



APOLLO

CSM "J" SERIES MISSION EXPERIMENTS



Space Division
North American Rockwell

CSM LOGISTICS
TRAINING

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SYSTEMS DATA

SECTION 2

SUBSECTION 2.11

MISCELLANEOUS SYSTEMS DATA
(SCIENTIFIC INSTRUMENT MODULE EXPERIMENTS)

2.11.1 INTRODUCTION

The CSM J-Missions utilize the orbiting command service module (CSM) in surveying various characteristics of the moon. Monitoring alpha, gamma, and X-ray emissions from the lunar surface should shed light on not only the moon's composition but also its origin and evolution. Homogeneity and similarity of the surface and subsurface are also gleaned from these remote sensing techniques. The composition of the lunar ambient atmosphere and its dynamics are also explored. The cameras and laser altimeter, utilized in the early J-Missions should not only help in selecting landing sites but should provide invaluable information to support the selenodetic and cartographic goals of the lunar mapping program.

The majority of the J-Missions experimental equipment are mounted in the scientific instrument module (SIM) housed in sector 1 of the service module. The equipment, within the SIM varies from mission to mission.

2.11.2 APOLLO 16 (SIM A) EXPERIMENT COMPLEMENT

The first of the J-Missions utilizes a SIM equipped to support eight different experiments. Figure 2.11-1 shows SIM A as it looks after the protective cover has been jettisoned. The alpha particle spectrometer and X-ray fluorescence detectors share the same enclosure. The latter experiment utilizes an additional piece of equipment mounted on the opposite side of the service module. Note that the gamma-ray spectrometer is shown in an undeployed position on its 25-foot boom assembly. The X-ray fluorescence detectors, gamma-ray and alpha particle spectrometers are used in a remote compositional survey of the lunar surface.

The panoramic camera, the fourth experiment mounted in SIM A is used to photograph future landing sites and other areas of interest on the lunar surface. Additional photographic coverage of the lunar surface is afforded by the 3-inch mapping camera. This unit is used in conjunction with the laser altimeter for cartographic coverage of the lunar surface.

The lunar atmosphere is sampled by the seventh experiment. This dual beam mass spectrometer is deployed on a 24-foot boom.

A subsatellite is included in the experimental complement of SIM A. Within the subsatellite, three different experiments are housed. The subsatellite is launched from the SIM early in the experiment period and is self-sufficient.

MISC

SIM EXPERIMENTS

SYSTEMS DATA

SM-2A-2217

Rework

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Figure 2.11-1. SIM A Experiment Complement

SIM EXPERIMENTS

SYSTEMS DATA

2.11.2.1 X-Ray Fluorescence (S161)

2.11.2.1.1 General Specifications

Experiment Objective:

To perform compositional survey of lunar surface. Should yield data about nature of surface material, measure of homogeneity of surface, and by comparison with gamma-ray results, whether surface is similar to subsurface. Desirable operation concurrent with other selenochemical experiments: gamma ray and alpha particle.

Power Requirements: 28 VDC (See figure 2.11-2)

Standby: 21.0 watts
 Average: 26.0 watts
 Peak: 34.0 watts

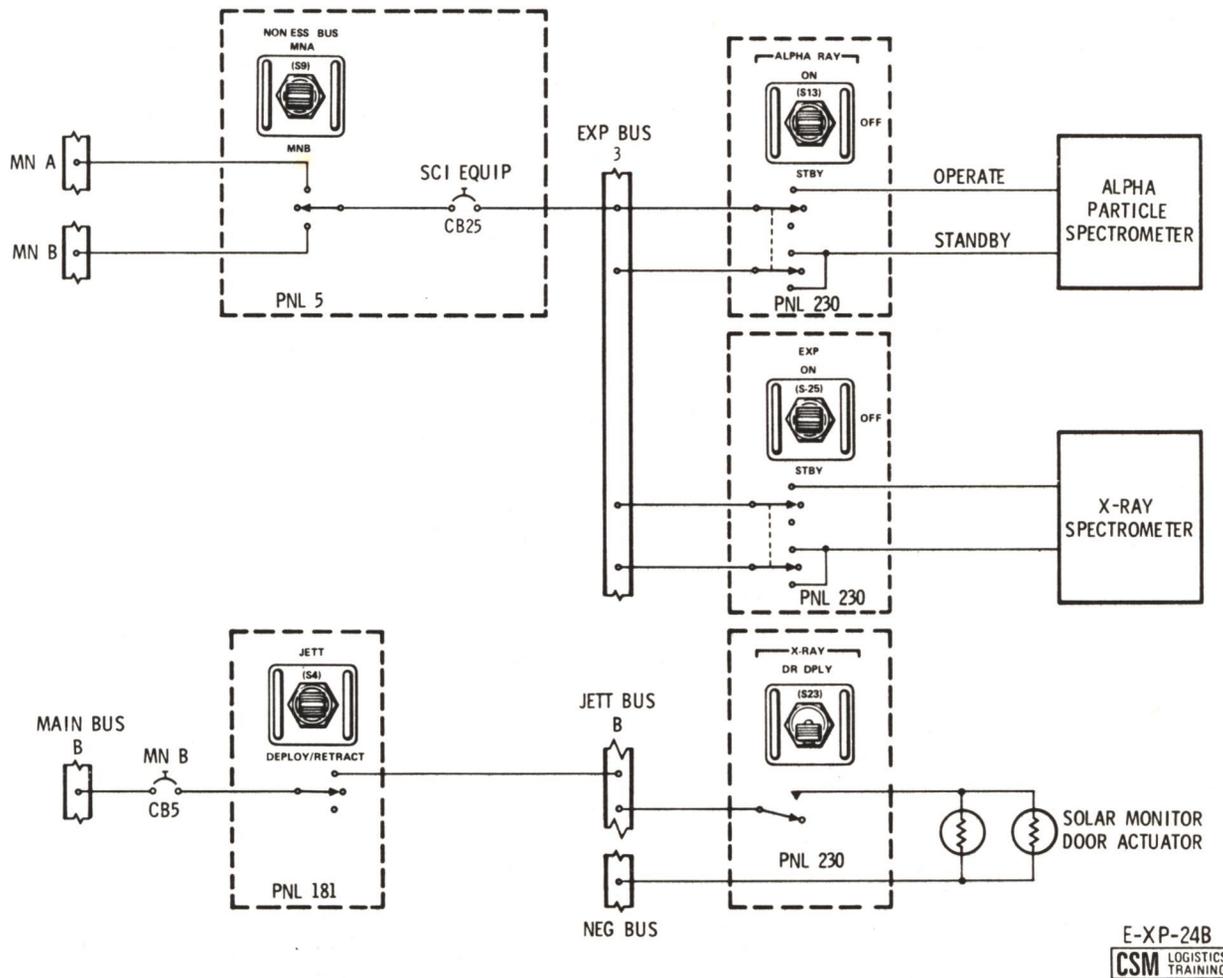


Figure 2.11-2. Power Distribution

E-XP-24B
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SIM EXPERIMENTS

SYSTEMS DATA

Temperature:

Operating range: -4 to +122°F
 Operating point: 100°F (maximum); 60°F preferred

Field of View:

Scanner (sensor): 60° nadir-centered
 Solar monitor: $\pm 53^\circ$ of the detector centerline.

Pointing:

Accuracy: $\pm 5^\circ$
 Knowledge: $\pm 2^\circ$

Data System Interface:

Measurement Identification	Measurement Description	Range (volts)	Samples per Second
SL 1050 K	X-ray PHA (figure 2.11-3)	0-65,535 counts	10
SL 1051 K	X-ray LVPS (summer) monitor	0-5	1
SL 1053 V	Discriminator reference voltage (-12 volts) monitor	0-5	1
SL 1054 V	+6.75-volt analog PS monitor	0-5	1
SL 1055 V	+5.0-volt digital PS monitor	0-5	1
SL 1056 T	X-ray processor temperature monitor	0-5	1
SL 1057 T	X-ray detector temperature monitor	0-5	1
SL 1059 T	X-ray LVPS temperature monitor	0-5	1
SL 1060 T	Lunar X-ray detector temperature monitor	0-5	1
SL 1061 T	Solar X-ray detector temperature monitor	0-5	1

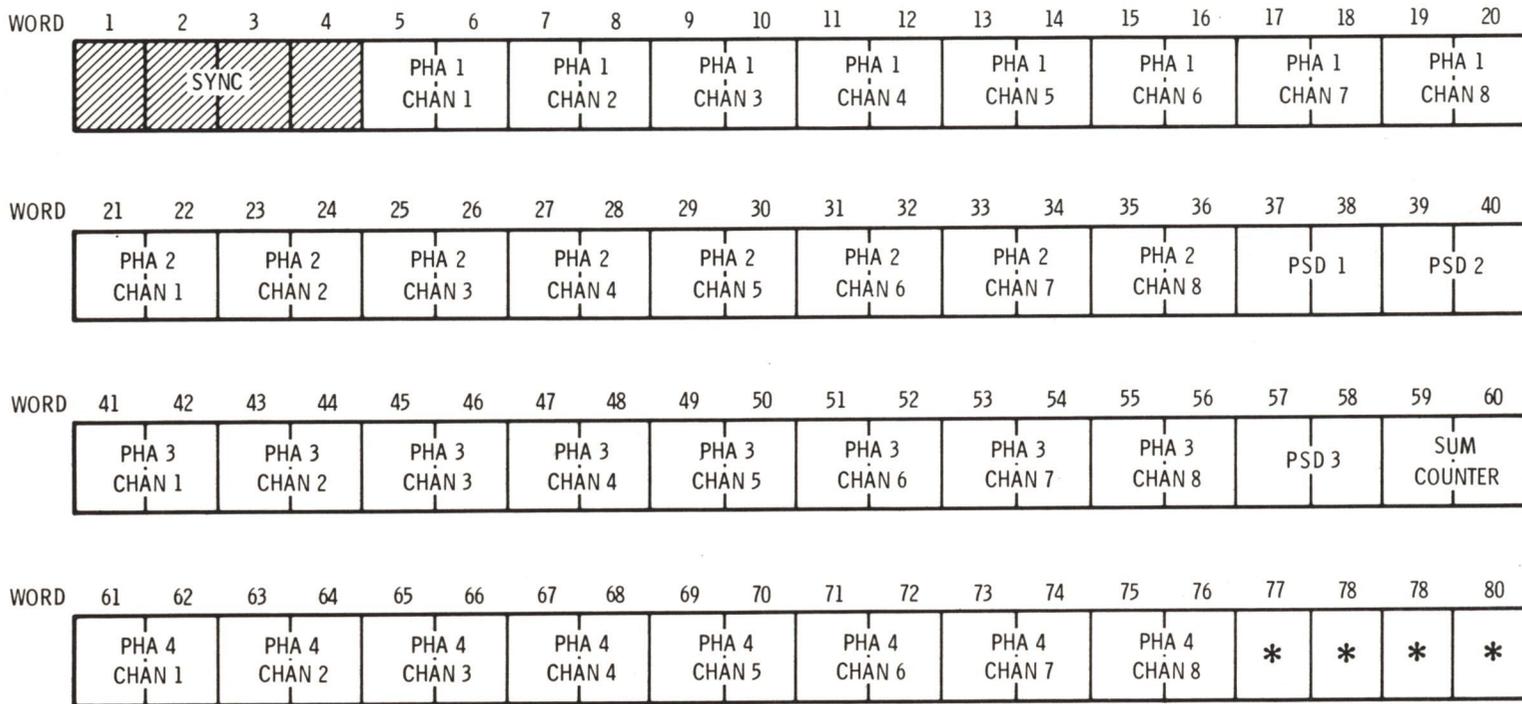
2.11.2.1.2 Experiment Description

Solar X rays should interact with the lunar surface to produce characteristic fluorescent X rays. The measurement of these X rays should yield the following information about the lunar surface.

- a. Data about the nature of surface material.
- b. A measure of the homogeneity of the surface as one sweeps around the moon.
- c. By comparison with the gamma-ray results, some idea of the extent of gardening and whether the composition of the surface is like that of the subsurface.

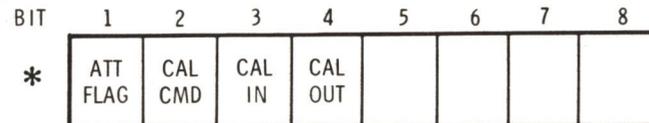
SIM EXPERIMENTS

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LEGEND

- CAL = CALIBRATION
- ATT = ATTENUATOR
- PHA = PULSE HEIGHT ANALYZER
- PSD = PULSE SHARE DISCRIMINATOR



E-XP-49
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Figure 2.11-3. X-Ray Particle Count Digital Format

SYSTEMS DATA

The requirement is to differentiate between fluorescent X rays and radiation back-scattered from the lunar surface. This can be achieved by balanced filter techniques and pulse height analysis. Background radiation induced by cosmic radiation on the detector walls can be reduced electronically by pulse height discrimination. A sun-oriented X-ray monitor is included in order to compare the incident radiation to the fluorescent radiation. The analog output from the pulse height discriminators of the X-ray sensor and from the solar X-ray monitor is digitized and transmitted to the experiment-spacecraft data transmission system.

The experiment is flown in Apollo lunar orbit (a nominal 60-mile orbit) and is continuously operated throughout the experiment period. That period is to be approximately 24 hours after LM ascent stage retrieval. Analytical data are collected from the light side of the moon and background information on the dark side.

The K-line radiation yield of Na, Mg, Al, Si, K, Ca, and Fe from the lunar surface is measured during the quiet, active, and flare periods of the sun as occurs during the experiment operation period. Similarly, the instantaneous solar X-ray spectrum is measured for background information and to determine the excitation conditions.

2.11.2.1.3 Equipment Description

The experimental hardware consists of gas-filled proportional counters, passive filters, plus supporting electronics. The proportional counters are of two types: three identical detectors, each of which has an effective area of about 25 cm², that remain oriented towards the lunar surface, and a small proportional counter that monitors the solar X-ray emission (figures 2.11-4 and 2.11-5). All the detectors are filled to a pressure of one atmosphere with the standard P-10 mixture (90 percent argon, 10 percent methane). These counters are sealed and have entrance windows of 0.001 inch beryllium. Fixed filters that significantly modify the spectral responses are placed in front of two of the lunar sensors; the two filters consist of magnesium and aluminum. In this manner, the difference between adjacent pairs of lunar sensors is conditioned mostly by the fluorescent line from a single element. Operation of the detectors requires a very stable high-voltage source of about 2300 volts. This is part of the experimental equipment.

A charge-sensitive preamplifier is mounted directly on the back of each detector. This circuit integrates and amplifies the proportional counter output to a level of between 0.3 and 3 volts while preserving the analog information contents of the signal amplitude and rise time (figure 2.11-6).

The outputs of the preamplifiers are stored in a unity gain buffer amplifier. This main amplifier produces a waveform that is suitable for the data processor pulse height analyzer. For operation of these circuits, regulated sources supplying +7 volts at 100 milliamperes are included in the experimental equipment. Packaging of the counter and the electronic components includes shielding against possible electromagnetic interference from the spacecraft system.

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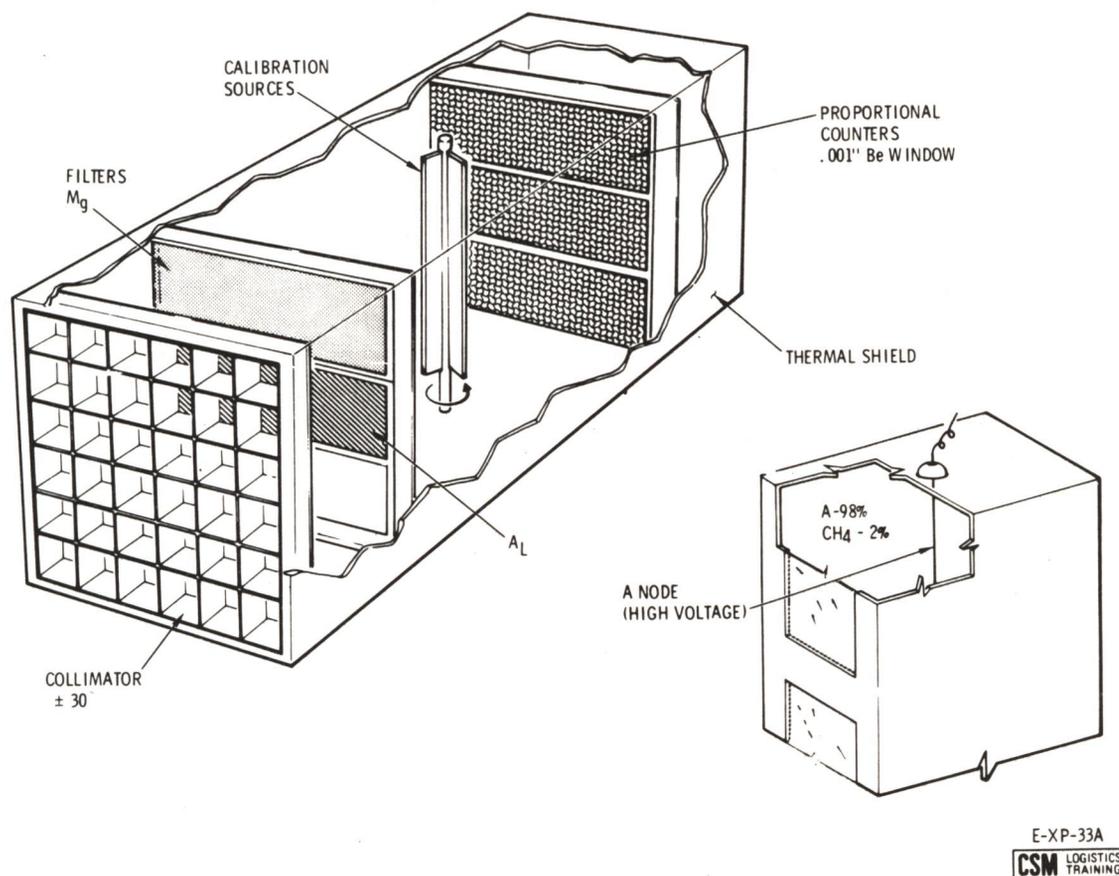


Figure 2.11-4. X-Ray Spectrometer Functional Configuration

2.11.2.1.4 Duty Cycle Requirements

Minimum 10 hours total in lunar orbit. Request maximum available operating time within the restrictions of CSM operational requirements.

Full sunlit lunar surface coverage required. Full dark side coverage is desired consistent with the required data coverage by the gamma-ray spectrometer.

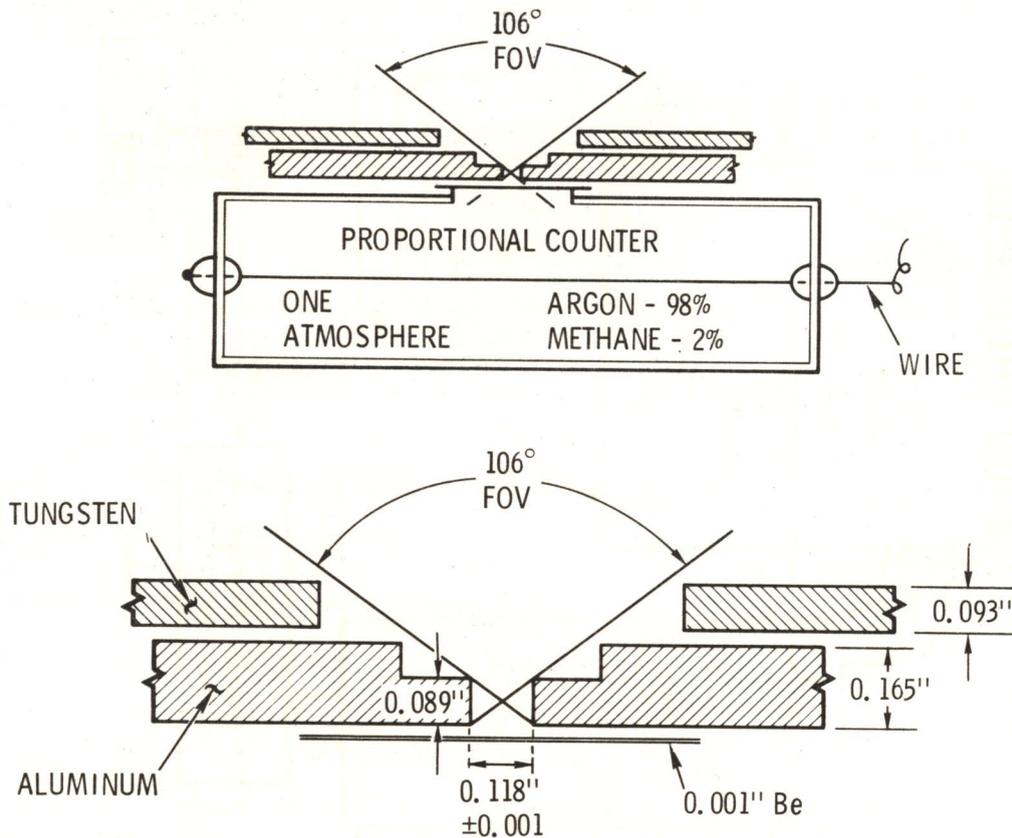
Once per day on lunar dark side, a maneuver to point and hold the sensor from 135 to 180 degrees from local vertical for a period of 15 minutes must be accomplished for calibration purposes.

Power must be removed from the X-ray experiment if the possibility of sunlight striking the detector exists.

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E-XP-35



Figure 2.11-5. Solar Monitor Proportional Counter

2.11.2.2 Alpha Particle Spectrometer (S162)

2.11.2.2.1 General Specifications

Experiment Objective:

To survey as large a portion of lunar surface as possible (at a spatial resolution of a few kilometers) for emission of alpha particles. Detection and localization of radon emissions from lunar crust should be possible by detection of monoenergetic alpha particle produced in Rn^{220} . Desirable operation concurrent with other selenochemical experiments: X ray and gamma ray.

Power Requirements: 28 VDC (See figure 2.11-2)

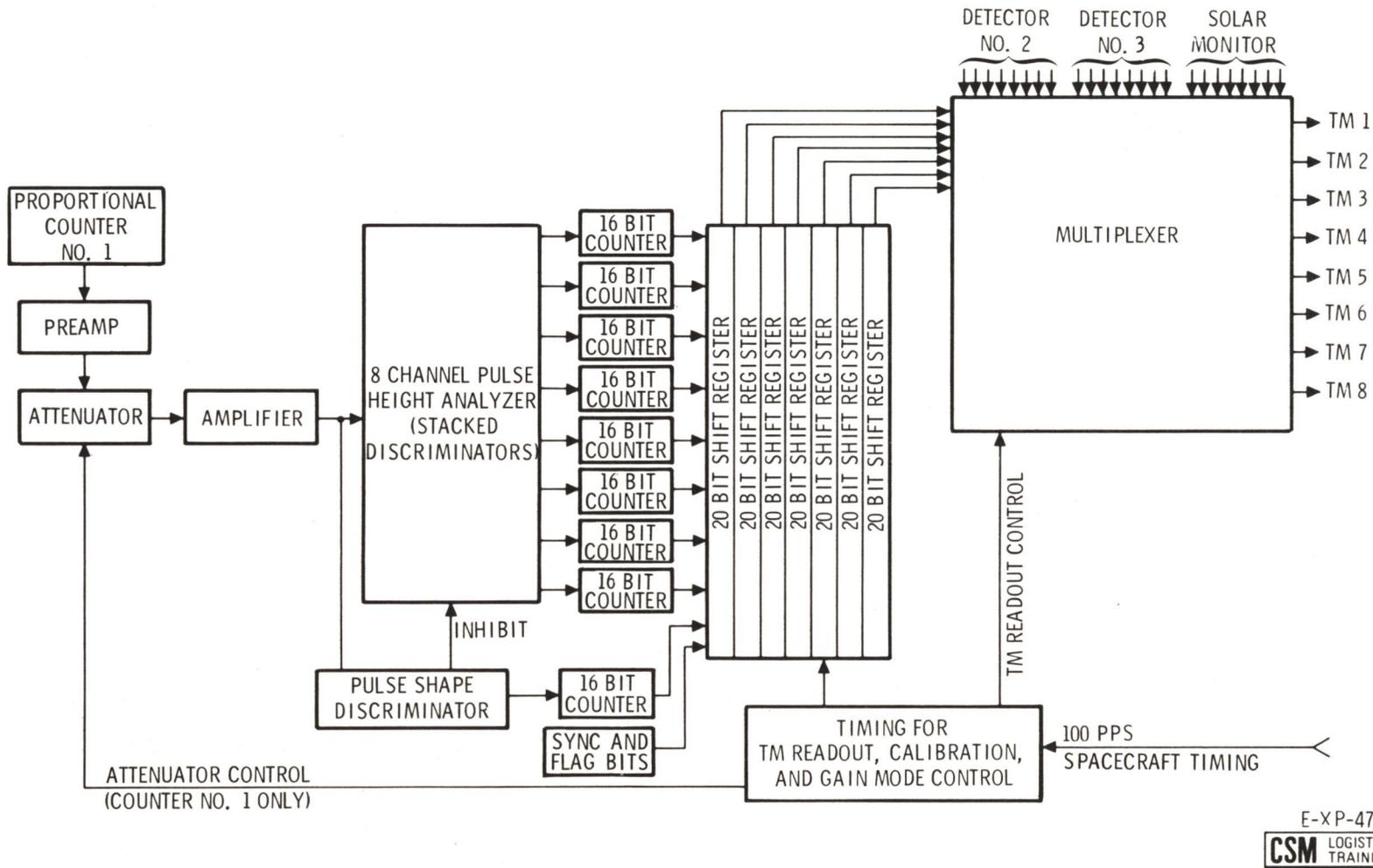
Standby: 5 watts
 Average: 13 watts
 Peak: 13 watts

Field of View:

+45° nadir centered

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SIM EXPERIMENTS



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Figure 2.11-6. X-Ray Spectrometer Block Diagram

MISC

SM2A-03-BLOCK II-(1)
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Temperature:

Operating range: -4° to +122°F

Data System Interface:

Measurement Identification	Measurement Description	Range (volts)	Samples per Second
SL 1065 K	Particle count	0-25	10
SL 1066 K	Detector identification	0-5	10
SL 1067 K	Alpha time-to-height converter	0-5	1
SL 1068 T	Detector wafer temperature monitor	0-5	1
SL 1070 T	Detector case temperature monitor	0-5	1
SL 1071 T	LVPS temperature monitor	0-5	1
SL 1072 V	Detector bias voltage	0-5	1
SL 1073 V	Discriminator reference voltage (-12 volts) monitor	0-5	1
SL 1069 V	+6.75-volt analog PS monitor	0-5	1
SL 1074 V	+6.75-volt ADC PS monitor	0-5	1
SL 1075 V	+5-volt digital PS monitor	0-5	1
SL 1076 V	Summed LVPS monitor	0-5	1

Operating Time Requirements:

10 hours measurement time required through complete orbit. Once each operating day, CSM must be rolled 180° on dark side for 15 minutes deep space background measurement.

