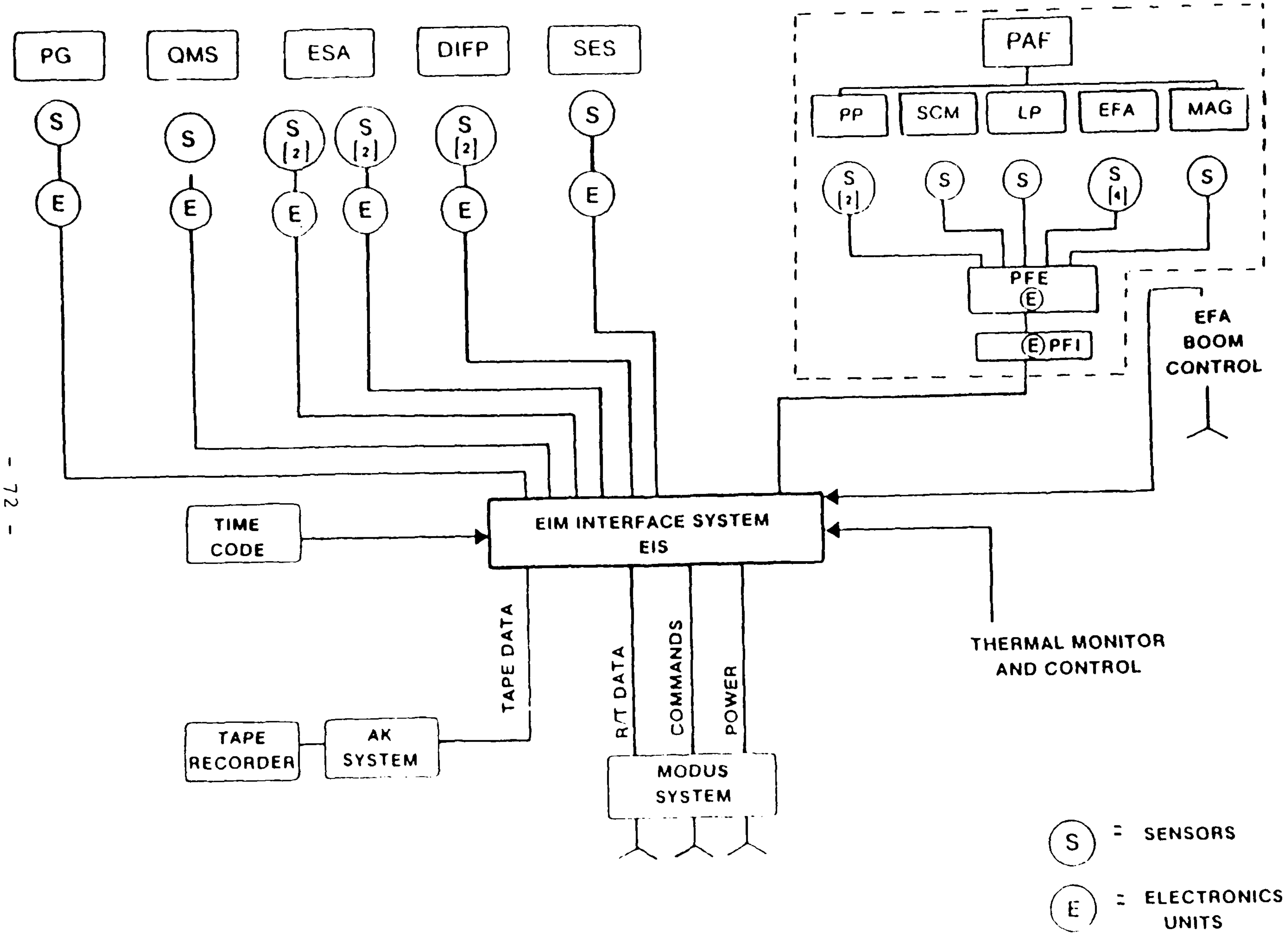


Figure 3.3.1. EIM-EIS Block Diagram

The EIS block diagram presented in Figure 3.3.2 may be subdivided into three functional parts connected through internal interfaces. One of the subsystems is dedicated to handle the digital data intended for storage on the magnetic tape. Digital data from the EIM instruments and the other subsystem of EIS are formatted into packets in the two RAM data buffers. While a new data packet is assembled in one of the buffers, the data previously stored in the other buffer are read by the Adaptation Kit (AK) electronics for storage on the tape.

The second major subsystem under the direction of a microcontroller manages a variety of tasks. There the analog and discrete signals are converted into digital data. The MET update receivers and counters are also located in the subsystem. The data and the time information to be included in the tape storage data are transmitted to the digital section through an internal interface. The commands are also received, processed by the microcontroller and redistributed from this section of EIS. The same instruments that provide digital data for the onboard storage, also provide digital data over a separate links for the real time transmission tothe ground. Once again a dual buffer system is used to format and to transmit the data. The packeted real time data are transferred from the buffer to the Data Handling Subsystem (DHS) of SPAS.

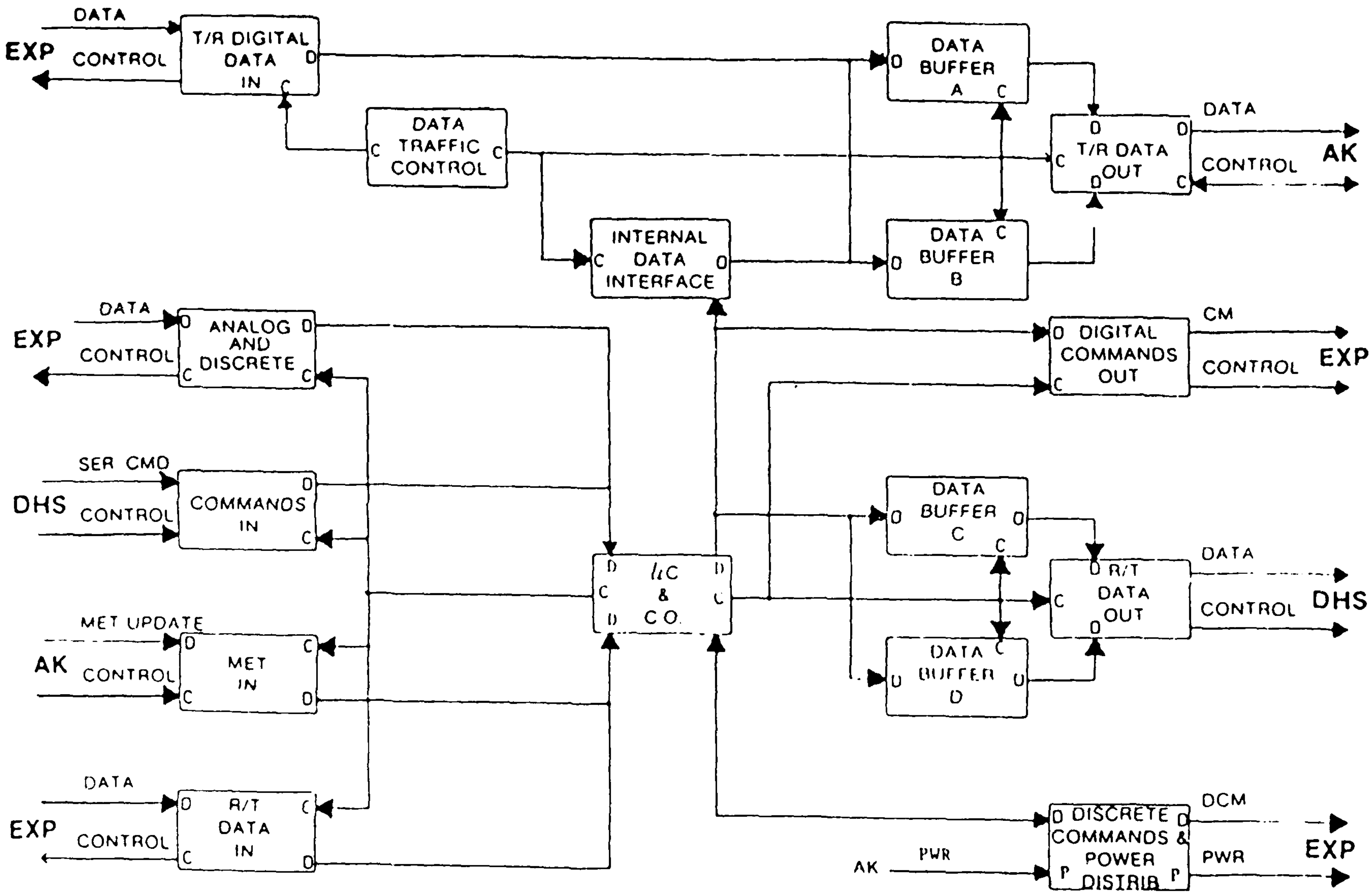


Figure 3.3.2. EIS Block Diagram

In addition to the power distribution and switching, the third subsystem also distributes bi-level commands and monitors the instrument power. A large number of relay and power line bi-level status monitors are also located in this section. The commands control signals and data are transmitted between this and the other sections of EIS through optoisolators. This opticalinterface is necessary tocomply with the requirement of signal and power ground separation.

3.3.3 Tape Storage Data Transceiver

All of the EIM data are stored in a digital form on a magnetic tape for post-flight reduction and analysis. Digital data are supplied to the EIS by 5 instruments: ESA-E, ESA-I, DIFP and PFI. A total of 90.24 kbps are received from these instruments, while SPAS is in the free flyer mode. The remaining 7.68 kbps are composed of the analog signal data, monitors, time code and packet headers. In the sortie mode (bay operations) the overall data rate is reduced to 12.24 kbps, of which 11 kbps are the digital data from the PAF and ESA instruments, while the rest carries monitor, time and header data. The serial digital data from each instrument are transferred to EIS in bursts of 8 bits at a time at the clock rate of 64 kHz. The burst rate corresponds to the byte rate allocated to each of the instruments. EIS controls the transfer of data by providing ENABLE and CLOCK signals at the appropriate times.

Functional block diagram of the digital data receiver together with the data rate allocations for each instrument specified in bytes per second (B/S) is shown in Figure 3.3.3-1. A single data receiver channel and the transfer timing diagrams for a single 8 bit word and for the duration of one data packet are depicted in Figures 3.3.3-2 and 3.3.3-3. It should be noted that the byte rate generator circuits are reset once per packet by the signal derived from the stable SPAS clock of 1024 kHz. Thus, synchronization with the MET data is reestablished once per packet time. It also should be pointed out that the internal interface, not specifically shown in the figures, consists of a tri-state buffer only.

The received data are formatted into 612 byte packets once every 50 ms in the free flyer mode and once every 400 ms in the sortie mode. A positive transition of a 1 Hz square wave available to the instruments marks the beginning of a 20 packet sequence in the free flyer mode. A 0.5 Hz signal could be made available, upon request, to mark the start of a 5 packet sequence in the sortie mode. The packet space and bit rate allocations are shown in Figures 3.3.3-4 and 3.3.3-5. The data from each instrument occupies a predetermined block of sequential locations within the packet. The first word received from the instrument during the packet interval occupies the lowest numbered location

