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CSM/LM SPACECRAFT OPERATIONAL DATA BOOK

VOL V

ALSEP DATA BOOK

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MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

CSM/LM SPACECRAFT OPERATIONAL DATA BOOK

VOLUME V

ALSEP DATA BOOK

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VOLUME V

REVISIONS

REV.	AMEND. NO.	DESCRIPTION	DATE	APPROVAL
	1	Insert revised pages 3-11, 3-12, 3-13, 3-14, 3-16, 3-22, 3-24, 3-30, 3-34, 3-37, 3-46, 3-47, 3-48, 3-49, 3-54, 3-55, 3-56 4-4, 4-6, 4-8, 4-10, 4-11, 4-13, 4-17, 4-19, 4-21, 5-3, 5-4, 5-8, 5-9, 5-10, 5-13	10/1/69	SED
	2	Insert revised pages 3-7, 3-28 and 4-8	11/7/69	SED

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ILLUSTRATIONS

TABLES

1.0 INTRODUCTION

1.1 PURPOSE

The Apollo Lunar Surface Experiments Package (ALSEP) Data Book presents parametric data defining the operational capabilities and limitations of the ALSEP and its constituent subsystems. The information is intended for use in mission planning, premission support studies and real-time missions operations.

1.2 CONTENT

The complete CSM/LM Spacecraft Operational Data Book consists of five separate volumes, defined as follows:

Volume I	CSM Data Book
Volume II	LM Data Book
Volume III	Mass Properties Data Book
Volume IV	EMU Data Book
Volume V	ALSEP Data Book

This volume, Volume V, is divided into five sections pertaining to ALSEP Array A. Appendices will contain individually self-sufficient presentations of data applicable to Early Apollo Scientific Experiments Package (EASEP), ALSEP Array B and ALSEP Array C.

1.3 AMENDMENTS

Amendments to this document will be made by page additions or replacements. Data changed by an amendment will be denoted by an amendment date in the upper right hand corner and a vertical bar in the page margin to locate the change.

1.4 ALSEP ABBREVIATIONS AND ACRONYMS

ABBREVIATION	DEFINITIONS
ALSEP	Apollo Lunar Surface Experiments Package
ARC	Ames Research Center
ASE	Active Seismic Experiment
CCGE	Cold Cathode Gauge Experiment
CCIG	Cold Cathode Ion Gauge
CPA	Curved Plate Analyzer
CPLEE	Charged Particle Lunar Environment Experiment
EASEP	Early Apollo Scientific Experiments Package
EGFU	Electronics Gimbal Flip Unit
EHT	Experiment Handling Tool
EPS	Electric Power Subsystem
EVA	Extravehicular Activities
FCA	Fuel Capsule Assembly
FHT	Flight Handling Tool
FTAT	Fuel Transfer Assembly Tool
GLA	Grenade Launch Assembly
HFE	Heat Flow Experiment
JPL	Jet Propulsion Laboratory
LM	Lunar Module
LP	Long Period
LSM	Lunar Surface Magnetometer
LSPO	Lunar Surface Project Office
LSOPO	Lunar Surface Operations Planning Office
MCC	Mission Control Center
ME	Magnetometer Experiment
MESA	Modularized Equipment Stowage Assembly
MUX	Multiplexer
PCU	Power Conditioning Unit
PDR	Power Dissipation Resistor
PDU	Power Distribution Unit
PET	Package Elapsed Time
PLSS	Portable Life Support System
PSE	Passive Seismic Experiment
RTG	Radioisotope Thermoelectric Generator
SCAS	Southwest Center for Advanced Studies
SEQ	Scientific Equipment Bay in LM
SIDE	Suprathermal Ion Detector Experiment
SP	Short Period
SRC	Sample Return Container
SWE	Solar Wind Experiment
SWS	Solar Wind Spectrometer
TDRT	Tie Down Release Tool
TM	Telemetry

2.0 ALSEP ARRAY A CONFIGURATION

The ALSEP Array A installation in relation to the LM is shown in Figure 2-1. Figure 2-2 is a plan view of the LM showing the ALSEP stowage compartments in the LM Scientific Equipment (SEQ) Bay and the exterior mounting for the Radioisotope Thermoelectric Generator (RTG) fuel cask. The experiment and support subsystems of the ALSEP Array A system are mounted for stowage in two subpackages as shown in Figures 2-3 and 2-4. Profiles of the four ALSEP Array A experiment subsystems are shown in Figures 2-5, 2-6, 2-7 and 2-8. Subsystem component dimensions and weights are listed in Table 2-1, while the ALSEP Array A experiments and associated Principal Investigators are listed in Table 2-2.