Pointing:

Accuracy: +5°
 Knowledge: +7°

2.11.2.2.2 Experiment Description

The alpha particle spectrometer measures the rate of radon (Rn²²⁰ and Rn²²²) evolution from the moon by detecting the alpha particles that are produced in their decay (figure 2.11-7). Based on a detector area of 30 cm² and a background rate equal to what was observed during the Surveyor alpha-scattering experiments, this observation can detect in one orbit a rate of radon evolution that is equal to or greater than 7×10^{-4} of the terrestrial

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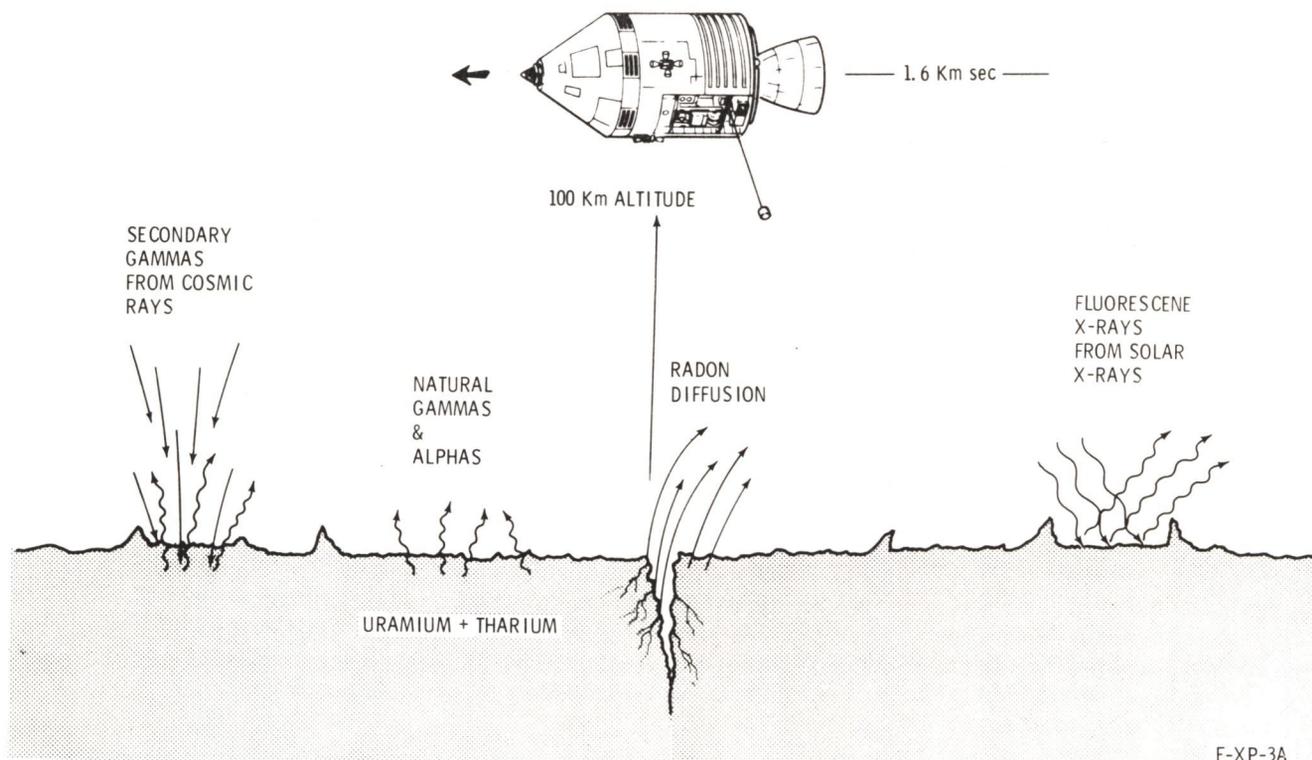


Figure 2.11-7. Radon Environment at Lunar Surface

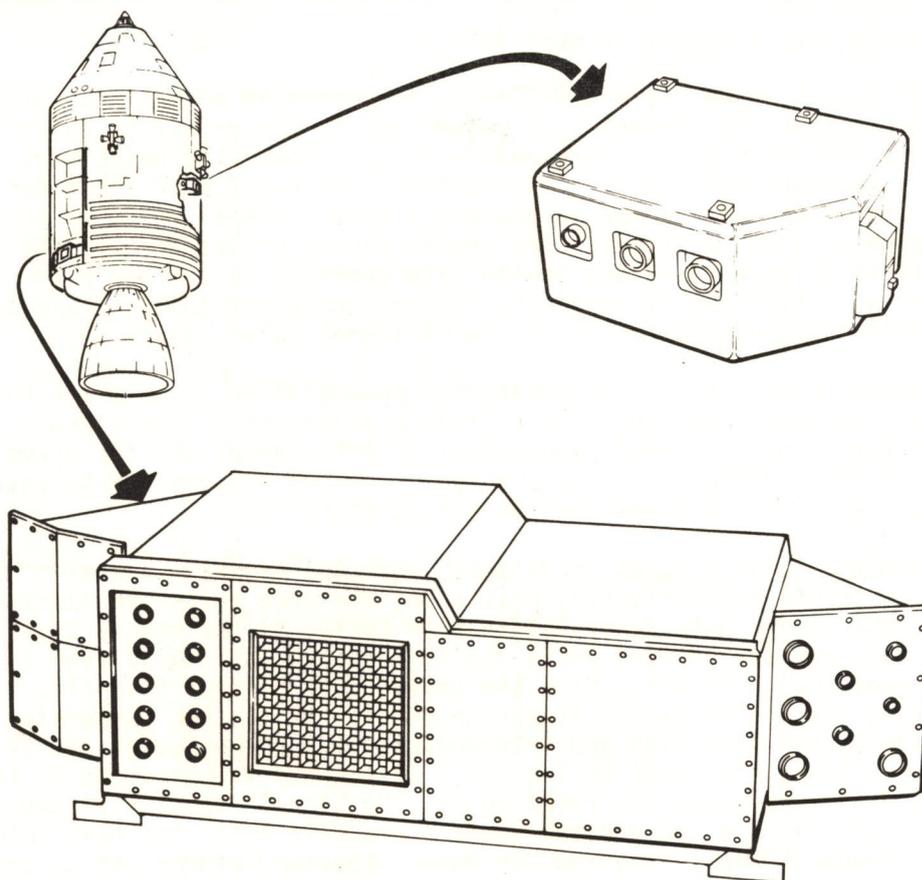
rate. With a total of N orbits, the sensitivity is increased by \sqrt{N} . This high sensitivity is possible because decaying radon atoms from a large region of the lunar surface are detected individually. Natural concentrations of uranium and thorium in the first few meters of the lunar surface are the source of the radon. There is good reason to believe that under certain conditions, a substantial amount of radon diffuses to the surface where it is emitted at thermal velocities and remains trapped by lunar gravity until decaying. Decay of radon above the surface results in the production of monoenergetic alpha particles plus an active deposit on the surface that emits additional alphas and gammas. The longer-lived isotope, Rn^{222} (half life = 3.8 days), has sufficient time to establish a uniform atmosphere of gravitationally trapped gas over the entire lunar surface. Rn^{220} ($T_{1/2} = 55$ sec) undergoes decay within a short distance of its point of evolution. The absence of any material around the moon which could slow the alphas down, allows a unique and sensitive way of detecting the radon evolution. The measurements determine the gross rate of radon evolution from the moon by observation of longer-lived isotope Rn^{222} and, in more advanced versions of the experiment, looks for localized sources of enhanced-emission radon by observing the decay of the shorter-lived isotope, Rn^{220} .

2.11.2.2.3 Equipment Description

The measuring equipment in this instrument is housed in an enclosure which also contains the X-ray fluorescence experiment (figure 2.11-8).

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Figure 2.11-8. X-Ray/Alpha Particle Spectrometer Enclosure

Alpha Detector Assembly

An alpha particle enters the surface-barrier solid-state detector and creates a number of ion-electron pairs. Since the particle is totally absorbed, the number of ion-electron pairs created is proportional to the incident particle energy. The electric field created by the bias voltage causes the ions and electrons to drift to the electrodes where their charge is gathered by the detector and preamp capacitance. A charge-sensitive preamplifier is used since the detector capacitance varies with time, temperature, and bias voltage. (A charge-sensitive preamplifier uses a capacitor in the feedback loop to create a Miller Effect input capacitance that is much larger than the detector capacitance, thereby swamping out the detector capacitance. The feedback capacitor and amplifier gain can be made extremely stable so the preamplifier output signal becomes independent of detector capacitance.)

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Alpha Processing Assembly (Figure 2.11-9)

The output of each preamplifier is processed in a nonlinear amplifier which reproduces the preamplifier pulse only to the extent to which it exceeds a precisely preset threshold voltage. Thus, the noise contribution of the silent preamplifiers is eliminated. The outputs of these ten nonlinear amplifiers are summed to produce a single signal which is then integrated in a pulse shaper. The shaped signal passes through the analog gate (if it is enabled by the analog gate control) to another pulse shaper and then to a 512-channel analog-to-digital converter (ADC), whose output is a digital representation of the input signal pulse height.

Simultaneously to being summed, the preamplifier signals are buffered and then sampled by threshold detectors to determine if the signals are greater than a preset level (equivalent to ADC channel 240 for example). If any of the threshold detectors trigger, one of the digital-to-analog converter (DAC) input flip-flops is set to logic 1.

When the logic 1 level is detected, all the digital-to-analog input flip-flop inputs are inhibited, preventing any more pulses from entering the DAC and the analog gate control flip-flop is set to the enable state. The analog gate remains enabled until the ADC detects the signal peak (Ready Signal goes low), at which time the analog gate control flip-flop is reset, inhibiting the analog gate. At the completion of the ADC conversion period, the ready signal goes high and interrogates the ADC output to see if the most significant bit (MSB) is logic 1. If the MSB is not logic 1, the DAC and ADC digital outputs are reset to the "No Signal" state. If the MSB is logic 1, the DAC and ADC digital signals are held until the next telemetry readout signal (10pps) is given, at which time the information is transferred to the telemetry register and the output storage and digital analyzer conversion section of the DAC. The ADC and DAC input section are then reset to analyze the next detector signal. If the ADC is converting (busy signal is low) when the telemetry readout signal (10pps) occurs, no transfer takes place and the information is held until the next telemetry readout signal.

An exponential time-to-height converter is included as an aid in determining the instrument count rate. The circuit is reset to full scale at the start of each telemetry period, and the output then decays exponentially towards zero volts. When the most significant bit of the ADC circulates, the decay is stopped and the voltage at that time stored until sampled by the telemetry readout signal.

2.11.2.2.4 Duty Cycle Requirements

Minimum 10 hours total in lunar orbit. Request maximum available operating time within the restrictions of CSM operational requirements.

Full orbital coverage is desired. Where DSE limitations prevent such coverage, repetitive gap is preferred consistent with the required data coverage of the gamma-ray spectrometer.

Once per operating day on lunar dark side a maneuver to point and hold the sensor from 135 to 180 degrees from local vertical for a period of 15 minutes must be accomplished for calibration purposes.

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Sun entering the instrument field of view (FOV) ($\pm 45^\circ$ from SIM pointing line) should be avoided.

2.11.2.3 Gamma-Ray Spectrometer (S160)

2.11.2.3.1 General Specifications

Experiment Objective:

Obtain evidence on origin and evolution of moon by determining the degree of chemical differentiation moon has undergone during its development. Desirable operation concurrent with other selenochemical experiments: X ray and alpha particle.

Power Requirements: 28 VDC (See figure 2.11-10)

Average: 8.2 watts
 Peak: 21.4 watts

Pointing:

Accuracy: $\pm 5^\circ$
 Knowledge: $\pm 2^\circ$

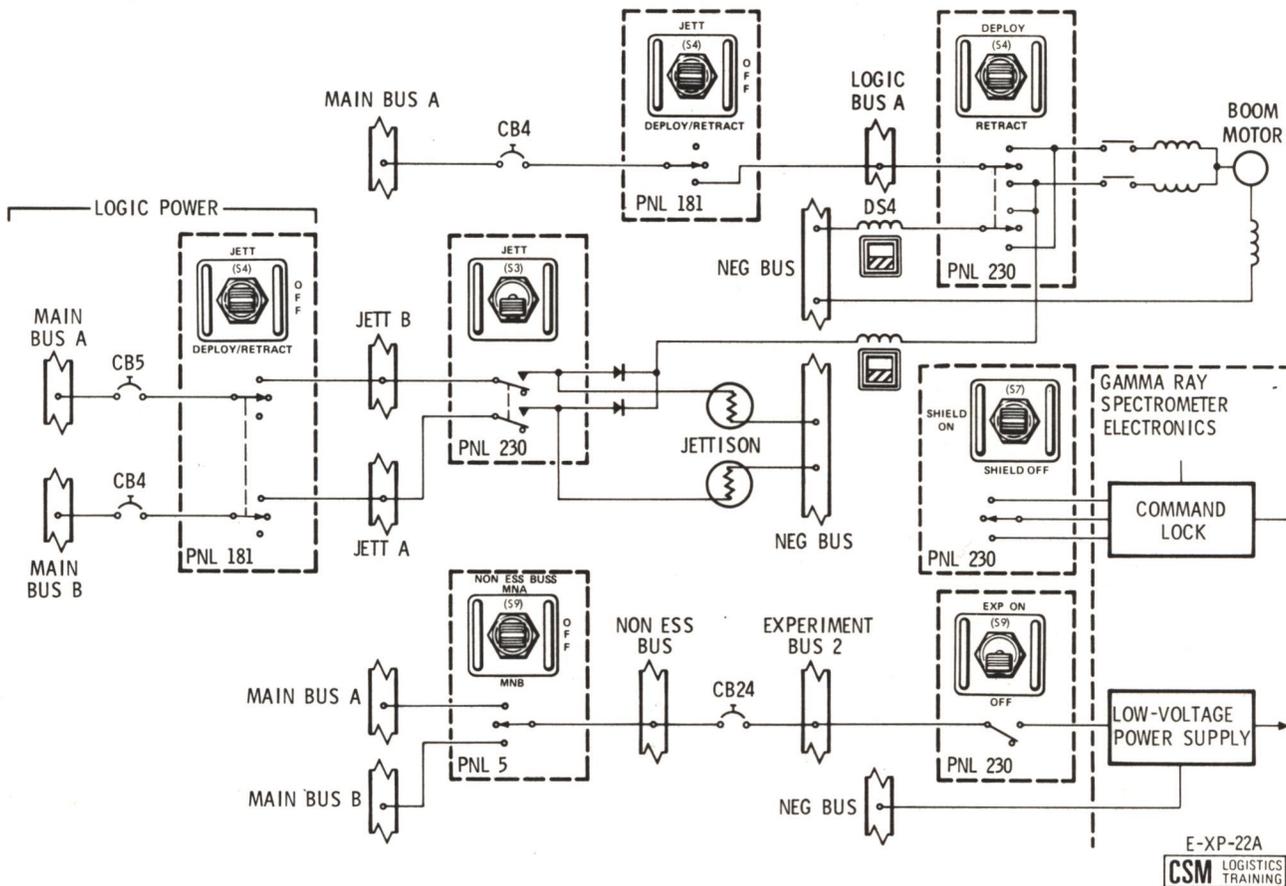


Figure 2.11-10. Gamma-Ray Spectrometer Power Distribution

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SYSTEMS DATA

Temperature:

Operating range: -4° to +120°F

Data System Interface:

Measurement Identification	Measurement Description	Samples per Second	Channel Code
SL 1085 T	Detector temperature	10	11A97
SL 1086 T	Electronics package temperature	10	11A99
SL 1087 T	Spectrometer serial output	SC 165 kHz FM-3	

Special Mechanisms:

Extendable and retractable boom (25 feet maximum)

Deployed spectrometer is within mapping and panoramic camera FOV when both are installed.

Constraints:

Sensor not to be exposed to magnitude flux greater than 2 Gauss.

Detector pointing at deep space with barbeque rotation acceptable in transearth mode.

2.11.2.3.2 Experiment Description

Chemical differentiation is the result of substantial melting within the moon at any time in the past or present, and is indicated at the surface of the moon by concentrations of various elements which are distinctive from the mean values measured in the solar atmosphere and meteorites.

The gamma-ray experiment is intended to determine the degree of chemical differentiation for the moon as a whole and, to the degree that counting time and statistics allow, map possible differences between large scale features. These data provide the base line for further geochemical exploration of the moon's surface.

The gamma-ray spectrometer measures the 0.1 to 10 mev radiation flux from the surface of the moon while in orbit around the moon. This flux has two components. One is the decay of natural radioactivity mixed in lunar surface material, the principal contributors to which are isotopes of potassium, uranium, and thorium plus radioactive daughters of the latter two. The intensity of these contributors is a sensitive function of the degree of differentiation. Gamma radiation is also produced by the interaction of cosmic ray particles with the nuclei of chemical elements making up the lunar surface.

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The observation of characteristic gamma-ray lines of decay and nuclear interaction are correlated with abundance. Sensitivity is improved by maximizing the available counting time and minimizing the spacecraft-produced radiation background interference.

Measurements are required in cislunar space with the same geometry as the lunar measurement for the primary objective of obtaining background reference data and secondarily, to obtain a spectrum of the cosmological gamma-ray flux.

The instrument also makes a continuing measurement of the integral cosmic ray flux with a time resolution of better than one second.

The data from this experiment are summed into energy spectra, and the characteristic lines of these spectra are related to abundance of geochemical sources on the lunar surface through laboratory and field tests. The incident fluxes are derived from the observed counting rate by calibrating the response of the detector.

As the gamma-ray background may well be at a much higher level than the gamma-ray signal, indicating potassium, uranium, and thorium, the data must be in sufficient quantity to make its reduction statistically significant.

2.11.2.3.3 Equipment Description

The instrument, which is mounted on an extendable boom attached to the Apollo command and service module (CSM), consists of three major subassemblies: the gamma-ray detector, the gamma-ray electronics, and the thermal shield and experiment support bracketry.

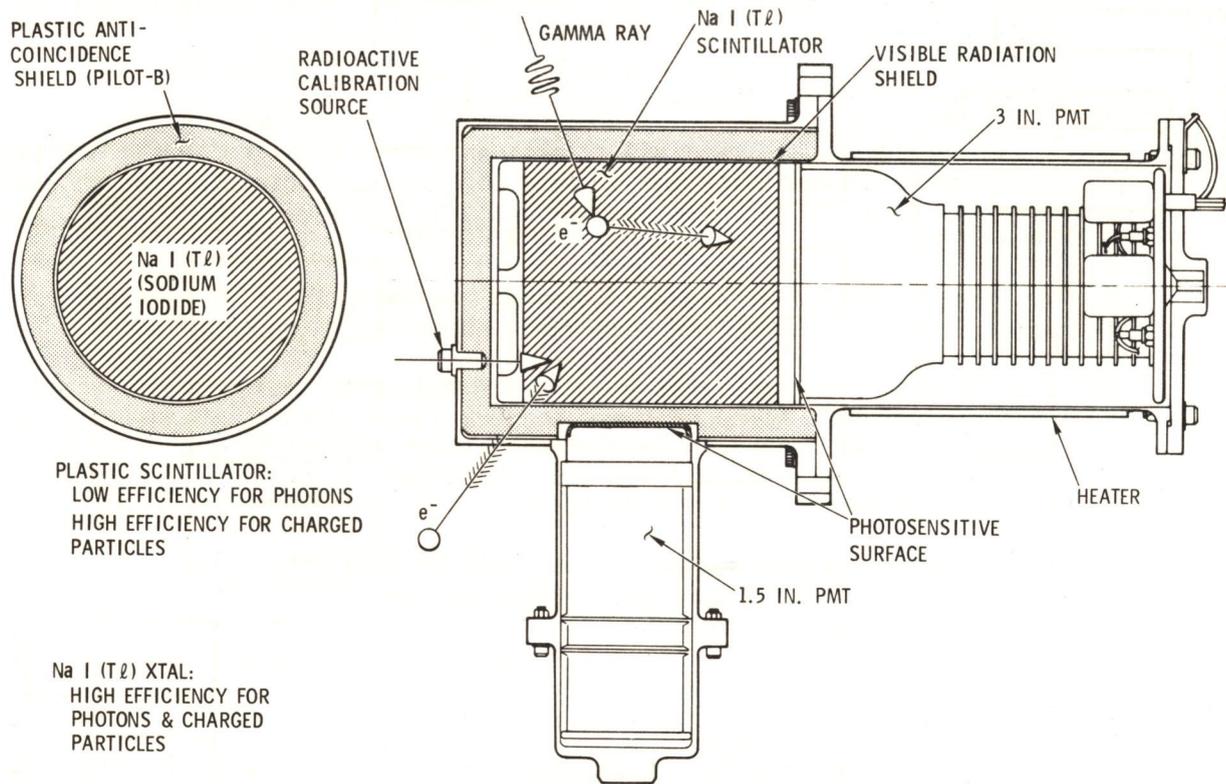
The gamma-ray detector (figure 2.11-11) is sensitive to charged particles and gamma rays, and is designed to analyze gamma rays using a NaI(Tl) scintillator viewed by a 3-inch photomultiplier tube (PMT). Charged particles are identified by a plastic scintillator (pilot-B) which surrounds, but is optically decoupled from, the NaI(Tl) crystal. The plastic is viewed by a separate 1-1/2-inch photomultiplier tube.

The gamma-ray electronics provides the operating voltages for the photomultiplier tubes and contains thermal control circuitry to stabilize the GRD thermal environment. The gamma-ray electronics processes the charge pulses from the detector into digital data for transmission on the Apollo telemetry system. This processing includes the rejection of charged-particle signals using anticoincidence techniques between plastic and inorganic scintillators, digitizing of gamma-ray signals, and the generation of a serial PCM bit train to modulate the spacecraft-provided subcarrier oscillator. The PCM format is a 128 10-bit word frame including frame/word sync and parity checks. Both gamma-ray analyses and instrument operating mode monitors are included in the PCM data format.

Gamma rays or charged particles interact in the NaI(Tl) crystal, producing a signal at the input to the analog-to-pulse width (A-PW) converter (figure 2.11-12). Charged particles are identified and rejected by the analog-to-digital converter (ADC) control logic since they produce coincident signals in both PMTs. The A-PW converter does not respond to signals

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PLASTIC SCINTILLATOR:
 LOW EFFICIENCY FOR PHOTONS
 HIGH EFFICIENCY FOR CHARGED
 PARTICLES

Na I (Tl) XTAL:
 HIGH EFFICIENCY FOR
 PHOTONS & CHARGED
 PARTICLES

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Figure 2.11-11. Gamma Ray Spectrometer Detector

of less than 0.57 pC (approximately 100 KeV at nominal high-voltage setting), thus providing a lower threshold to the analysis. The ADC control logic converts the pulse width to a 9-bit binary number using the 2-MHz system clock. This 9-bit number is inserted into the next available word in the PCM data format. The ADC control rejects gamma rays for analysis if the format generator has not accepted a previously analyzed event.

The three registers are included in the instrument to monitor system performance. (See figure 2.11-12.)

Shield events, that is, all events exceeding the 2 pC threshold of the shield discriminator, are counted in one register. Coincident events, all events causing the discriminator and the ADC to trigger within a specified time of each other, are counted in a second register. A third register counts clock pulses that are present only when the ADC is ready to accept a gamma ray, and thus provides a means for correcting the observed rate of analyzed events to a true gamma-ray flux.

The PCM format generator arranges the data from the ADC logic, the registers, and the command logic into a frame consisting of 128 10-bit words (figure 2.11-13). Each frame begins with a fixed sync pattern, followed by

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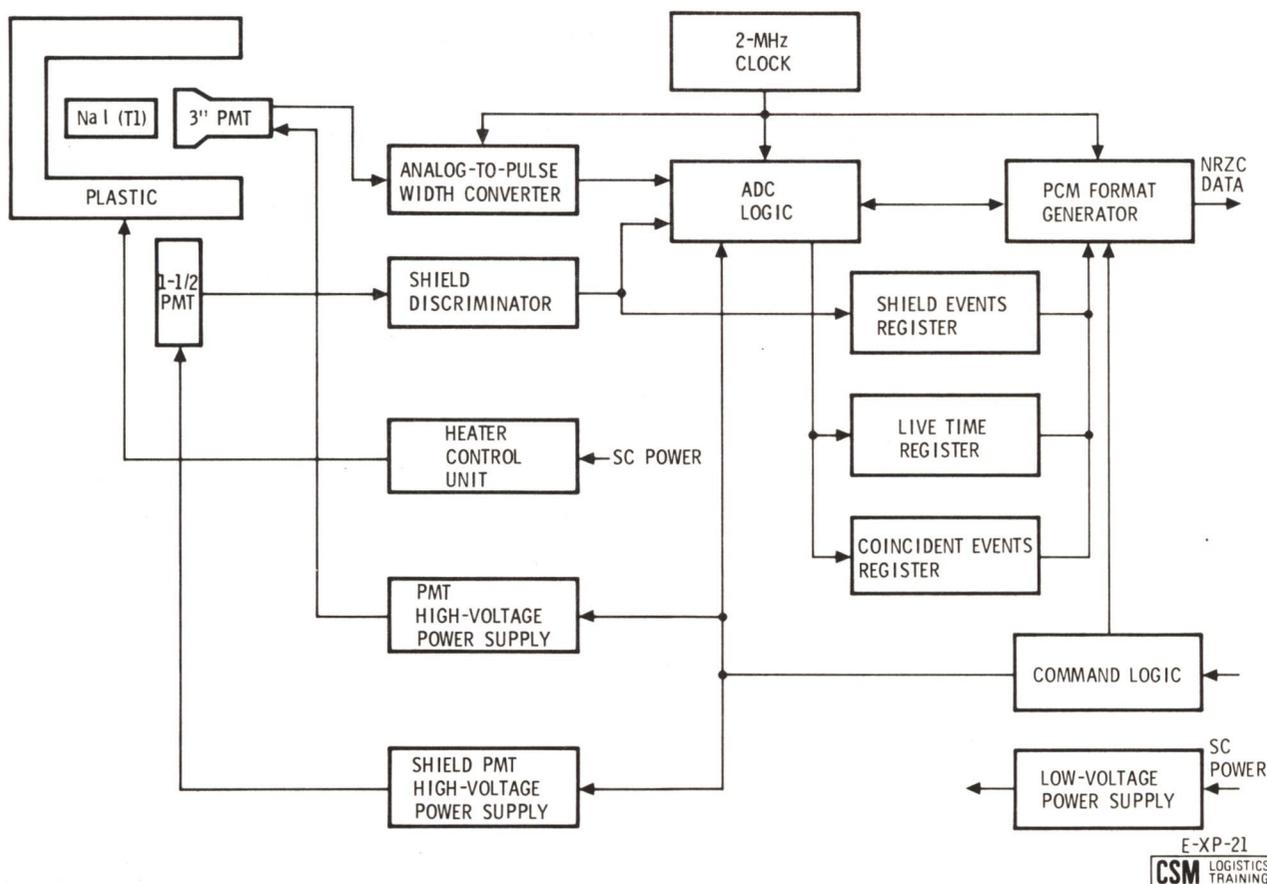


Figure 2.11-12. Gamma-Ray Spectrometer Block Diagram

four words which read out the command status and the three registers, and 121 words of gamma-ray data. The 125 data words are 9-bits plus odd parity. The bit rate is 265 microseconds, obtained from the system clock.