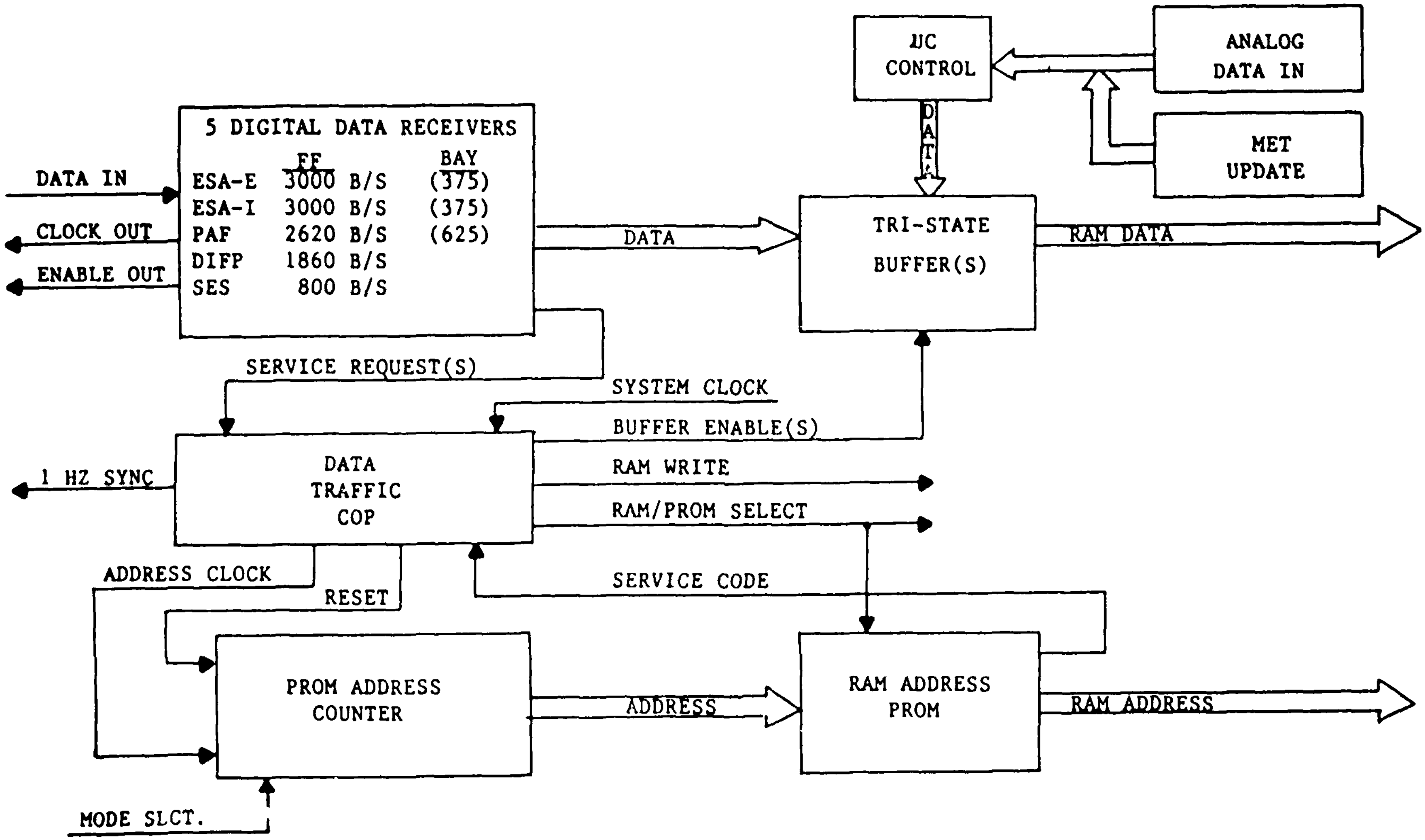


Figure 3.3.3-1. Digital Data Receiver

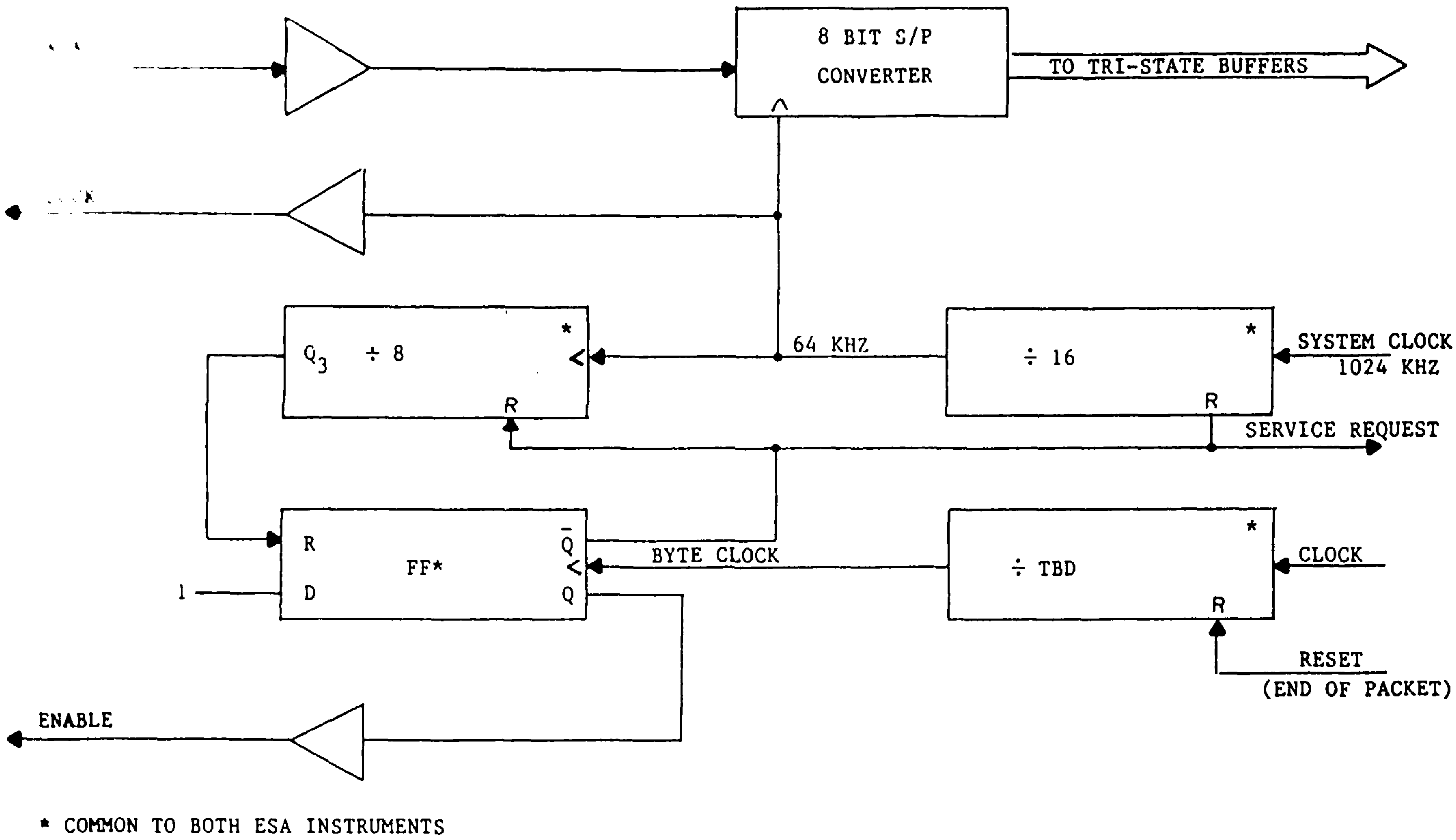
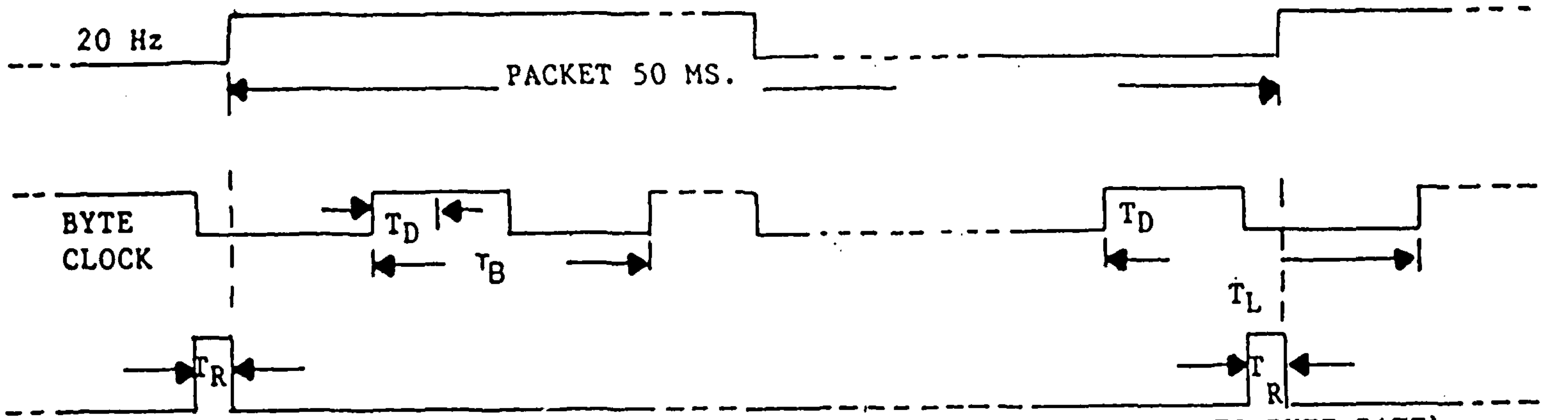
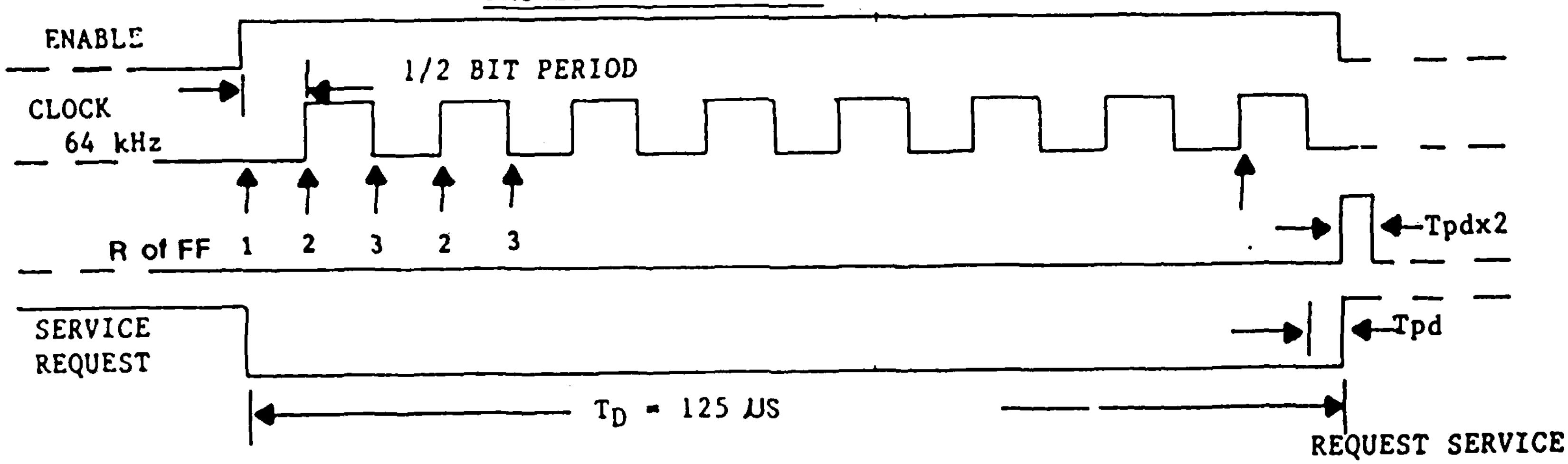


Figure 3.3.3-2. Typical Digital Data Channel



TB - SOURCE BYTE PERIOD (LENGTH OF PERIOD DEPENDS ON EXPERIMENTS BYTE RATE)
TD - DATA TRANSFER 125 μS (ONE WORD READ ON LEADING EDGE OF BYTE CLOCK)
TL - LAST $T_B = T_B \pm 10$ μS
TR - RESET = 36 ± 15 μS

PACKET PERIOD TIMING



1 - SOURCE LOADS DATA
2 - EIS SHIFTS DATA
3 - SOURCE SHIFTS DATA
4 - EIS SHIFTS LSB OF DATA

WORD TRANSFER TIMING

Figure 3.3.3-3. Data Transfer Timing

	BYTES	BYTES
PRIMARY HEADER		6
SECONDARY HEADER		10
DATA FIELD		596
ESA-E	150	
ESA-I	150	
PAF	131	
DIFP	93	
SES	40	
QMS	21	
PG	7	
EIS	2	
ONE'S CNT.	2	
TOTAL		612 BYTES

PACKET FORMATION/TRANSMISSION TIME = 50ms.

BIT RATE ALLOCATION	
HEADERS	2,560 bps
ESA-I	24,000 bps
ESA-E	24,000 bps
PAF	20,960 bps
DIFP	14,880 bps
SES	6,400 bps
QMS	3,360 bps
PG	1,120 bps
EIS	320 bps
ONE'S CNT.	320 bps
TOTAL	97,920 bps

Figure 3.3.3-4. Free Flyer Stored Data Packet

	BYTES	BYTES
PRIMARY HEADER		6
SECONDARY HEADER		10
DATA FIELD		596
ESA-E	153	
ESA-I	153	
PAF	255	
EIS	33	
ONE'S CNT	2	
TOTAL		612 BYTES

PACKET FORMATION/TRANSMISSION TIME = 408ms

BIT RATE ALLOCATION	
HEADERS	314 bps
ESA-I	3,000 bps
ESA-E	3,000 bps
PAF	5,000 bps
EIS	647 bps
ONE'S CNT	39 bps
TOTAL	12,000 bps

Figure 3.3.3-5. Sortie Stored Data Packet

within the asigned block. It should be noted that the ESA data from the two instruments is interwoven within the assigned block.

Figure 3.3.3-6 shows the functional diagram of the RAM system for the temporary storage of data while the packets are formatted. Complementary signals control the data flow into and out of the RAMS. The readout of data is under the AK control. EIS provides a READY flag, while AK supplies the GATE ENABLE and the CLOCK signals from which the LOAD/SHIFT signals for the output register are derived by EIS. The 97.92 kbps in the free flyer mode and the 12.24 kbps in the sortie mode are transferred in bursts at 512 kbps once during each packet period. The transfer control and timing sequences are shown in Figures 3.3.3-7 and 3.3.3-8. The output configuration is shown in Figure 3.3.3-9. A counter in the output counts the number of ONE'S in the bit stream of the packet being read. The obtained count is transmitted as the last two bytes of the packet. Thus some measure of data quality may be obtained during data reduction by comparing the transmitted and ground based counts. Other blocks in the Figure are self-explanatory.

3.3.4 Real Time Data Subsystem

EIM has been allocated 1280 bps on the real time data link of SPAS. With the exception of PG, which has an allocation of only 16 bps, each investigation has 200 bps at its disposal. Thus, both ESA instruments must share the

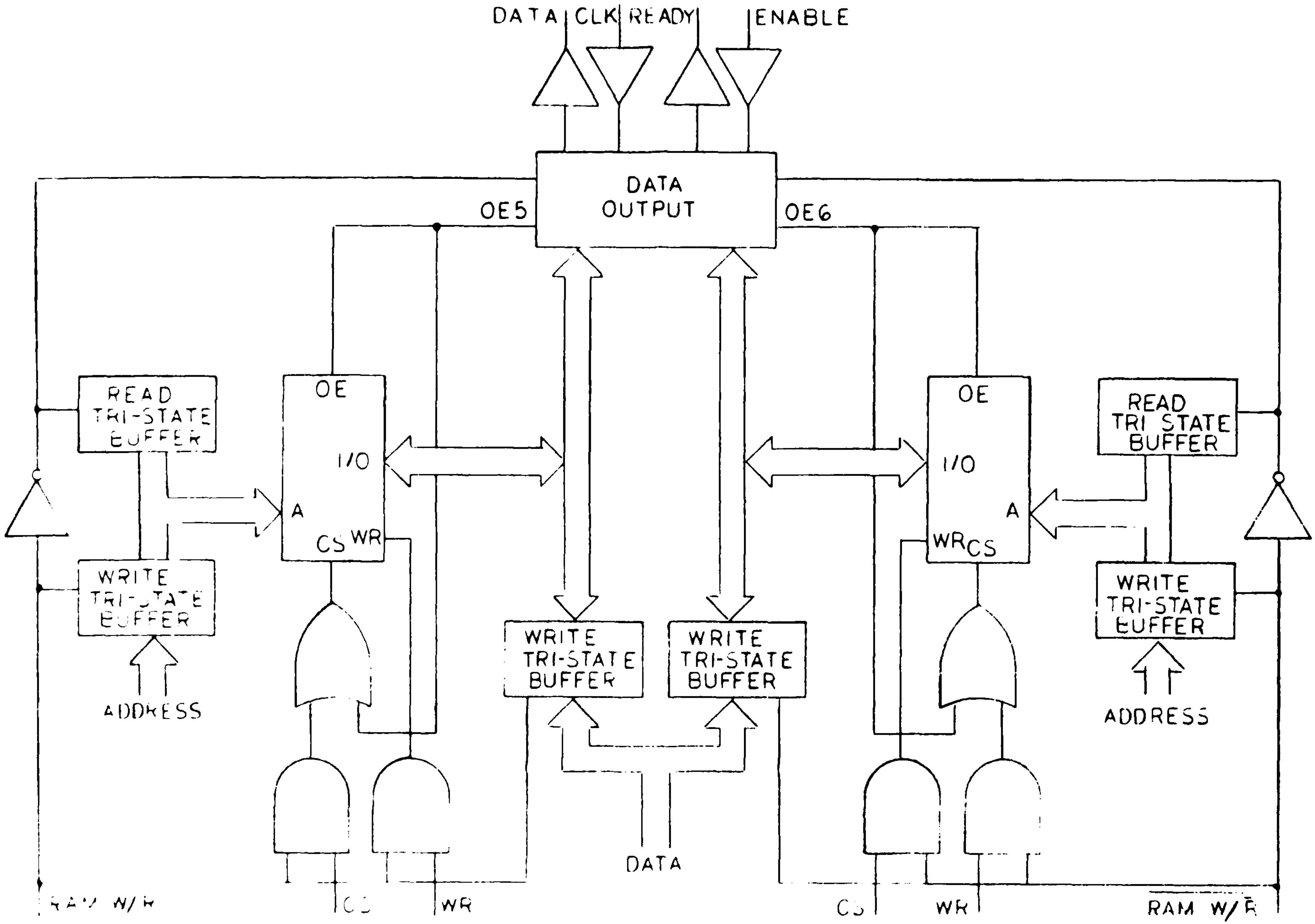
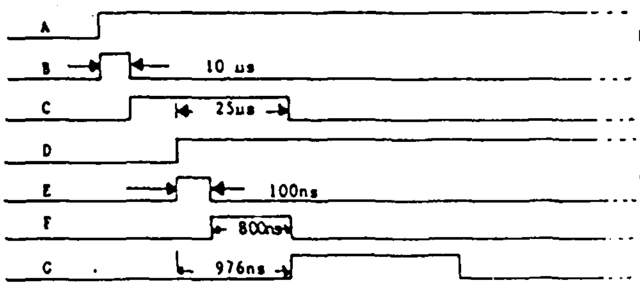
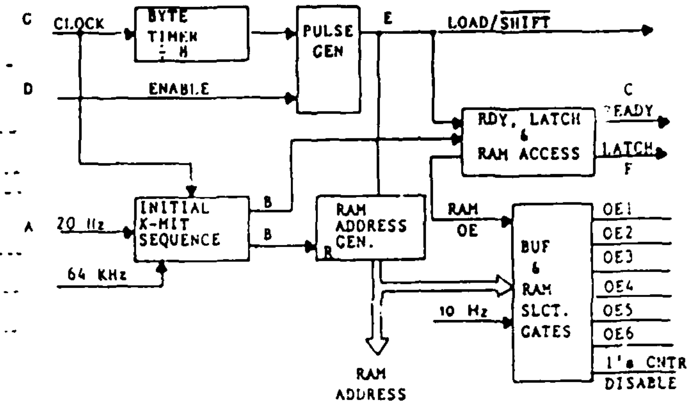


Figure 3.3.3-6. RAM for Stored Data





A. SELECT OUTPUT RAM AND CIRCUITS. 20Hz
B. RESET ADDRESS COUNTER; LOAD DATA INTO OUTPUT LATCH
C. SET READY SIGNAL
D. ENABLE SIGNAL ARRIVES
E. LOAD OUTPUT SHIFT REGISTER; ADVANCE ADDRESS COUNTER
F. LOAD OUTPUT LATCH WITH NEW DATA
G. CLOCK. DATA ACCEPTED ON LEADING EDGE.
EVENTS E,F,G ARE REPEATED EVERY 8 CLOCK PULSES UNTIL THE DATA FROM THE RAM AND ONE'S COUNTER HAVE BEEN TRANSMITTED.

Figure 3.3.3-7

Stored Data Output Transfer Control

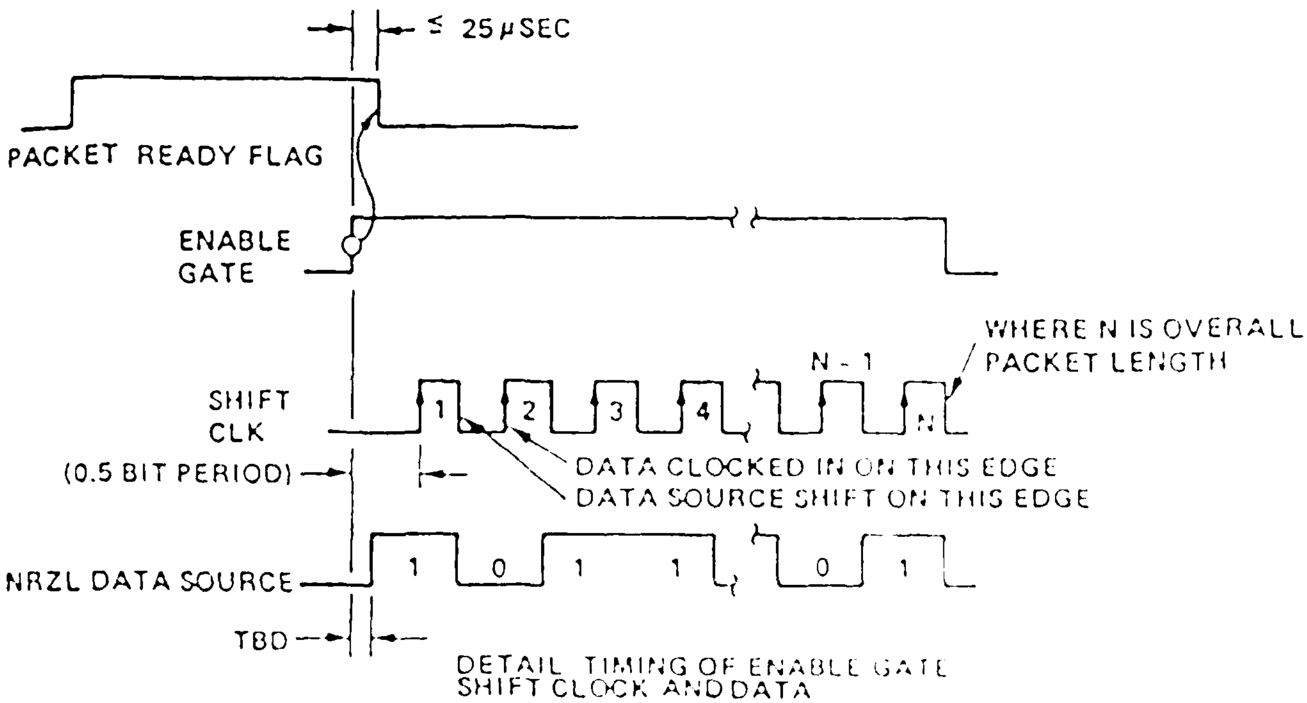


Figure 3.3.3-8.