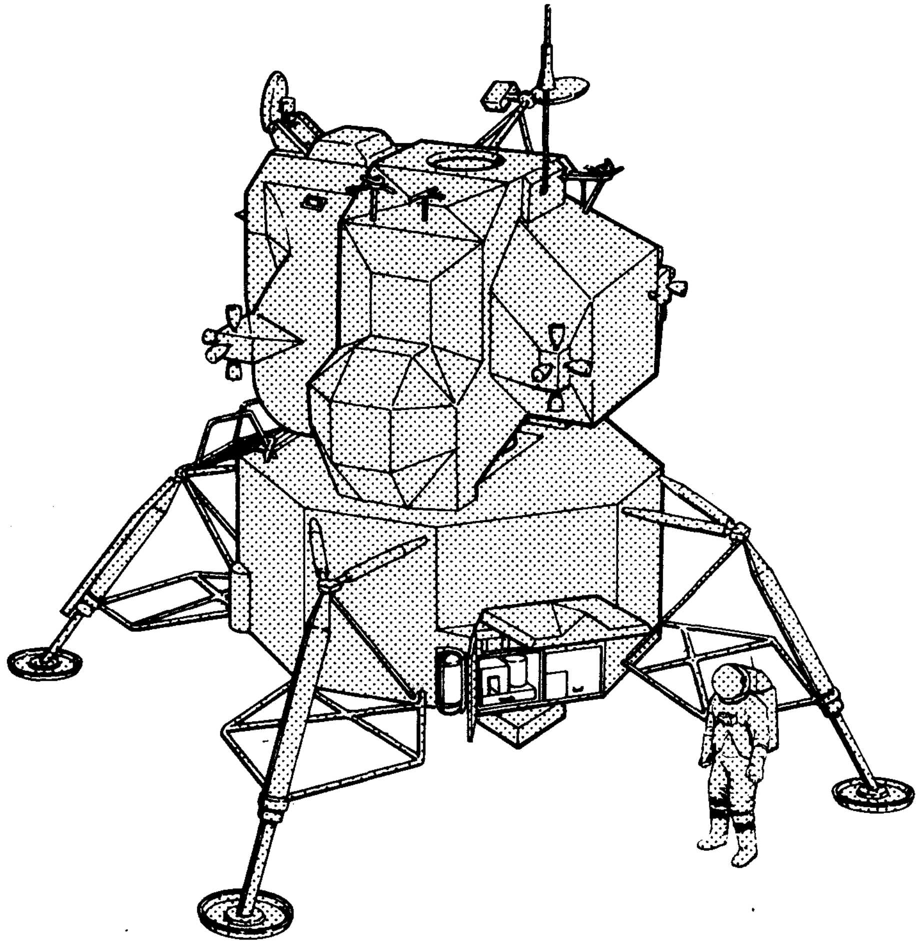


Figure 2-1 ALSEP INSTALLATION IN LM

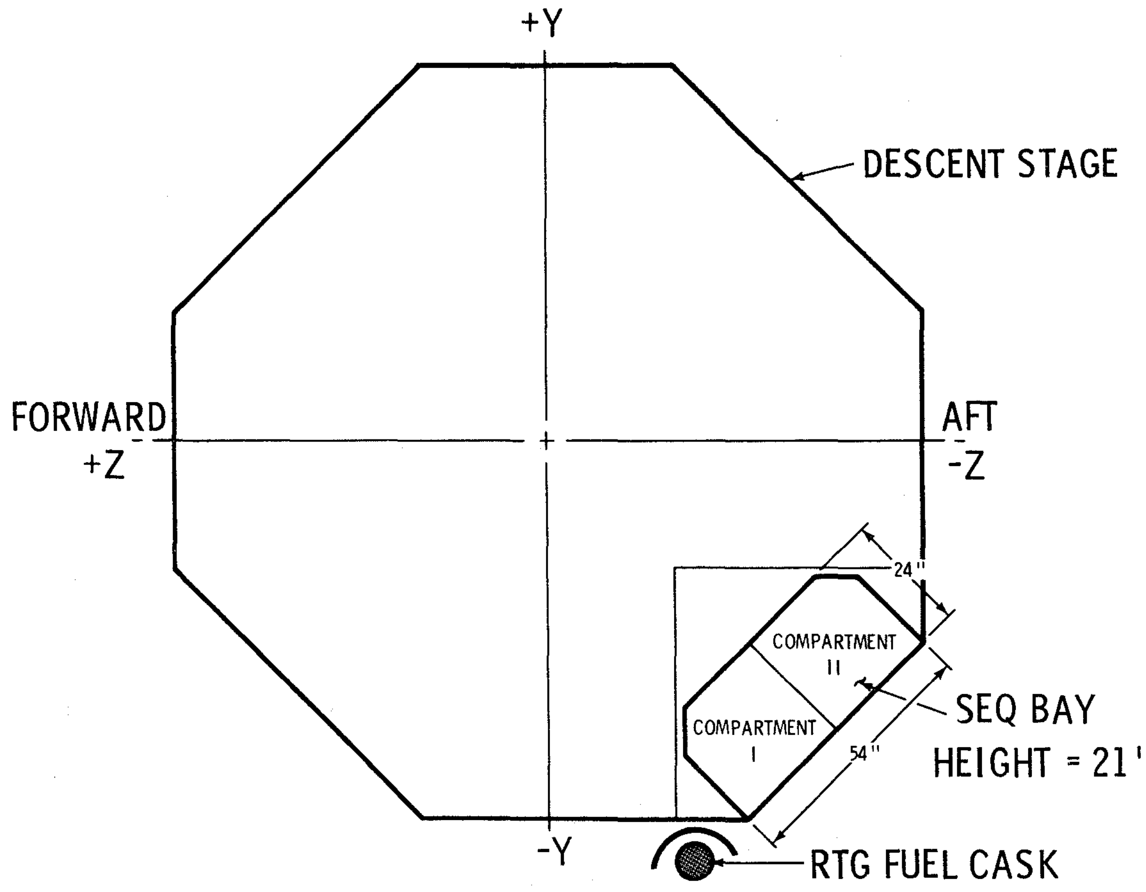


Figure 2-2 ALSEP STORAGE IN LM SEQ. BAY.