The command logic provides a method for altering the 3-inch PMT gain by varying its high voltage, for turning off the shield PMT supply, and for disabling the charged-particle anticoincidence logic to aid postflight data analysis.

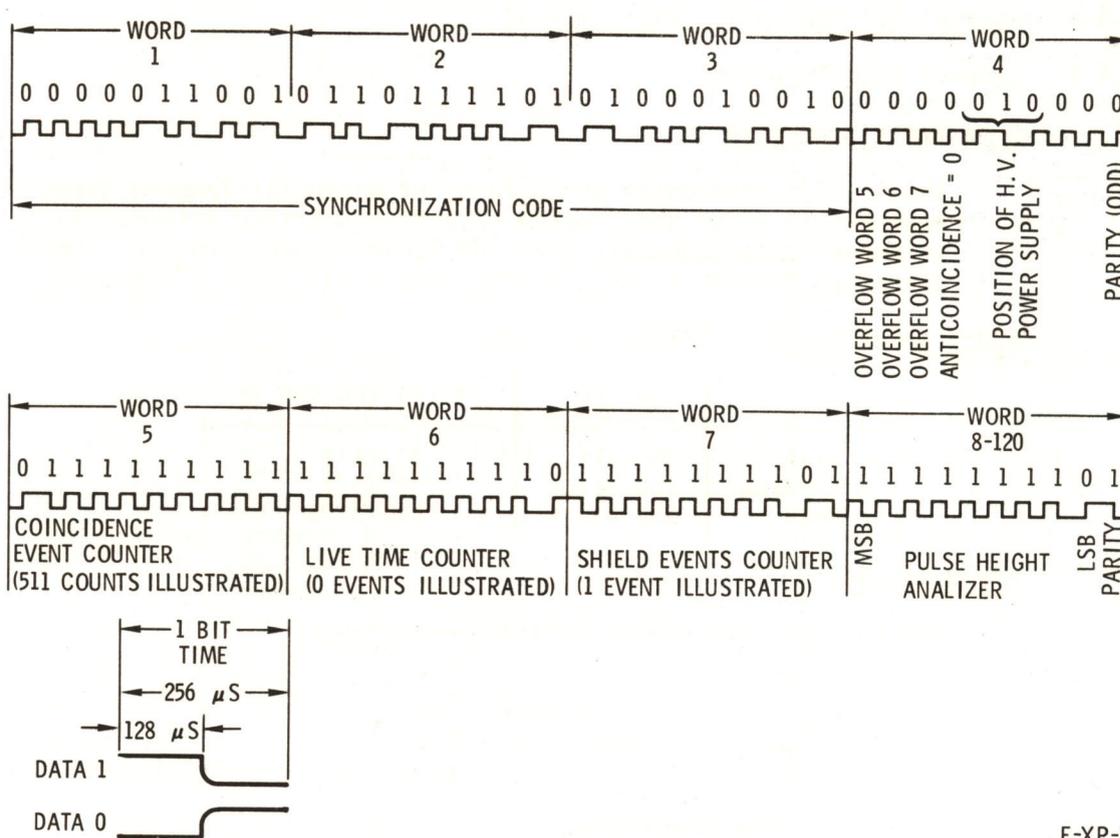
The low-voltage power supply uses a switching-mode regulator to convert the spacecraft power into the instrument operating voltages at nearly constant efficiency. This regulator is followed by precision series regulators providing 0.1 percent stable references for the system.

The high-voltage power supplies provide the up-to-1800-volt biases for the two PMTs. Hardwired taps on the references of the bias supplies allow preflight adjustment of the supplies to match the PMT characteristics.

The heater control circuit stabilizes the detector temperature at a nominal 15°C by controlling the application of the spacecraft 28-volt power to a 20-watt heater.

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Figure 2.11-13. Gamma Ray Spectrometer Serial Data Output Format

2.11.2.3.4 Duty Cycle Requirements

Minimum 10 hours total in lunar orbit. Request maximum available operating time (plan for 20 or more hours during crew wake periods for 10 or more hours during crew sleep periods), within the restrictions of CSM operational requirements.

Operation during TEC is for a minimum of 6 hours between 12 to 36 hours after TEI, and a maximum of 48 hours to start as soon after TEI as possible. An additional 2 hours of data with instrument stowed (boom retracted) is requested during the 12- to 36-hour period after TEI.

Full orbital coverage is required. Where actual operation is limited by DSE low bit rate operation and DSE dumps, which should occur consecutively for maximum operating data, either repetitive or staggered data gaps are highly desirable.

No special calibration maneuvers are required.

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2.11.2.4 Optical Bar Panoramic Camera (S163)

2.11.2.4.1 General Specifications

Experiment Objective:

Obtain high resolution photography of potential landing sites and exploration areas and provide selective detailed information to support selenodetic/cartographic goals of lunar mapping program. Desirable operation concurrent with metric camera and laser altimeter.

Power Requirements: (figure 2.11-14)

	28 VDC	3Ø 115 VAC 400 Hz
Standby	75 watts	30 VA/Ø
Average	150 watts	30 VA/Ø
Peak	350 watts	100 VA/Ø

Field of View:

40° fore and aft (total) x 108° cross-track

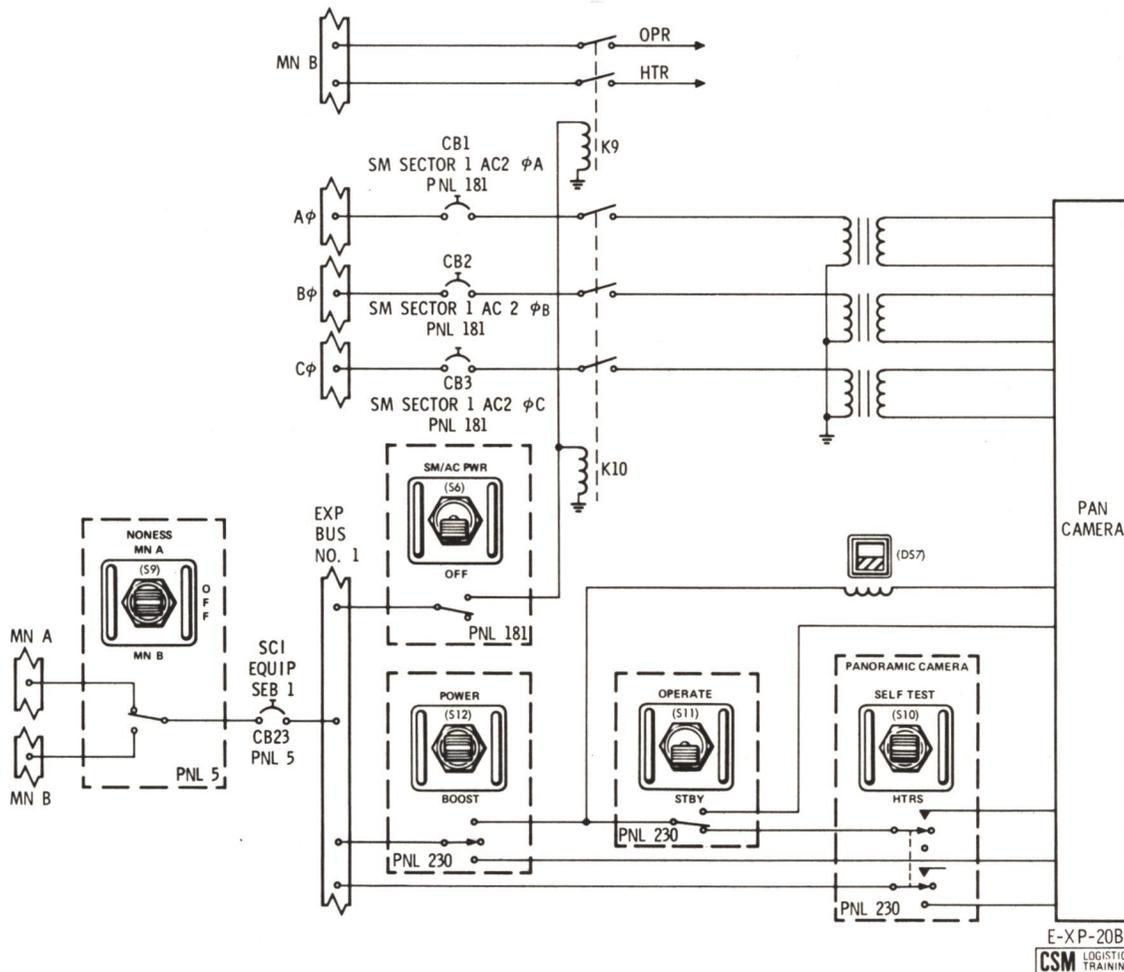


Figure 2.11-14. Panoramic Camera Power Distribution

SIM EXPERIMENTS

SYSTEMS DATA

Temperature:

Nonoperating range: 40° to 100°F
 Operating range: 85° to 95°F

Data System Interface:

Measurement Identification	Measurement Description	Samples per Second	Range
SL 1030 V	V/H command voltage	10	10-20 mrad/sec
SL 1031 X	Air solenoid	10	OFF-ON
SL 1032 T	Film magazine temperature	10	30°-100°F
SL 1033 H	Framing roll position	10	0-47 inches
SL 1034 H	Shuttle position	10	2.7 in./volt
SL 1035 C	Lens torque	10	
SL 1036 X	Capping shutter	10	OFF-ON
SL 1037 V	FMC velocity	10	4 mrad/sec/volt
SL 1038 H	Exposure	10	0-2000 ft-Lambert
SL 1039 T	Lens barrel temperature	10	75°-105°F
SL 1040 T	Lens forward temperature	10	75°-105°F
SL 1041 T	Lens aft temperature	10	75°-105°F
SL 1042 T	Camera mechanism temperature	10	30°-110°F

Operating Time Requirements:

10-20 hours standby for thermal stabilization

Three to four sunlit side passes duration of approximately 40 minutes operation each pass. (30° after sunrise terminator to 30° before sunset terminator during early, middle, and last part of experiment mission phase.)

Astronaut Support:

EVA retrieval of film cassette. Release latch requires approximately 15-1b force (figure 2.11-15).

CM Stowage:

Film cassette (19 inches diameter by 7 inches wide) 88 pounds

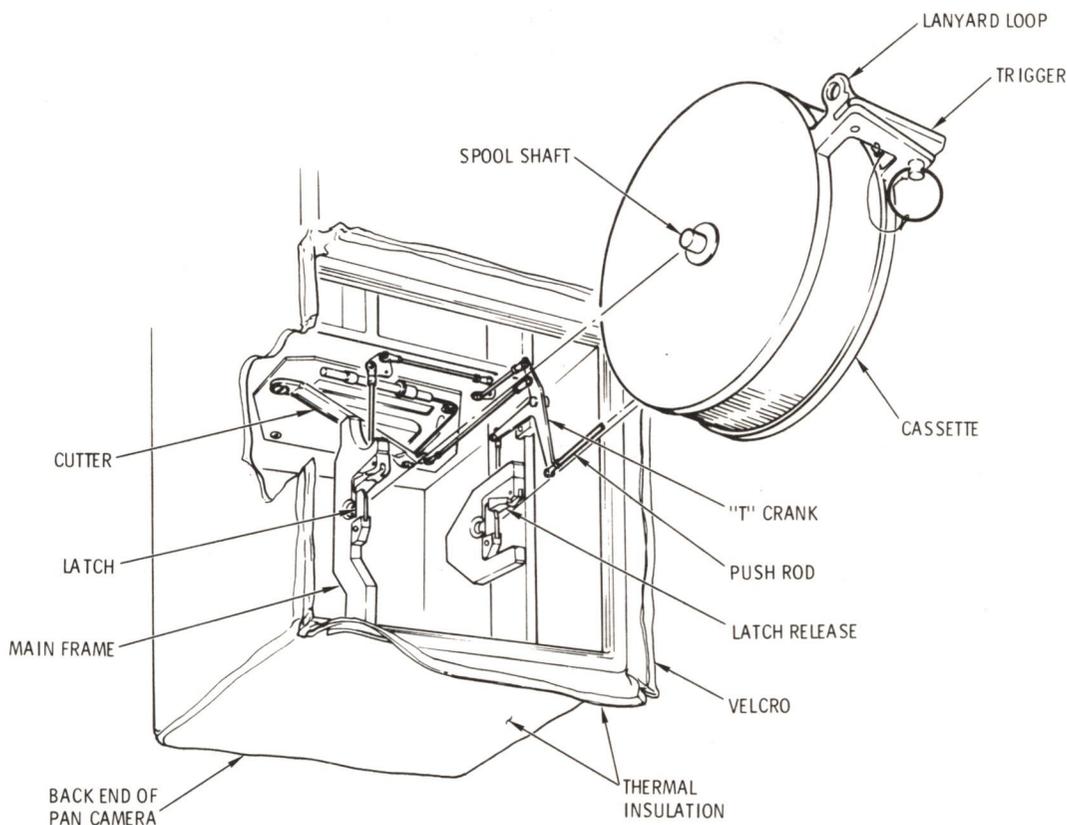
Pointing:

Accuracy: $\pm 2^\circ$

Knowledge: $\pm 2^\circ$, $\pm 0.05^\circ/\text{sec}$ CSM rates allowables. Knowledge to mapping camera within $\pm 0.1^\circ$

SIM EXPERIMENTS

SYSTEMS DATA



E-XP-42
CSM LOGISTICS TRAINING

Figure 2.11-15. Pan Camera Cassette and Release Mechanism

Constraints:

Once each 24-hour period (after flight film loading) camera must be cycled 5 frames to prevent film set. Camera lens must not be pointed at sun. CSM +X-axis in direction of velocity vector. Avoid contamination. Cassette should not be exposed to more than 45 foot-candles illumination intensity for periods of more than 45 minutes or equivalent. When camera lens is at 70°F, heater is OFF. Approximately 150 watts required at 40°F.

2.11.2.4.2 Experiment Description

The immediate problem that must be solved in planning a successful lunar program of scientific explorations is the lack of high resolution photographic information in those areas of high scientific interests that lie outside of coverage of lunar orbiter missions. In this sense, the early objective of the panoramic camera experiment is to provide unified high resolution surface imagery which can be used to evaluate both the scientific merit of these landing sites as well as the vehicle landing constraints.

SIM EXPERIMENTS

MISC

SYSTEMS DATA

Similarly, this information also aids in the establishment of design parameters for various mobility systems, instrument systems, and support facilities that are presently proposed for extending the operating radius of manned and unmanned surface explorations. The requirement for high resolution photography to support the definition and design of these systems is likely to increase during the program as efforts are made to maximize the scientific return from landing missions.

Lunar landing-site analysis and selection well in advance of the mission can significantly improve the efficiency of activities on the lunar surface. The same is even more true for manned or automated surface traverse missions. Only a thorough analysis of high resolution photography (the resolution must be three to five times better than the sizes of potential topographic hazards for the system under consideration) can provide high confidence in the operational suitability of landing sites or exploration areas. Identification and photogrammetric studies of features of high scientific interest in the vicinity of candidate landing sites can reduce the time needed for scientific activities during the lunar missions and also provide important inputs to the site selection process. After the first few Apollo landings, lunar landing sites will be selected on the basis of potential scientific value. No attempt has been made to compile a comprehensive list of the requirements of scientific disciplines other than those of geodesy/cartography. However, the following examples illustrate several representative applications.

The geologists have expressed a requirement for lunar photography of potential exploration areas to 1-meter resolution for use in planning scientific activities on the lunar surface.

It is proposed to survey an area of several hundred square kilometers several times with 1-meter resolution orbital photography at 1- to 3-year intervals to extend meteoroid flux measurements to larger masses.

2.11.2.4.3 Experiment Description

Theory of Operation

The camera (figure 2.11-16) operates in a nearly horizontal attitude, with its line-of-sight folded to the vertical by two mirrors. Panoramic scanning is accomplished by rotating the lens, configured in an N-shaped cell, about a horizontal axis. Forward motion of the vehicle is compensated for by tilting the stereo gimbal. The tilt rate is regulated as a direct function of $E(V/h)$.

The camera operates in a "skip-scan" mode in which the optical bar makes two revolutions for every frame of photography. At the maximum design V/h rate of 0.050-radian-per-second, almost 5 seconds elapse between the end of one exposure and the beginning of the next, thus permitting a relatively long interval for effective foreaft tilt. This design consideration ensures that the tilt motion does not introduce forces acting to disturb the vehicle.

The camera is designed to operate in high-altitude vehicles with a minimum of control and program inputs.

SIM EXPERIMENTS

SYSTEMS DATA

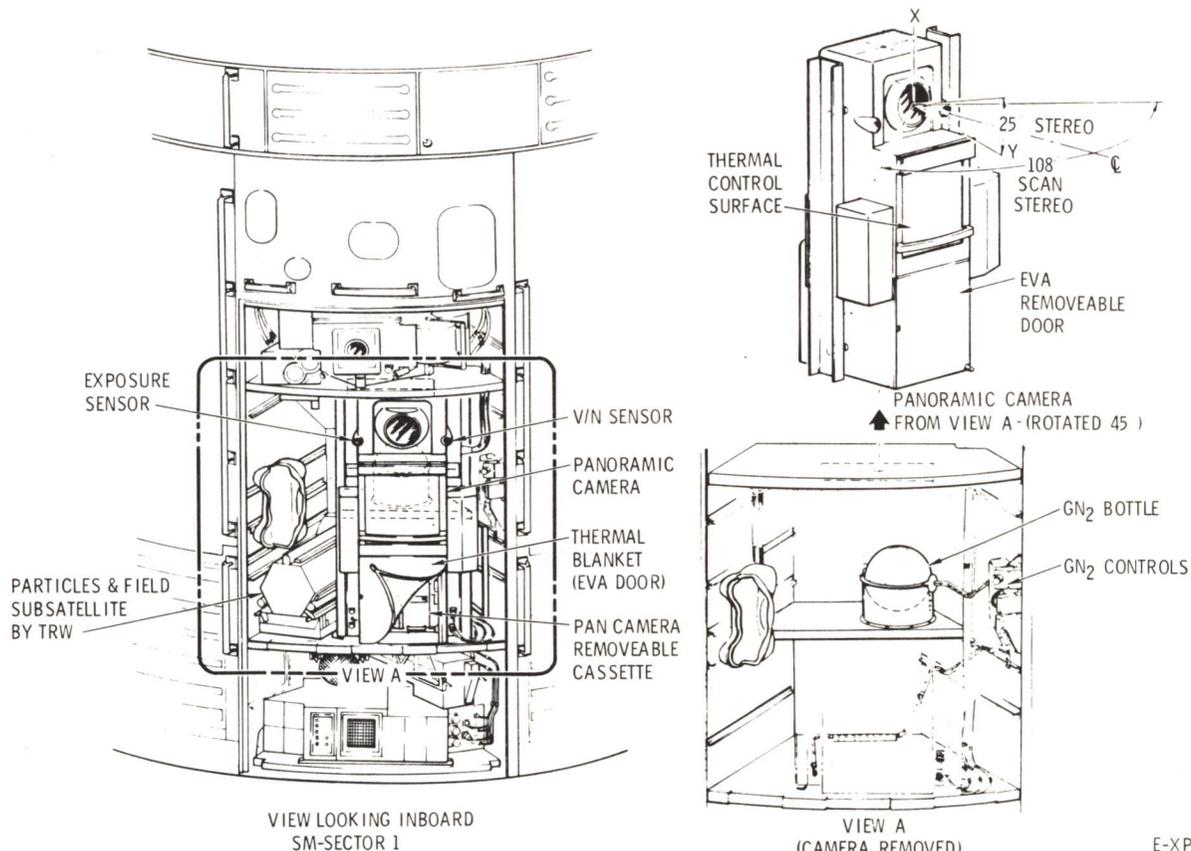


Figure 2.11-16. Optical Bar Panoramic Camera

During operation, the optical bar scan servo sets the cycling rate and acts as the master servo. By means of a cycle control unit, the film transport, data recorder, and automatic exposure control servos are slaved to the master servo (figure 2.11-17).

When the power circuits are energized, the camera starts to operate upon receipt of an operate command. The operate circuit energizes the drive servo, simultaneously releasing the film spool brakes. The optical bar then accelerates toward the rate established by the signal from the V/h sensor. At the same time, the film spools are accelerated toward the average spooling velocity, also derived from the E(V/h) signal. (The film metering drive is locked out so that it drives the film over a complete scan only when the supply storage loop has attained sufficient storage.)

For any particular E(V/h) signal level, the lens assembly rotates at a constant velocity while the film is intermittently driven through the focal plane area. The spools are driven at a nearly constant velocity while the storage loops in the shuttle assembly supply film from the intermittent scan transport.

Camera cycling is accomplished by means of an optisyn encoder attached to the optical bar. The optisyn drives logic circuits in order to perform the various phases of the camera operating cycle.

SIM EXPERIMENTS

SIM EXPERIMENTS

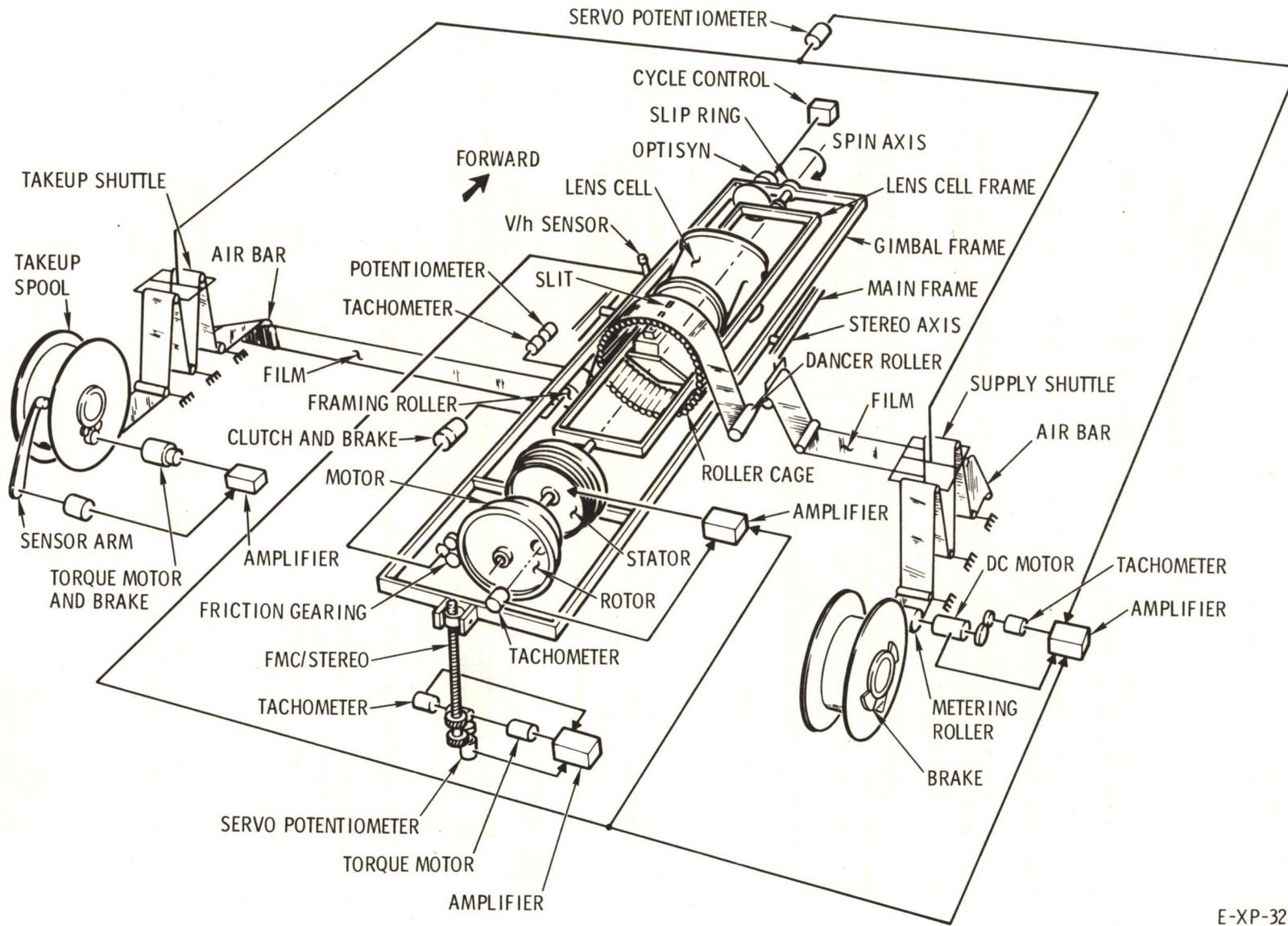


Figure 2.11-17. Pan Camera Drive and Control Diagram

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CSM LOGISTICS TRAINING

SYSTEMS DATA

2.11.2.4.4 Duty Cycle Requirements

Operating time is approximately three daylight passes; one pass early in the 3-day experiment period, one in the middle and one near the end.

Each panoramic camera operation coincides with a mapping camera pass consistent with requirements of the preceding paragraph.

All operations of the camera are scheduled such that the CSM +X-axis is in the direction of the velocity vector.

Gamma-ray spectrometer and mass spectrometer booms must be retracted from FOV during camera operations.

No sunlight should be allowed in pan camera FOV. Pan camera lens systems FOV is 11 degrees along the ground track and 108 degrees cross track with center on the SIM centerline.

A camera warmup time of approximately 10 hours is required to ensure nominal operation temperature before camera operation is started. (This time may vary depending on the result of thermal studies.)

2.11.2.5 Three-Inch Lunar Mapping Camera (S166)

2.11.2.5.1 General Specifications

Experiment Objective:

Obtain high quality metric photographs of surface from lunar orbit combined with time-correlated stellar photography for selenodetic/cartographic control. Desirable operation concurrent with 24-inch panoramic camera, laser altimeter.

Instruments:

Mapping camera: 3-inch focal length, f/4.5 aperture, rotary shutter
Stellar camera: 3-inch focal length, f/2.8 aperture, rotary shutter
Mapping-stellar interlock angle: 96°

Power Requirements: 28 VDC (See figure 2.11-18.)