Stored Data Output Timing

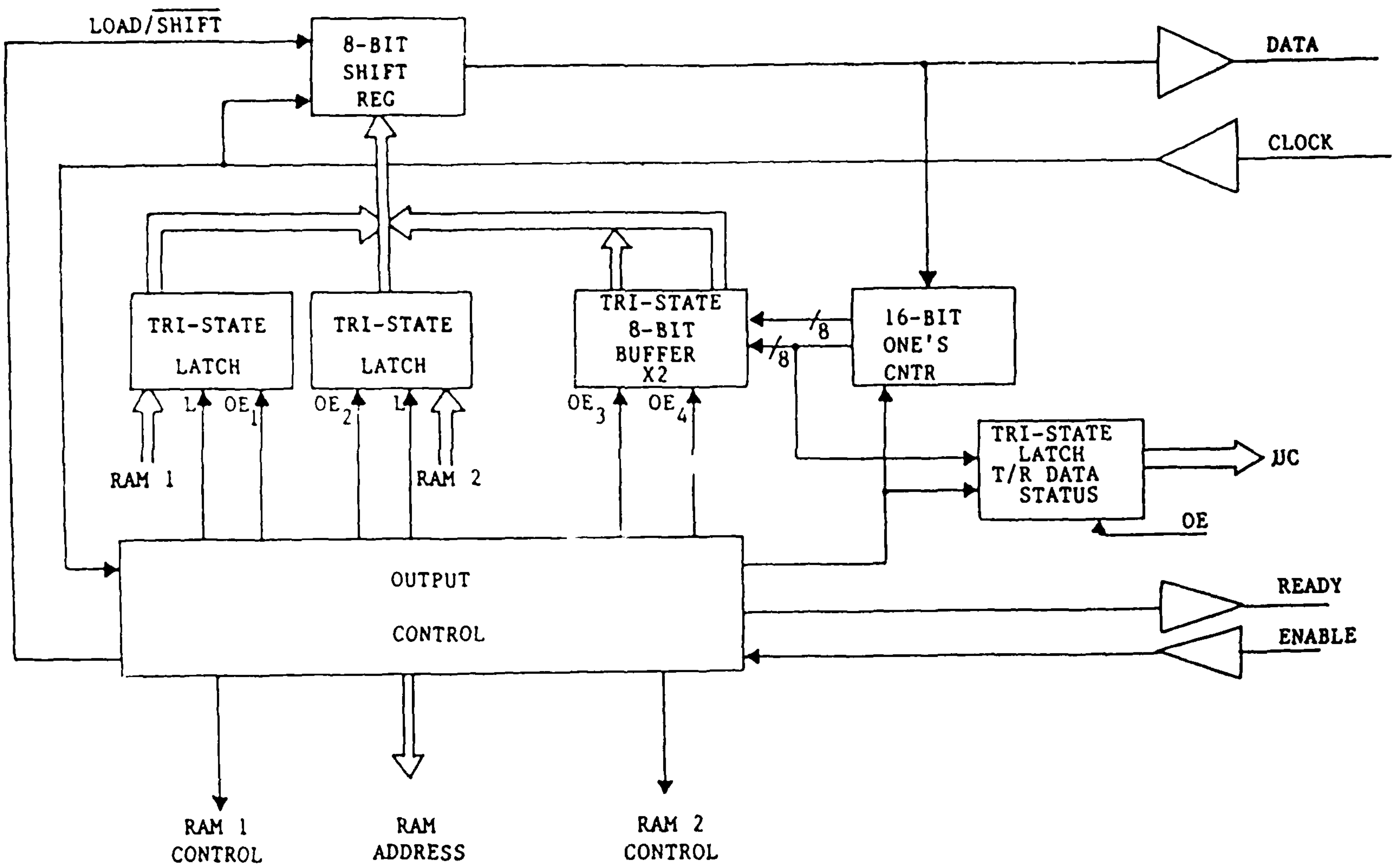


Figure 3.3.3-9. Stored Data Output Block Diagram

allocation of 200 bps. Once again, the bulk of data are received by EIS in digital form. Analog data and system monitors are processed by EIS.

A packet of 320 bytes as shown in Figure 3.3.4-1 is assembled and then transmitted to DHS every two seconds. The transmission takes place at a continuous rate of 1280 bps and is under EIS control. The necessary clock and synchronization signals dictated by DHS requirements are derived from the 1024 kHz system clock supplied by SPAS avionics. The digital data transfer from the instruments to EIS is also under EIS control. The data from each instrument is gathered once per second in a continuous burst at 16 kbps. The transfer from each instrument starts at a well defined time following the positive transition of the 1 Hz synchronization square wave. There is a requirement that the instrument data must have at least one transition in 32 consecutive bits. This requirement is enforced by EIS. Whenever these missing transitions are detected, EIS introduces one on its own. Usually the LSB of the offending word is complimented. Analog and monitor data handled by EIS are also packeted at well defined times with proper transitions where required. The EFA deployment monitor signals are placed as the first 8 bytes in the packet data field just after the secondary header. These signals are displayed in the AFT deck of the space craft.

	BYTES	BYTES
PRIMARY HEADER		6
SECONDARY HEADER		10
DATA FIELD		304
ESA - E	26	
ESA - I	24	
PAF	76	
DIFP	50	
SES	50	
QMS	50	
PG	4	
EIS	22	
ONE'S CNT.	2	
TOTAL		320 BYTES

PACKET FORMATION/TRANSITION TIME = 2 SEC.

BIT RATE ALLOCATION

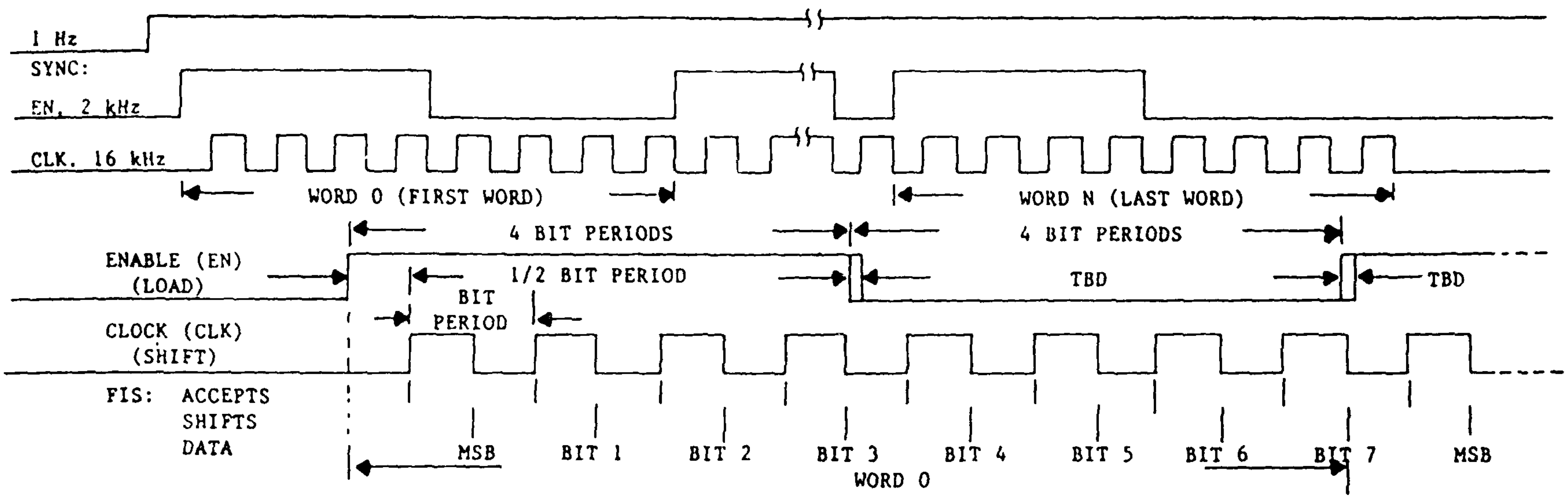
HEADERS	64 bps
ESA - E	104 bps
ESA - I	96 bps
PAF	304 bps
DIFP	200 bps
SES	200 bps
QMS	200 bps
PG	16 bps
EIS	96 bps
ONE'S COUNT	8 bps
TOTAL	1280 bps

Figure 3.3.4-1. Real Time Data Packet

The data transfer timing diagram for one instrument is presented in Figure 3.3.4-2. Both, a single 8 bit word transfer timing and the complete burst timing diagrams are shown. The receiver block diagram is shown in Figure 3.3.4-3. Sixteen bit shift register is filled with data before it is read by the microcontroller. The uC in conjunction with the control logic determine when to switch the multiplexers and thus, the data control signals to the different instruments. The signals are always switched in ZERO state to avoid possible spurious transitions. For that reason ENABLE is switched to the next instrument before the clock and the data multiplexers are advanced. The FLG 1 and FLG 2 signals preset the logic when the ADDRESS COUNTERS for ENABLE, DATA and CLOCK are to be incremented. Thus, the logic circuits release the uC from the duties of precise timing.

The dual RAM subsystem where the packets are assembled is very similar tothe RAM for the tape storage data and therefore is is omitted from this section. The output circuits, including waveforms dictated by DHS are shown in Figures 3.3.4-4 through 3.3.4-6.

The output control generates the required signals to connect the appropriate RAM to the output buffers and to load the buffers and subsequently the output shift register with data. RAM address selection and the "Packet Start" sync pulse for DHS, as well as, the ONE's counter reset are



NOTE:

1. DATA COLLECTED IN A CONTINUOUS BURST ONCE PER SECOND.
2. CLOCK RATE 16 Kbps
3. ENABLE SQ. WAVE 2 kHz
4. AFT DECK DISPLAY INFORMATION WILL BE TAKEN FROM THE FIRST BYTES OF DATA COLLECTED FROM EACH EXPERIMENT.
5. ENABLE AND CLOCK SIGNALS ORIGINATE IN EIS.
6. DATA <u>MUST</u> CONTAIN AT LEAST ONE TRANSITION EVERY 32 BITS.

Figure 3.3.4-2. Real Time Data Input Timing Diagram

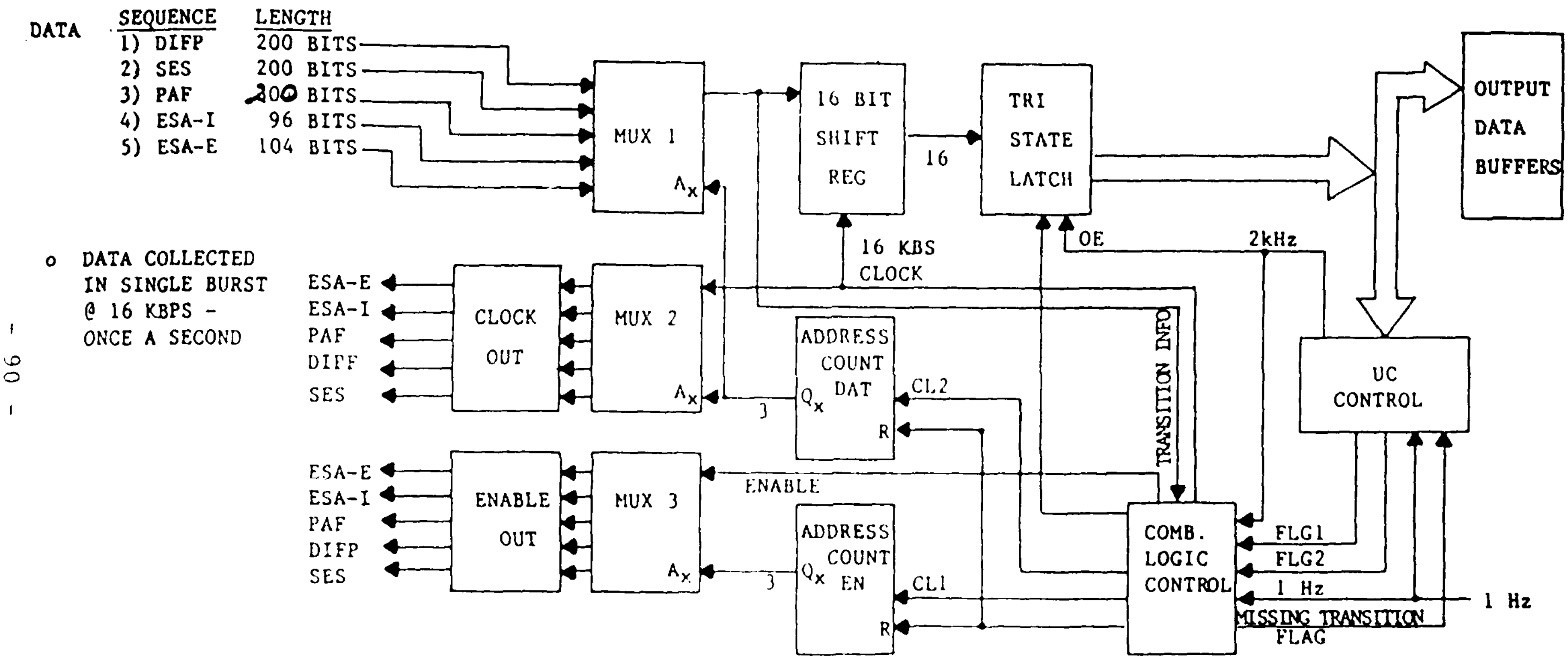
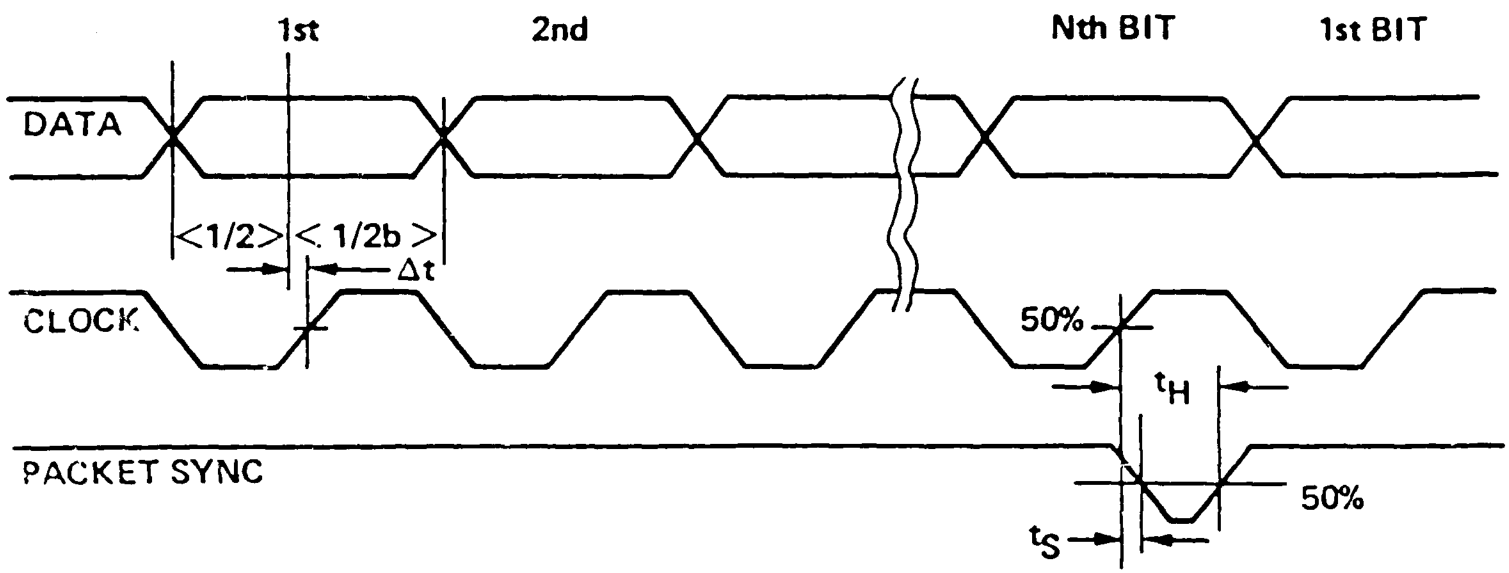


Figure 3.3.4-3. Real Time Data Receiver



DATA ARE VALID ON POSITIVE GOING EDGE OF CLOCK. USER SETS FIRST BIT OF WORD WITH POSITIVE GOING EDGE OF SYNC.