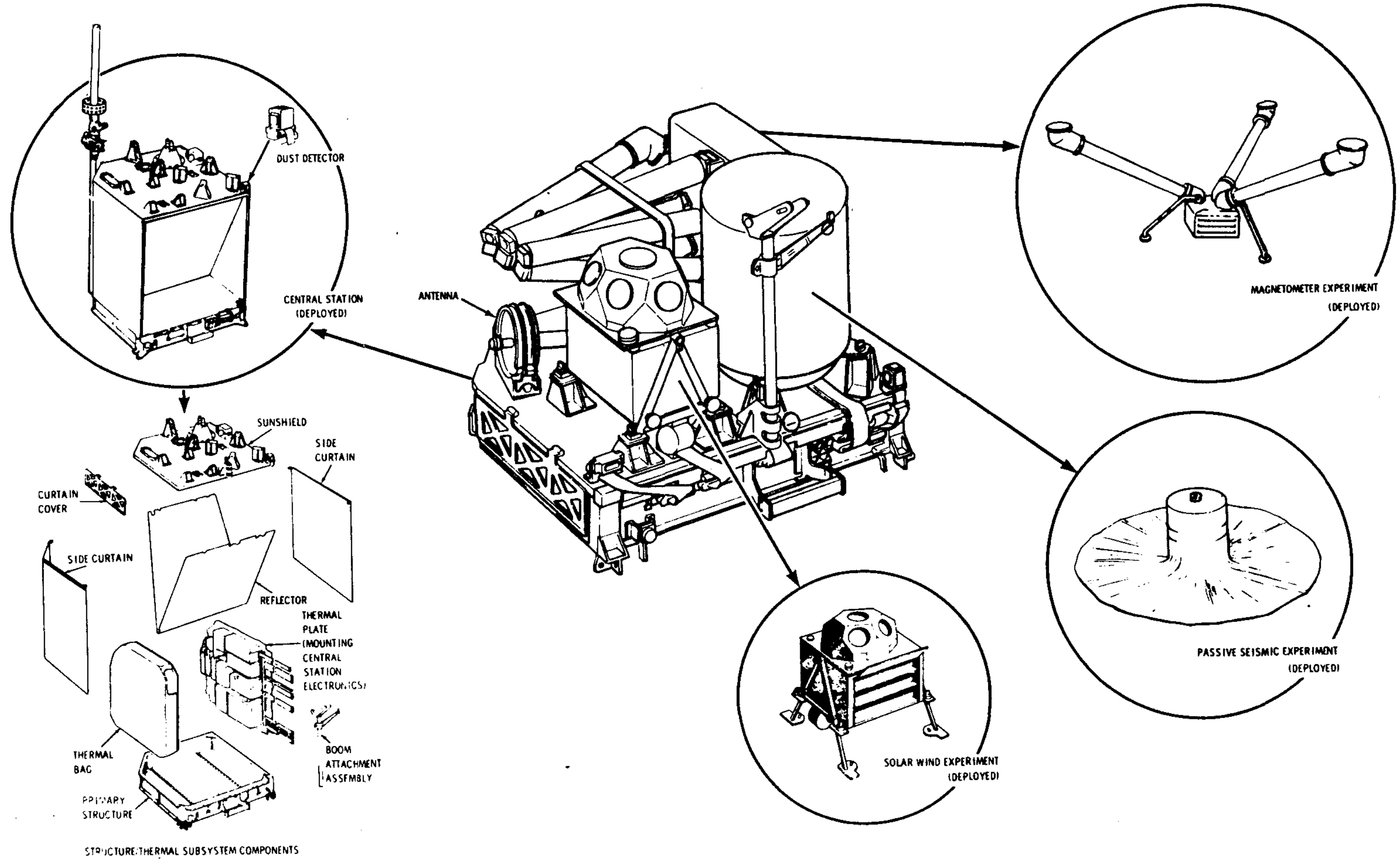


Figure 2-3 ALSEP Array A Subpackage No. 1

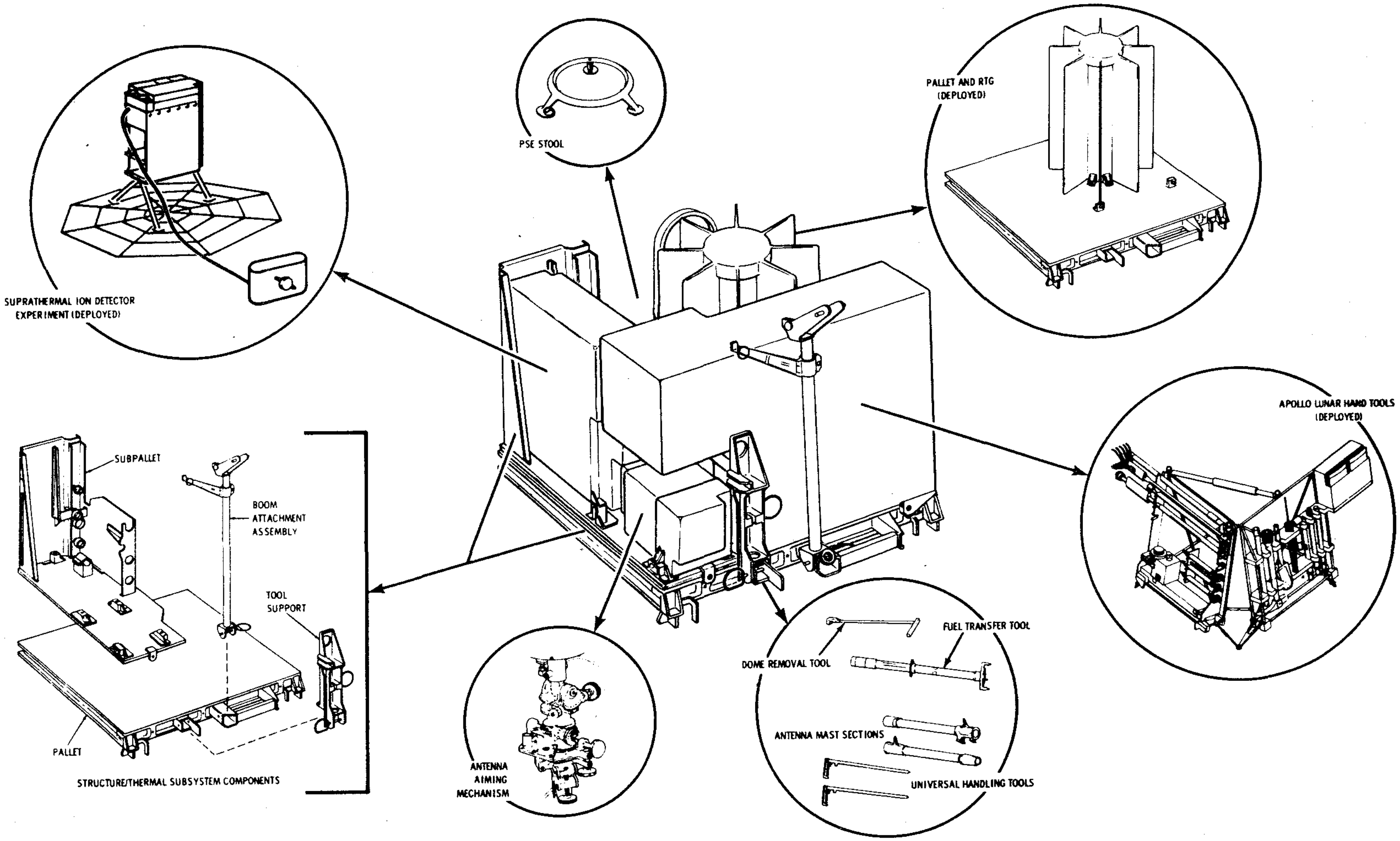
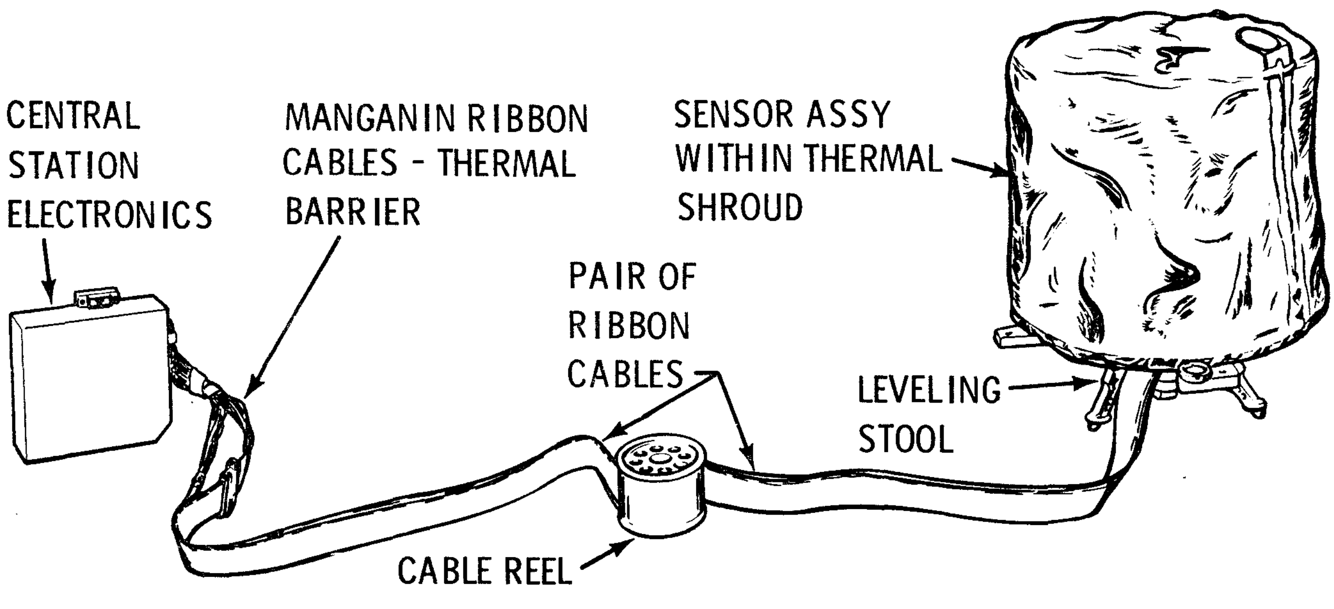