Standby: 15 watts
Operating: 100 watts
Average: 100 watts
Peak: 200 watts

Temperature:

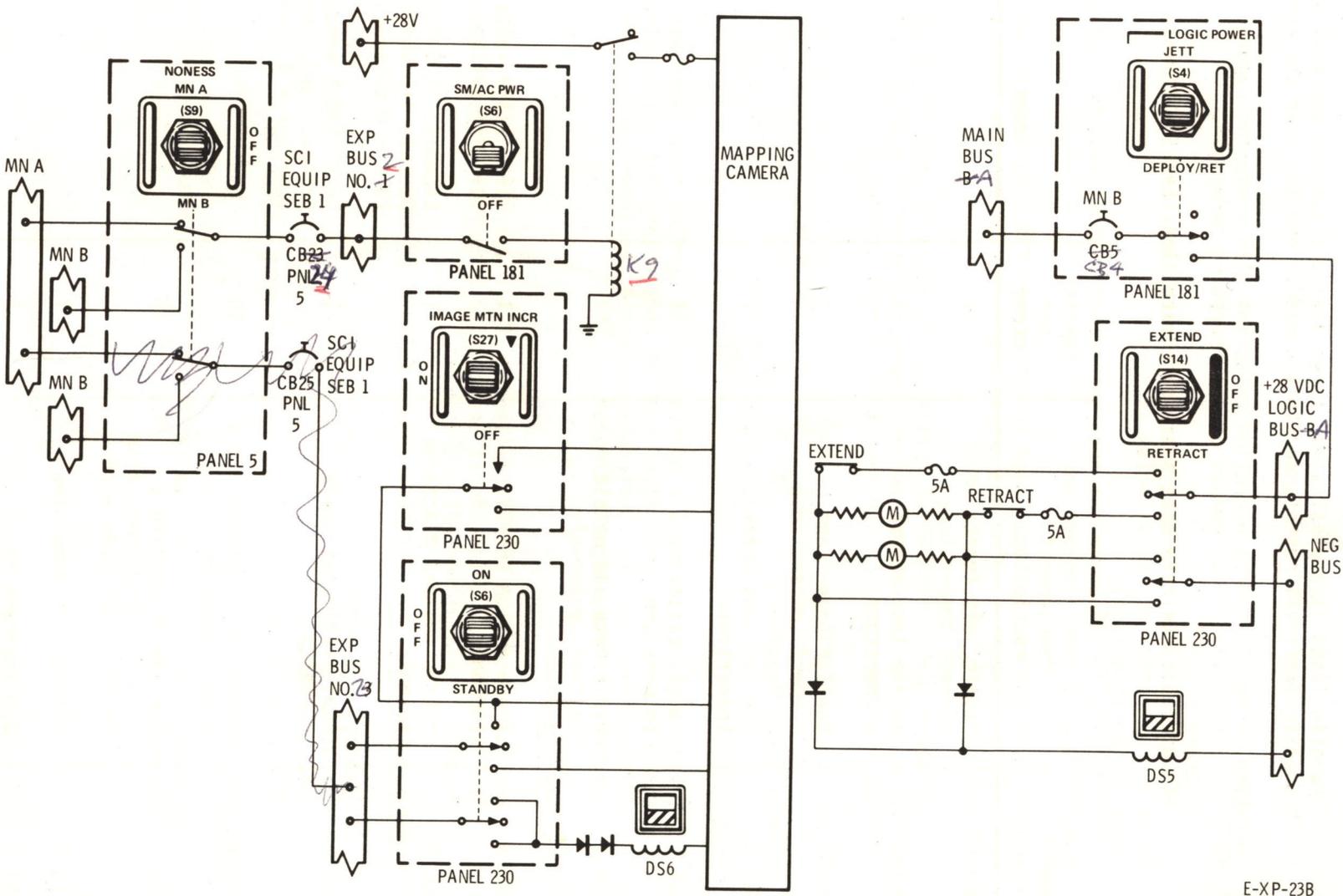
Nonoperating range: 40° to 120°F
Operating range: 60° to 80°F

MISC

SIM EXPERIMENTS

SYSTEMS DATA

SIM EXPERIMENTS



E-XP-23B
 CSM LOGISTICS TRAINING

Figure 2.11-18. 3-Inch Mapping Camera Power Distribution

*PNL 230
 V36-977101*

SM2A-03-BLOCK II-(1)
APOLLO OPERATIONS HANDBOOK

SYSTEMS DATA

Field-of-View: (See figure 2.11-19.)

Mapping lens: 74° x 74°
Stellar lens: 24° with cone flats

Pointing:

Accuracy: +2°
Knowledge: Own reference spacecraft rates less than 0.1°/sec.

Data System Interface:

Measurement Identification	Measurement Description	Samples per Second	Range
SL 1160 T	Metric lens front element temperature	1	
SL 1161 T	Metric lens barrel temperature	1	
SL 1162 T	Stellar lens front element temperature	1	
SL 1163 T	Stellar lens barrel temperature	1	
SL 1164 T	Supply casset temperature	1	
SL 1177 X	Cycle rate and metric shutter center-of-exposure	160	
SL 1165 X	Image motion OFF/ON commands	1	Off: 1.5+1 volts On: 4+1 volts
SL 1166 R	Metric shutter discharge speed	1	Standby: 1.5+0.5 volts Operate 4+1 volts (Off = 0 volts)
SL 1168 X	Deploy/film cut ready commands	1	Cut: 1+0.5 volts Deploy: 3+0.5 volts (neither = 4.5 min)
SL 1173 X	Metric film motion/metric exposure	10	
SL 1180 X	Stellar film motion, IRIG B, pretrigger, data request, altitude word	10	
SL 1176 Q	Metric film remaining <i>IN TAKE-UP CASSETTE</i>	1	
SL 1181 V	V/H increase level	1	

MISC

SIM EXPERIMENTS

E-XP-15C
CSM LOGISTICS TRAINING

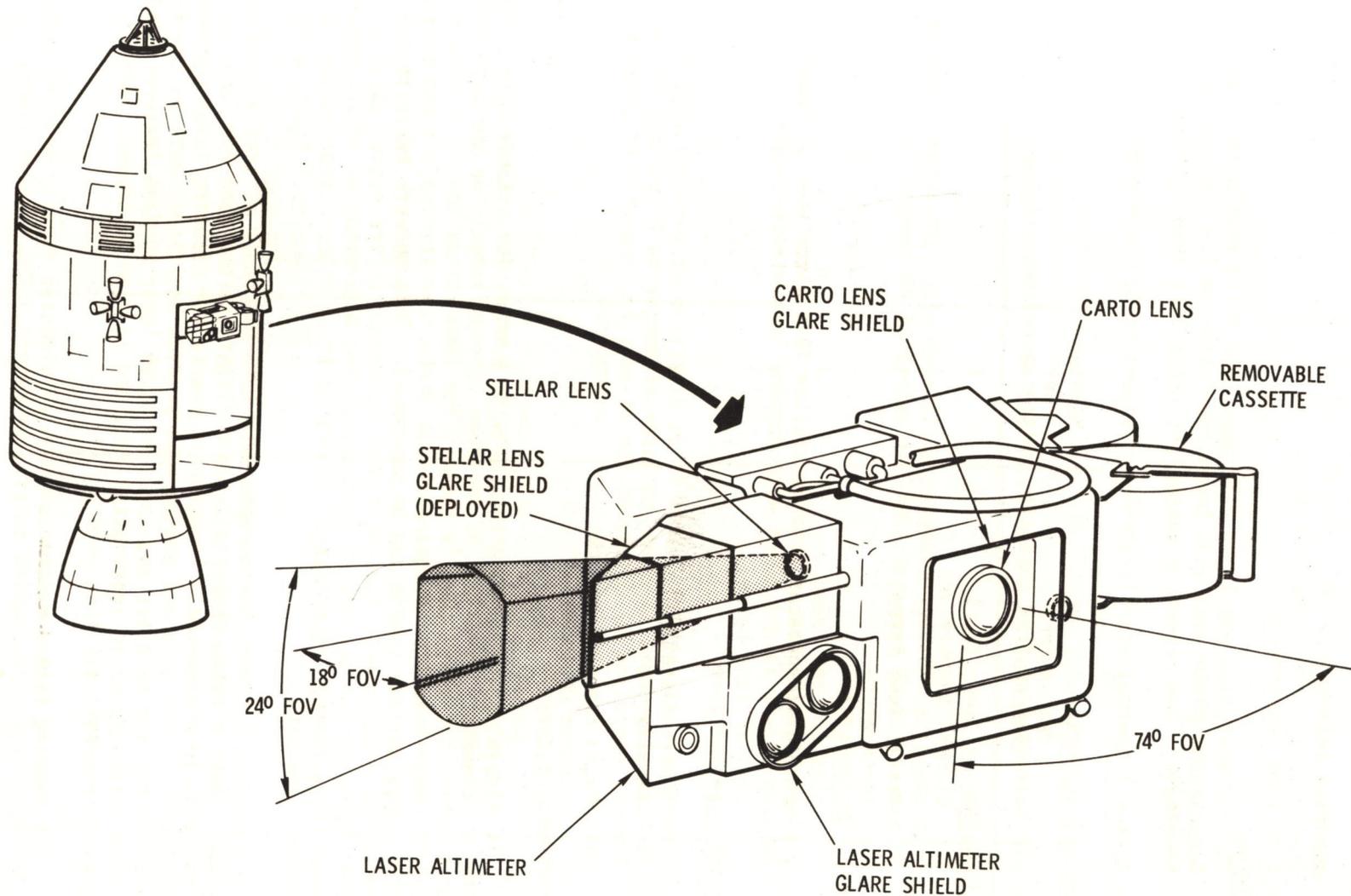


Figure 2.11-19. Mapping Camera and Laser Altimeter

SYSTEMS DATA

Time Correlation:

Modified IRIG-B

Operating Time Requirements:

Minimum operation one light side pass each third revolution. (Minimum time is one photo pass each tenth revolution on low inclination orbits).

STBY for thermal stabilization subsequent to SIM door open.

Astronaut Support:

EVA retrieval of film cassette, switch operations.

CM Stowage:

Film cassette (14-inch-diameter by 11-inch wide)/20 pounds. Should not be exposed to CM temps of 100°F in excess of 48 hours.

Special Mechanisms:

Deployment mechanism to provide stellar lens clear view of lunar horizon 96° to flight plane with mapping lens viewing nadir.

Constraints:

Camera operations when X-axis is in direction of velocity vector. Mechanically "bore sighted" to laser altimeter to 20 minutes of arc. Current operation is scheduled for +X-axis in direction of velocity vector.

2.11.2.5.2 Experiment Description

The mapping camera photographs provide a means for establishing a lunar geodetic network. The extent of coverage depends largely on the type mission on which the experiment is flown. The ideal situation is to obtain complete lunar coverage so that a single photogrammetric adjustment of the entire lunar surface sphere can be performed. This network fulfills all foreseeable requirements for positional reference on the moon. It also forms the basis for subsequent photogrammetric determination of the gravitational field through resection of camera position with respect to the control network.

The mapping camera photographs also form the basis of specialized cartographic maps ranging from small-scale flight charts, used for lunar orbit operations, to medium-scale topographic charts for planning lunar surface operations. These maps and photographs provide additional data on the form, distribution, and relative abundance of major lunar surface features, and provide terrain profile information required to plan subsequent lunar exploration missions.

The mapping camera system consists of a metric quality mapping camera utilizing 5-inch film coupled to stellar camera. The stellar camera

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SYSTEMS DATA

provides an attitude reference for data reduction of the mapping camera film. The mapping camera has a 3-inch focal length and 74° x 74° field-of-view producing a 92 x 92-nautical-mile format at 60-nautical-mile altitude.

The camera is oriented such that the terrain lens is pointed at nadir and the stellar lens points at the stellar field 90° from the direction of flight. Photographs are taken with 78 percent forward overlap to provide stereoscopic imagery.

2.11.2.5.3 Equipment Description

The mapping camera consists of two individual cameras integrated into a single unit, a metric camera that performs the cartographic function, and a stellar camera to provide spacecraft attitude information. The mapping camera provides a resolution of 20 meters at 60 nautical miles and 114 l/mm area weighted average resolution. The data, in the form of film, is stored in a removable cassette which must be retrieved and returned to earth by the astronaut. Figure 2.11-20 shows the film drive, exposure, and take up mechanisms for both the stellar and metric cameras.

2.11.2.5.4 Duty Cycle Requirements

Minimum operation for required coverage is one light side pass every third revolution. (No sleep period operations should be scheduled.)

Mapping camera operation should coincide with laser altimeter data collection.

No sunlight should be allowed in metric or stellar camera FOV.

A camera warmup time of approximately 3 hours is required to ensure nominal operating temperature before camera operation is started.

The camera should be cycled once each 24+6 hours, test cycle switch closure. (No warmup required.)

EVA is required for film retrieval.

2.11.2.6 Laser Altimeter (S175) (figure 2.11-21)

2.11.2.6.1 General Specifications

Experiment Objectives:

Provide precise time-correlated altitude information for use in conjunction with tracking data and pictures taken by the mapping and panoramic camera.

Power Requirements:

	28 VDC	115 VAC, 400 Hz, 3 Phase
Average	54 watts	7 volt-amps/phase
Peak	97 watts	7 volt-amps/phase

SIM EXPERIMENTS

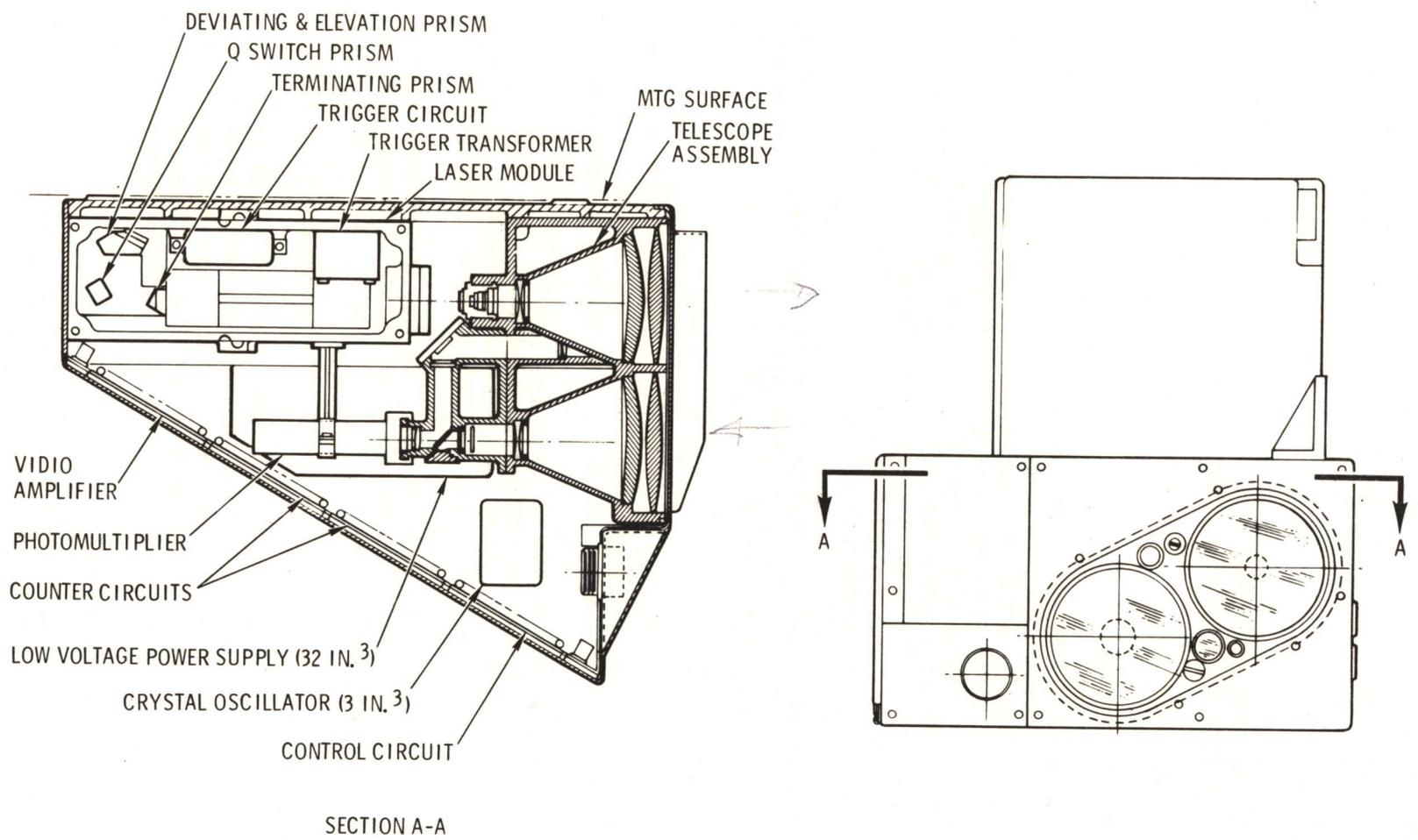


Figure 2.11-21. Laser Altimeter

E-XP-45
CSM LOGISTICS TRAINING

SYSTEMS DATA

Temperature:

Nonoperating range: -30° to 257°F
Operating range: 65° to 160°F

Field-of-View:

200 microradians (receiver)
300 microradians (transmitter beamwidth)

Data System Interface:

Analog outputs:

Supply voltages:

Analog outputs between 0 and 5 vdc are generated for each of the following laser altimeter voltages:

- a. Regulated -5 vdc (event on analog channel)
- b. Photomultiplier voltage -1800 vdc
- c. Pulse forming network to voltage 3 kv

Cavity temperature:

Analog output proportional to the laser cavity temperature will be generated to provide for detection of problems which could be related to abnormal temperature.

Digital Outputs:

The laser altimeter electronics generate a 24-bit digital serial output consisting of:

- a. An 18-bit altitude word direct reading in meters (in natural binary)
- b. 6 binary events reflecting:
 1. Regulated 6 bolts: Present or absent
 2. Q-switch motor speed: A logical output is generated to signify that the Q-switch motor is operating or nonoperating.
 3. Krytron (SCR) trigger: Change in the logic state of this output verifies proper capacitor discharge for flash-lamp firing.
 4. Laser output: This output changes state if the laser output falls below the minimum required for maximum altitude.
 5. Range overflow: A range overflow signal indicates that the range counter did count but no target returns within the minimum and maximum altitudes were received by the counter.
 6. Metric camera data request pulse: This signal verifies that a camera data request pulse was received.

Operating Time Requirements:

Dependent upon experiments being supported. Four complete orbital revolutions are required, independent of mapping camera operation.

SIM EXPERIMENTS

SYSTEMS DATA

Pointing:

Accuracy: $\pm 2^\circ$
Knowledge: Functions with mapping camera

Constraints:

Covers should be provided for the optics to prevent contamination of critical surfaces. Photomultiplier tube of receiver should be protected against direct solar illumination.

2.11.2.6.2 Experiment Description

The determination of the moon's gravitational field from analysis of lunar orbiter perturbations, of which the main result is the mass concentrations, is of great importance to the study of the moon's structure and evolution. However, the lack of accurate topographic elevations makes it difficult to draw inferences as to internal structure because the contribution to the gravitational field of the visible topography cannot be subtracted out accurately. Also the spectrum of the long wave variations in topography is of significance to lunar structure itself. This experiment should yield data to facilitate resolving these problems.

The laser altitudes are used with DSIF tracking from the earth to determine improved orbits. The variations in topographic variations are then determined by subtracting the laser altitudes from the orbital radial coordinates. This procedure should give the topographic variations with an accuracy approaching that of the instrumentation, because the wavelengths of topographic variations is much shorter than the wavelengths of variations in the error of the radial coordinate of the orbit.

2.11.2.6.3 Equipment Description (Figure 2.11-22)

The instrument is essentially a ranging device depending on spacecraft attitude information for final data reduction. The light source is a pulsed ruby laser operating at a 6943-angstroms wavelength with 200 millijoule pulses of 10-nanosecond duration at repetition rates up to 3.75 pulses per minute.

The transmitter produces a 300-microradian beam width and the receiver has a 200-microradian FOV. The time base oscillator operates at approximately 150 MHz to provide 1-meter range resolution.

The completed altimeter will be delivered to Fairchild for attachment to and boresighting with the mapping camera (MC).

2.11.2.6.4 Duty Cycle Requirements

Minimum operation requirements are to support mapping camera (all assigned missions).

Protective shutter closes when sun is within 2 degrees of receiver FOV centerline; however, altimeter should not be deliberately directed toward sun.

SIM EXPERIMENTS

SIM EXPERIMENTS

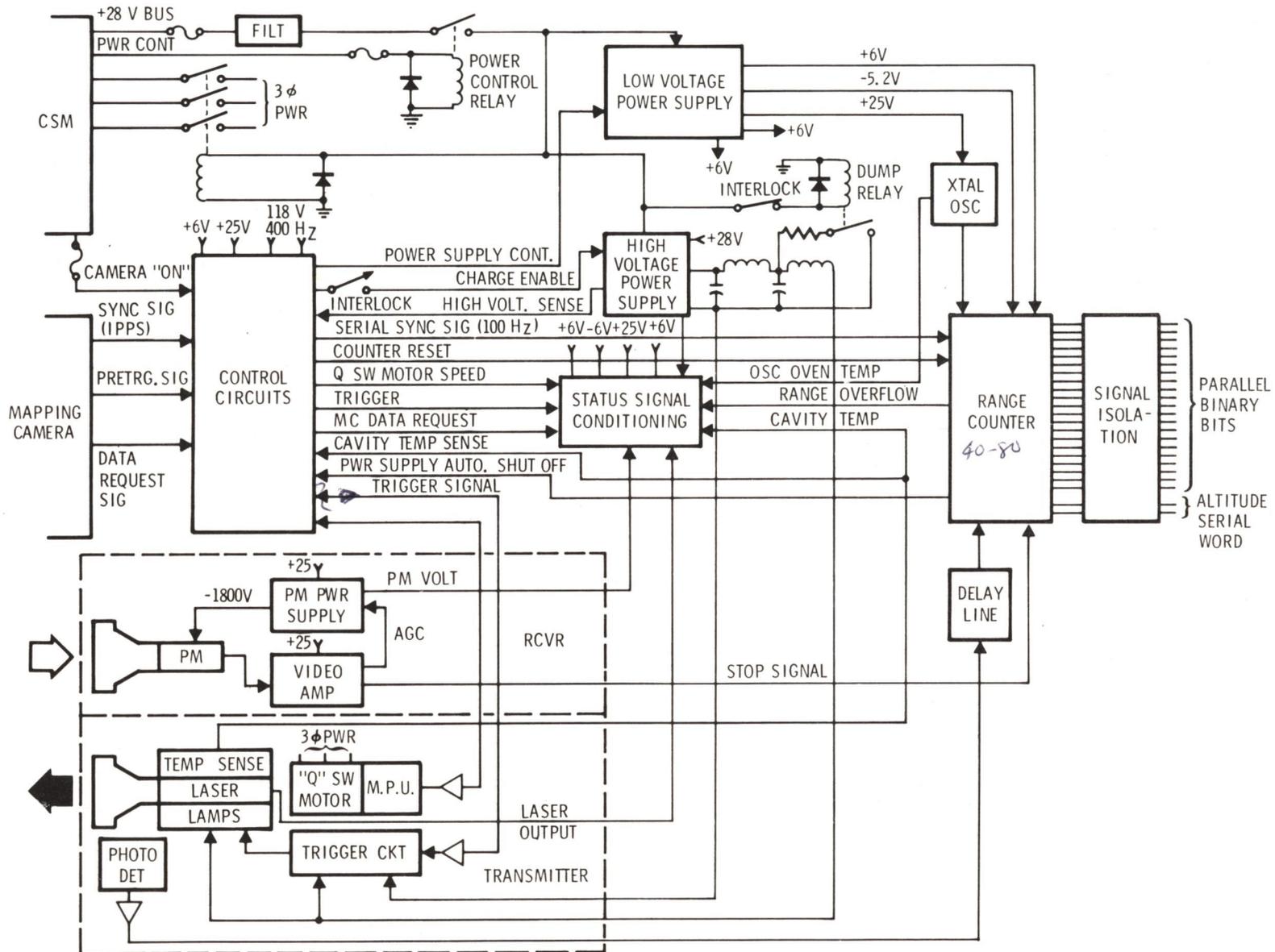


Figure 2.11-22. Laser Altimeter Block Diagram

E-XP-43
CSM LOGISTICS TRAINING

SYSTEMS DATA

2.11.2.7 Mass Spectrometer (S165)

2.11.2.7.1 General Specifications

Experiment Objectives:

Obtain data on composition of lunar ambient atmosphere as an aid in understanding mechanisms of release of gases from the surface, as a tool to locate areas of volcanism, and for determining distribution of gases in lunar atmosphere.

Instrument:

Magnetic sector-field mass spectrometer with a Nier-type thermionic electron bombardment is such that masses of 12-28 amu and 28-66 amu may be determined.

Power Requirements: 28 VDC (See figure 2.11-23.)

Standby: 5 watts
Average: 15 watts
Peak: 20 watts

Temperature:

Nonoperating range: -58° to 176°F
Operating range: -4° to 140°F

Pointing:

Accuracy $\pm 5^\circ$
Knowledge $\pm 5^\circ$

Field of View:

Must clear spacecraft minimum of 18 feet (preferred aft-facing in direction of motion). Preferred location at rear of SIM bay. CSM -X axis along the velocity vector within $\pm 5^\circ$.

Data System Interface:

For data characteristics, refer to the following listing.