TIME SKEW	$\lvert\Delta t\rvert \leq 5\ \mu s$
CLOCK DUTY CYCLE	50% ± 10%
$t_{SET\ UP}$	$5\ \mu s \leq t_S \leq 10\ \mu s$
t_{HOLD}	$20\ \mu s \leq t_H \leq 50\ \mu s$

Figure ?.3.4-4. DHS Data Transfer Timing

AD-A183 541 INSTRUMENTATION AND COMMUNICATION SYSTEMS FOR SOUNDING ROCKETS AND SHUTTL..(U) NORTHEASTERN UNIV BOSTON MASS ELECTRONICS RESEARCH LAB J S ROCHEFORT ET AL. 27 APR 87 AFGL-TR-87-0139 F19628-83-C-0037 F/G 25/1 2/2

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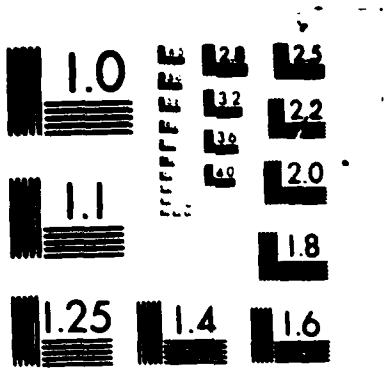


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

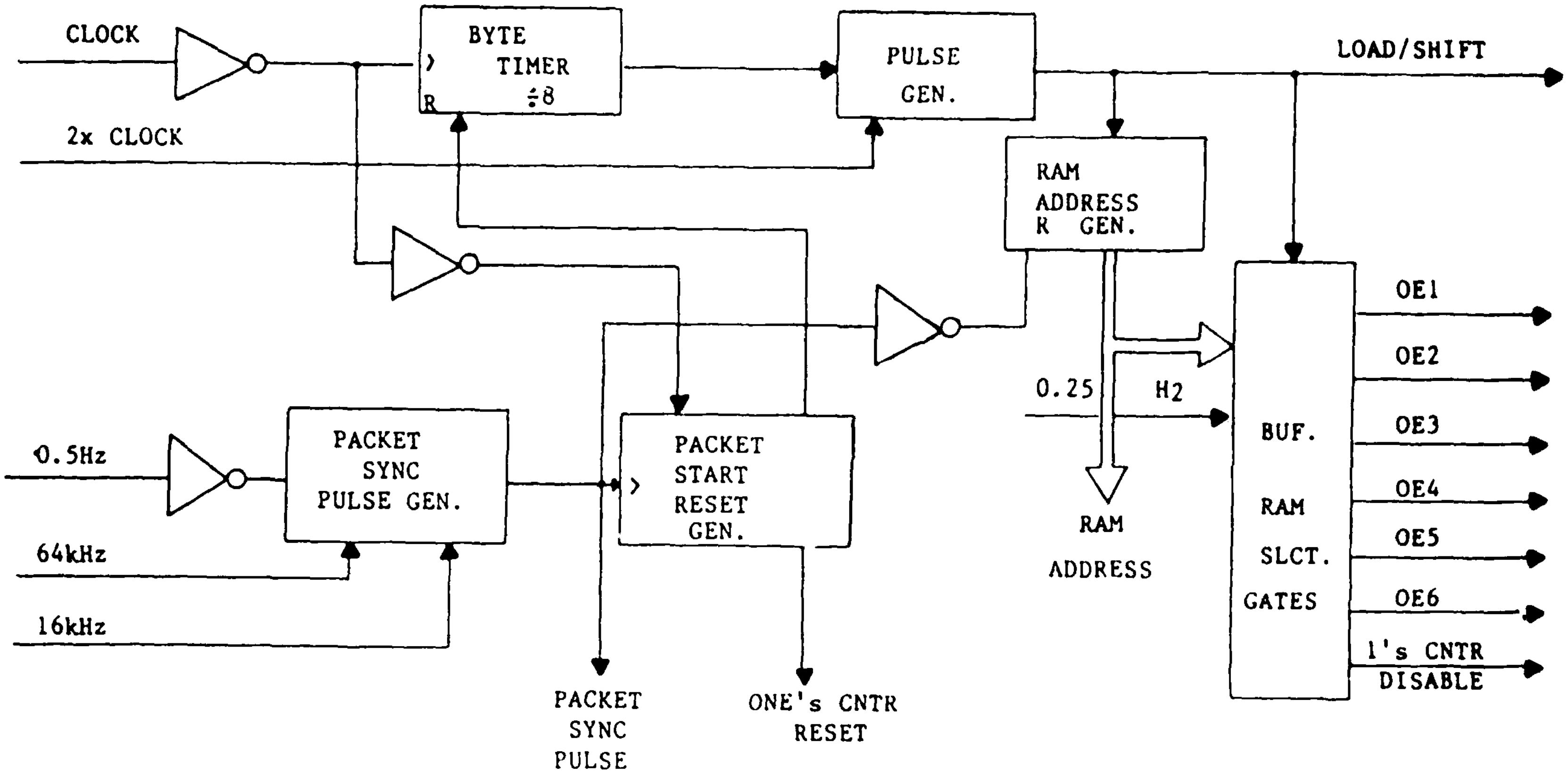
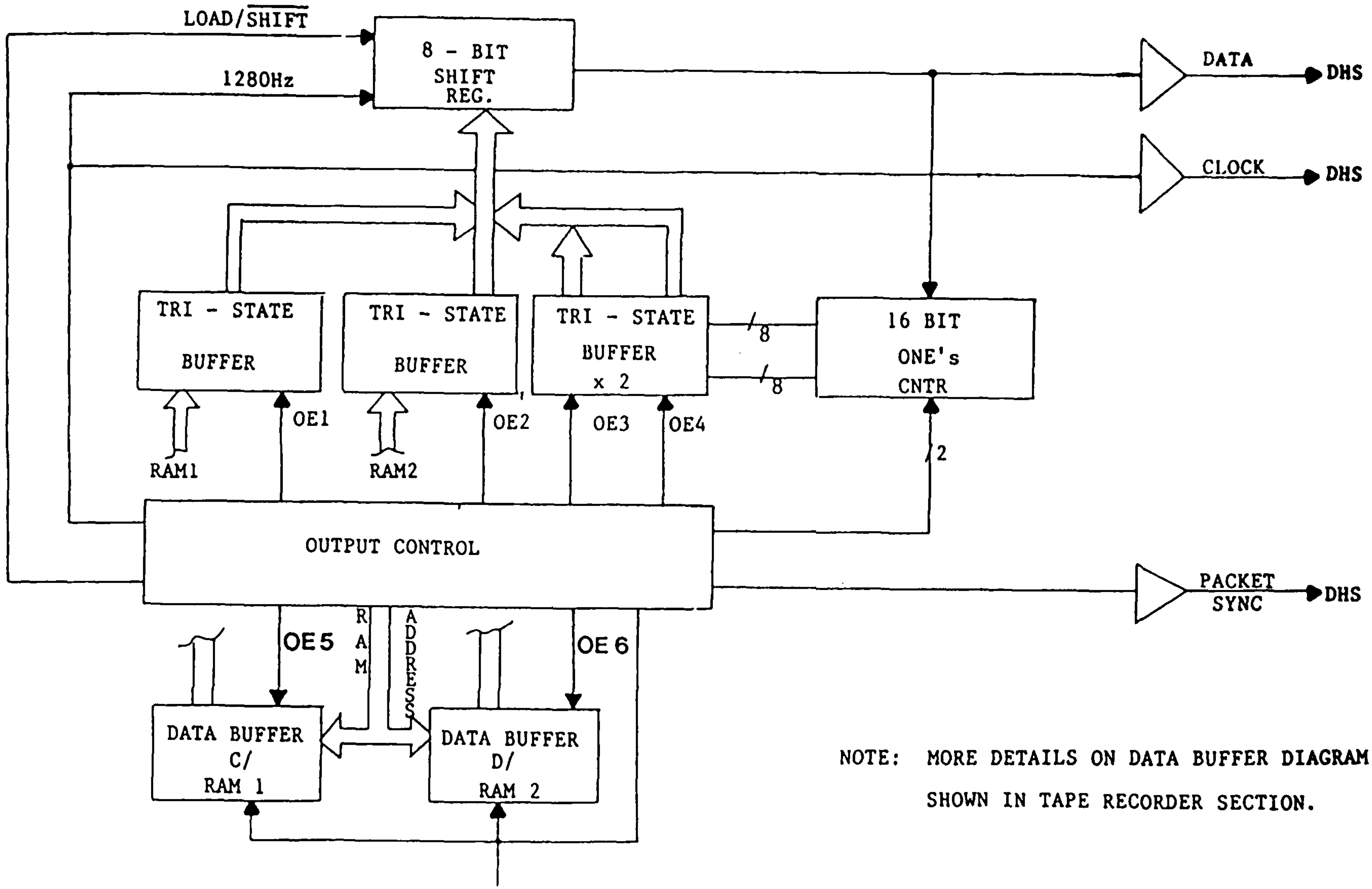


Figure 3.3.4-5. Real Time Data Output Control



NOTE: MORE DETAILS ON DATA BUFFER DIAGRAM SHOWN IN TAPE RECORDER SECTION.

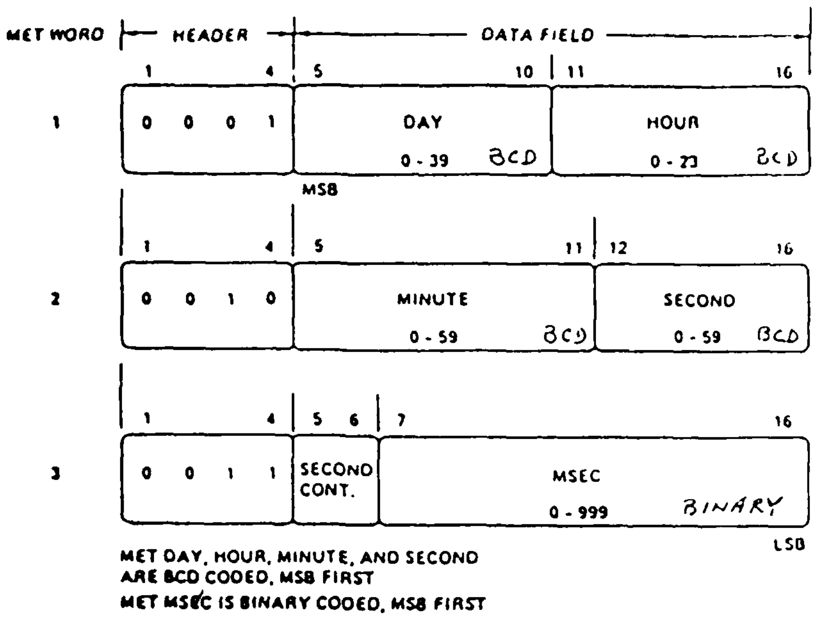
Figure 3.3.4-6. Real Time Data Output

generated in this subset of circuits. To insure word synchronization, the byte counter is reset at the start of each new packet. These pulse generators are combinations of D-TYPE FF triggered, set and reset by the various derivatives of the 1024 kHz system clock. The output circuits are very similar to the tape storage data output and are self explanatory.

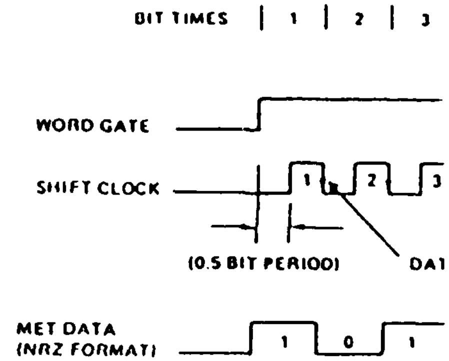
3.3.5 Time Tagging of Data

During a mission the DHS provides periodic MET updates to the users of SPAS. These updates, in a form of three 16 bit words, are transmitted to the user under the DHS control. The received time code must be stored until the DHS issues a sync pulse announcing that the stored code represents the correct MET at that moment. Between the updates presettable counters driven by the 1024 kHz system clock may be used to provide the time tagging requirements of the experimenters.

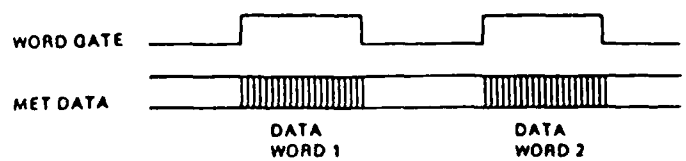
The three 16 bit update words are transmitted at a rate of 8 kbps with each word separately gated. The MET update format, sequence and timing diagram are shown in Figure 3.3.5-1. The EIS circuits to utilize the time data are shown in Figure 3.3.5-2. The incomming data is first stored in the 48 bit shift register. Upon receipt of the MET SYNC pulse , a synchronizing circuit is activated. Within one system clock period, the circuit produces a reset pulse equal to one clock period to load the BCD/BIN counter with



MET SERIAL DATA OUTPUT FORMAT



MET SERIAL DIGITAL TI



MET WORD SEQUENCER

Figure 3.3.5-1. MET Data

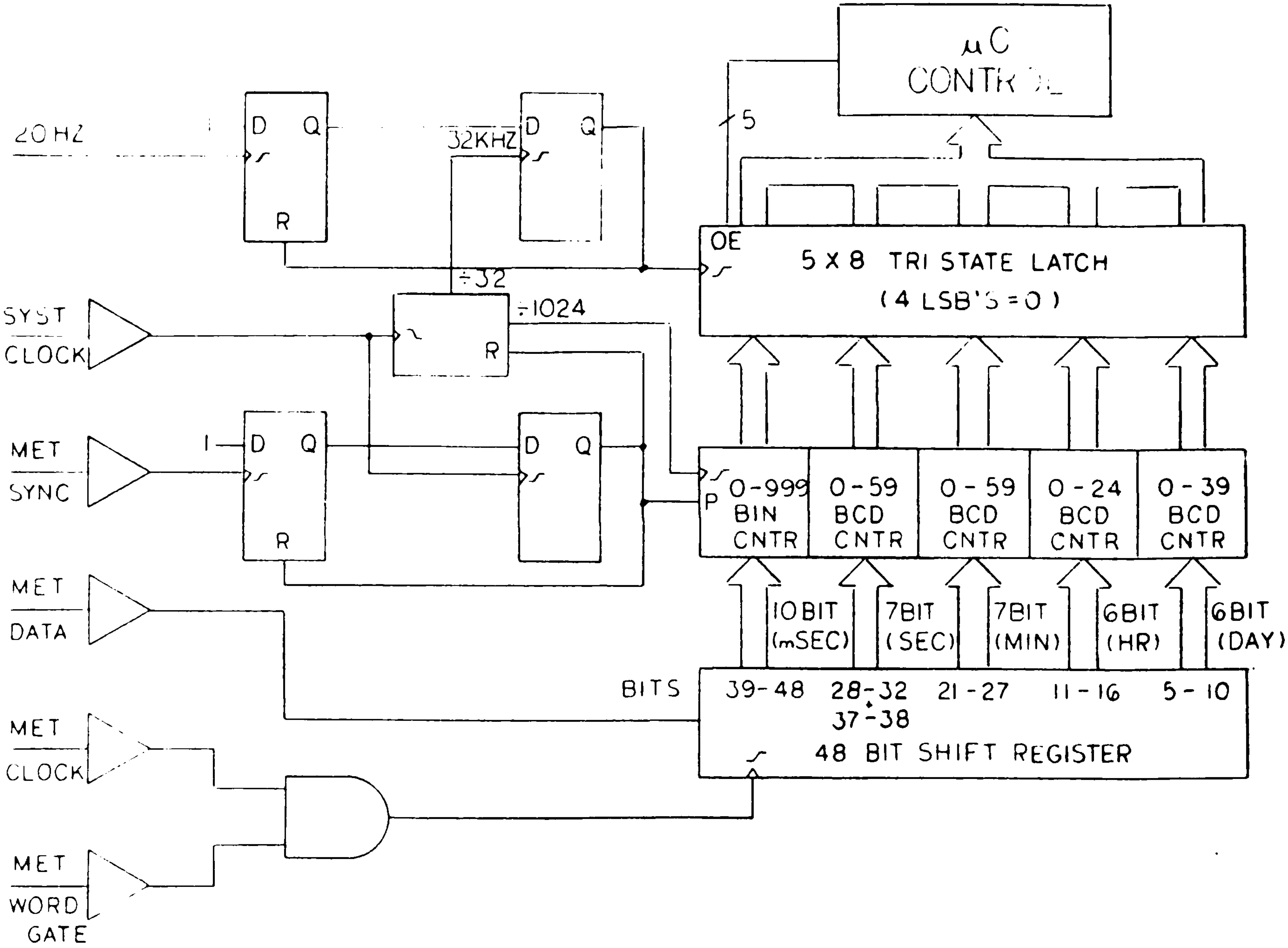


Figure 3.3.5-2. MET Data Sub-System

the contents of the shift register. During the loading process the header bits are removed from the update data. Thus, only 36 bits are loaded into the counter. At the same time, the scaler circuit generating a 1 kHz clock signal for the counter is reset. The first increment in the MET data takes place approximately 500 us later on the positive edge of the 1 kHz clock. Thus, the original time error is approximately $\pm$500 us referred to the MET update. At the start of each new packet the contents of the counter are transferred into a holding register. From there, at the convenience of uC, the time data are inserted into the packet. Once again, a synchronizing circuit is employed to prevent transfer of data while the contents of the counter are changing.

Since a well-defined time relationship exists between the insertion of the data into the packet and the start of the packet formation, the time tag of data in the packet is accomplished. Only additional information necessary to refine the time tag is the elapsed time between when the data was gathered and the time that it was transmitted to EIS. This relationship must be established by each instrument using the 1 Hz sync waveform and for the periodic transfer control signals used in digital data circuits.

3.3.6 Commands

Twenty-seven unique 16 bit serial commands have been allocated to EIM. These commands are received, processed and distributed to the appropriate instruments as 41 eight-bit serial and 66 bi-level commands. Instrument, as well as, internally executed commands are included in the count. The commands are transmitted from SPAS arionics to EIS at a clock rate of 8 kbps at the frequency not to exceed one command per second. To satisfy the EIM requirements, two commands from SPAS are combined to generate a single command for an instrument.

Only the 8 LSB's from each SPAS command are accepted by EIS. The first command uniquely defines one of 14 addresses identifying the instrument, while the second command identifies the task to be performed. Codes with a distance of at least 2 have been selected for that purpose. The command matrix is shown in Figure 3.3.6-1. The command identification and verification process is shown in the form of a flow graph in Figure 3.3.6-2.

The word structure, timing and the functional diagram of the command receiver are shown in Figures 3.3.6-3 and 3.3.6-4.

After the 16 bit command word has been transmitted, the 8 LSB's remain in the shift register. A READY flag is set by the 5 bit counter. The microcontroller enables the buffer, resets the counter and processes the command.