Figure 2-4 ALSEP Array A Subpackage No. 2

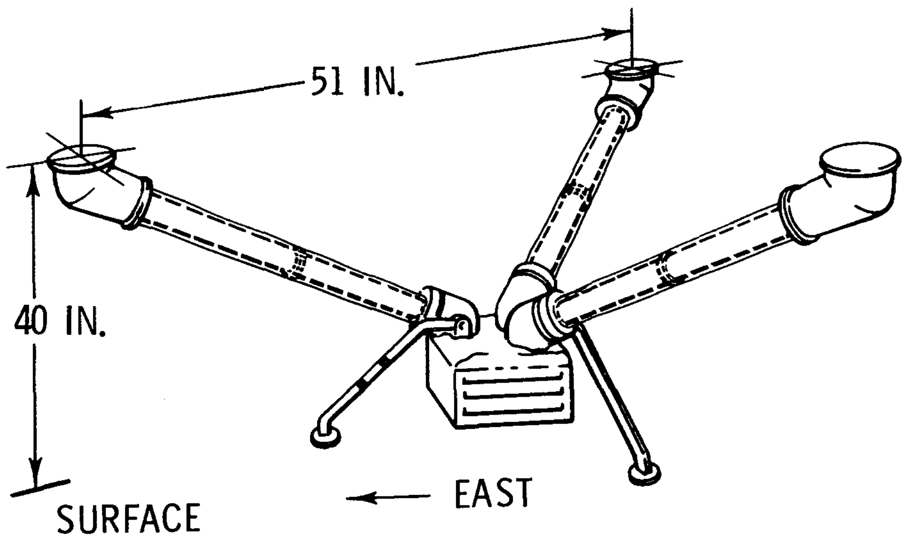
TABLE 2-1 ALSEP ARRAY A SUBSYSTEMS CONFIGURATION

SUBSYSTEM	CHARACTERISTIC	VALUE
ALSEP ARRAY A:	Total Weight	282.3 lbs.
Subpackage No. 1 (SEQ Bay Compartment No. 1)	Dimensions Weight	25.23 x 27.07 x 21.65 in. 121.25 lbs.
Lunar Surface Magnetometer Passive Seismic Experiment Solar Wind Spectrometer Dust Detector * Antenna * Data Subsystem * Power Conditioning Unit *		
Subpackage No. 2 (SEQ Bay Compartment No. 2)	Dimensions Weight	25.23 x 27.07 x 21.65 in. 97.06 lbs.
Suprathermal Ion Detector Radioisotope Thermoelectric Generator Stool for PSE Apollo Lunar Hand Tools ALSEP Deployment Tools Antenna Gimbal Package * Antenna Mast Sections *		
* Part of Central Station		
Fuel Cask & Mounting	Dimensions Weight	29.0 x 12.5 x 13.0 in. 59.6 lbs.
Passive Seismic Experiment	Height Diameter Weight	15 in. 11 in. 19.39 lbs.
Lunar Surface Magnetometer	Stowed Dimensions Deployed Height Sensor Head Separation Weight	25.5 x 11.95 x 10.75 in. 40 in. 60 in. 19.9 lbs.
Solar Wind Spectrometer	Stowed Dimensions Deployed Dimensions Weight	9 x 11 x 12.5 in. 12 x 11 x 13.4 in. 12.5 lbs.
Suprathermal Ion Detector Experiment/Cold Cathode Gauge Experiment	Dimensions Weight	15.25 x 4.5 x 13 in. 20.56 lbs.

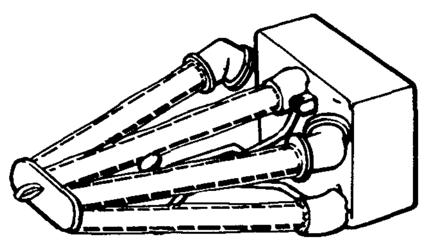


NASA EXPERIMENT NO. S 031
PRINCIPAL INVESTIGATOR: DR. G.V. LATHAM,
COLUMBIA UNIVERSITY

Figure 2-5 PASSIVE SEISMIC EXPERIMENT



DEPLOYED



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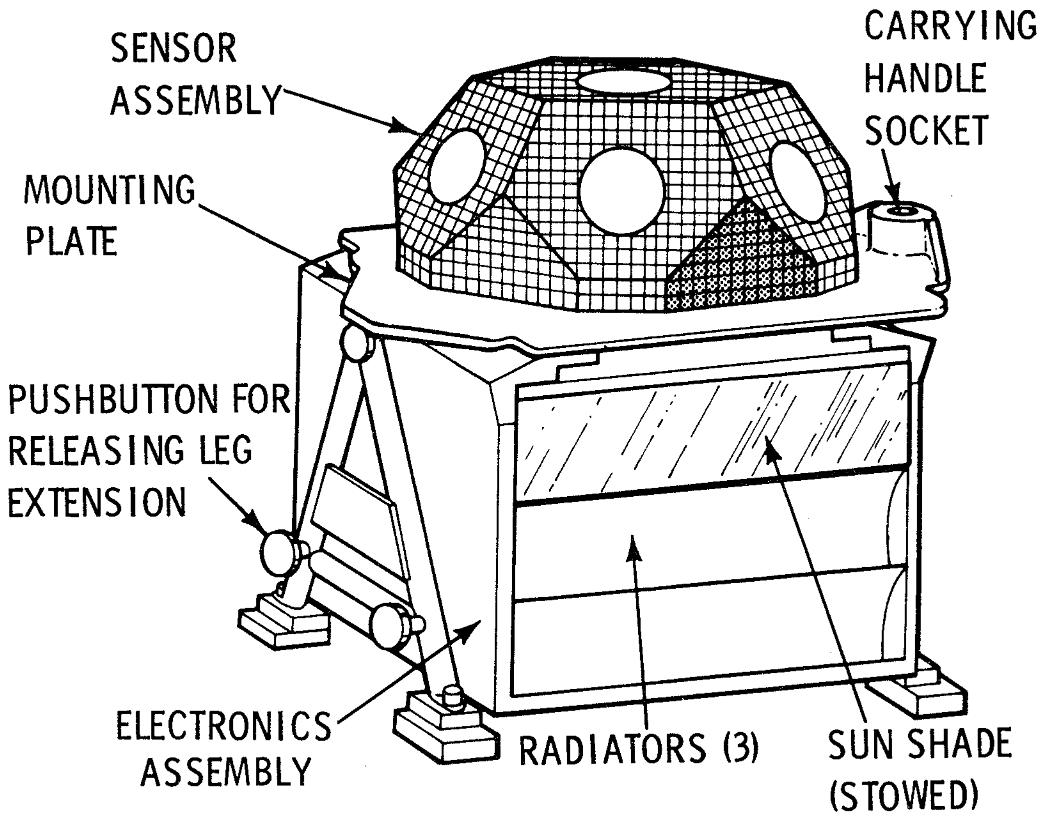
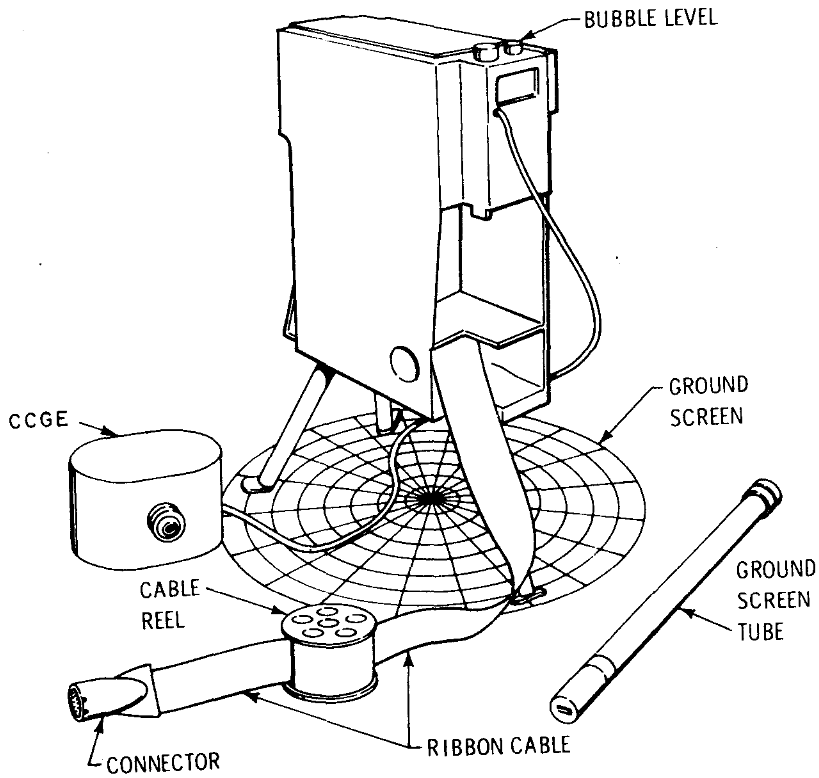
NASA EXPERIMENT NO. S 034
PRINCIPAL INVESTIGATOR: DR. C. P. SONETT,
AMES RESEARCH CENTER