SIM EXPERIMENTS

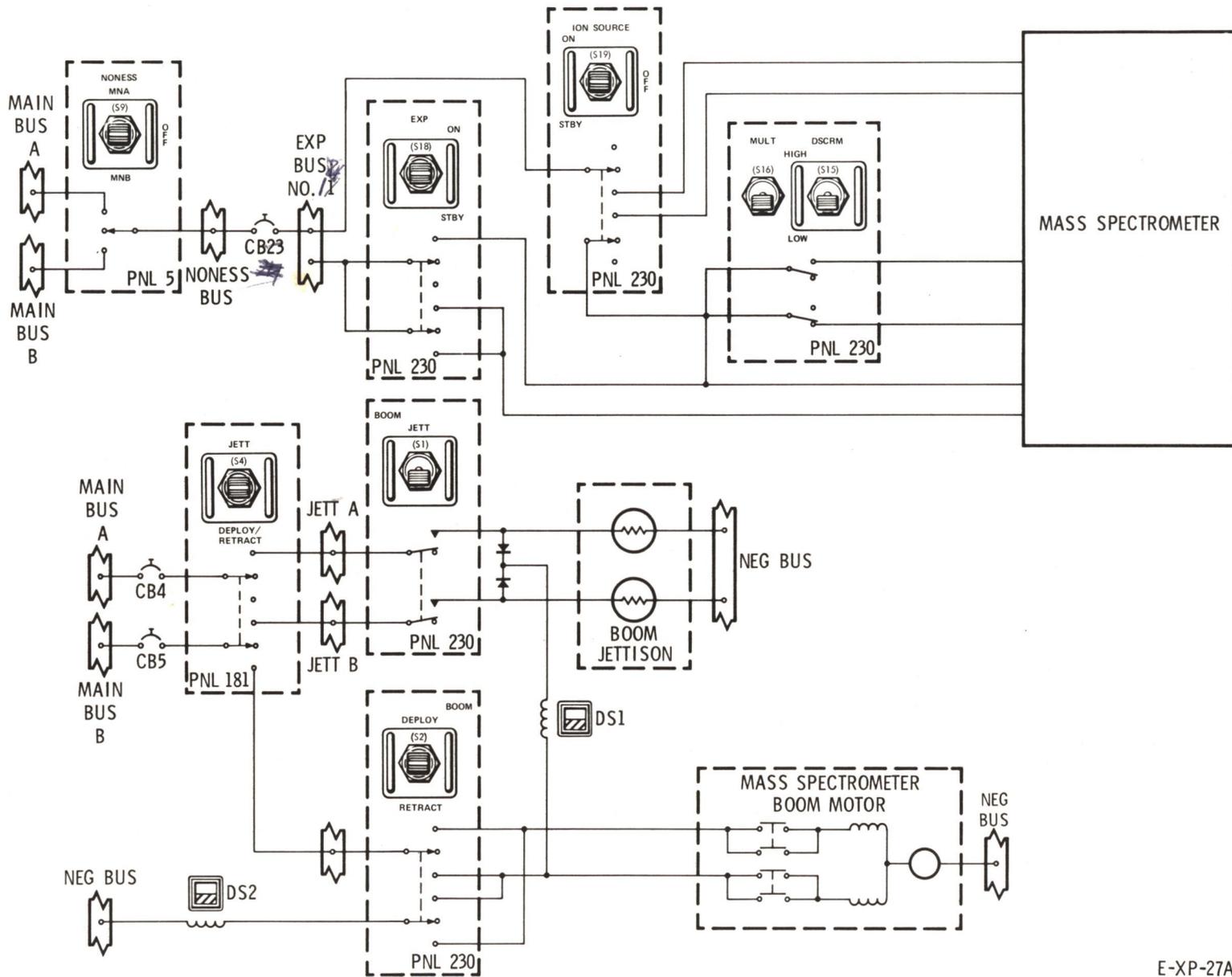


Figure 2.11-23. Mass Spectrometer Power Distribution

E-XP-27A
 CSM LOGISTICS TRAINING

SIM EXPERIMENTS

SM2A-03-BLOCK II-(1)
APOLLO OPERATIONS HANDBOOK

SYSTEMS DATA

Measurement Number	Measurement Nomenclature	Parameter	Range	Sub-Commutator Position
SL 1082 K	Data A Low Mass	Ion counter No. 1 (12-28 AMU)	10^{-7} - 10^{-13} torr	NA
SL 1083 K	Data B High Mass	Ion counter No. 2 (28-66 AMU)	10^{-7} - 10^{-13} torr	NA
SL 1084 X	Data C Sweep Start Flag	Sweep Start Flag	Event ON/OFF	NA
SL 1124 V	Mass Spec Combined Data	+12-volt monitor	0-30 volts	1
		+5-volt monitor	0-10 volts	2
		-12-volt monitor	0-20 volts	3
		-15-volt monitor	0-18.75 volts	4
		Emission current monitor	0-100 micro amps	5
		Filament current monitor	0-2 amps	6
		Instrument current monitor	0-1 amp	7
		(a) normal operation		
		(b) normal & heater operation		
		Elect. multiplier H.V. (12-28 AMU)	1500-1800 volts	8
		(a) multiplier Hi		
		(b) multiplier Lo		
		Elect. multiplier H.V. (28-66 AMU)	1500-1800 volts	9
		(a) multiplier Hi		
		(b) multiplier Lo		
		Sweep H.V. monitor		10
Temp. No. 1 (electronics)	-50° to +80°C	11		
Temp. No. 2 (ion source)	-50° to +350°C	12		
Multiplier Flag	Event (ON/OFF)	13		
(a) multiplier Hi	ON			
(b) multiplier Lo	OFF			
Discriminator Flag	Event (ON/OFF)	14		
(a) discriminator Hi	OFF			
(b) discriminator Lo	ON			
Filament Flag	Event (No.1 ON/ No. 2 ON)	15		
(a) filament No. 1	1 - ON			
(b) filament No. 2	2 - ON			
Marker	Event - ID	16		

Note: Each set of data words consists of two 10 bit words, one for each AMU range, plus one discrete flag bit to indicate sweep start. The data is stored in the spectrometer buffer registers and sampled in the scheduled sequential manner of the SDS PCM system. All buffer registers of the mass spectrometer is internally sequenced to ensure no updating occurs during the scheduled sampling interval. Real time data display is required for both the science and housekeeping data.

SIM EXPERIMENTS

SYSTEMS DATA

Time Correlation:

10 pulses per second (preferred) or 1 pulse per second (acceptable)

Operating Time Requirements:

2 complete lunar orbits per data collection period (minimum), 12 complete orbits desirable and 1 hour (min) operation during TEC plus boom retraction sequence.

Special Mechanisms:

24-foot (minimum) extendable/retractable boom.

Constraints:

Contamination by leakage of cabin gas and outgassing of structure may reduce experiment effectiveness.

2.11.2.7.2 Experiment Description

Study of the composition and distribution of gases in the lunar atmosphere is important to two current problems. First is the understanding of the origin of the lunar atmosphere. Light gases, such as hydrogen, helium, and neon probably originate from neutralization of solar wind ions at the surface of the moon, while Ar^{40} is most likely due to radioactive decay of K^{40} , and Ar^{36} and Ar^{38} may be expected as spallation products of cosmic ray interactions with surface materials. Molecular gases, such as carbon dioxide, carbon monoxide, hydrogen sulfide, ammonia, sulphur dioxide, and water vapor may be produced by lunar volcanism.

The second problem is related to transport processes in planetary exospheres. The exosphere of the earth, and that of almost any other planet, is bounded by a dense atmosphere in which hydrodynamic wind systems complicate the problem of specifying appropriate boundary conditions for exospheric transport. This contrasts sharply with the situation in the lunar atmosphere, which is entirely a classical exosphere, with its base the surface of the moon. The lunar exosphere should be amenable to accurate, analytical study, and experimental determination of the global distributions of lunar gases can provide a reasonable check on theory, giving confidence to the application of theoretical techniques to transport problems in the terrestrial exosphere.

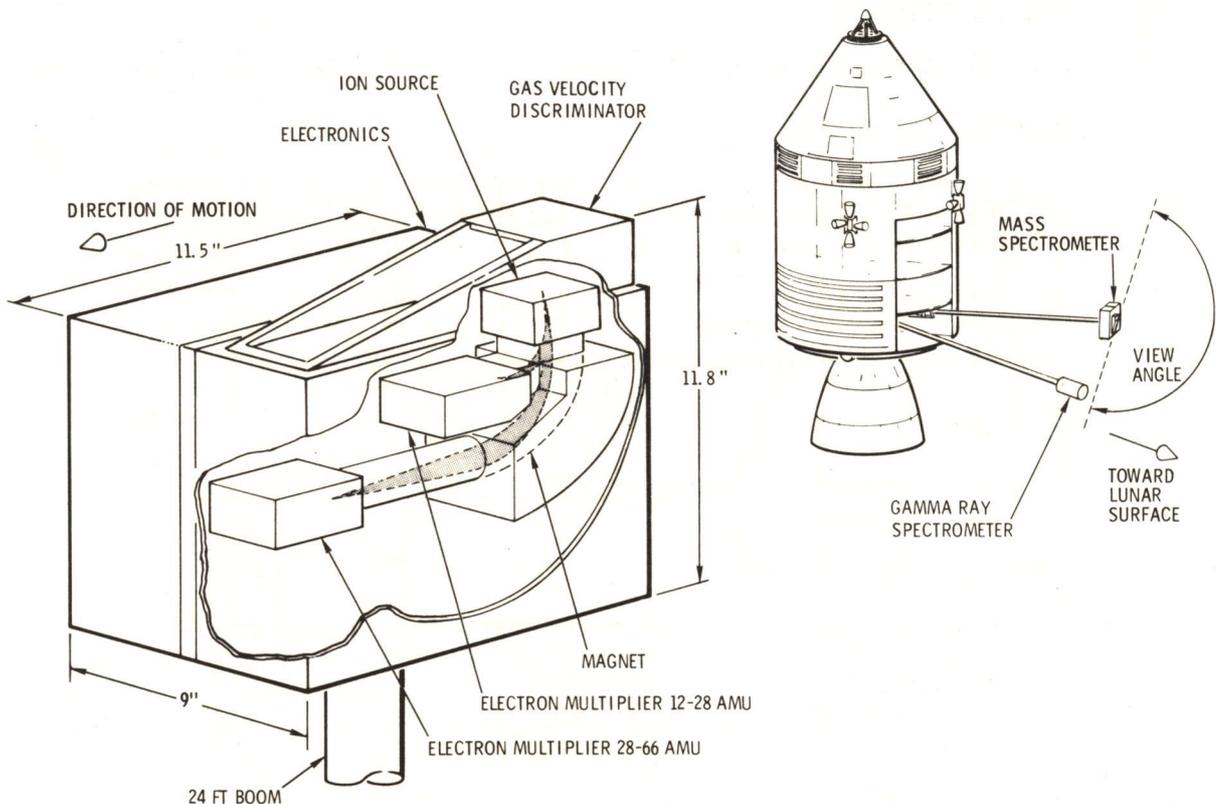
2.11.2.7.3 Equipment Description

The mass spectrometer is mounted on a 24-foot boom which is to be extended from bay 1 of the service module. This unit contains, besides the mass spectrometer, the preamplifiers, counters, high-voltage power supplies, filament regulator and preregulator. It weighs approximately 22 pounds and has dimensions of 11-1/2 x 11.8 x 9 inches. The boom that supports the package is attached to a mount at the rear of the bay 1 area. (See figure 2.11-24.)

MISC

SIM EXPERIMENTS

SYSTEMS DATA



E-XP-6B
CSM LOGISTICS TRAINING

Figure 2.11-24. Mass Spectrometer

Basically the instrument is a magnetic sector-field mass spectrometer with a Nier-type thermionic electron bombardment ion source. The ion source chamber has a positive potential which is varied from 780 to 1960 volts. Neutral gases that enter the chamber and become ionized are accelerated by this potential through a set of collimating slits before being injected into a magnetic analyzer at zero potential. These ions pass through a uniform magnetic field which separates them into different circular trajectories according to mass. Those with path radii of 1.63 inches and 2.50 inches emerge through collector slits into separate detectors and counting systems. The range of variation of the ion source chamber potential is such that masses of 12 to 28 amu and 28 to 66 amu are simultaneously scanned by the two detectors. The positive potential of the ion source chamber performs a second function of preventing atmospheric ions from entering the instrument.

Figure 2.11-25 is a functional block diagram of the mass spectrometer and its associated electronic circuits. The emission control circuit provides the basic voltages to both chambers of the mass spectrometer. It not only controls the power to the redundant filaments but also the focus grid, and the J-plates at both chambers. Control of the ion chamber voltage rests basically with the digital sweep control circuit and high-voltage power supply sweep circuits. The voltage is cycled through 620 steps

SIM EXPERIMENTS

SYSTEMS DATA

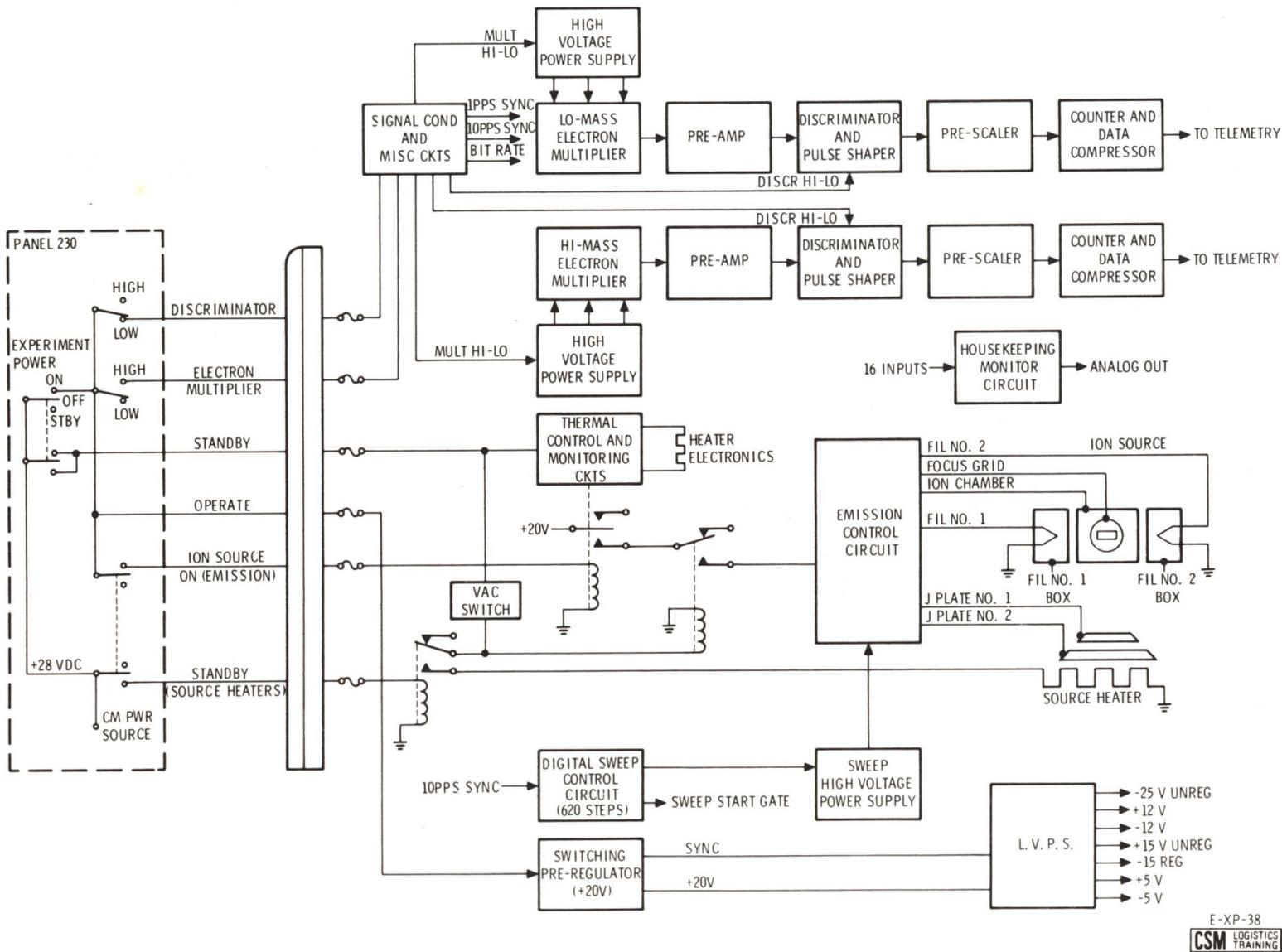
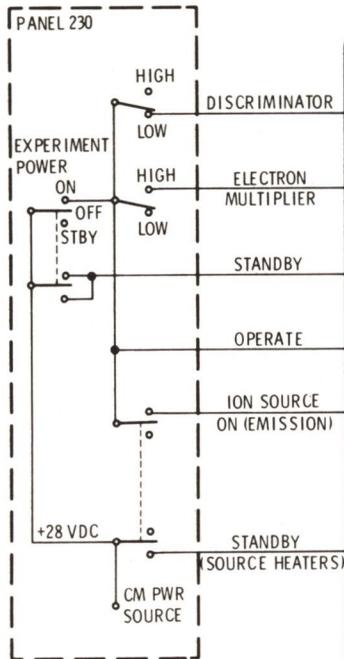


Figure 2.11-25. Mass Spectrometer Block Diagram

E-XP-38
 CSM LOGISTICS TRAINING

SIM EXPERIMENTS



MISC

SYSTEMS DATA

lasting 0.1 second each. The first 15 steps provide a check on background noise count for both electron multipliers and their electronics, while the second 15 steps are utilized for calibration. The remaining steps vary the voltage to the ion chamber from 780 to 1960 volts starting with one volt and then increasing to two-volt increments. The counting system for each atomic mass unit range contains a 21-bit accumulator. Data compression reduces the digital data output to two 10-bit words plus one discrete status flag bit to indicate the sweep start. Housekeeping data is internally subcommutated onto one analog output at the rate of one measurement per second.

The discrete data consists of one digital bit which is a status flag to indicate the ion acceleration voltage sweep position. During the first 30 voltage steps of the 620-step voltage sweep, the sweep start flag is a digital ZERO. For the remaining 590 voltage steps, the sweep start flag is a digital ONE. The total ion acceleration voltage sweep time for the total 620 voltage steps is 62 seconds.

The multiplier high-low switch basically changes the sensitivity of the electron multipliers. The discriminator high-low switch affects the trigger level of the discriminator and pulse shaper circuitry. It should be noted that in no way do these switches affect the range of mass spectrometer but rather affect the sensitivity of its detector and its associated processing circuitry.

2.11.2.7.4 Duty Cycle Requirements

Minimum of two revolutions in lunar orbit per data collection period is required. At least 12 revolutions should be planned.

During TEC, a minimum of one hour operation is required no sooner than 6 hours after the most recent SPS RCS burn associated with TEI or a midcourse correction. Also during TEC an additional period of operation shall consist of a boom retraction sequence of five equal steps with 7 minutes of operation at each step location. The final location should be in the fully retracted position.

Optimum instrument operation requires that no effluent dump (urine, waste water, fuel cell purges, etc.) should occur during nor within five hours immediately preceding any spectrometer data collection period.

Minimum acceptable instrument operation requires that no effluent dump should occur during nor within 2 hours immediately preceding any spectrometer data collection period.

In lunar orbit, a 6-hour cumulative warmup period (ion source standby) is required before the start of the initial data collection. All subsequent lunar operation requires 30 minutes warmup. Data collection should occur only when the CSM -X axis is in the direction of the velocity vector.

During TEC, a warmup period of 3 hours is required and the CSM -X axis must be aligned within 5 degrees of the velocity vector during data collection. The CSM may be rolled to maintain PTC.

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SYSTEMS DATA

The boom must be deployed for all data collection except during the additional operation in the boom retraction sequence of five equal steps with 7 minutes of operation at each step location.

2.11.2.8 Subsatellite (S173/S174/S164)

2.11.2.8.1 General Specifications

Experimental Objectives:

Study wave particle interactions while in 60-NM circular lunar orbit. Study information of earth's magnetosphere and solar wind boundary layer over moon. Study magnetic field interaction with moon and measure particle flux in and near plasma sheet. Monitor solar flare electron events. (See figure 2.11-26.)

Track the subsatellite in lunar orbit by means of S-band Doppler measurements from the ground to enhance determination of lunar gravity field.

Instrument:

Charged particle detectors, magnetometers, optical aspect, and clock are carried in a self-sufficient satellite. Data storage unit, power system, command decoder, and S-band transponder are included.

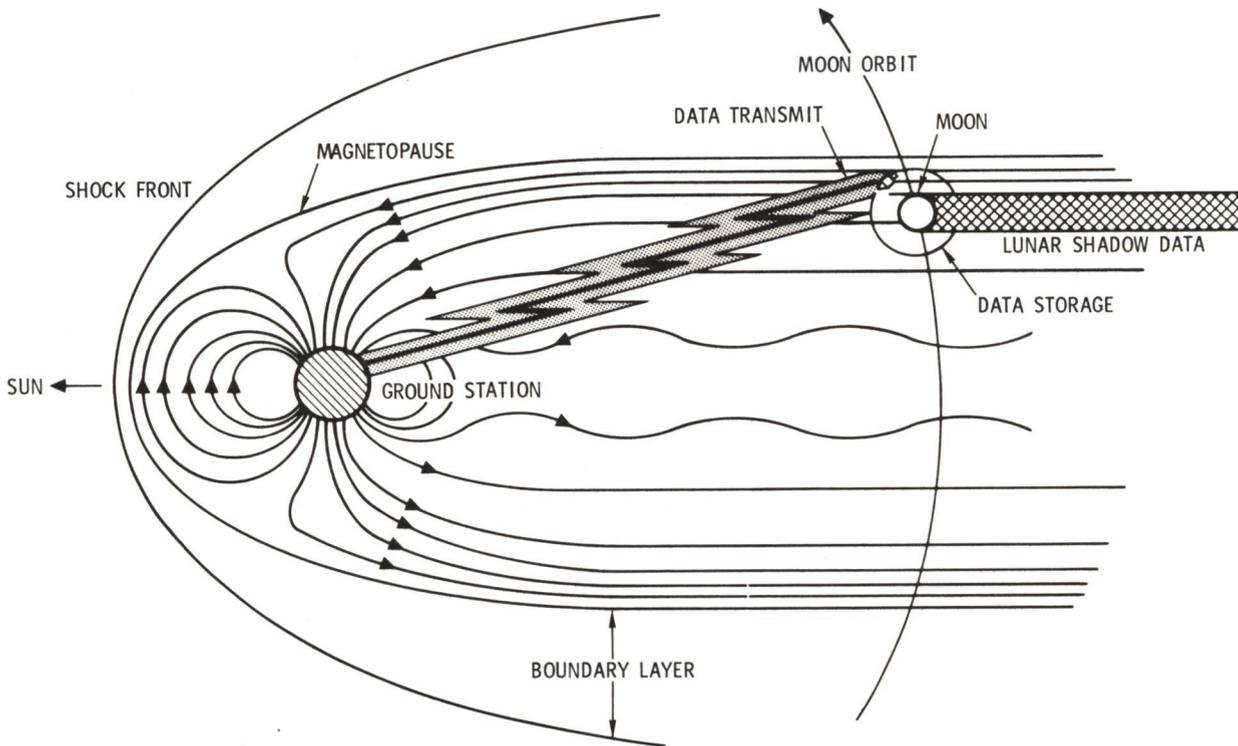


Figure 2.11-26. Subsatellite Operational Environment

E-XP-26
CSM LOGISTICS TRAINING

SIM EXPERIMENTS

MISC

SYSTEMS DATA

Envelope/Weight:

Approximately 31 inches long, hexagonal cross section with 12-inch flats approximately 80 pounds (figure 2.11-27).

2.11.2.8.2 Experiment Description

The Magnetotail Measurements:

Vector magnetometer surveys have been the major means of determining magnetic fields in space. Many basic properties of the interplanetary medium, bow shock, and magnetosphere have been determined by this means.

Although by and large highly successful, the method does have limited ability to detect weak, directed components due to considerable variability of the fields.

Thus it has not been possible to find or to rule out the existence of a field component normal to the magnetopause. Such a component bears directly on the question of openness of the magnetosphere. Also, it has not been possible to identify which field lines surrounding the neutral sheet in the tail connect on both ends to the earth and which go far behind the earth, perhaps entering interplanetary space.

Recently a new method complementary to vector magnetometers has been described. This method is able to determine the large scale topology of field lines under certain conditions. It is essentially a particle tracing technique which determines where particles have been and where they go on the particular field lines under study. The tracer particles are supplied by the sun. The method also requires the presence of a large absorber such as the moon. As a spacecraft orbits the moon a pattern of varying solar electron intensity is produced. The characteristics of the field lines are then deduced from the symmetry properties of these patterns.

The Boundary Layer:

The empirical study of the boundary layers and discontinuities in naturally occurring plasmas is, in most cases, greatly complicated by the motion of the layers. This problem has arisen, for example, in the studies of the bow shock and magnetopause at the earth.

On the basis of present evidence, the interaction of the solar wind with the moon occurs very close to the lunar surface. The boundary layer for this interaction extends from the lunar surface outward to some distance which is as yet unknown, but which is estimated to be of the order of 100 kilometers. We have, then, a boundary layer that is fixed in space, since the inner boundary is the lunar surface, and variable in thickness. Thus, in this particular boundary layer, complications due to the motion do not exist.

The goal of this part of the experiment is to obtain data on the physics of this interaction region or boundary layer. The characteristics of the boundary layer are determined by the properties of the plasma as well as those of the moon. Thus, the study of the interaction region will yield information on the external plasma, the interior of the moon, the surface, and the lunar ionosphere.