	ADRS. COMM. IN HEX	TASK COMMAND IN HEX													
		B1	B2	B4	B7	B8	BB	BD	BE	D3	D5	D6	D9	DA	DC
PG	23	EN	DIS	ON	OFF										
QMS	25	EN	DIS	ON	OFF	COV OPN	COV CLS	COV P ON	COV P OFF	MODE 1	MODE 2	MODE 3	MODE 4	AUTO LONG	AUTO SHORT
SES1	26	EN	DIS	ON	OFF	MODE 1	MODE 2	MODE 3	MODE 4	MODE 5	MODE 6	MODE 7	MODE 8		
SES2	29					MODE 9	MODE 10	MODE 11	MODE 12	MODE 13	MODE 14	MODE 15	MODE 16		
DIFP	2A	EN	DIS	ON	OFF	MODE 1	MODE 2	MODE 3	MODE 4	MODE 5					
ESA1	2C	EN	DIS	ON	OFF	MODE 1	MODE 2	MODE 3	MODE 4	MODE 5	MODE 6	MODE 7	MODE 8		
ESA2	41			HV ON	HV OFF	MODE 1S	MODE 2S	LOWSWP ON	LOUSWP OFF						
PAF	42	EN	DIS	ON	OFF	MODE 1	MODE 2	MODE 3	MODE 4	MODE 5	MODE 6				
EFA1	44	EN	DIS	DEP	STP	RET									
EFA2	47	EN	DIS	DEP	STP	RET									
EFA3	48	EN	DIS	DEP	STP	RET									
EFA4	4B	EN	DIS	DEP	STP	RET									
EIS	4D						BAY	FREE FLT							
	4E														

Figure 3.3.6-1. Command Matrix

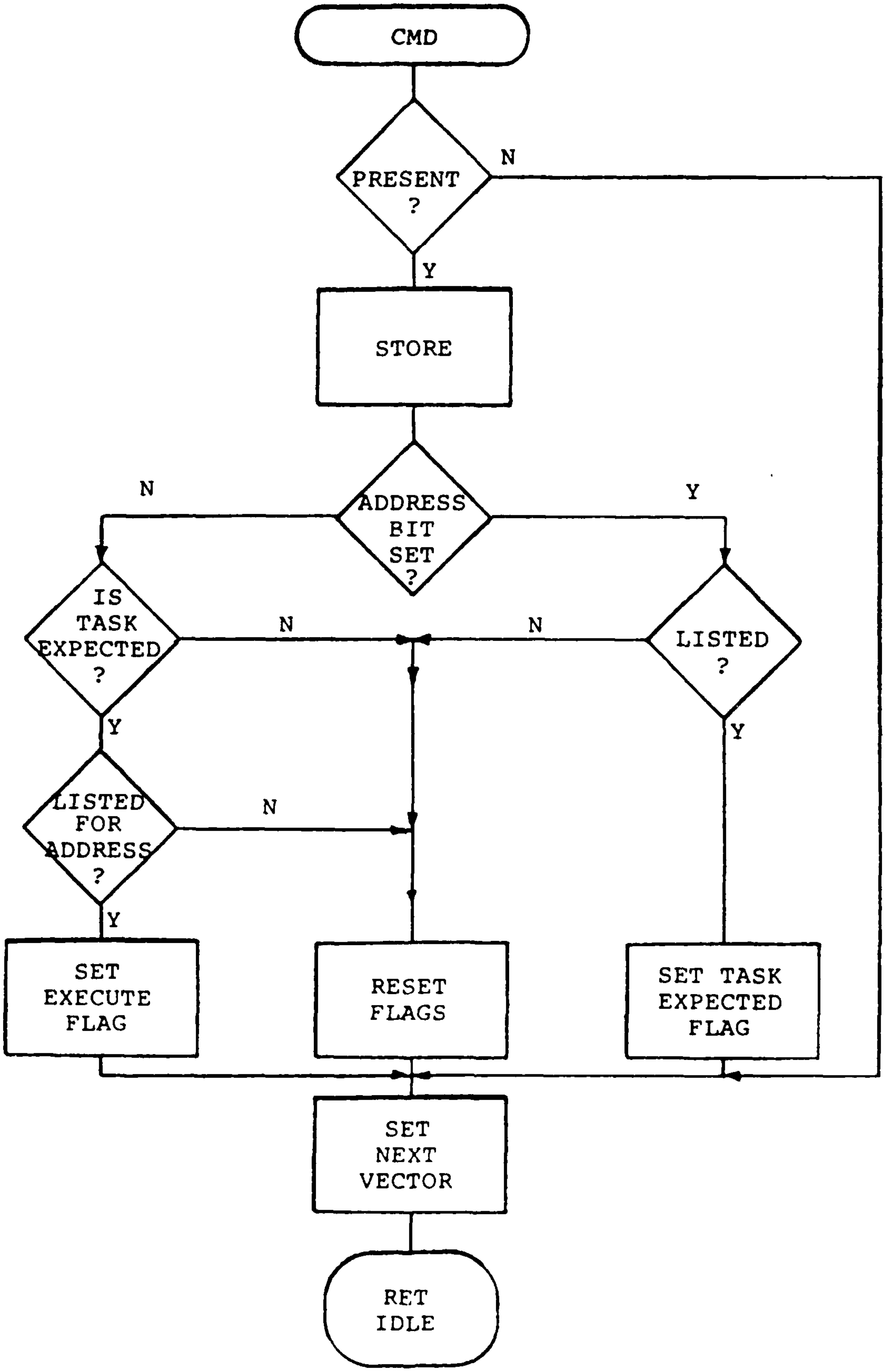


Figure 3.3.6-2. Command Verification

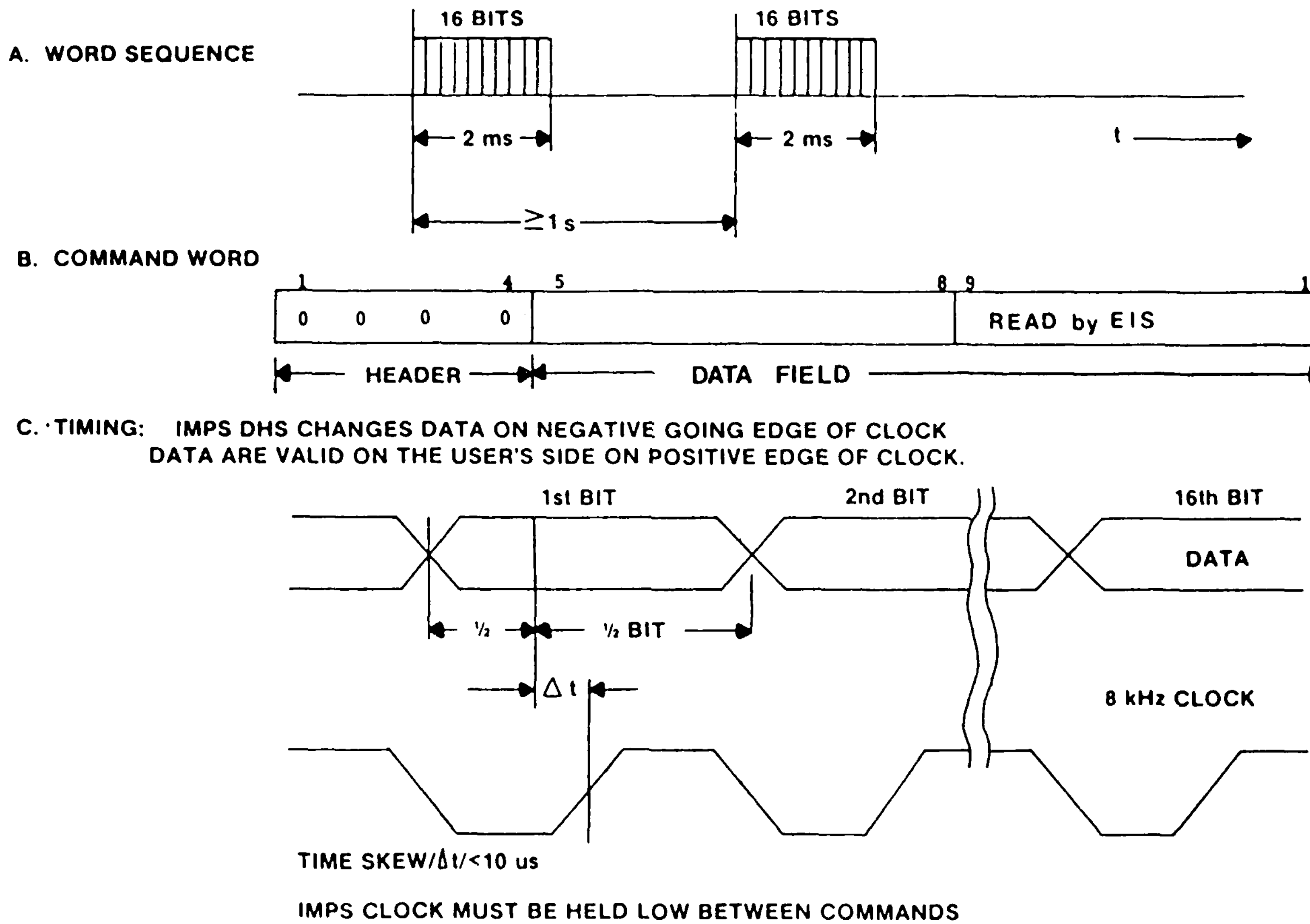
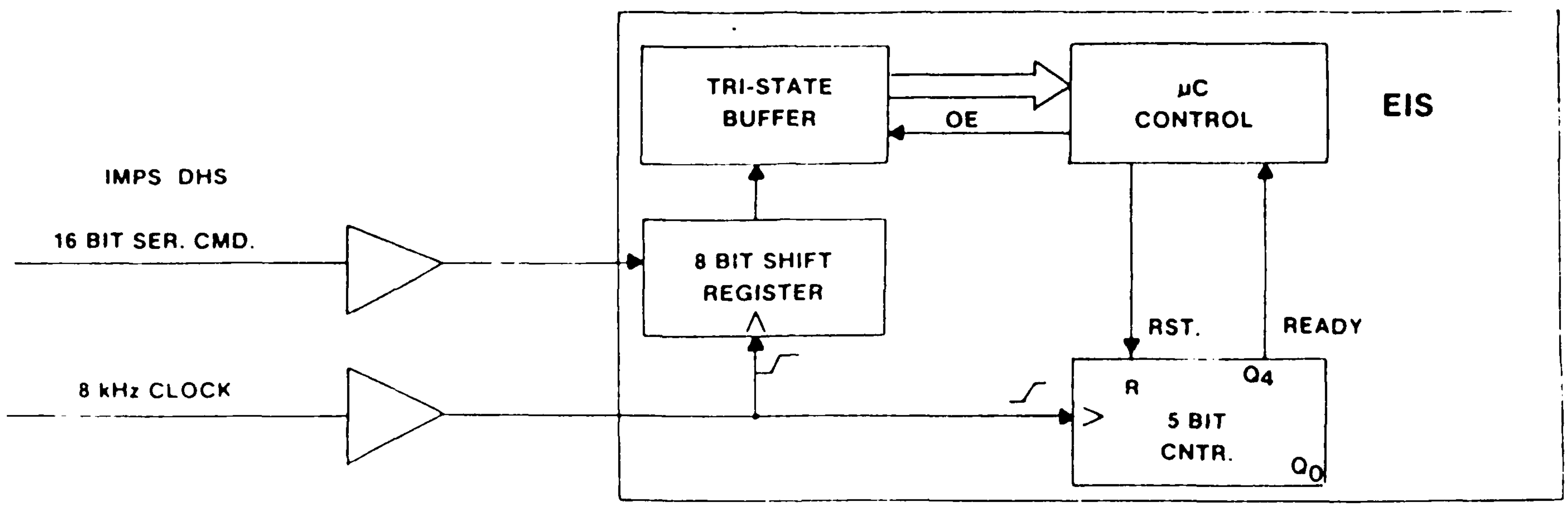


Figure 3.3.6-3. Command Signal Structure



- 27 UNIQUE COMMANDS RECEIVED FROM IMPS
- ONLY 8 LSB'S RECOGNIZED BY EIS
- TWO MODUS COMMANDS REQUIRED FOR ONE EIS TASK
  - 8 BIT ADDRESS FOLLOWED BY
  - 8 BIT TASK COMMAND
- EIS INCOMMING COMMAND PROCESSING
- 8 BIT COMMAND CODES HAVE DISTANCE OF TWO FROM EACH OTHER

Figure 3.3.6-4. Command Receiver

3.3.7 Analog and Discrete Data

A total of 16 analog data signals from QMS, PG and EFA deployed distance monitors are proessed by EIS. For these signals conversion rates of 100 S/S, 10 S/S and 1 S/S are used Only the pressure data from PG requires 10 bit resolution. Other signals, including 19 internal monitors are converted using 8 bit resolution. In addition to the analog signals EIS handles 14 external and 48 internal bi-level monitors.

3.3.8 Interface Circuits

Two types of digital interface circuits are used to transmit signals between the EIM instruments and EIS. The circuits are shown in Figure 3.3.8-1. In one of the configurations a differential line driver and receiver are employed. A shielded twisted pair of wires connect the two units. The additional components are included to limit current in the event of accidental short, to provide some matching to the transmission line during signal transitions and to remove spurious high frequency components from the lines. These circuits are employed exclusively in the ESA data links. The only exception is the 1 Hz square wave which is transmitted through the second interface configuration shown in the figure. In this configuration CMOS 4000 TYPE circuits are used as single ended drivers. The driver consists of three buffers connected in parallel

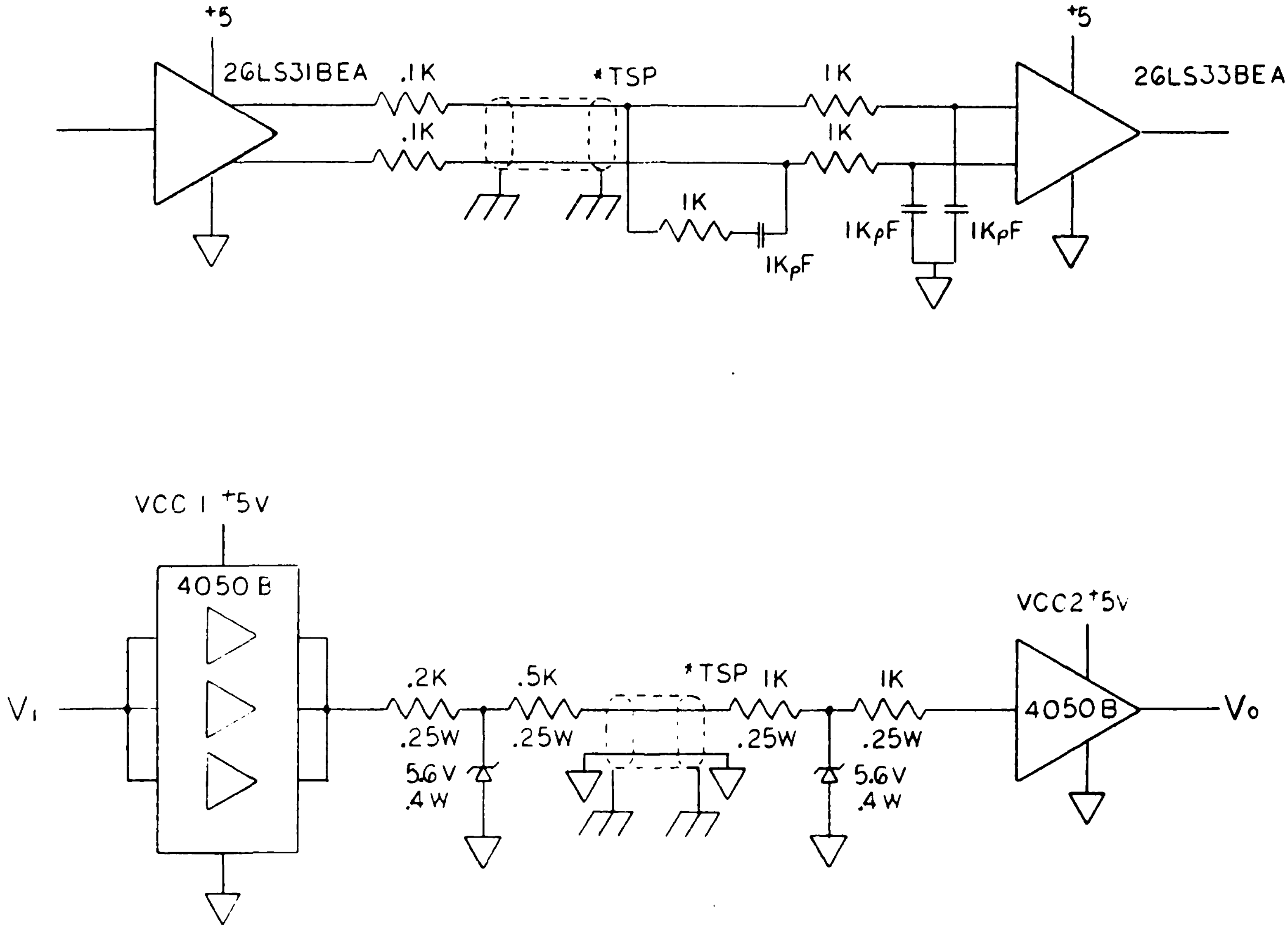


Figure 3.3.8-1. Digital Interface Circuits

to enhance the driving capability. The resistors and the zener diodes are included to increase protection against electrostatic discharge and to limit currents in case of accidental short. Once again, a twisted shielded pair of wires are used to connect the two units. Due to the relatively slow response time of the CMOS devices, not additional filtering is introduced into the transmission circuits.

The interface circuits for the analog and the descrete signals are shown in Figure 3.3.8-2. Once again CMOS units with protective components are used for the descrete signals. The existing analog instruments employ operational amplifiers with typical protection circuits shown. The EIS employs an analog multiplexer with built in overvoltage protection which is further enhanced by the resistor-zener diode circuits on each of the inputs.