Figure 2-6 LUNAR SURFACE MAGNETOMETER



NASA EXPERIMENT NO. S 035
PRINCIPAL INVESTIGATOR: DR. C. W. SNYDER,
JET PROPULSION LABORATORY

Figure 2-7 SOLAR WIND SPECTROMETER



NASA EXPERIMENT NO. -SIDE-S 036
PRINCIPAL INVESTIGATOR: DR. J. W. FREEMAN,
RICE UNIVERSITY

NASA EXPERIMENT NO. -CCGE-S 058
PRINCIPAL INVESTIGATOR: DR. F. S. JOHNSON,
SOUTHWEST CENTER FOR ADVANCED STUDIES

Figure 2-8 SUPRATHERMAL ION DETECTOR EXPERIMENT/ COLD CATHODE GAUGE EXPERIMENT

3.0 ALSEP ARRAY A OPERATIONAL DATA

This section includes operational data, figures and tables illustrating the performance of the ALSEP subsystems described in Section 2.0.

In the measurement tables found in Section 3.0, the normal operating range is defined as the maximum and minimum excursion values of a particular measurement which are expected in continued experiment operation; the nominal value is the mean value at which the measurement is observed during the most usual operational mode; the red-line limits are defined as the extreme high and low values beyond which that particular measurement may not deviate without immediate attention and possible corrective action.

3.1 STRUCTURAL/THERMAL CONTROL SUBSYSTEM

3.1.1 Thermal Control

The Central Station contains a 10-watt thermostatically controlled heater (Data Subsystem Heater #3) on the thermal plate which is energized when the thermal plate temperature drops below -10° F nominal. This heater is controlled by commands 024 and 025. There are also 10-watt and 5-watt heaters (Data Subsystem Heaters #1 and #2) on the thermal plate which are controlled by commands 055, 056, and 057.

Two resistive loads dissipate excess electrical energy as heat external to the radiator plate on the power dissipation module. Power Dissipation Resistor (PDR) #1 dissipates 7 watts and PDR #2 dissipates 14 watts.

Internal and external temperature measurements of the Central Station will be continually monitored and managed through the choice of operational modes so that continued optimum performance can be assured. Normal operating ranges, upper and lower red-line limits of the thirteen measurements of Central Station temperatures are shown in Table 3.1-1.

TABLE 3.1-1 CENTRAL STATION STRUCTURAL-THERMAL TEMPERATURES

TM MEAS. NO.	MUX CHANNEL	DESCRIPTION	NORMAL OPERATING RANGE - °F		NOMINAL OPER. VALUE °F	RED-LINE LIMITS °F	
			LOW	HIGH		LOW	HIGH
AT-1	27	Sunshield #1	-240	+95	-80	-300*	+300*
AT-2	42	Sunshield #2	-240	+95	-80	-300*	+300*
AT-3	4	Thermal Plate #1	0	+140	+83	-25	+150
AT-4	28	Thermal Plate #2	0	+125	+83	-25	+150
AT-5	43	Thermal Plate #3	0	+125	+83	-25	+150
AT-6	58	Thermal Plate #4	0	+125	+83	-25	+150
AT-7	71	Thermal Plate #5	0	+125	+83	-25	+150
AT-8	59	Left Side Structure #1	-210	+236	0	-300*	+300*
AT-9	87	Right Side Structure #2	-210	+236	0	-300*	+300*
AT-10	15	Bottom Structure #3	-210	+258	+6	-300*	+300*
AT-11	88	Back Structure #4	-50	+250	+28	-300*	+310*
AT-12	60	Inner Multilayer Insulation	-20	+157	+64	-25	+167
AT-13	72	Outer Multilayer Insulation	-135	+210	+26	-300*	+300*

* Red-line limits are sensor limits.

3.2 ELECTRICAL POWER SUBSYSTEM (EPS)

3.2.1 Radioisotope Thermoelectric Generator (RTG)

Thermal equilibrium and stabilized electrical power output of the RTG will be achieved approximately 1.5 hours after the fuel capsule has been placed in the RTG. Full scale operation of the ALSEP via ground commands will not be attempted until after this stabilization period. Prior to the time when the astronaut connects the cable from the RTG to the Central Station, the RTG output is shorted by means of the astronaut connector.

In order to prevent overheating and possible damage to the RTG, a constant load must be maintained on the RTG at all times after fueling. The current drawn from the generator by this load reduces the generator "hot side" temperature and thus prevents the generator from overheating and causing a degradation effect on the thermoelectric couples. The RTG is a power limited device. Attempts to draw system power in excess of rated maximum generator power will cause the Power Conditioning Unit (PCU) output voltages to drop out of tolerance. See Table 3.2-4.

The RTG operational parameters are shown in Table 3.2-1. The telemetry measurements used to make power calculations are shown in Table 3.2-2. Normal operating ranges, upper and lower red-line limits of the six RTG temperatures are shown in Table 3.2-3. Figures 3.2-1, 3.2-2, 3.2-3 and 3.2-4 are graphs which illustrate normal operating characteristics of the RTG.