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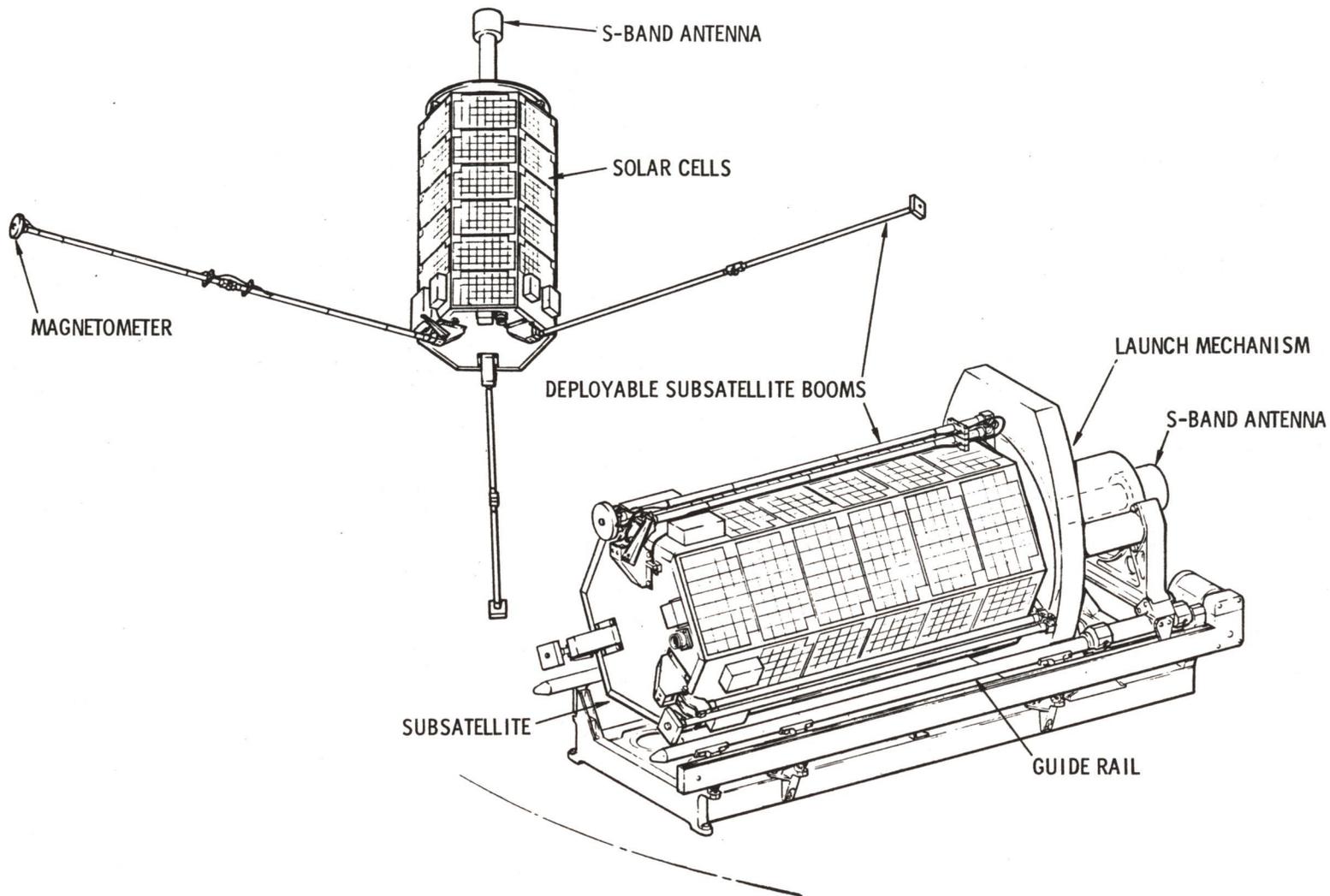


Figure 2.11-27. Subsatellite With Launching Mechanism

E-XP-28 B
CSM LOGISTICS TRAINING

SYSTEMS DATA

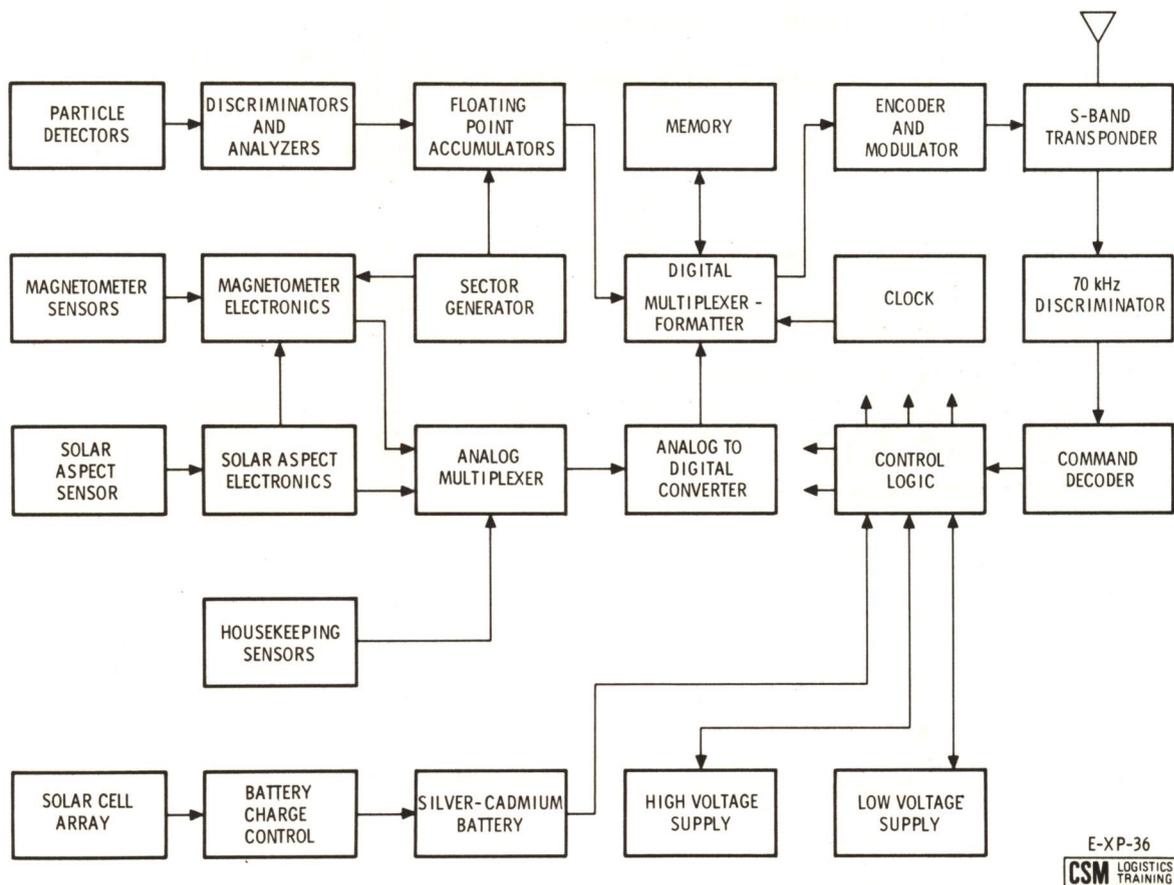
S-Band Tracking:

Accurate measurement of a subsatellite's natural lunar orbit position over meaningful periods of time allows definition of a lunar mass model. Such a model, when correlated with lunar shape information, enhances and supports future lunar activities by permitting greater surface landing accuracy, backside landings, and more accurate or alternate orbit determinations, and gives the scientific community a basic model for such considerations as lunar origin and subsurface structure.

2.11.2.8.3 Equipment Description

Figure 2.11-28 is a simplified overall block diagram of the subsatellite. The equipment falls into five broad classifications

- Sensors and ancillary equipment
- Data processing and storage equipment
- Command decoder
- S-band transponder
- Electrical power system



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Figure 2.11-28. Subsatellite Functional Block Diagram

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The specific equipment which make up these classifications are as follows:

- a. Sensors and their ancillary equipment
 - Particle detectors with the discriminators and analyzers
 - Magnetometers with their electronics
 - Sector generator
 - Solar aspect sensor and its electronics
 - Assorted housekeeping sensors and conditioners
- b. Data processing and storage equipment
 - Analog multiplexer
 - Analog-to-digital convertor
 - Digital multiplexer and formatter
 - Encoder and modulator
 - Floating point accumulator
 - Memory
 - Clock
- c. Command decoder
 - 70 kHz discriminator
 - Sub-bit detector
 - Digital processor
- d. S-band transponder
 - S-band receiver
 - S-band transmitter
 - Converter
 - Diplexer
- e. Electrical power system
 - Solar cell array
 - Battery charge control
 - Battery
 - High- and low-voltage power supplies

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Sensors and Ancillary Equipment

Figure 2.11-29 shows the location at the particle detectors with their field of view. Each general type of detector will be discussed in the subsequent paragraphs along with a brief description of the supporting electronics.

Particle Telescope System

A diagram of the particle telescope is shown in figure 2.11-30. Each telescope (A & B) consists of two fully depleted surface barrier silicon nuclear particle detectors. The front detector is of sufficient depth to detect electrons from 25 Kev to 320 Kev and protons from 25 Kev to 2 mev. The second detector in the telescope performs an anti-coincidence (veto) function for those particles that completely penetrate the front detector. Two telescopes are used with a foil over the entrance aperture of the second (B) to differentiate between protons and electrons in the lower energy channels.

Each detector is connected to an individual charge-sensitive pre-amplifier and gain-shaping amplifier. The front detector signal is analyzed in the energy range of 25 Kev to 2 mev and, in the absence of a signal from the second detector of greater than 30 Kev, acts as a strobe for a 6-channel pulse height analyzer. When operating, either

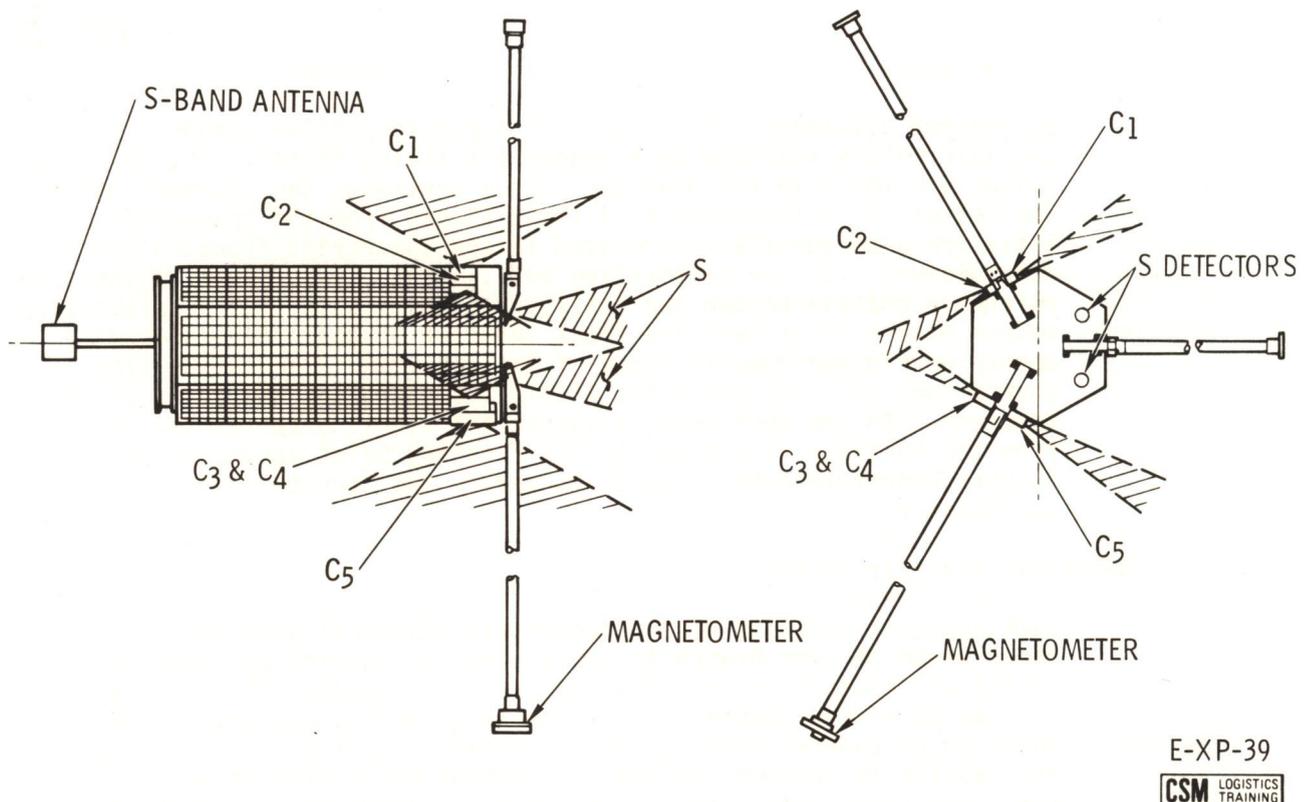
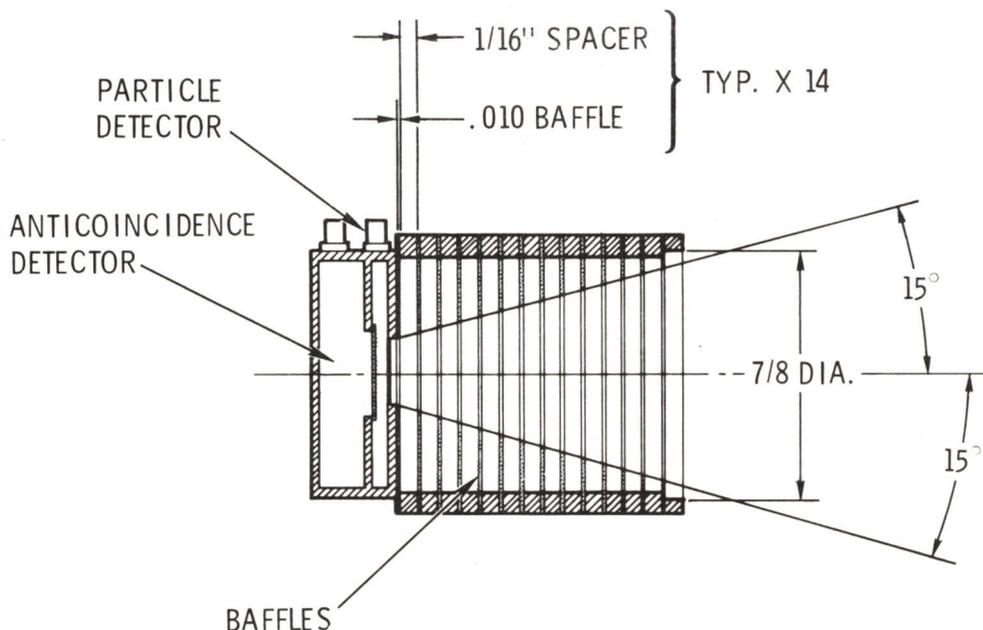


Figure 2.11-29. Subsatellite Sensor Arrangement and Viewing Angles

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Figure 2.11-30. Subsatellite Particle Telescope

of the two telescopes (A or B), with their respective strobe signals, are alternately selected by a spacecraft timing signal. The resulting pulses are fed into the analyzer, which separates the incident energies. The selection is performed by a logic signal from the spacecraft. These are subsequently accumulated in the spacecraft floating point accumulators. In the calibration mode, a spacecraft signal changes the reference voltage to the two analyzer channels such that a calibration source placed on or near the front detector of both telescopes will appear within the dynamic range of the analyzer. The calibration source does not emit particles within the operating energy range of interest. In the test mode, a spacecraft signal disables the inputs from the particle telescopes to the floating point accumulators and inserts appropriate pulse rates to verify the operation of each accumulator.

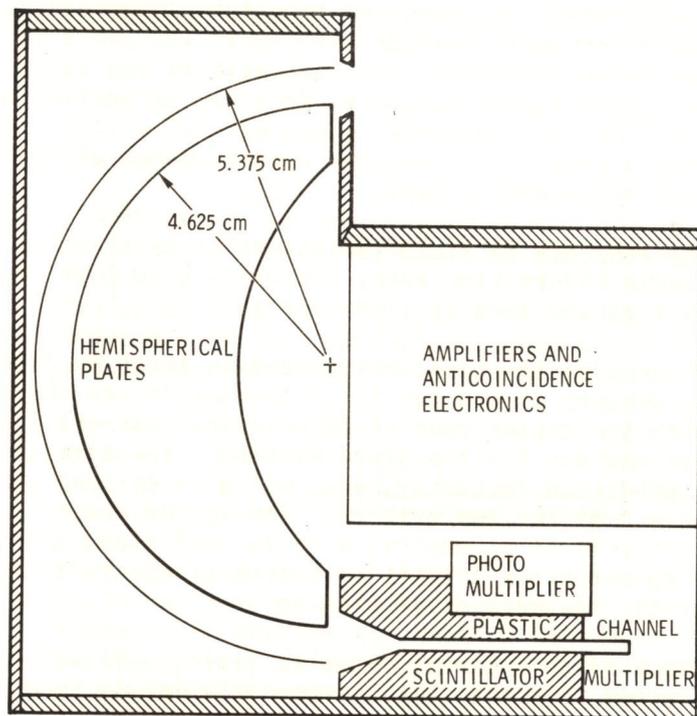
Spherical Analyzer System

Each analyzer consists of two concentric spherical sections with the inner plate of each biased to admit electrons having the appropriate energy of interest as per figure 2.11-31. Analyzers A1 and A2 are the two lowest energy channels. The electrons from analyzers A1 and A2 are detected by channeltrons and the resultant signal is processed by electronics in channels C1 and C2. Sensor C3 is similar and detects the higher count rates from analyzer A3. Sensor C4 uses three funnel mouth spiraltrons in parallel for greater counting sensitivity and

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Figure 2.11-31. Subsatellite Spherical Analyzer

shares with C3 the electrostatic analyzer A2. Since C3 and C4 are physically in the same assembly, they are electrostatically shielded from each other to prevent crosstalk. The electrons from analyzer A4 are detected by five parallel funnel spiraltrons. An anti-coincidence plastic scintillator is used for channels C4 and C5, the details of which will be explained in the following section. The outputs of channels C1 through C5 are gated to the floating point accumulators by a spacecraft signal. Appropriate counting rates to test the following point accumulators may be switched in to verify proper count compression in the floating point accumulators.

The calibration, test logic, and housekeeping subsystem generates the appropriate test frequency and conditions the logic interface from the spacecraft. Typical housekeeping functions include supply voltage monitors, temperature sensors, etc.

Magnetometer

The instrument is a bi-axial fluxgate magnetometer, similar to the UCLA ATS-1 magnetometer.

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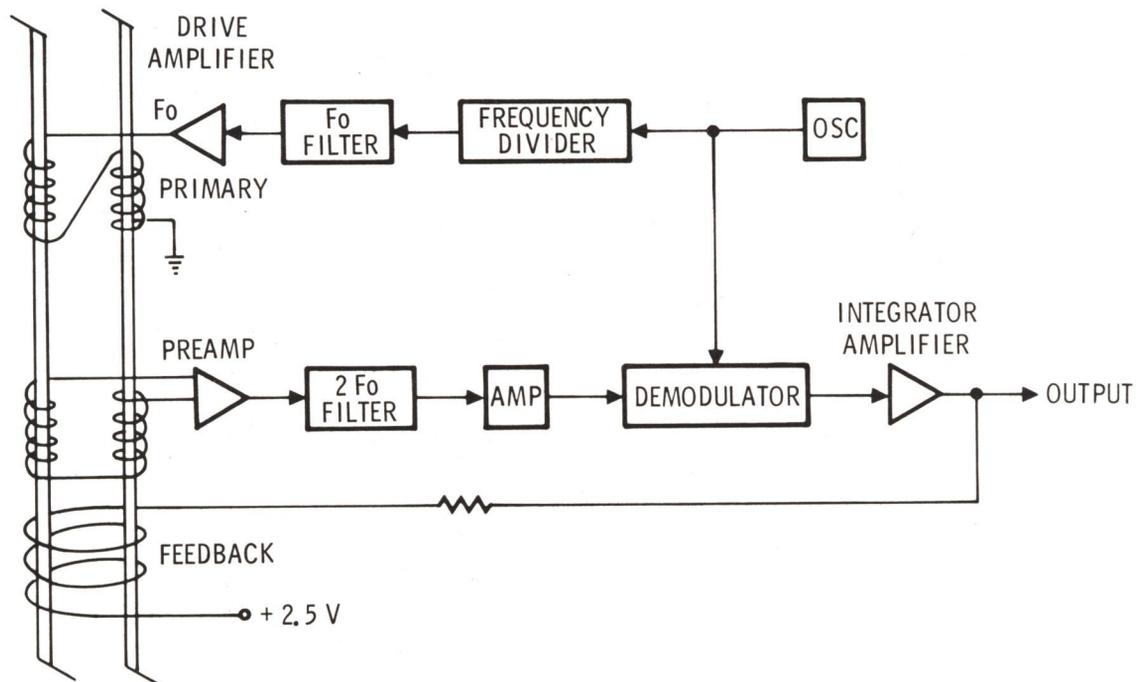
SYSTEMS DATA

Each field measurement includes the magnitude and polarity of each of two mutually orthogonal vector components (B_p and B_T), one parallel and the other perpendicular to the spin axis of the vehicle; and the angle of the perpendicular component from the projection of the sun-spacecraft line of the equatorial plane of the vehicle. The instrument sends back field data over a maximum dynamic range of $0+200$ gamma and additional housekeeping data.

The frequency response to field variations is selected on the basis of the available information rate, typically 0 to 0.05 Hz at the highest data rate and less at lower rates.

The block diagram of the basic instrument is shown in figure 2.11-32. The fluxgate sensors of the two field components are mounted at the end of a boom with two cables running back to the spacecraft per sensor, one for drive and one for the sense winding. The carrier generator generates a reference frequency, $4f_0$, which is divided down twice and supplied to each of the two drivers. The latter comprise a bandpass filter to purify f_0 of harmonics, a drive amplifier, and a matching transformer to match the transistor output circuitry to the low impedance of the fluxgate drive winding.

In the presence of an external magnetic field, a fluxgate sense winding picks up a second harmonic ($2f_0$) component which is coupled into the input of the second harmonic detector. A bandpass filter tuned to $2f_0$



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Figure 2.11-32. Subsatellite Basic Magnetometer

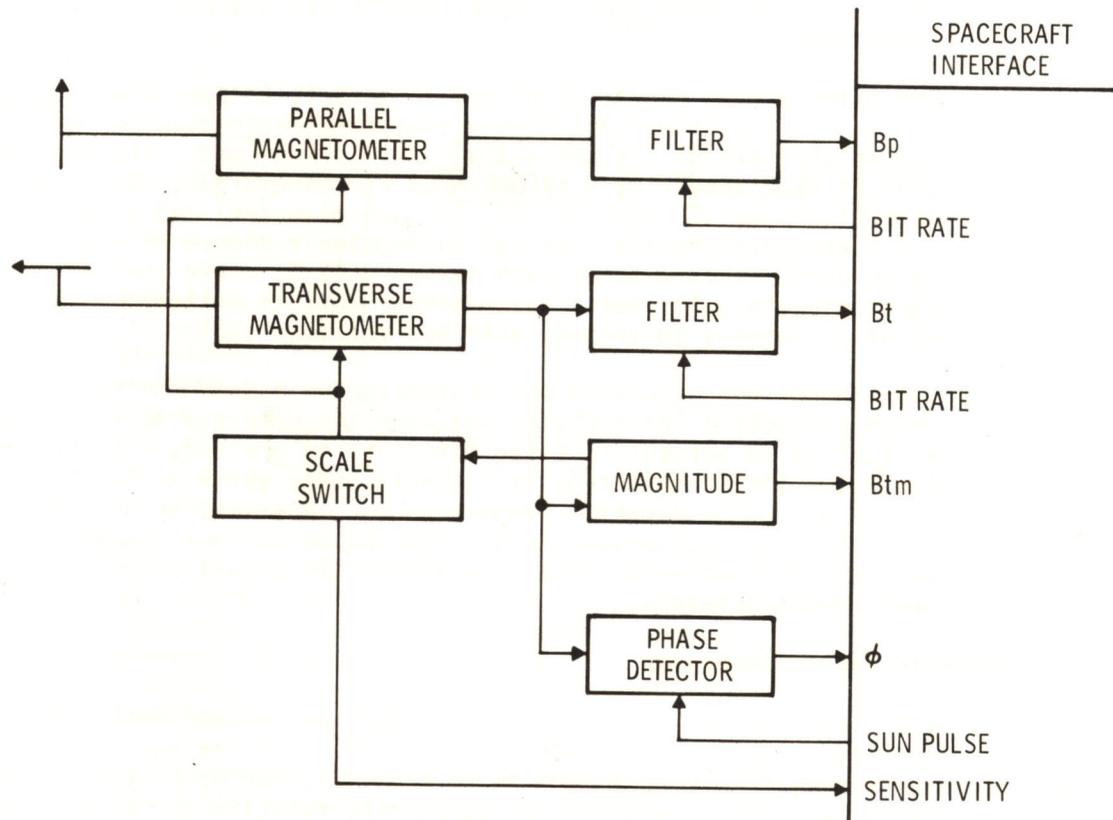
SIM EXPERIMENTS

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at this input selects the second harmonic from first harmonic interference because of unbalance in the fluxgate. The filter is a passive filter in order to avoid possible self-generation of second harmonics which might be caused by an active unit.

The second harmonic component is proportional to the ambient magnetic field at the sensor cores, and is amplified and filtered further before being applied to a full-wave synchronous detector (driven by a synchronous reference signal at $2f_0$ from the carrier generator). After further d-c amplification, the resulting signal is fed back to the fluxgate sense winding in such a way as to provide a stable servoing magnetometer whose sensor cores always operate in the center of their B-H loops except for the error signal.

The two second harmonic detectors supply filtered versions of B_p and B_T directly to the telemetry, the filtering time constants being controlled by a bitrate logic switch (figure 2.11-33). A calibrate control is also available on command, in order to check operations of the sensor feedback loops. The low range of the instrument is 0+50 gammas; however, if the absolute magnitude of either B_p or B_T exceeds the top of this range, a scale range logic circuit toggles both channels into the 0+200 gamma range. The sensitivity toggles back when the absolute magnitudes of both B_p and B_T drop below 40 gammas. A scale-out signal to the telemetry indicates which of the two ranges is being used.



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Figure 2.11-33. Subsatellite Magnetometer Block Diagram

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The analog output of the magnetometer is fed to the on-board ADC and converted to a 9-bit word (8-bit ADC, 1-bit range) according to a sampling schedule which varies depending upon the magnetic environment of the spacecraft and its anticipated rate of variation.

The magnetometer senses the absolute magnitude of B_T , which is called B_{TM} , and the azimuth of the first positive-going zero crossing of B_T with respect to the projection of the sun-spacecraft line on the equatorial plane of the vehicle, which is called ϕ . From these data, the vector component B_T can be determined. It should be noted that B_T is sinusoidally spin-modulated because of spacecraft rotation (typically 5 to 10 rpm).

With the fluxgate sensors mounted on the end of the boom and with careful experiment package preparation, calculations indicate that a very high quality magnetometer experiment can be carried out even in the interplanetary magnetic field.

Solar Aspect Sensor

To meet the requirement for subsatellite attitude determination, a solar aspect sensing system is installed on the subsatellite. The basic sensor develops an analog output signal in the form of a pulse whose width is proportional to the angle between the sun line and the spacecraft equatorial plane. The sensing system consists of two sensing units, one covering the upper hemisphere and one covering the lower hemisphere.

The principle of operation of the sensors is an aperture whose shape is such that a linear relationship between photodetector "on" time and solar latitude (on the spacecraft) is achieved. The photodetector used in each sensor is a HP5082-4203 PIN photodiode, which has a sensitive area of 0.002 cm² (0.020 inch diameter) and a sensitivity of 0.5 microamp/microwatt. It has an angular response of +45° from the optic axis. This enables each sensor unit to cover the full 90° from equatorial to polar axis. Each sensor unit is calibrated to 0.1° accuracy using a solar simulator and rotating tables.

Each sensor unit contains the photodetector and an amplifier switch which produces a level change whenever the detector is illuminated by a light of 30 percent of solar intensity or greater. The output, when the satellite is spinning, is a 5-volt pulse which is 0.05 to 0.25 of a spin period in duration, depending on the elevation of the sun above the satellite equatorial plane. This pulse is then supplied to the sun sensor electronics which processes this signal to yield the desired measurements.

Magnetic Sector Generator

The spacecraft's scientific instrumentation package requires a scan feature to determine directional properties of the particle fluxes. Therefore, the logical step is to supply sectoring pulses in synchronization with the spacecraft rotation rate relative to the magnetic field vector. The magnetic sector generator furnishes these pulses by generating a fixed number of pulses during every other revolution of the spacecraft. This system generates eight pulses every other revolution period over a rotational rate range from 7 to 14 rpm.