The internal interfaces using the optocouplers for the monitor and the bi-level commands are shown in Figures 3.3.8-3 and 3.3.8-4. Eight bits in each case are reserved for data transfer, while the remaining optical circuits are used to transfer. The buffer and/or the latch selection codes. The interface between the EIS and the arionics of SPAS is dictated by the Interface Control Document (ICD). The Figures 3.3.8-5, 3.3.8-6 and 3.3.8-7 are reproduced from "SPAS/IMPS-1 Interface Control Document (ICD)", 19 September 1986, Version 2.0. It should be noted that the specified

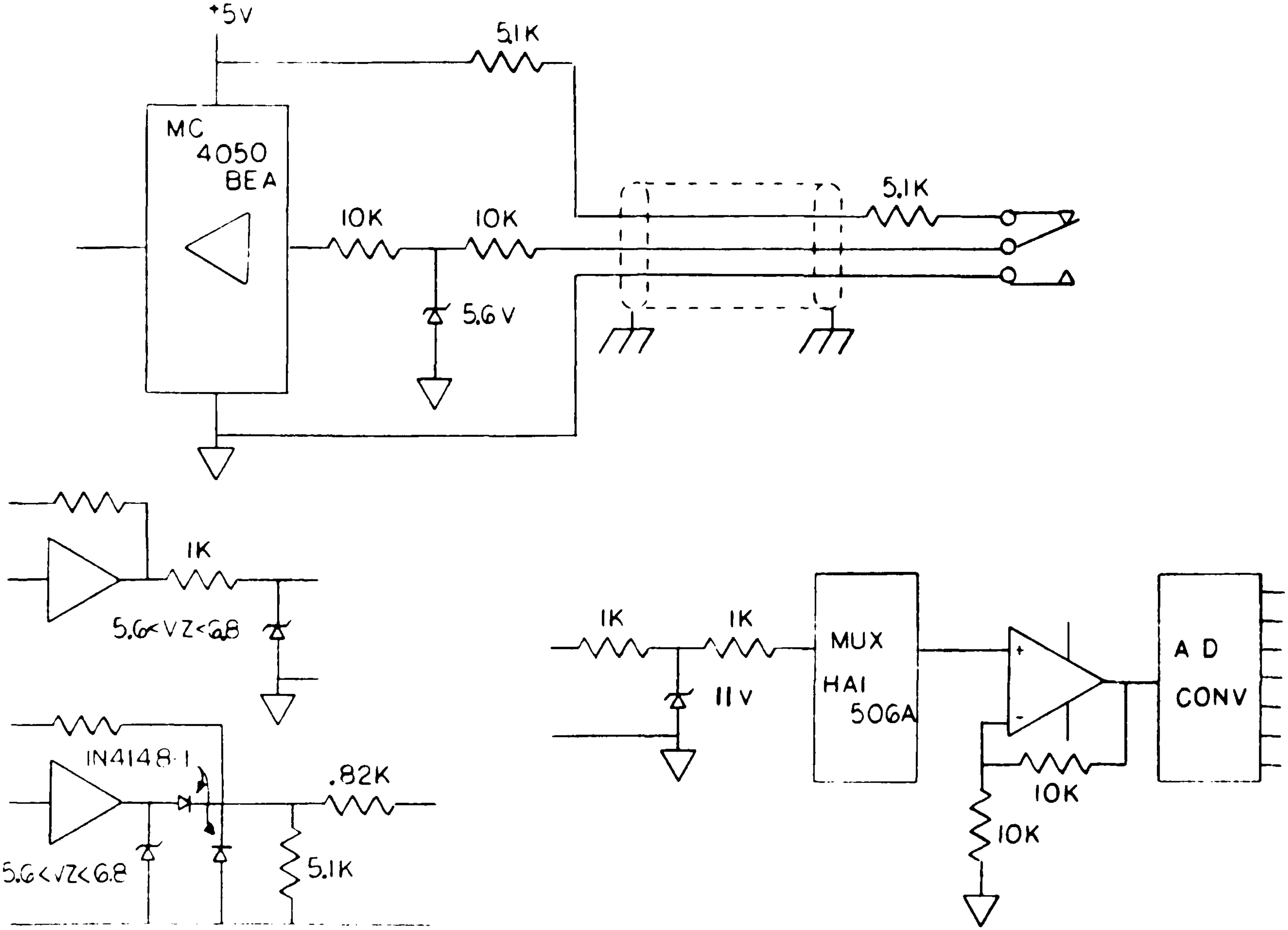


Figure 3.3.8-2. Analog Interface Circuits

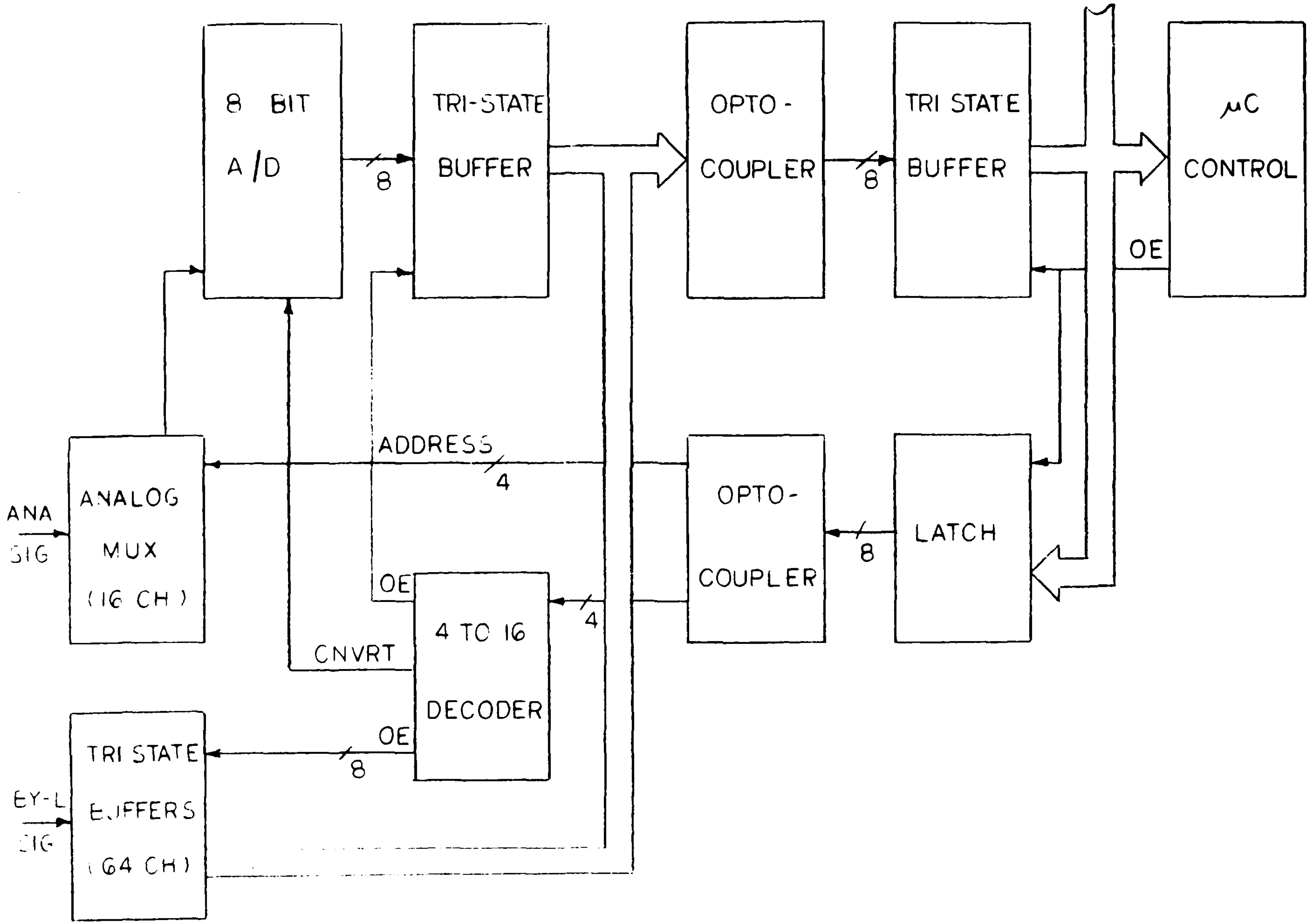


Figure 3.3.8-3. Opto-Interface for Data

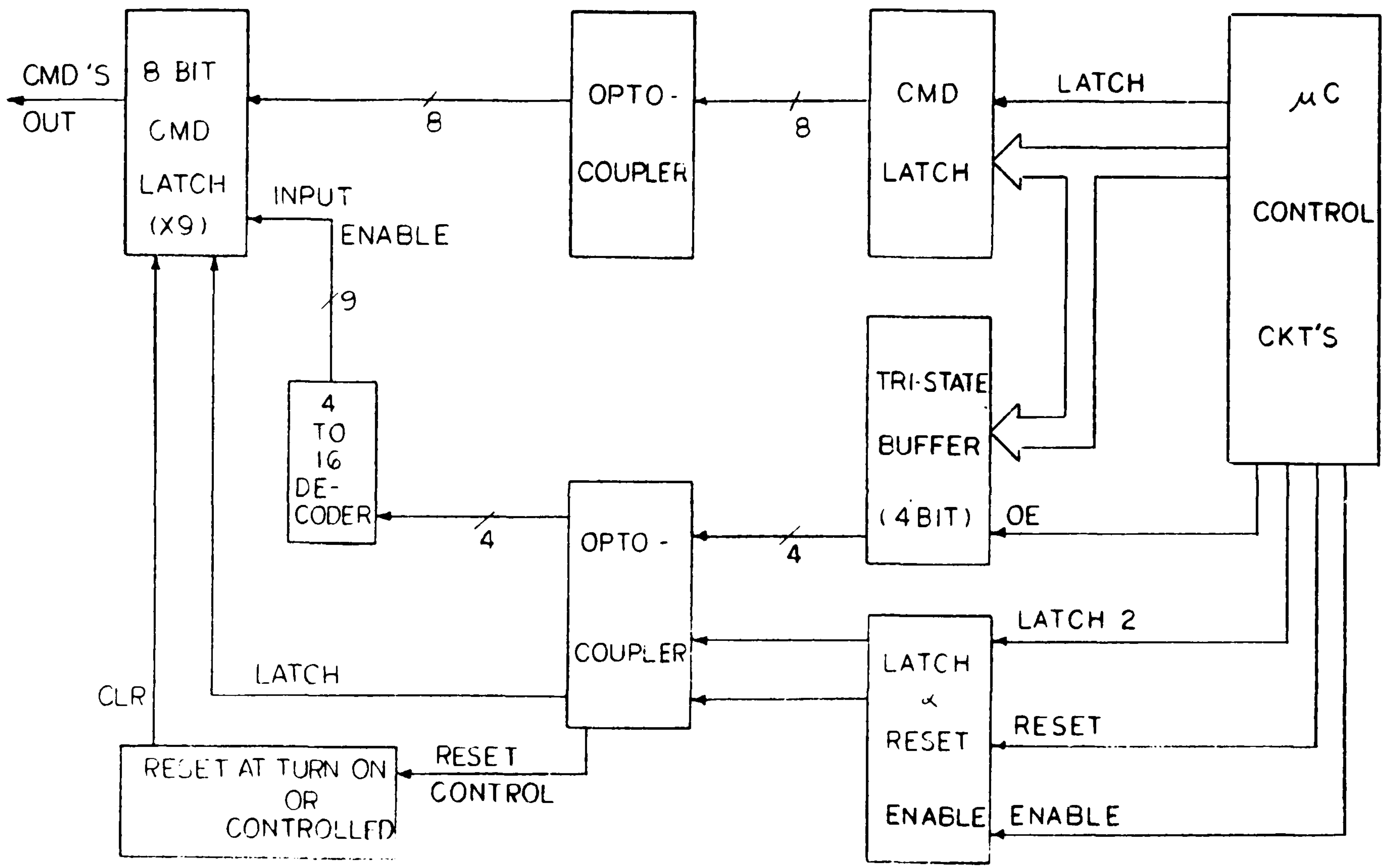


Figure 3.3.8-4. Opto-Interface for FDR Commands

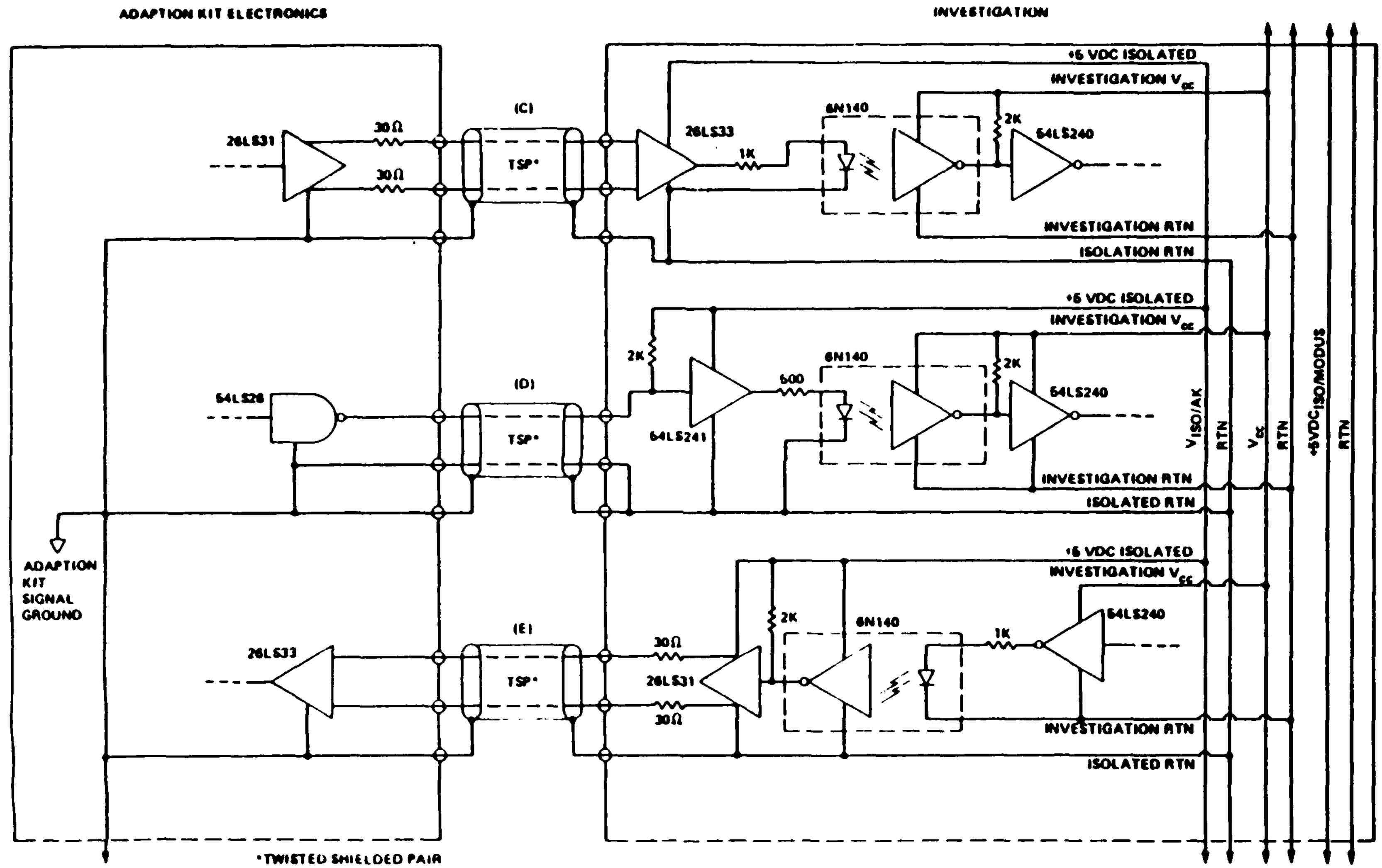


Figure 3.3.8-5. Typical EIS to AK Low Speed Interface

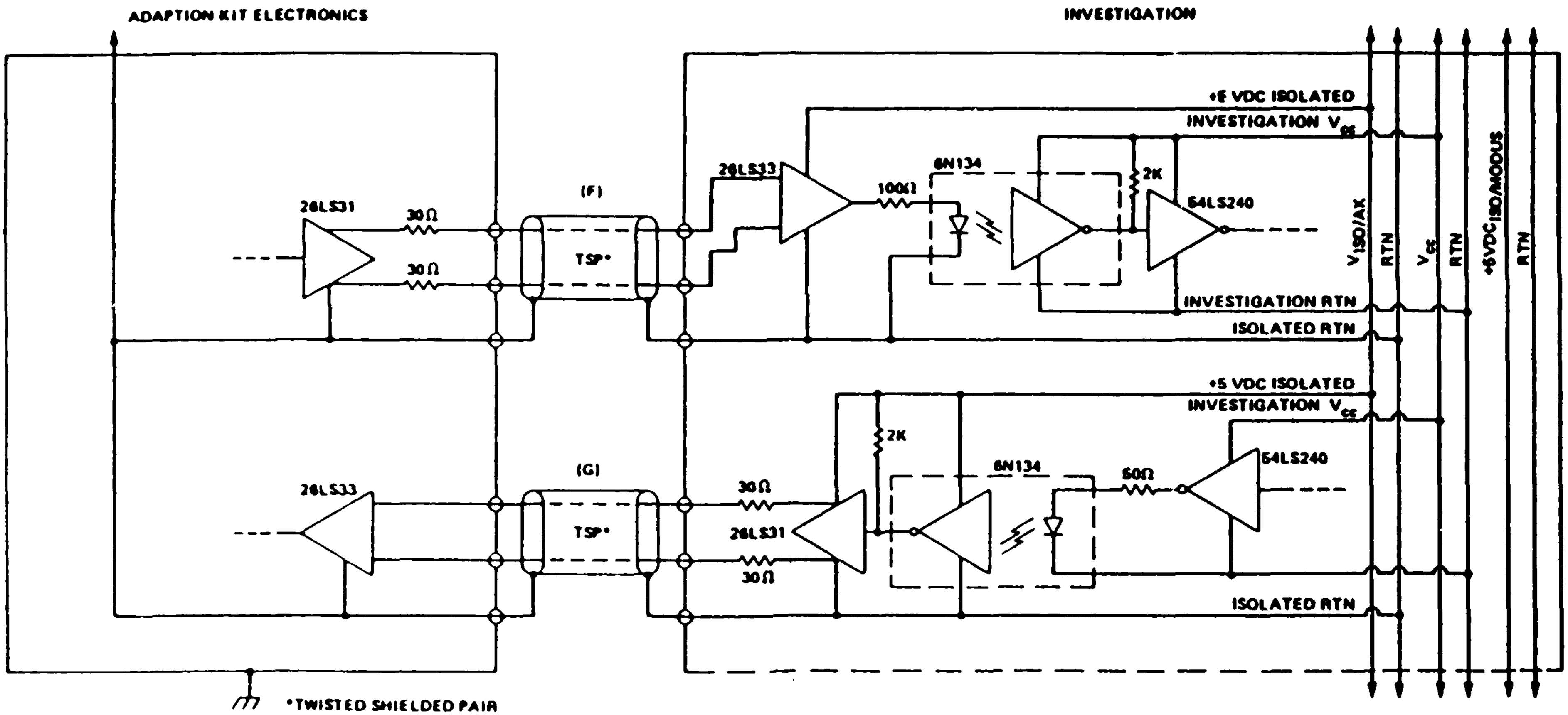


Figure 3.3.8-6. Typical EIS to AK High Speed Interface

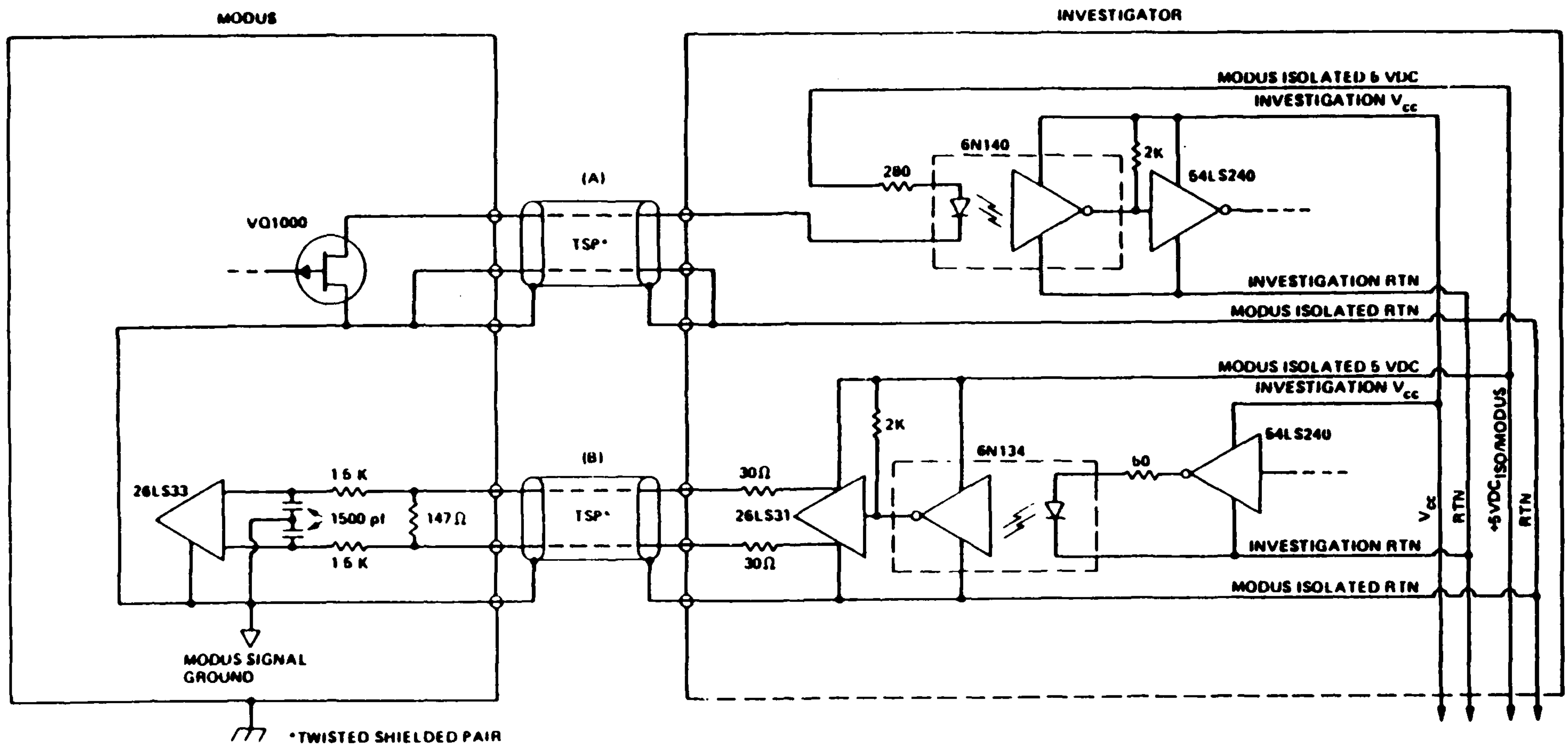


Figure 3.3.8-7. Typical EIS to Modus Interface

interface requires the EIS to supply two isolated voltage sources to drive the optocoupler circuits in addition to the one voltage source already needed for the digital circuits.

3.3.9 Power Distribution

The EIM-EIS system is expected to consume approximately 87 watts of power. Twenty (20) watts are reserved for the EIS. The rest are distributed to the various instruments over 6 circuits. Additional 7 circuits require temporary power to drive deployment/retraction motors. The QMS cover drive requires 25 watts for a duration of 25 seconds each to open and to close. Each EFA consumes approximately 6.5 watts during deployment and retraction duration of which is still TBD.

EIS power control block diagram is shown in Figure 3.3.9-1. Two additional EFA circuits are not included in the diagram, but they are identical to the ones shown. It should be pointed out, that each circuit contains two interrupts. The SES and ESA circuits shown with a single relay have another relay in their own electronics.

A typical power circuit is shown in Figure 3.3.9-2. The double fusing arrangement using a diode preceeds the first relay. Also each relay and power line is equipped with a bi-level status monitor. A current monitor is included in the return conductor of each power circuit.

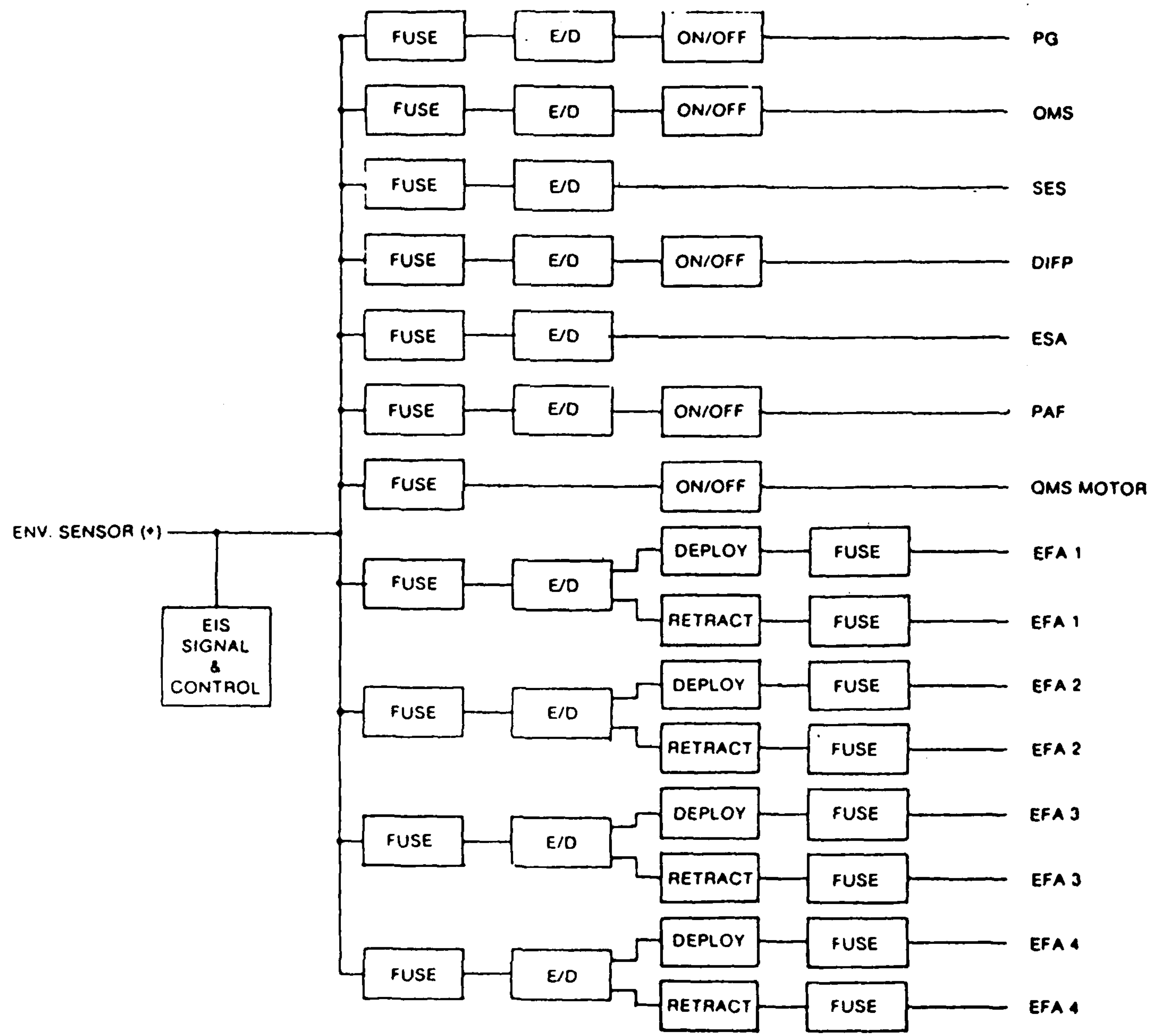


Figure 3.3.9-1. Power Control

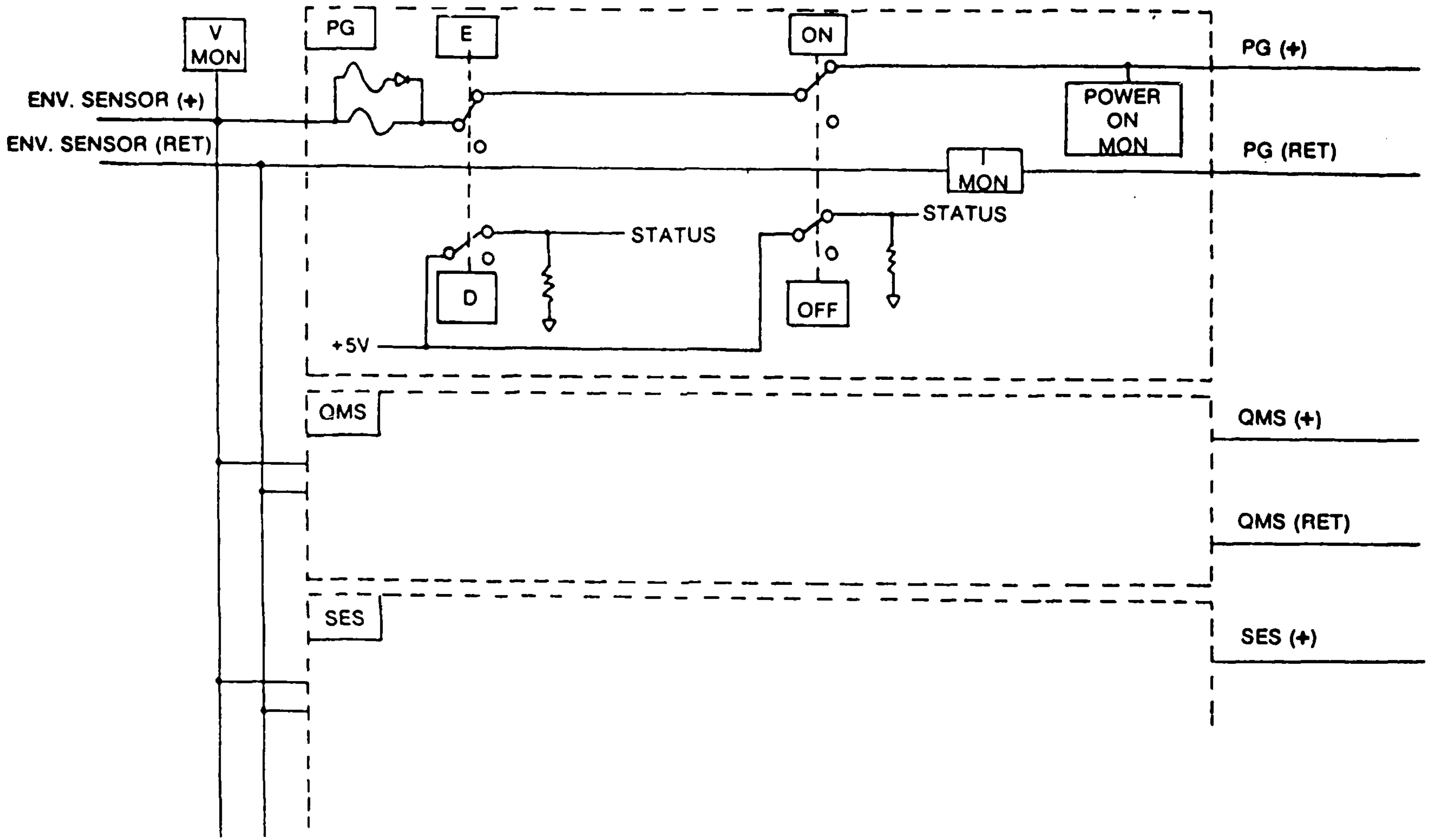


Figure 3.3.9-2. Typical Power Circuit

3.3.10 Status

Preliminary design of the EIS has been completed to a level allowed by the existing requirements of the EIM instruments. Also, the process of selection and approval of "non-standard" parts has been delaying the final selection of methods and circuits to meet these requirements.

The Preliminary Design Review (PDR) of PAF cluster of instruments has been delayed and their requirements have not been stabalized. Preliminary design meetings have indicated that some changes in the requirements presented in this report will be made. There appears to be a desire on the part of the PPI contractor to have a direct access to the system clock (1024 kHz), the MET data and have some additional bi-level commands. These requirements can easily be satisfied at the expense of increased complexity of the EIS interface, provided space can be made available within the EIS enclosure. The enclosure has already been designed under another AFGL contract by Northeastern University; therefore, it is hoped that a way may be found by the PFI designers to utilize the available signals to synchronize and time tag their data so successfully employed by other instruments.