TABLE 3.2-1 RTG OPERATIONAL PARAMETERS

Characteristics	Value	TM Measurement No.
Output Power	66-70 watts, nominal for 1 year	AE-03 X AE-04
Output Voltage	16 vdc. nominal	AE-03
Current	4 amps, nominal	AE-04
Hot Frame Temp.	1145°F, max. Red-Line	AR-01, AR-02, AR-03
Cold Frame Temp.	545°F, max. Red-Line	AR-04, AR-05, AR-06
Fuel Capsule Thermal Output	1480 watts, +0, -20	No TM Measurement

NOTE: Cold Frame Temp. + 30°F = Cold Junction Temp.
Hot Frame Temp. - 50°F = Hot Junction Temp.
See Table 3.2-3 for normal operating ranges

TABLE 3.2-2 ALSEP POWER CALCULATIONS

TM Measurement No.		Resultant Calculation in Watts
(AE-03) X (AE-04)	=	RTG Output Power
(AE-03) X (AE-05)	=	Reserve Power PCU 1
(AE-03) X (AE-06)	=	Reserve Power PCU 2
(RTG Output Power) - (Reserve Power) - (PCU Conv. Dissip.)	=	(PCU Output Power to ALSEP)

TABLE 3.2-3 RTG TEMPERATURES

TM MEAS. NO.	MUX CHANNEL	DESCRIPTION	NORMAL OPERATING RANGE - °F		NOMINAL OPER. VALUE °F	RED-LINE LIMITS °F	
			LOW	HIGH		LOW	HIGH
AR-1	6	Hot Frame #1 Temp.	1000	1120	1054	980	1145
AR-2	37	Hot Frame #2 Temp.(Resistor) *	1023	1027	1025	1014	1037
AR-3	52	Hot Frame #3 Temp. **	1000	1120	1107	980	1145
AR-4	7	Cold Frame #1 Temp.	405	500	478	401	545
AR-5	67	Cold Frame #2 Temp. **	415	500	426	401	545
AR-6	82	Cold Frame #3 Temp.(Resistor)*	510	512	511	507	515
		* Temp. Sensor Deleted; Fixed Resistor Substituted; Not a Valid Temperature Measurement ** Intermittent Sensor Output During Final Test					

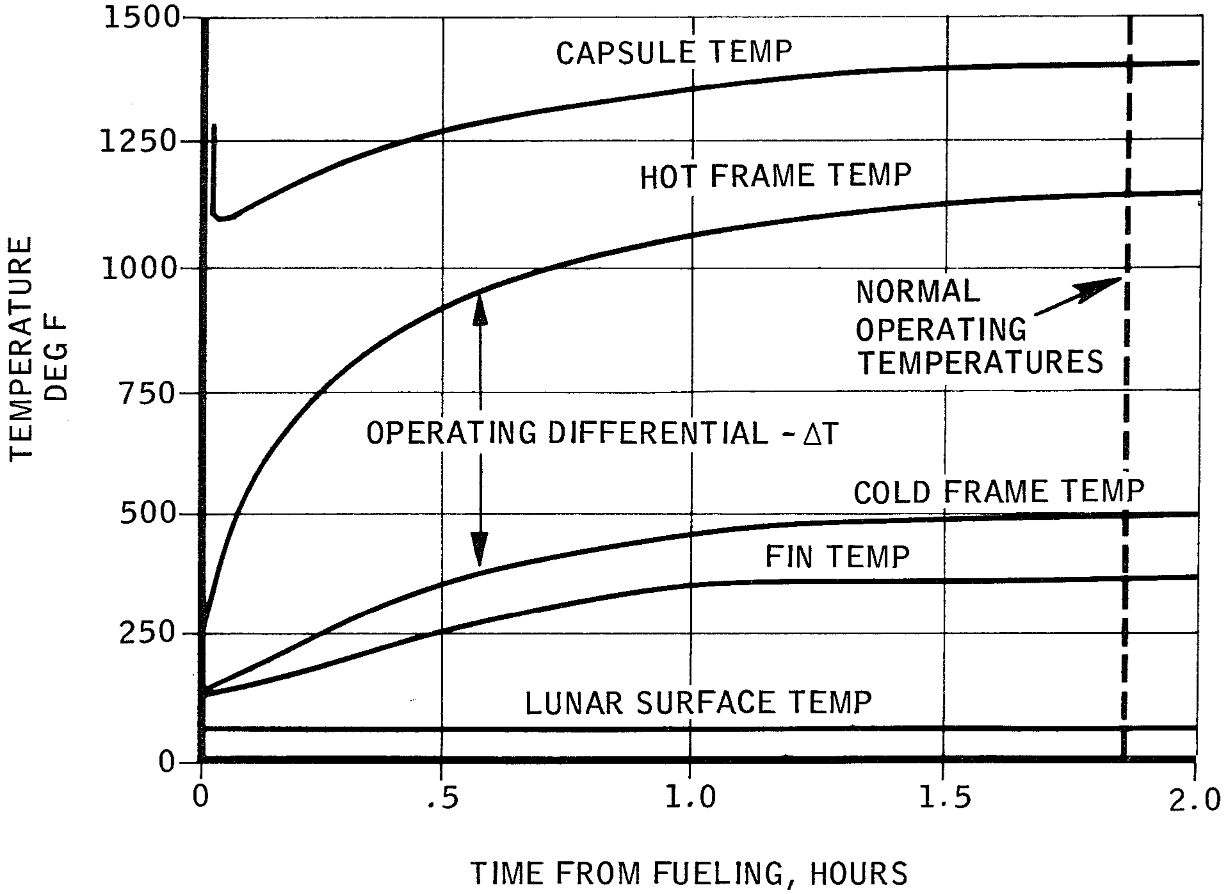
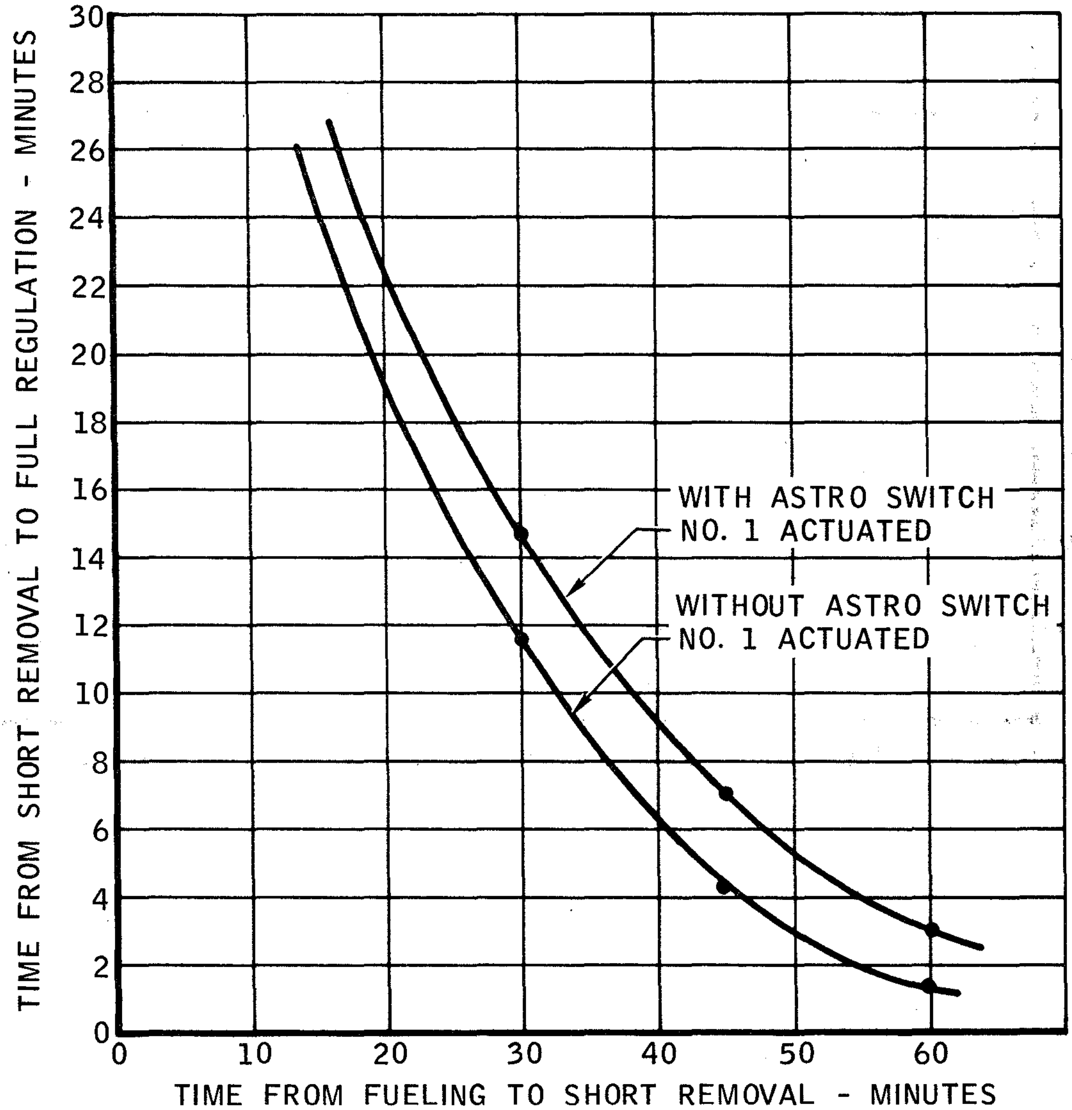