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The magnetic sector generator (MSG) operates from a constant frequency source and a synchronization pulse generated during the zero crossing of the magnetic field signal. The basic principle of operation can be described as a generation of K -pulses per spacecraft rotation period. When a digital number representing the rotation period is generated with a given frequency source (f_3) and compared to another digital number generated by a counter whose input frequency is $K \times f_3$, there will be a coincidence of the output during one rotation of the spacecraft.

The basic function of the magnetic sector generated is to generate eight pulses which divide equally the rotation period every other revolution. These pulses divide the rotation period into time intervals from which the sectoring pulses are obtained.

Data Processing and Storage Equipment

The data processing and storage equipment (DPSE) performs these primary functions:

- a. Supplies floating point accumulators to count the incoming particle experiment data.
- b. Performs analog-to-digital conversion for the analog inputs.
- c. Multiplexes scientific and engineering data into a single data stream for application to the memory or directly to the transmitter.
- d. Generates all timing signals for the spacecraft and scientific experiment from a crystal controlled clock.
- e. Supplies all logic and spacecraft control from the command inputs received from the command logic unit.
- f. Supplies to the transmitter a modulated subcarrier input, with or without convolutional encoding.

A block diagram of the DPSE is shown in figure 2.11-34. The DPSE interfaces directly with the storage unit and the remainder of the spacecraft electronics.

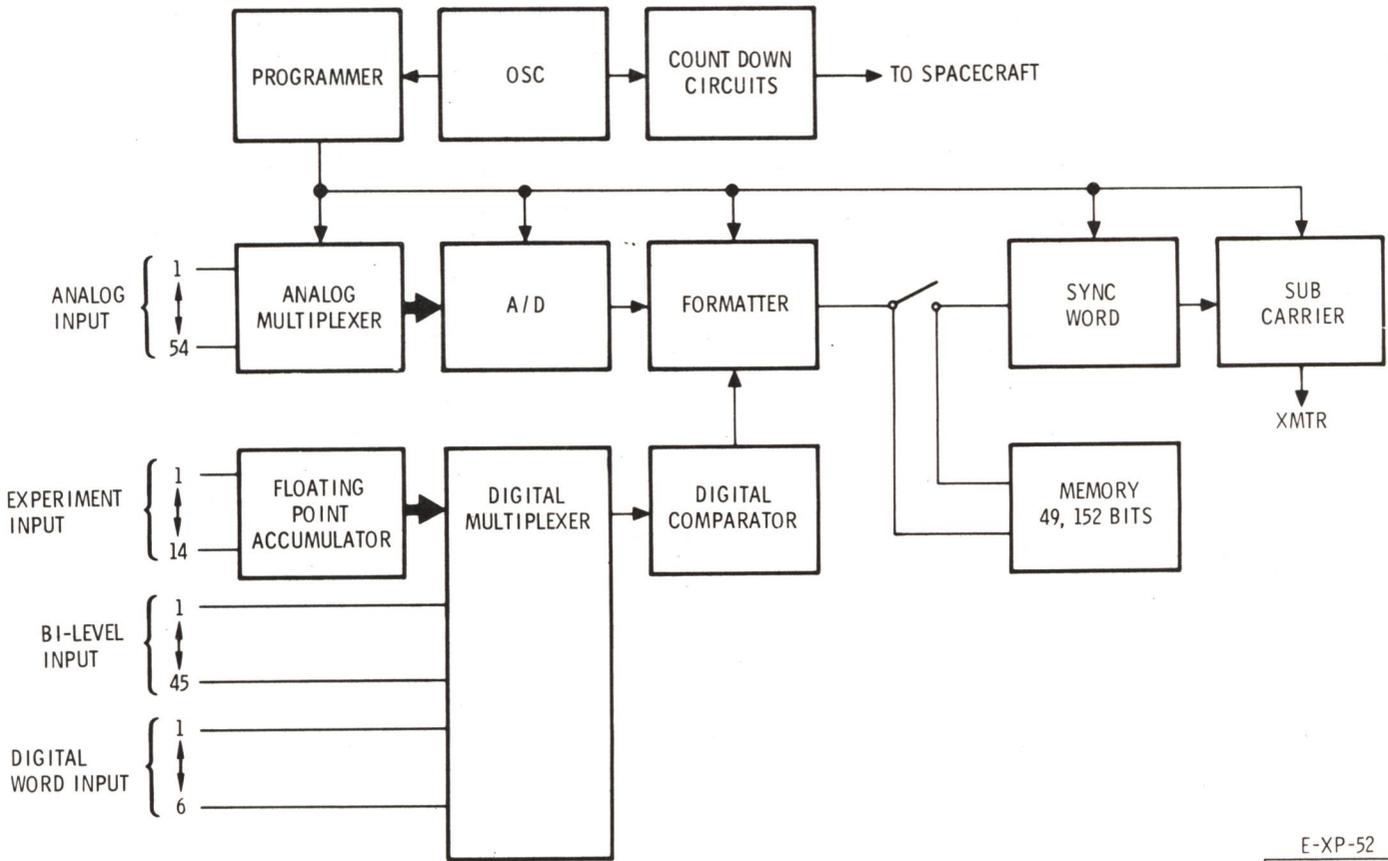
The floating point accumulators have a maximum count capacity of 2^{24} counts and count with a worst case error of 6 percent using an eight-bit output. The outputs of the accumulators are applied to the digital multiplexer which has a capacity of 99 bi-level and six digital word inputs.

An eight-bit ADC is used which accepts analog inputs from the magnetometer and the spacecraft status circuits. All analog inputs are applied to the ADC through the analog multiplexer which has a maximum capacity of 54 analog inputs. The designs for both the analog and digital multiplexers were developed and used on the TRW Pioneer Spacecraft. The programmer controls the digital and analog multiplexers and the ADC, producing a serial data stream at the formatter output which is applied to the memory or directly to the modulator for real time transmission.

Two eight-bit words are used for frame synchronization. The frame synchronization words are not stored in the memory, but are added upon memory readout or are added directly to the output data stream for real time transmission.

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Figure 2.11-34. Data Processing and Storage Equipment Block Diagram

The formatted data is then applied to the subcarrier oscillator which provides to the transmitter a NRZ-L frequency shifter square wave subcarrier.

A crystal control clock with a countdown chain generates the required bit rates and other subsystem frequencies. The clock input is also applied to an 18-bit accumulator for the purpose of measuring mission elapsed time. With this elapsed-time clock, the time resolution is 0.4 second per count with a total count capacity of 102,400 seconds or 1.2 days.

Command Decoder and Control Logic

The command decoder for the S-band version of the satellite is designed to operate with a signal structure derived from the Apollo command format.

Input Signal

The command message is transmitted in the form of a phase shift key (PSK) modulated sine wave which, along with a linearly added sinusoidal synchronization signal, frequency modulates a 70-kHz subcarrier. Each command message bit is encoded into 5 sub-bits, each having a duration

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of one-fifth of a message bit interval. Each sub-bit is represented by a phase shift key symbol, two cycles of a 2-kHz sine wave. The sub-bit rate is, then, 1000 bps which corresponds to a message bit rate of 200 bps.

The composite audio signal contains sub-bit modulation and synchronization waveforms. The sync subcarrier, f_c , at 1000 Hz is properly phased such that its negative to positive zero crossings occur simultaneously with the beginning of each sub-bit. The modulated data subcarrier occurs in each of two phases: The positive going zero crossing occurs at the beginning of a sub-bit when a sub-bit "1" is transmitted, and the negative going zero crossing occurs when a "0" is transmitted. The data and synchronization subcarriers are linearly added with an amplitude ratio equal to 1.0 ± 0.1 .

The decoder is divided into three functional processing blocks: the FM discriminator, sub-bit detector, and digital processor (figure 2.11-35).

The FM discriminator accepts a frequency modulated signal at 70 kHz from the uplink receiver and recovers the composite audio command signal. This signal is provided to the sub-bit detector as its input signal.

The sub-bit detector demodulates the PSK data by means of a correlation detector and provides sub-bit synchronization derived from a phase-lock loop which tracks the 1000-Hz synchronization subcarrier. In addition, the sub-bit detector provides a loop-lock status output which is used

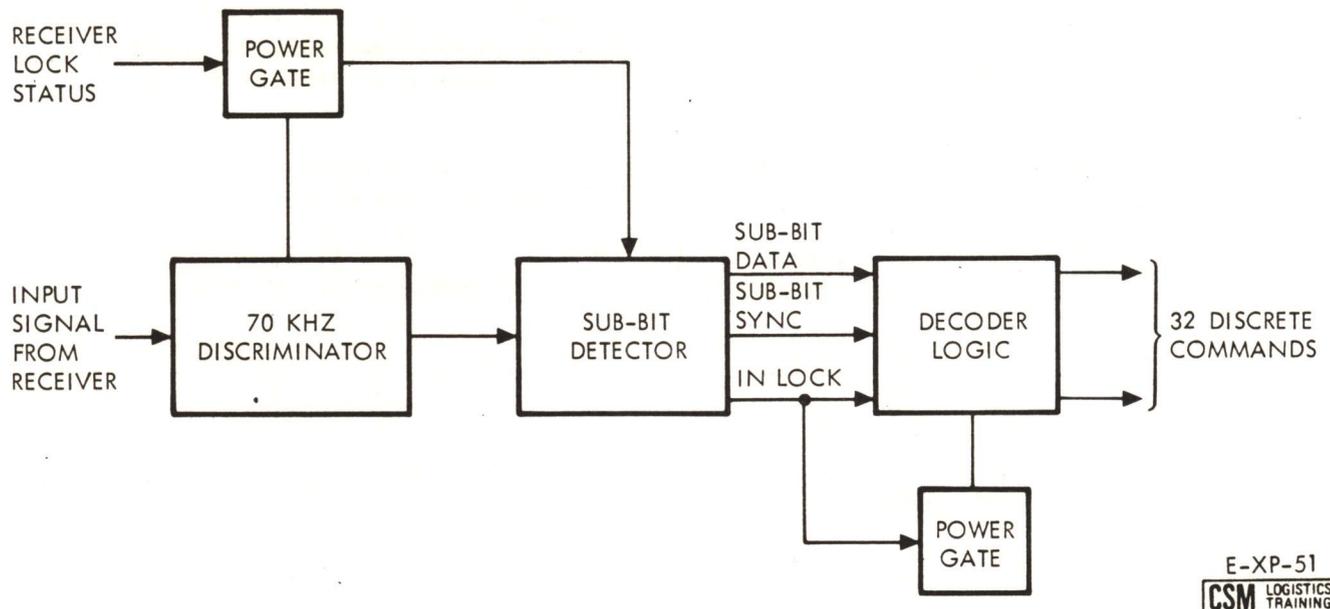


Figure 2.11-35. Subsatellite Command Decoder Block Diagram

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to gate the d-c power to the digital processor. Power turnon to the FM discriminator and the sub-bit detector is controlled by the receiver lock status function. This reduces the decoder standby power to less than 50 mW.

The digital processor verifies the command message and routes the command. Included in the operation of the digital processor is the decoding of the message bits from the sub-bit code.

S-Band Transponder

The complete S-Band transponder subsystem consists of a transmitter, receiver, converter, decoder, and diplexer.

The block diagram of the transponder is shown in figure 2.11-36. The uplink signal at 2101.8 MHz (221 f) passes from the antenna through the diplexer to the receiver. The receiver phase-locks to the carrier and demodulates the 70 kHz command subcarrier. The receiver output is fed to the command decoder where the subcarrier is demodulated. The resultant composite audio signal is decoded for command execution.

The transmitter is phase modulated by a 3.9 kHz (IRIG-9) subcarrier from the data handling subsystem. The subcarrier contains the PCM telemetry data. The transmitter can be operated in either of two modes, one from an internal crystal oscillator or with a drive signal from the receiver. Two-way coherent doppler can be obtained when the receiver is providing the transmitter drive signal. The transmitter down-link output at 2282.5 MHz (240 f) is fed to the antenna through the diplexer.

The dc-dc converter supplies regulated voltages to power the receiver, transmitter, and decoder. The +15-volt input to the transmitter is switched off when the transmitter is not in use. The transponder is capable of operating in four modes, which will be selected by command. The logic to select and implement these modes is external to the transponder.

- Coherent Mode - The receiver is locked to an uplink signal and the transmitter radiates a coherent downlink signal.
- Noncoherent Mode - The receiver is not locked to an uplink signal and the transmitter radiates a noncoherent downlink signal.
- Ready Mode - The receiver is on but not locked to an uplink signal and the transmitter is off. When the receiver locks to an uplink signal, the transmitter is turned on and radiates a coherent downlink signal.
- Receive Only Mode - The receiver is on, but the transmitter remains off whether an uplink signal is present or not.

The following telemetry signals are provided:

Receiver loop stress (control voltage to the VCO)
Receiver signal present (locked or unlocked status)
Transmitter temperature
Converter output voltages.

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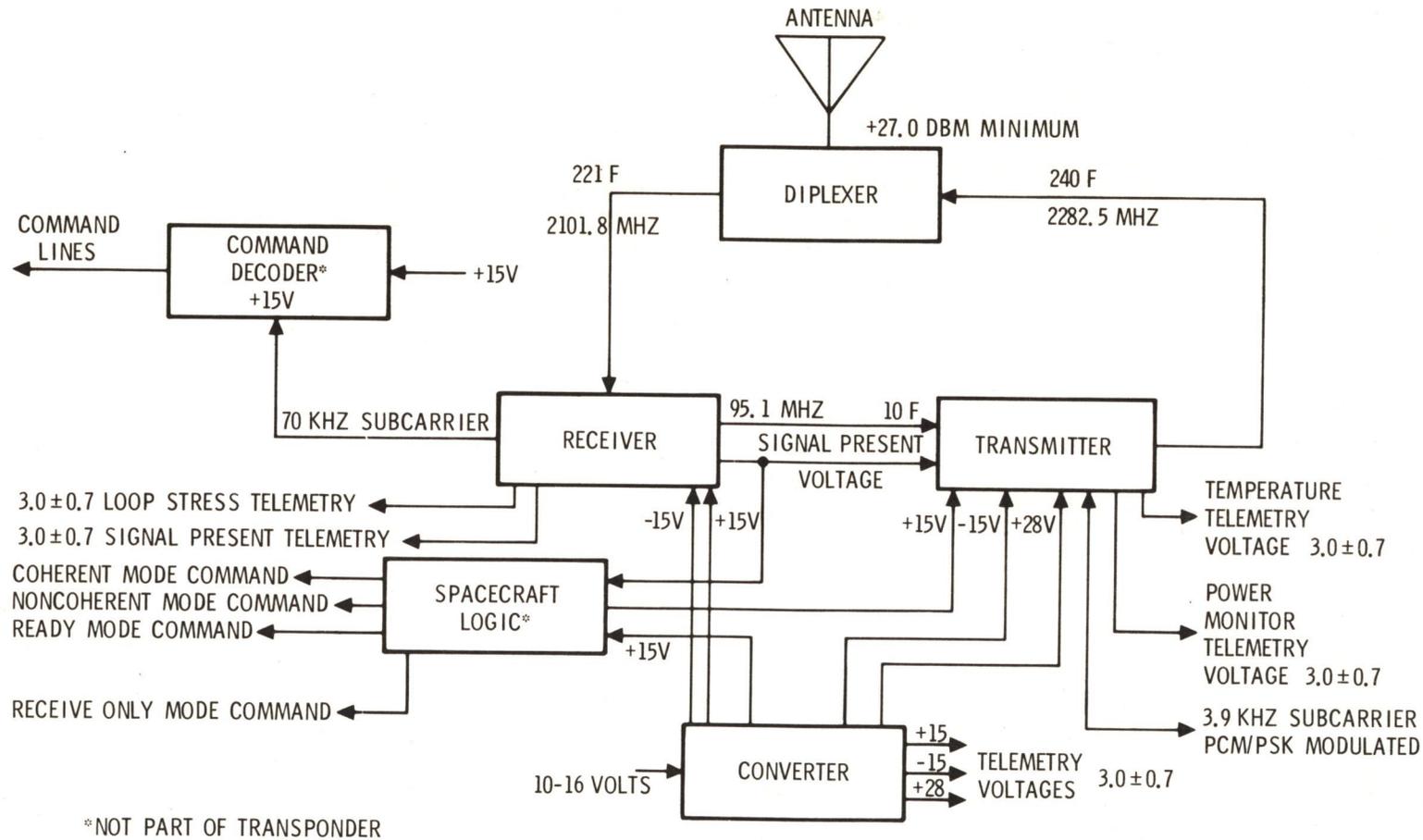


Figure 2.11.36. Subsatellite S-Band Transponder

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During the coherent and the noncoherent or real time data mode, the transponder status measurements are monitored and inserted into the data format as substitutions for normal data storage words without changing the actual format. The data subcarrier is transmitted whenever the transmitter is on. Thus there is no need to store the transponder monitor functions. The location of these measurements are defined in the detailed phase of the program.

Electrical Power

The electric power subsystem is designed to provide the capability of continuous operation of the satellite in the 60-nautical-mile lunar orbit with maximum eclipse times. The power subsystem is a primary/secondary system with an array of solar cells as the primary source of power and a rechargeable silver-cadmium battery as the secondary source which sustains operation during the eclipse portion of the orbit. The electric power subsystem includes the solar cell array, the battery, a battery charge control circuit, a low-voltage power converter-regulator, a power switching and distribution unit, and a high-voltage supply unit. A block diagram of the subsystem is contained in figure 2.11-28.

The size of the solar array is the basic limitation on the electrical power system capability. The spacecraft size is limited by the available envelope within the SIM. If power in excess of the capability of the solar array were required, then it would be necessary to periodically curtail operations so that the battery could be recharged. For this reason, particular attention has been devoted to minimizing sub-unit power requirements.

2.11.3 ADDITIONAL SIM EXPERIMENTAL COMPLEMENTS

In addition to the experiments described in the Apollo 16 SIM complement, several other experiments are scheduled for subsequent missions. The exact makeup of each of the experimental complements is, to date, quite fluid so only a brief description of additional experiments is made.

The far U-V spectrometer monitors the composition of the lunar atmosphere and supplements the information gathered on previous missions by the mass spectrometer.

A map of the lunar surface temperature on the dark side of the moon is assembled from the l-R scanning radiometer data and correlated with the photographic data.

2.11.3.1 Far Ultra-Violet Spectrometer (S169)

2.11.3.1.1 General Specifications

Experimental Objectives:

Determination of lunar atmosphere composition and density with a far ultra-violet Ebert spectrophotometer (FUV) aboard a lunar orbiting manned Apollo spacecraft.

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Instrument:

1/2-meter focal length Ebert spectrometer with 6 cm long slits, 1/2 cm wide, a 100 cm grating with 3600 grooves/mm, used in second order and collecting optics to direct dispersed radiation to a solar-blind low, dark current photomultiplier tube employing pulse counting circuitry.

Envelope/Weight:

Instrument (integral unit): 30 pounds (8.5 x 12 x 47 inches maximum)

Power Requirements: 28 VDC

Standby: 0 watts
Average: 10 watts
Peak: 0 watts

Temperature:

Nonoperating range: -58° to +122°F
Operating range: -58° to +86°F

Field of View:

Centerline of spectrometer field-of-view is 60° from +X-axis and 23° from SIM centerline toward the -Z-axis

Pointing:

Accuracy: +5°
Knowledge: +3°

Data System Interface:

Scientific Data: 1 digital (8-bit parallel) channel at 10 samples per second. Recorded and dumped.

Time Correlation:

1 pps (10 pps preferred)

Operating Time Requirements: (Minimum of three lunar orbit modes)

Mode 1: 5 orbits with +X-axis in direction of velocity vector

Mode 2: 5 orbits with -X-axis in direction of velocity vector

Mode 3: Centerline of spectrometer 110° to sun-moon line and CSM is in inertial hold. Full orbital coverage. Two hours of data TEC for calibration.

Constraints:

No obstructions are to be allowed within the FOV during operation. Contamination is to be avoided and data collection should be scheduled for as long after waste water or urine dump and fuel cell purge as possible.

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2.11.3.1.2 Duty Cycle Requirements

Minimum operation consists of three lunar revolution modes, mode 1 and 2 require five revolutions each and mode 3 requires one revolution.

Full orbital coverage is desired. Data collection for mode 1 is when the +X axis is in the direction of the velocity vector, mode 2 is when the -X axis is in the direction of the velocity vector, and mode 3 is when the centerline of the FUV spectrometer is 110° to the sun-moon line (centerline of FUV spectrometer FOV is 60° from the CSM +X-axis and 23° from the SIM centerline toward the -Z-axis) and the CSM is in inertial hold.

The FUV spectrometer operation during TEC is required for calibration purposes. Approximately 2 hours of data taken during PTC is adequate.

FOV and FUV spectrometer is 60° in CSM X-axis and 90° across the CSM X-axis, and 23° from the SIM centerline toward the -Z-axis.

No obstructions are allowed in FOV during data collection.

FUV data collection should be scheduled as long after a water dump, a urine dump, or a fuel cell purge as possible.

2.11.3.2 Infra-Red Scanning Radiometer (S171)

2.11.3.2.1 General Specifications

Experimental Objectives:

Obtain a surface temperature map of unilluminated portions of lunar surface at higher resolution than heretofore possible. Locate, identify, and study anomalously hot or cold regions. Correlate results with other data from lunar orbiting spacecraft, and study possibility of obtaining emission spectra from lunar surface in follow-on experiments. Desirable lunar surface photographic data correlation with radiometer FOV.

Instrument:

Thermister bolometer immersed in silicon and cross-track scanner, electronics package signal conditioner and beryllium heat sink. Scanner mirror rotates through an angle of 150° (FOV) at 48 rpm.

Power Requirements: 28 VDC

Standby: 2 watts
Average: 8 watts
Peak: 12 watts

Temperature:

Nonoperating range: 0° to 122°F
Operating range: 41° to 113°F

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Field of View:

150° (unit requires 7.5° of deep space scanning).

Pointing:

Accuracy: $\pm 5^\circ$
Knowledge: $\pm 2^\circ$

Data System Interface:

Scientific Data: 2 analog channels VCO (2 kc frequency requirement),
2 analog channels at 1 sample per second. DSE recorded and dumped.

Operating Time Requirements:

Minimum of two data collection periods of three dark side passes each (terminator to terminator) separated by minimum of 24 hours. Data collection should extend approximately 10 percent beyond terminator for calibration.

Constraints:

Deployed instruments and antennas must be retracted from IR FOV during data collection periods. Contamination to be avoided. Sensor will be damaged if temperature exceeds 122°F.

2.11.3.2.2 Duty Cycle Requirements

Minimum operation consists of two data collection periods of three dark side passes each from terminator to terminator.

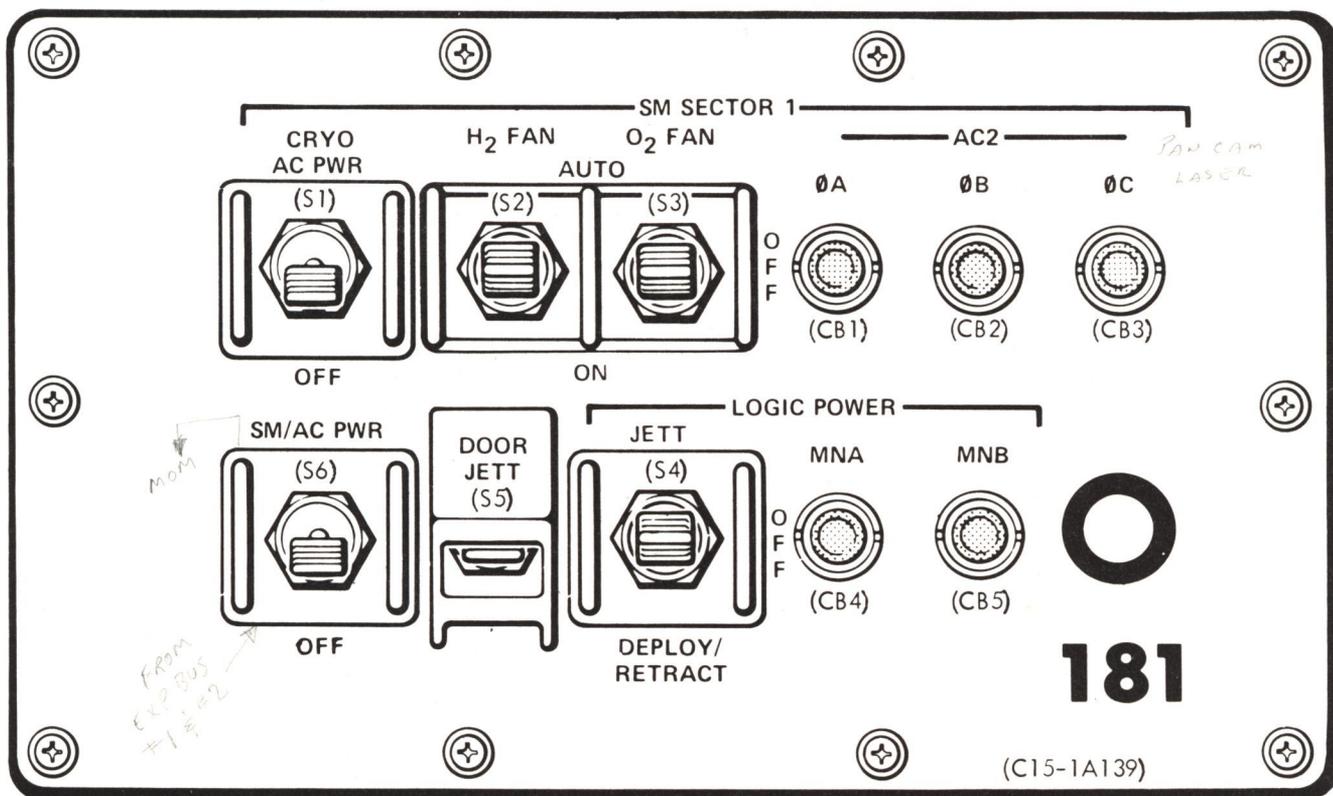
Only dark side data is required. The two data collection periods should be separated by a minimum of 24 hours.

Each pass should extend approximately 10 percent onto the lighted side for calibration purposes.

The infra-red scanning radiometer is in standby from just before SIM door jettison and never turned off until completion of data collection. All attitudes which would allow the sun to enter the infra-red scanning radiometer FOV should be avoided (FOV = 21 milliradians with 150° scan with scan centerline misaligned 8° from SIM centerline). Infra-red scanning radiometer data collection should also be scheduled as long after a water or urine dump as possible.

Deployed instruments and antennas, such as EM sounder and sounding radar, must be retracted from infra-red scanning radiometer FOV during data collection periods.