It may be observed by reading the report that only references have been made to the analog to digital converter and to the microcontroller. Even a functional diagram for the two control blocks have been omitted. The reason for this is an uncertainty which a number of devices will be approved by the parts specialists at JPL. None of the available parts on the QPL fully satisfy the requirements of the system. Therefore, the so called "non-standare" parts have been chosen and submitted for approval. Which of these parts are approved will determine the approach taken to implement the necessary functions. For similar reasons the final design of the functional blocks described in this report has been delayed. Few of the ideas have been implemented and tested, but the circuits cannot be finalized and reported until the fate of their parts is known.

Another stumbling block has been the selection of power supplies. The selected high efficiency units have been rejected as not meeting the hybrid tests under the Method 5008 of MIL-STD-883C. The only suggested replacements are bulky, overpowered and inefficient units violating Policies and Requirements (PAR) guidelines not to use linear units for power requirements of over 5 watts.

Once the parts problem has been resolved, the circuit design to implement the functional blocks may be undertaken. Also, the analog signal conversion and interfacing methods with the rest of the EIS can ben be established. The real time, command and monitor data flows paths and control circuits will depend, to a large extent, whether a microcontroller or a microprocessor is finally chosen to handle the task. A power source may have to be designed and built if suitable units cannot be found.

4.0 LOW EFFORT PROGRAMS

4.1 Extreme Ultra-Violet (EUV) Experiment

The last in a series of seven balloon flights for Dr. Hall was scheduled for April 1983. The system description is detailed in the Final Report of the previous contract. Small modifications to the command receiver/decoder were made to allow an additional ground command, and an additional subcarrier oscillator was installed to allow the inclusion of a digital altimeter. New lithium flight batteries were tested and the FM/FM telemetry was recertified for flight.

The field party arrived at Holloman AFB, New Mexico on 12 April 83. Preflight preparations included installation of flight batteries (which has to be shipped separately due to DOT regulations for lithium) and performance verification using the gound receiving station at the Detatchment 1 building. After a one day flight delay due to high surface winds, the balloon was launched at 0700 MST on 20 April 83. All flight systems operated properly with good experimental data being received until after cut-down. The payload was recovered with minimal impact damage.

4.2 Slow-Scan Television (HP-TEM)

The general description of the slow-scan television effort appears in the Final Report of the prior contract. This system was being developed for low-rate video framing (three per second) for the HP-TEM payload. The trajectory of this payload was to exceed usual sounding rocket ranges and thus would require either greater transmitter power or bandwidth reduction to insure high quality signals. The reduction of the frame rate from 30 to 3 per second would reduce the required bandwidth from 10.0MHz to about 1.0MHz.

A camera was received late in December of 1982 (Fairchild Model 3000). It was modified for this factor of 10 reduction in frame rate by changing the master timing clock from 14.318 MHz to 1.4318 MHz and readjustment of dark current balance. Since all timing functions are derived from the master oscillator, the vertical, horizontal, blanking and synchronization pulses were properly reduced by the clock modification.