Figure 3.2-1 RTG WARM-UP CYCLE



NOTES:

1. FULL REGULATION IS 36 WATTS @ 16 VOLTS.
2. A VARIATION OF ± 3 MINUTES MUST BE ALLOWED DUE TO VARIABLES AFFECTING RTG LUNAR SURFACE OPERATION.

Figure 3.2-2 RTG POWER PROFILE

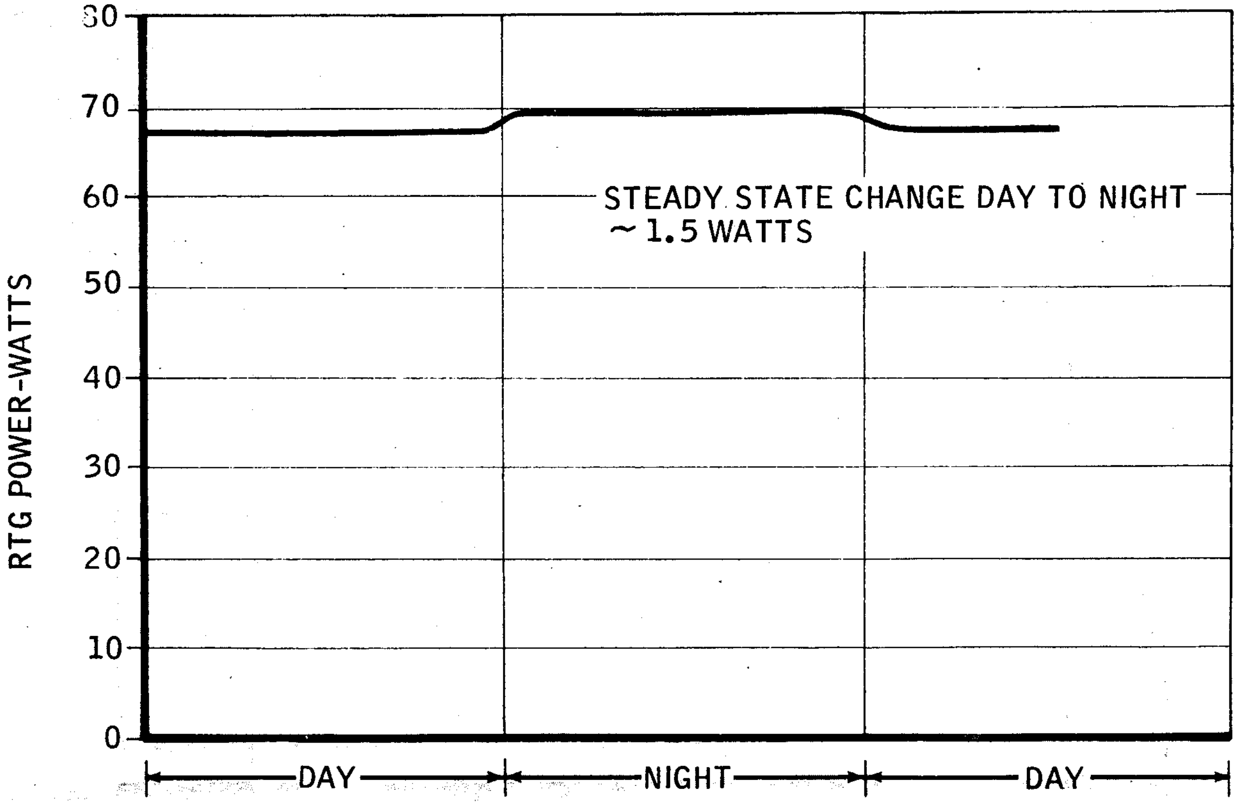


Figure 3.2-3 RTG POWER OUTPUT vs DAY/NIGHT CYCLES

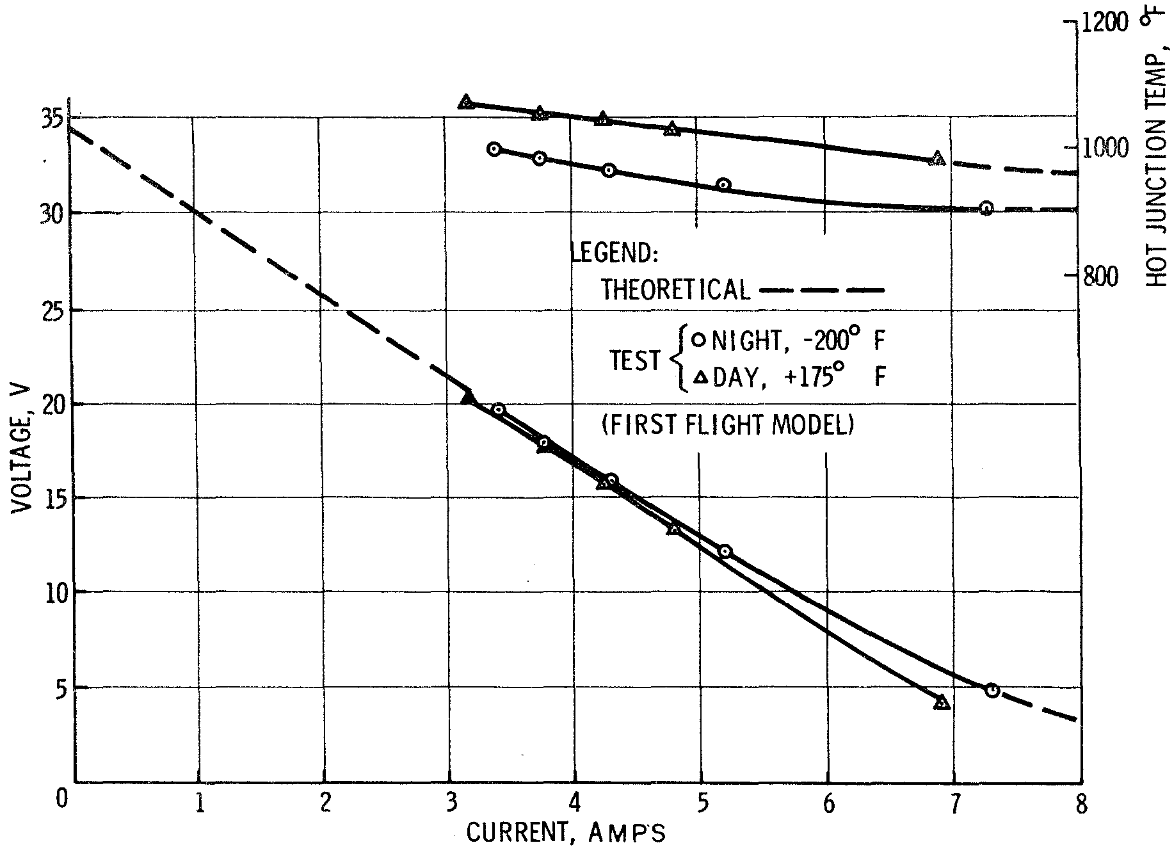


Figure 3.2-4 RTG DAY/NIGHT EFFECTS

3.2.2 Power Conditioning Unit (PCU)

Subsequent to ALSEP deployment and connection of the cable from the RTG to the Central Station, the PCU starts automatically. The PCU has a hold-off circuit which prevents PCU turn-on until the output power is about 36 watts minimum. Thereafter, no command must be sent which will cause an increase in load greater than the reserve power as shown by the calculations illustrated in Table 3.2-2.

The astronaut will throw Astronaut Switch #1, which overrides the PCU power hold-off circuit before he leaves the ALSEP deployment site to return to the LM.

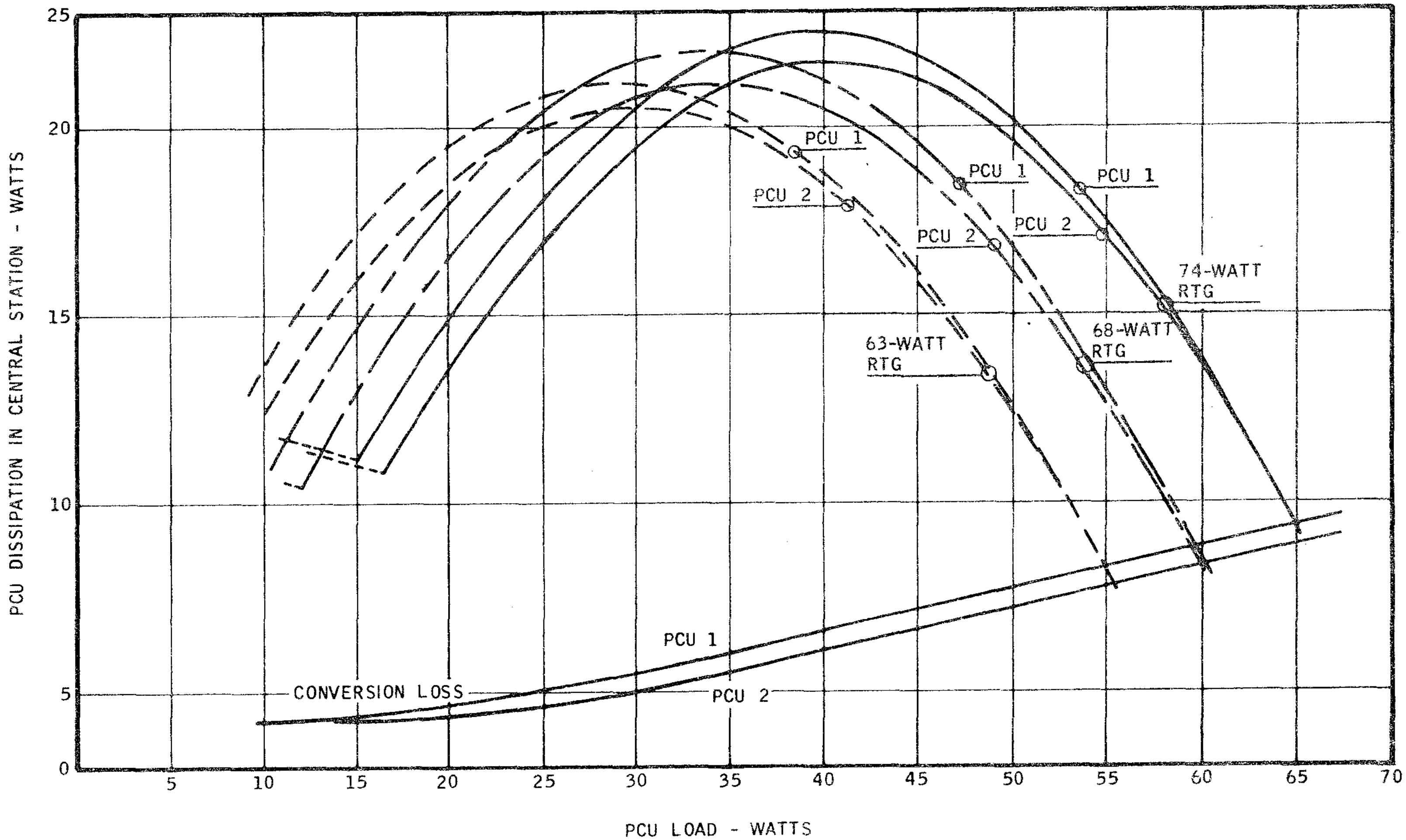
The EPS includes redundant Power Conditioners, PCU #1 and PCU #2, with both automatic and ground command selection of the standby unit. PCU #1 is preset to be energized at initial lunar activation. In the event of an over-voltage or