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for training purposes only

SM2A-03-BLOCK II-(1)
 APOLLO OPERATIONS HANDBOOK
 CONTROLS AND DISPLAYS

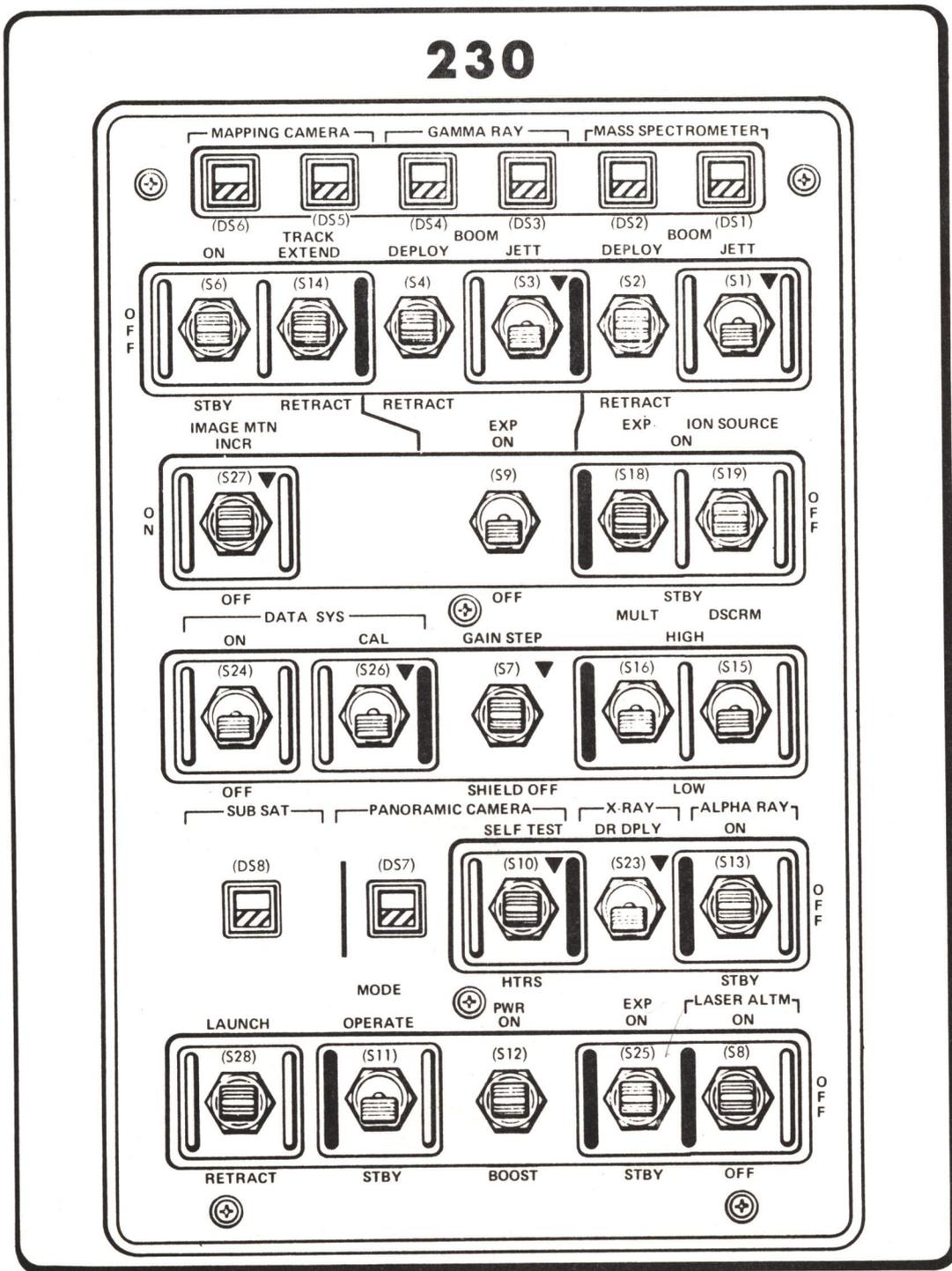
Panel	Reference Designator	Sys.	Nomenclature and Position	Function	Circuit Breaker	Power Source	Remarks
181	CB1	SIME	SM SECTOR 1 AC 2 ØA	Protects circuit providing ØA, AC bus 2 power to panoramic camera and Laser altimeter.	N/A	AC bus 2 ØA	
181	CB2	SIME	SM SECTOR 1 AC 2 ØB	Protects circuit providing ØB, AC bus 2 power to panoramic camera and Laser altimeter.	N/A	AC bus 2 ØB	
181	CB3	SIME	SM SECTOR 1 AC 2 ØC	Protects circuit providing ØC, AC bus 2 power to panoramic camera and Laser altimeter.	N/A	AC bus 2 ØC	
181	CB4	SIME	SM SECTOR 1 LOGIC POWER MNA	Provides circuit protection between main bus A and one contact of SM SECTOR 1 - LOGIC POWER - JETT-DEPLOY/RETRACT switch (Panel 181).	N/A	DC main bus A	
181	CB5	SIME	SM SECTOR 1 LOGIC POWER MNB	Provides circuit protection between main bus B and one contact of SM SECTOR 1 - LOGIC POWER - JETT-DEPLOY/RETRACT switch (Panel 181).	N/A	DC main bus B	

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Panel	Reference Designator	Sys	Nomenclature and Position	Function	Circuit Breaker	Power Source	Remarks
181	S1	SIME	SM SECTOR 1 CRYO AC PWR OFF	Connects three-phase a-c power to SM SECTOR 1 - H ₂ FAN and O ₂ FAN switches (Panel 181). Disconnects power from SM SECTOR 1 - H ₂ FAN switches (Panel 181).	CRYOGENIC FAN MOTORS TANK 2 AC2 ØA, ØB, ØC (Panel 226)	AC bus 2	
181	S2	SIME	SM SECTOR 1 H ₂ FAN AUTO OFF ON	Allows automatic operation of H ₂ tank 3 fan motors through pressure switch control. (On at 225 psia - off at 260 psia.) Disconnects power from H ₂ tank 3 fan motors. Directly turns on fan motors in H ₂ tank 3.	CRYOGENIC FAN MOTORS TANK 2 AC2 ØA, ØB, ØC	AC bus 2	
181	S3	SIME	SM SECTOR 1 O ₂ FAN AUTO OFF ON	Allows automatic operation of O ₂ tank 3 fan motors through pressure switch control. (On at 865 psia - off at 935 psia.) Disconnects power from O ₂ tank 3 fan motors. Directly turns on fan motors in O ₂ tank 3.	CRYOGENIC FAN MOTORS TANK 2 AC2 ØA, ØB, ØC (Panel 226)	AC bus 2	

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Panel	Reference Designator	Sys	Nomenclature and Position	Function	Circuit Breaker	Power Source	Remarks
181	S6	SIME	SM SECTOR 1 SM/AC PWR OFF	Arms mass spectrometer, subsatellite, and gamma ray boom release circuits. Enables 3-phase a-c power from a-c bus 2 to enable panoramic camera and Laser altimeter. Enables d-c power from SM main bus B to panoramic camera, mapping camera, and Laser altimeter. Removes power.	N/A N/A	Experiment bus 1 Experiment bus 2	Experiment bus 1 receives power from NONESS bus and is protected by INSTRUMENTS - SCI EQUIP-SEB 1 circuit breaker (Panel 5). Experiment bus 2 receives power from NONESS bus and is protected by INSTRUMENTS - SCI EQUIP-SEB 1 circuit breaker (Panel 5).



for training purposes only

Panel	Reference Designator	Sys	Nomenclature and Position	Function	Circuit Breaker	Power Source	Remarks
230	DS1	SIME	MASS SPECTROMETER (BARBER POLE) (GRAY)	Indicates mass spectrometer boom jettison was initiated. Indicates normal, non-activated boom jettison circuit. After barber pole, indicates completion of jettison sequence.	LOGIC POWER MNA & MNB (Panel 181)	DC main buses A and B	LOGIC POWER JETT-DEPLOY/RETRACT switch (Panel 181) must be in JETT position to enable circuit.
230	DS2	SIME	MASS SPECTROMETER (BARBER POLE) (GRAY)	Indicates mass spectrometer boom is in its extension or retraction cycle. Indicates mass spectrometer boom fully extended or retracted.	LOGIC POWER MNA & MNB	DC main buses A and B	LOGIC POWER JETT-DEPLOY/RETRACT switch (Panel 181) must be in DEPLOY/RETRACT position to enable circuit.
230	DS3	SIME	GAMMA RAY (BARBER POLE) (GRAY)	Indicates gamma ray spectrometer boom jettison function has been initiated. Indicates gamma ray spectrometer boom jettison circuit not activated or after barber pole the completion of the jettison.	LOGIC POWER MNA & MNB (Panel 181)	DC main buses A and B	LOGIC POWER JETT-DEPLOY/RETRACT switch (Panel 181) must be in JETT position to enable circuit.
230	DS4	SIME	GAMMA RAY (BARBER POLE) (GRAY)	Indicates gamma ray spectrometer boom is in its extension or retraction cycle. Indicates gamma ray spectrometer boom fully extended or retracted.	LOGIC POWER MNA & MNB (Panel 181)	DC main buses A and B	LOGIC POWER JETT-DEPLOY/RETRACT switch (Panel 181) must be in DEPLOY/RETRACT position to enable circuit.

SM2A-03-BLOCK II-(1)
 APOLLO OPERATIONS HANDBOOK
 CONTROLS AND DISPLAYS

Panel	Reference Designator	Sys	Nomenclature and Position	Function	Circuit Breaker	Power Source	Remarks
230	DS5	SIME	MAPPING CAMERA (BARBER POLE) (GRAY)	Indicates mapping camera is being extended or retracted. Indicates mapping camera is fully deployed or retracted.	N/A	Logic bus B	LOGIC POWER - JETT-DEPLOY/RETRACT sw Panel (181) must be in the DEPLOY/RETRACT position to enable the circuit. Logic bus receives power from main bus B through LOGIC POWER MNB circuit breaker on Panel 181.
230	DS6	SIME	MAPPING CAMERA (BARBER POLE) (GRAY)	Indicates: a. Mapping camera out of temperature limits when camera is in STBY mode. When camera is ON, it could indicate out-of-temperature limits or a mechanical failure in camera. b. The image motion compensating device is in the normal starting position when IMAGE MTN switch (S27) is released from the INCR position. c. The film cutting process not completed. Indicates: a. Camera off. b. Camera go. c. Film cutting complete.	N/A	a. Experiment bus 1 and JETT bus A b. Same as a. c. JETT bus A	Experiment bus 1 receives power from INSTRUMENTS - SCI EQUIP-SEB 1 circuit breaker on Panel 5 and the LOGIC POWER - JETT-DEPLOY/RETRACT switch (Panel 181) in JETT position.
230	DS7	SIME	PANORAMIC CAMERA (BARBER POLE) (GRAY)	Indicates: a. Camera out-of-temperature limits. b. Mechanical failure in camera. Indicates: a. Camera off. b. Camera normal.	N/A	Experiment bus 1	Experiment bus receives power from INSTRUMENTS - SCI EQUIP-SEB 1 circuit breaker on Panel 5.

Panel	Reference Designator	Sys	Nomenclature and Position	Function	Circuit Breaker	Power Source	Remarks
230	DS8	SIME	SUB SAT (BARBER POLE) (GRAY)	Indicates: a. SUB SAT DEPLOY-launch cycle incomplete. b. SUB SAT retract cycle incomplete. Indicates: a. SUB SAT stowed or retracted. b. SUB SAT launch cycle completed.	N/A	TBD	
230	S1	SIME	MASS SPECTROMETER BOOM JETT (OFF)	Jettisons the mass spectrometer and mass spectrometer boom assembly. Opens jettison circuit.	N/A	JETT bus A	JETT bus A receives power from main bus A through the LOGIC POWER - JETT-DEPLOY/RETRACT switch (Panel 181) when in JETT position.
230	S2	SIME	MASS SPECTROMETER BOOM DEPLOY (CENTER) RETRACT	Powers deploy side of mass spectrometer boom motor. Removes power from mass spectrometer boom motor. Powers retract side of mass spectrometer boom motor.	N/A	Logic bus B	Logic bus B receives power from main bus B through LOGIC POWER MNB circuit breaker and DEPLOY/RETRACT position of LOGIC POWER switch on Panel 181.
230	S3	SIME	GAMMA RAY BOOM JETT (OFF)	Jettisons gamma ray spectrometer and gamma ray spectrometer boom assembly. Opens jettison circuit.	N/A	JETT bus B	JETT bus B receives power from main bus B through LOGIC POWER - JETT-DEPLOY/RETRACT switch in JETT position.

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Panel	Reference Designator	Sys	Nomenclature and Position	Function	Circuit Breaker	Power Source	Remarks
230	S4	SIME	GAMMA RAY BOOM DEPLOY (CENTER) RETRACT	<p>Powers deploy side of gamma ray boom motor.</p> <p>Removes power from gamma ray boom motor.</p> <p>Powers retract side of gamma ray boom motor.</p>	N/A	Logic bus A	Logic bus A receives power from main bus A through LOGIC POWER MNB circuit breaker and DEPLOY/RETRACT position of LOGIC POWER switch on Panel 181.
230	S6	SIME	MAPPING CAMERA ON OFF STBY	<p>Setting switch to ON position makes the following mapping camera functions operative.</p> <ol style="list-style-type: none"> a. Thermal control heaters b. All telemetry c. All camera functions associated with producing photographic record d. Arms IMAGE MTN switch. <p>Setting switch to OFF position inhibits all mapping camera functions with the exception of the TRACK function. Additionally, if switch was previously set in ON position, those functions associated with ON position will continue to occur for a maximum of one mapping camera photographic cycle.</p> <p>Setting switch in STBY position makes the following mapping camera functions operative.</p> <ol style="list-style-type: none"> a. Thermal control heaters b. Supply cassette back-tensioning c. Temperature monitoring telemetry d. Provides one of two required arming signals for FILM CUT function. 	N/A	Experiment bus 1	Experiment bus 1 receives power from INSTRUMENTS - SCI EQUIP-SEB 1 circuit breaker on Panel 5.

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Panel	Reference Designator	Sys	Nomenclature and Position	Function	Circuit Breaker	Power Source	Remarks
230	S7	SIME	GAMMA RAY GAIN STEP (SHIELD ON) SHIELD OFF	Increments high voltage stepping switch, thus increasing instruments sensitivity (momentary). Normal operational position which enables antenna coincidence circuit and all telemetered counters. Disables anticoincidence circuit which disables input to shield event counter.	N/A	Gamma ray spectrometer	Internal command reference voltage fed to switch.
230	S8	SIME	LASER ALTM ON OFF OFF	Applies power to laser altimeter and its heater circuits. Removes power from laser altimeter. Same as above.	N/A	Experiment bus 1	Experiment bus 1 receives power from INSTRUMENTS - SCI EQUIP-SEB 1 circuit breaker on Panel 5.
230	S9	SIME	GAMMA RAY EXP ON OFF	Applies basic power to gamma ray spectrometer. Removes power to gamma ray spectrometer.	N/A	Experiment bus 1	Experiment bus 1 receives power from INSTRUMENTS - SCI EQUIP-SEB 1 circuit breaker on Panel 5.
230	S10	SIME	PANORAMIC CAMERA SELF TEST OFF HTRS	Advances film in camera 5 frames to preclude film setting (momentary). Normal - open circuit position. Applies power to heaters in camera (150w).	N/A	Experiment bus 1	PANORAMIC CAMERA - OPERATE-STBY must be in STBY position and POWER-OFF in POWER position (Panel 230) for switch to receive power.

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Panel	Reference Designator	Sys	Nomenclature and Position	Function	Circuit Breaker	Power Source	Remarks
230	S11	SIME	PANORAMIC CAMERA MODE OPERATE STBY	Enables panoramic camera circuits for operation and applies power to heaters. Applies power to PANORAMIC CAMERA - SELF TEST switch on Panel 230.	N/A	Experiment bus 1 through PANORAMIC CAMERA - POWER switch on Panel 230	Experiment bus 1 receives power from INSTRUMENTS - SCI EQUIP-SEB 1 circuit breaker on Panel 5.
230	S12	SIME	PANORAMIC CAMERA PWR ON OFF BOOST	Applies power to operate PANORAMIC CAMERA - OPERATE-STBY switch on Panel 230. Removes power from switch. Applies power to spool torque motors (25w).	N/A	Experiment bus 1	Experiment bus 1 receives power from INSTRUMENTS - SCI EQUIP-SEB 1 circuit breaker on Panel 5. Protects camera mechanism and film during ΔVs.
230	S13	SIME	ALPHA RAY ON OFF STBY	Applies power to alpha ray spectrometer and alpha spectrometer heaters. Removes power. Applies power to alpha ray spectrometer heaters.	N/A	Experiment bus 1	Experiment bus 1 receives power from INSTRUMENTS - SCI EQUIP-SEB 1 circuit breaker on Panel 5.
230	S14	SIME	MAPPING CAMERA TRACK EXTEND OFF RETRACT	Causes mapping camera and laser altimeter to extend out of SIM. Removes power. Causes mapping camera and laser altimeter to retract into SIM.	N/A	Logic bus B	Logic bus B receives power from main bus B through LOGIC POWER MNB circuit breaker and LOGIC POWER - JETT-DEPLOY/RETRACT switch on Panel 181. Full extension is approximately 18 inches and requires a maximum of 4 minutes to occur. The switch may be left in extend or retract position.

Mission _____

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Panel	Reference Designator	Sys	Nomenclature and Position	Function	Circuit Breaker	Power Source	Remarks
230	S15	SIME	MASS SPECTROMETER DSCRM HIGH LOW	Allows mass spectrometer to operate in high discrimination range. Switches mass spectrometer to lower discrimination range.	N/A	Experiment bus 1 through MASS SPECTROMETER EXP switch (Panel 230)	Experiment bus 1 receives power from INSTRUMENTS - SCI EQUIP-SEB 1 circuit breaker on Panel 5.
230	S16	SIME	MASS SPECTROMETER MULT HIGH LOW	Selects higher operational range for mass spectrometer. Allows mass spectrometer to operate in lower operational range.	N/A	Experiment bus 1 through MASS SPECTROMETER EXP switch (Panel 230)	Experiment bus 1 receives power from INSTRUMENTS - SCI EQUIP-SEB 1 circuit breaker on Panel 5.
230	S18	SIME	MASS SPECTROMETER EXP ON (OFF) STBY	Supplies power to mass spectrometer and its following switches on Panel 230. a. MASS SPECTROMETER - DSCRM - HIGH-LOW b. MASS SPECTROMETER - MULT - HIGH-LOW c. MASS SPECTROMETER - ION SOURCE - ON-OFF-STBY Removes power. Supplies power to mass spectrometer heaters.	N/A	Experiment bus 1	Experiment bus 1 receives power from the nonessential bus.

Panel	Reference Designator	Sys	Nomenclature and Position	Function	Circuit Breaker	Power Source	Remarks
230	S19	SIME	MASS SPECTROMETER ION SOURCE ON (OFF) STBY	Supplies power to filaments within mass spectrometer and mass spectrometer. Removes power. Supplies power to heaters within mass spectrometer.	N/A	Experiment bus 1 through MASS SPECTROMETER EXP switch on Panel 230	Experiment bus 1 receives power from INSTRUMENTS - SCI EQUIP-SEB 1 circuit breaker on Panel 5. Power not routed through power switch for heaters in STBY position.
230	S23	SIME	X-RAY DR DPLY (DOWN)	Applies power to solar monitor door release actuator. Inhibits door deploy circuit.	N/A	JETT bus B	JETT bus B receives power from main bus B when LOGIC POWER - JETT-DEPLOY/RETRACT switch and LOGIC POWER MNB circuit breaker on Panel 181 is in the JETT position.
230	S24	SIME	DATA SYS ON OFF	Applies primary power to SIM data system electronics. Removes power from SIM data system electronics.	TELECOMMUNICATIONS PMP POWER PRIM FLT BUS (Panel 225)	Primary flight bus	Up Data Link system can remove power from SIM data system or return system to switch position status.
230	S25	SIME	X-RAY EXP ON OFF STBY	Applies power to X-ray spectrometer and X-ray spectrometer heater circuits. Removes power from X-ray spectrometer and heater circuits. Applies power to X-ray spectrometer heater circuits.	N/A	Experimental bus 1	Experimental bus 1 receives power from INSTRUMENTS - SCI EQUIP-SEB 1 circuit breaker on Panel 5.

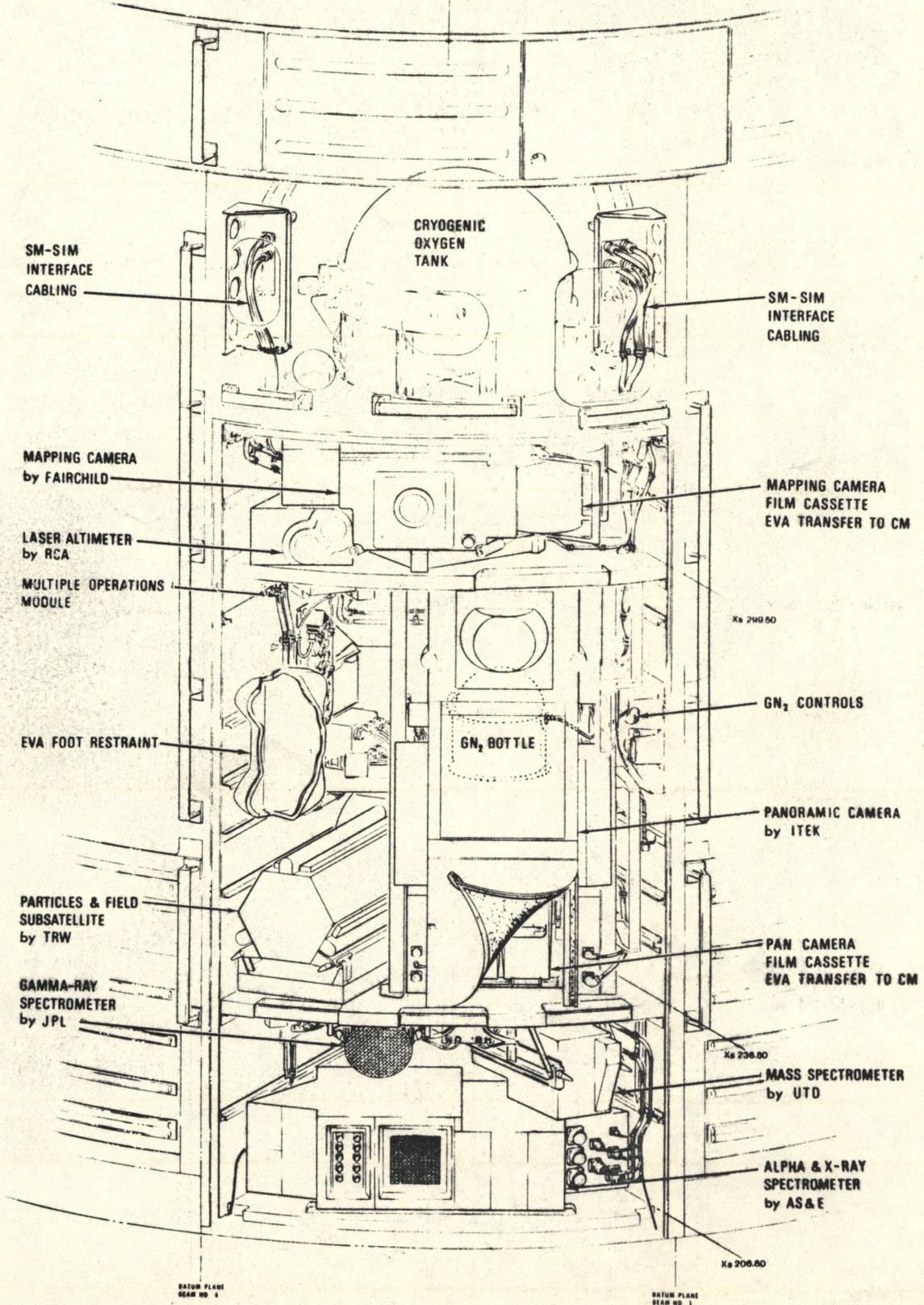
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Panel	Reference Designator	Sys	Nomenclature and Position	Function	Circuit Breaker	Power Source	Remarks
230	S26	SIME	DATA SYS CAL (DOWN)	Enables data system calibrate function which steps subcarrier oscillators through three calibrated conditons. Inhibits calibrate function.	N/A	Primary flight bus through DATA SYS-CAL-EQUIP switch in EQUIP position on Panel 230	Up Data Link system can remove power from SIM data system or return system to status indicated by (S24) EQUIP - ON-OFF switch.
230	S27	SIME	MAPPING CAMERA IMAGE MTN INCR ON OFF	Each time the IMAGE MTN switch is set to its momentary INCR position, and released (causing switch to return to ON position), a pulse is produced. This pulse causes mapping camera internally generated V/H signal to increase in value by approximately <u>TBD</u> percent. A total of five such steps is provided. When pulsed five times the V/H control reverts to the nominal initial setting. Enables image motion correction mechanism to function. Locks out image motion correction capability of mapping camera.	N/A	Mapping camera	Lockout is effective no later than one mapping camera photographic cycle following setting to OFF position.

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Panel	Reference Designator	Sys	Nomenclature and Position	Function	Circuit Breaker	Power Source	Remarks
230	S28	SIME	SUB SAT LAUNCH (OFF) RETRACT	<p>a. Switches power to extend side of motor in sub-satellite deployment device.</p> <p>b. Arms pyro launch circuit.</p> <p>a. Removes power from deployment device motor.</p> <p>b. Opens pyro launch circuit.</p> <p>a. Switches power to retract site of motor in subsatellite deployment device.</p>		<p>a. JETT bus A and B</p> <p>b. PYRO A (LDEC)</p> <p>a. JETT bus A and B</p> <p>b. PYRO A (LDEC)</p> <p>a. JETT bus A and B</p>	<p>b. Circuit also requires full extension limit switch closure and power on LDEC pyro A bus.</p> <p>b. Same as b.</p>

J-MISSION SIM BAY SM112/113 COMMON



SM-SIM
INTERFACE
CABLING

SM-SIM
INTERFACE
CABLING

MAPPING CAMERA
by FAIRCHILD

MAPPING CAMERA
FILM CASSETTE
EVA TRANSFER TO CM

LASER ALTIMETER
by RCA

MULTIPLE OPERATIONS
MODULE

Xa 240.50

EVA FOOT RESTRAINT

GN₂ BOTTLE

GN₂ CONTROLS

PARTICLES & FIELD
SUBSATELLITE
by TRW

PANORAMIC CAMERA
by ITEK

GAMMA-RAY
SPECTROMETER
by JPL

PAN CAMERA
FILM CASSETTE
EVA TRANSFER TO CM

Xa 238.00

MASS SPECTROMETER
by UTD

ALPHA & X-RAY
SPECTROMETER
by AS&E

Xa 200.50

DATUM PLANE
BEAR NO. 1

DATUM PLANE
BEAR NO. 1