Since the semiconductor sensor array was now being scanned 10 times slower, the dark current (which is a function of both exposure time and temperature) increased by a factor of ten. A flight model would require temperature compensation of the sensor to overcome temperature induced changes in dark current.

Using the slow scan converter purchased during the last contract, the overall system performed successfully. The camera itself was ruggedly built with high quality printed circuit boards and low profile components which could, with small mechanical modifications, pass the vibration and shock specifications of the launch system.

Termination of the HP-TEM program brought work on this item to a close.

4.3 Sensor Ejection System (SES) A31.200

The SES payload, described in detail in the previous Final Report was integrated during the first two weeks of January 1983. Shock and vibration tests were accomplished at Acton Laboratories on 21 January 1983.

The field party arrived at White Sands Missile Range, New Mexico on 8 February 1983 to begin final preflight tests. The payload was launched on 1 March 1983. All systems performed satisfactorily. Recovery was accomplished the next day with minimal damage to the payload.

4.4 ELIAS

The ELIAS payload, A51.971, an Earth Limb Infrared Atmospheric Structure experiment basically consisted of a telescoped radiometer, a low-light level TV camera and a celestial aspect sensor with other supportive instruments. Its test objectives were to measure spatial and temporal variability of auroral and air-glow emissions at the earth's limb.

Consulting help was given to AFGL scientists to assure that all data was telemetered using the best technology. The payloads involved were integrated by industry and it was necessary to monitor the interfaces for and with Air Force scientists. This work was started under Contract F19628-81-C-0029 and was completed under this contract.

The payload was originally brought to PFRR, Alaska in February 1982 and was not launched due to insufficient scientific conditions. Coordination was provided to minimize any data conflicts between ELIAS and CWAMI during the launch window that opened on March 3, 1983, at PFRR. The payload was finally launched on March 18, 1983.

4.5 SPIRIT-I

The SPIRIT-I payload, A51.378, a Spectral Infrared Rocket Interferometer Telescoped experiment, was a high spectral resolution earth limb rocket experiment designed to test auroral and airglow emission models in the longwave infrared. The Talos Castor boosted vehicle was originally scheduled for launch from PFRR, Alaska in January 1985.

The role of Northeastern personnel was again similar to that on the ELIAS program and was initiated under Contract F19628-81-C-0029 by participation in the Preliminary Design Review on 17 and 18 November 1982.

Northeastern participated in the Critical Design Review with a member on the evaluation team for the SPIRIT payload. The CDR was held at the Stewart Radiance Laboratory, Bedford on 24 and 25 May 1983. Constructive comments were made to LCR relative to the proposed telemetry systems and the deviation schedules for the four S-band communication links.

The payload arrived at the PFRR, Alaska on December 2, 1985, and was eventually launched on April 8, 1986.

4.6 STATE

The STATE payload, A11.074, a revised version of the Aeronomy payload described in the Final Report of the previous contract was rescheduled for launch at PFRR, Alaska during early June 1983. The experiment was to be flown in conjunction with a series of small probes on Super Arcas vehicles.

The main payload had a PCM/FM/FM telemetry system at 2259.5MHz with twelve subcarrier oscillators as listed below:

IRIG CHANNEL	FREQUENCY	DATA
21	165.0 kHz	DC Probe
20	124.0 kHz	PFP Analog
19	93.0 kHz	TRADAT Ranging
18	70.0 kHz	PFP Digital (PCM)
17	52.5 kHz	Atomic Oxygen (PCM)

IRIG CHANNEL	FREQUENCY	DATA
16	40.0 kHz	Solar Aspect (PCM)
15	30.0 kHz	Nitric Oxide (PCM)
14	22.0 kHz	Nitric Oxide Cell Position
13	14.5 kHz	European Photometer
12	10.5 kHz	Commutator (1X48NRZL)
11	7.35 kHz	5577°A Photometer
10	5.40 kHz	Magnetometer

Tracking of the main payload was to be accomplished by use of the TRADAT ranging system at 547MHz and also an S-band radar transponder.

The second link was on board a 10 inch sphere at 2269.5MHz as a PCM/FM/FM telemeter consisting of three subcarrier oscillators as listed following:

IRIG CHANNEL	FREQUENCY	DATA
H	165.0 kHz	PCM Accelerometer
18	70.0 kHz	Wideband Accelerometer A
16	40.0 kHz	Wideband Accelerometer B

Tracking of the sphere was to be accomplished by use of a C-band radar transponder.

The STATE payload completed its integration and vibration testing successfully on May 20, 1983. The payload and personnel arrived at the PFRR on June 6, 1983. The launch window was opened on June 13, 1983. The vehicle was successfully launched at 2151 hours on June 15, 1983, and followed an azimuth of 355° with a launch elevation of 84° to an apogee of 131.46 km. The telemetry, tracking and ranging systems all performed as expected with LOS occurring at T + 437 seconds. The only failure in was in the measurement of Atomic Oxygen. This was carried on IRIG Channel 17 and telemetry indicated failure at lift off.

4.7 ARCAS-LIPID

Northeastern University's Electronics Research Laboratory received funding on its three contracts, F19628-83-C-0037, F19628-81-C-0029 and F19628-81-C-0162 in order to develop a small integrated rocket payload containing a Mass Spectrometer instrument. All associated electronics, power supply timing systems, telemetry and structures were included. The subject contract was to supply the appropriate telemetry system. Initial contact was made with the project scientist and a technical interchange meeting was held on May 30, 1985. This program lost its funding for FY86 so that all effort was terminated by July 1, 1985.

4.8 LAIRTS

LAIRTS is a Large Infrared Telescope System which was intended to result in a series of launches beginning in 1988 with eventual flights on future shuttles using the Space Transportation System (STS). AFGL was scheduled to fund and carry out the LAIRTS design and breadboarding through

October 1985 with teams utilizing existing contractors. Space Division funding of the payload construction phase was expected to begin at that time.

A preliminary System Design Review was held at AFGL on August 30 and 31, 1983 and followed up by the System Design Review on January 24, and 25, 1984. Northeastern University Electronics Research Laboratory personnel were asked by the Aerospace Instrumentation Branch to monitor these sessions because of their R & D studies and possible eventual involvement. Northeastern telemetry engineers attended the general session and the sub group sessions on Data Handling and Storage.

Northeastern was also represented on the conceptual design review panel to evaluate the technical progress and determine if the conceptual approach, and proposed solutions to problems, were valid for the LAIRTS project. The review took place at AFGL on 1 and 2 May 1984.

Unfortunately the program then became Zero Funded for FY86 and the final weekly meeting of the working group was conducted on June 13, 1985.

5.0 FIELD SUPPORT

This section contains a tabulation of those instances in which field programs required Northeastern personnel to provide professional and technician level support at field locations. In most instances the travel indicated was to launch ranges to install and operate airborne equipment or provide ground support. In some instances travel was involved with facility evaluation, conferences, or meetings. In any event whenever overnight travel was undertaken the trip was classified as field support and is consequently listed.

PURPOSE OR LAUNCH DATE	LOCATION	VEHICLE TYPE & DESIGNATION	TRIP DURATION	STAFF
3/1/83	White Sands Missile Range, New Mexico	Sensor Ejection System (A31.200)	2/8/83 to 3/3/83	Wheeler
3/18/83	Poker Flat Research Range, Alaska	Elias (A51.971)	2/22/83 to 3/12/83	O'Connor
4/12/83	Poker Flat Research Range, Alaska	CWAMI (A30.276)	2/22/83 to 3/12/83	O'Connor
			2/22/83 to 3/24/83 and 4/2/83 to 4/14/83	Marks
4/20/83	Holloman AFB, New Mexico	EUV (Balloon)	4/12/83 to 4/24/83	Poirier
6/15/83	Poker Flat Research Range, Alaska	STATE (A11.074)	6/6/83 to 6/17/83	Marks
Site Visit	Wallops Flight Facility, Virginia	IMS (A20.327-1,2)	6/28/83 to 6/29/83	Poirier

PURPOSE OR LAUNCH DATE	LOCATION	VEHICLE TYPE & DESIGNATION	TRIP DURATION	STAFF
10/31/83 11/14/83	Wallops Flight Facility, Virginia	IMS (A20.327-1) (A20.327-2)	10/19/83 to 11/14/83	Poirier
Conference	Las Vegas, Nevada	ITC'84	10/22/84 to 10/26/84	Rochefort Poirier
3/17/85	Sondrestrom Fjord Greenland	PIIE (A21.427)	2/20/85 to 3/17/85	Marks
Vacuum Test	Johnson Space Center, Texas	BERT-I & ERNIE (A19.250)	3/4/85 to 3/18/85	Poirier Wheeler
Meeting*	San Diego, California	ITF Sub-committee on Education	5/14/85 to 5/16/85	Rochefort
6/14/85	White Sands Missile Range, New Mexico	BERT-I & ERNIE (A19.250)	6/2/85 to 6/17/85	Poirier Wheeler
Technical Interchange Meeting	Air Force Weapons Lab, New Mexico	BEAR (A24.602)	6/24/85 to 6/26/85	Poirier
Technical Interchange Meeting	Air Force Weapons Lab, New Mexico	BEAR (A24.602)	7/29/85 to 7/31/85	Rochefort Poirier
Preliminary Design Review	Utah State Univ. Logan, Utah	EXCEDE III (A24.570)	8/5/85 to 8/8/85	Rochefort Wheeler
EMI Test	Los Alamos National Lab, New Mexico	BEAR (A24.602)	9/30/85 to 10/3/85	Rochefort Poirier Wheeler
Conference	Las Vegas, Nevada	ITC'85	10/29/85 to 10/31/85	Rochefort
Technical Interchange Meeting	Los Alamos National Lab, New Mexico	BEAR (A24.602)	12/16/85 to 12/18/85	Poirier

*Costs paid by ITF

PURPOSE OR LAUNCH DATE	LOCATION	VEHICLE TYPE & DESIGNATION	TRIP DURATION	STAFF
No Launch	Poker Flat Research Range, Alaska	HIRAM (A30.579)	1/2/86 to 1/23/86	O'Connor
No Launch	Poker Flat Research Range, Alaska	HIRAM (A30.579)	1/2/86 to 2/8/86 and	Marks
No Launch	Poker Flat Research Range, Alaska	HIRAM (A30.579)	2/13/86 to 3/9/86 and	Marks
No Launch	Poker Flat Research Range, Alaska	HIRAM (A30.579)	3/18/86 to 4/14/86	Marks
Preliminary Design Review	Air Force Weapons Lab, New Mexico	BEAR (A24.602)	1/6/86 to 1/8/86	Rochefort Poirier
4th Working Group Meeting	Jet Propulsion Lab., Pasadena, California	IMPS (STS)	1/27/86 to 1/30/86	Sukys
Technical Interchange Meeting	Los Alamos National Lab, New Mexico	BEAR (A24.602)	3/24/86 to 3/26/86	Poirier
Critical Design Review	Air Force Weapons Lab, New Mexico	BEAR (A24.602)	6/23/86 to 6/29/86	Rochefort Poirier
Technical Interchange Meeting	Los Alamos National Lab, New Mexico	BEAR (A24.602)	8/27/86 to 8/29/86	Poirier
Technical Interchange Meeting	Science Applica-tions Interna-tional Corp., Washington	BEAR (A24.602)	9/10/86 to 9/12/86	Poirier
Technical Interchange Meeting	Naval Research Laboratory, Washington, DC	BEAR (A24.602)	10/15/86 to 10/16/86	Rochefort Poirier
Technical Interchange Meeting	Air Force Weapons Lab, New Mexico.	BEAR (A24.602)	11/11/86 to 11/13/86	Rochefort Poirier

6.0 TESTING PROGRAMS

6.1 Evaluation Studies of Telemetry System Components

Evaluation studies and environmental tests of certain airborne telemetry system components have been carried out under this contract. This program was started under a previous contract, AF19(605)-3506 in April 1958, continued under later contracts, AF19(628)-2433, AF19(628)-5410, F19628-68-C-0197, F19628-71-C-0030, F19628-73-C-0148, F19628-76-C-0111 and F19628-80-C-0050 and has been quite productive. In order to arrive at a comparative evaluation of commercial equipment, all major manufacturers were invited to submit certain categories of system components on consignment. The electrical and environment characteristics were then measured and evaluated, and the results classified as proprietary information and made available to AFGL and the individual manufacturers concerned.

In recent years no new manufacturers have supplied components for testing on a consignment basis. As a result the test procedures have been modified to adhere to the requirements set forth in specific programs. Those units that were tested completely were reported in Scientific Report No. _ and 4 of this contract.

In support of all the AFGL rocket and balloon programs, airborne components were tested using the procedures as a quality control system prior to flight. All data is supplied to AFGL and placed on file at Northeastern. The following is a tabulation of all components tested during the period of this contract:

Voltage Controlled Oscillators - 138

UHF Transmitters - 67

6.2 EMI/EMC Testing For Shuttle Launches

In early January 1984, Northeastern agreed to a new work item involved with setting up procedures and test reporting for the Electromagnetic Interference and Compatibility Testing of AFGL experiments that may eventually be involved with shuttle launches. In order to do this, the requirements of the Johnson Space Center document 07700 Volume XIV have to be compared with the requirements of the Lockheed Interface Control Document as the integrating contractor. Then the specifics of any AFGL experiment must be investigated to see what testing from Military Standards 461A, 462, 463 and 826A and Mil-E-6051D are applicable to fulfill the requirements set forth in the Lockheed ICD.

The first experiment considered was the Mesa Accelerometer (Frank Marcos, LYD) for the S85-1 program. Due to the fact that the experiment had not changed from that used in the Lockheed/Bell Aerospace program and testing of May 1976 a waiver in EMI/EMC testing was granted for the current experiment in the S85-1 program.

The second set of experiments considered were the following:

1. - HUP (801A) Horizon Scanning Spectrometer
   (Bob Huffman, LKO)
2. - QINMS (804A) Ion Neutral Mass Spectrometer
   (Ed Triczinski, LKD)

These experiments are scheduled for a future shuttle launch. Due to the fact that 801A and 804A both flew on a previous shuttle (SETS-1) the test report from that program had to be compared to the current experiments and the specific Lockheed ICD to determine which, if any, tests of an EMI/EMC nature had to be conducted.

Discussions with Mr. Francis LeBlanc, LKO and his contractor Mr. Kenneth Wilson of Research Support Instrument, Inc., Baltimore on the HUP experiment, and with Mr. Edward Triczinski, LKD on the QINMS experiment revealed that no hardware changes had been made. All mode of operation changes were strictly involved with software. Therefore, the requirements set forth in the HUP and QINMS ICD's require no additional tests from those performed for the SETS-1 (801A and 804A) experiments.

The HUP instrument had successfully completed EMC testing at Sanders Associates in 1981 under a Northeastern University contract for a previous STS mission. Since that test there has been no change to the flight instrument. After reviewing the EMC Test Plan 801A and EMC Test Report

3497, ERL verified compliance to the LMSC EMC Plan D886826 and forwarded these reports to LMSC on September 10, 1985.

The QINMS instrument was also tested in 1981 and has had no changes in its flight instrument. Once more, after reviewing the EMC Test Plan 804A and EMC Test Report 3503, ERL verified compliance tothe LMSC EMC Plan D886826 and forwarded these reports to LMSC on September 10, 1985.

7.0 PERSONNEL

A list of the engineers, technicians and students who contributed to the work reported is given below:

J. Spencer Rochefort, Professor of Electrical and Computer Engineering, Principal Investigator.

Lawrence J. O'Connor, Senior Research Associate, Engineer.

Raimundas Sukys, Senior Research Associate, Engineer.

Norman C. Poirier, Research Associate, Engineer.

Thomas P. Wheeler, Research Assistant, Engineer.

Richard H. Marks, Technician, Electrical Engineering.

Frederick J. Tracy, Technician, Electrical Engineer.

Harry M. Tweed, Technician, Electrical Engineer.

William R. Whitehouse, Technician, Electrical Engineering.

Javier Ascue, Graduate Assistant.

Jonathan Clifford, Project Assistant.

Stephen Filippone, Project Assistant.

Kevin Hutchinson, Project Assistant.

Souren Lefian, Project Assistant.

Andrew S. Oelkers, Project Assistant.

John O'Neill, Project Assistant.

David Sachs, Project Assistant.

James Thurber, Project Assistant.

Daniel Weinberg, Project Assistant.

8.0 RELATED CONTRACTS AND PUBLICATIONS

AF19(604)-3506	1 April 1958 through 30 June 1963
AF19(628)-2433	1 April 1963 through 30 Sept. 1966
AF19(628)-5140	1 April 1965 through 30 Sept. 1968
AF19628-68-C-0197	1 April 1968 through 30 Sept. 1971
AF19628-71-C-0030	1 April 1971 through 31 March 1974
AF19628-73-C-0148	9 Jan. 1973 through 30 April 1976
AF19628-76-C-0111	1 Jan. 1976 through 30 Nov. 1979
AF19628-80-C-0050	4 Dec. 1979 through 3 Dec. 1982
AF19628-83-C-0037	4 Dec. 1982 through 31 Dec. 1986

N.C. Poirier and T.P. Wheeler, "Remote Data Acquisition System", Scientific Report No. 1, Contract F19628-83-C-0037, April 1, 1984. Report AFGL-TR-84-0115, ADA143347.

N.C. Poirier and T.P. Wheeler, "Programmable PCM Encoder", presented at the International Telemetry Conference, 1984 on October 24, 1984, at Las Vegas, Nevada.

N.C. Poirier and T.P. Wheeler, "Programmable PCM Encoder", Scientific Report No. 3, Contract F19628-83-C-0037, December 31, 1986. Report AFGL-TR-87-0067.

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