under-voltage condition, an automatic switchover feature selects PCU #2. If automatic switchover to PCU #2 has occurred, Command 060, PCU #1 Select will be noted as highly critical. Command 062 selects PCU #2. Since there is no automatic switchover from PCU #2 to PCU #1, this command is highly critical and should be executed only after determining that PCU #1 is on the verge of failing.

The over-under voltage circuit which senses the +12-volt bus will cause switching from PCU #1 to PCU #2 if an over-voltage of $+13\pm0.25$ vdc persists for 10 ms. Similarly, switching will occur on an undervoltage of $+11\pm0.25$ vdc which persits for 300 ms.

The PCU provides six sources of power at the voltage levels and tolerances shown in Table 3.2-4. PCU power output levels are illustrated in Figure 3.2-5.

TABLE 3.2-4 PCU OUTPUT VOLTAGES

Nominal Bus Voltage, vdc	Upper Limit	Lower Limit
+ 29	+ 29.40	+ 28.59
+ 15	+ 15.40	+ 14.80
+ 12	+ 12.10	+ 11.85
+ 5	+ 5.25	+ 4.85
- 6	- 5.85	- 6.15
- 12	- 11.80	- 12.40


PCU DISSIPATION IN CENTRAL STATION - WATTS
PCU LOAD - WATTS
0
5
10
15
20
25
5
10
15
20
25
30
35
40
45
50
55
60
65
70
PCU 1
PCU 2
PCU 1
PCU 2
PCU 1
PCU 2
74-WATT RTG
68-WATT RTG
63-WATT RTG
CONVERSION LOSS
PCU 1
PCU 2

3.2.3 Power Distribution Unit (PDU)

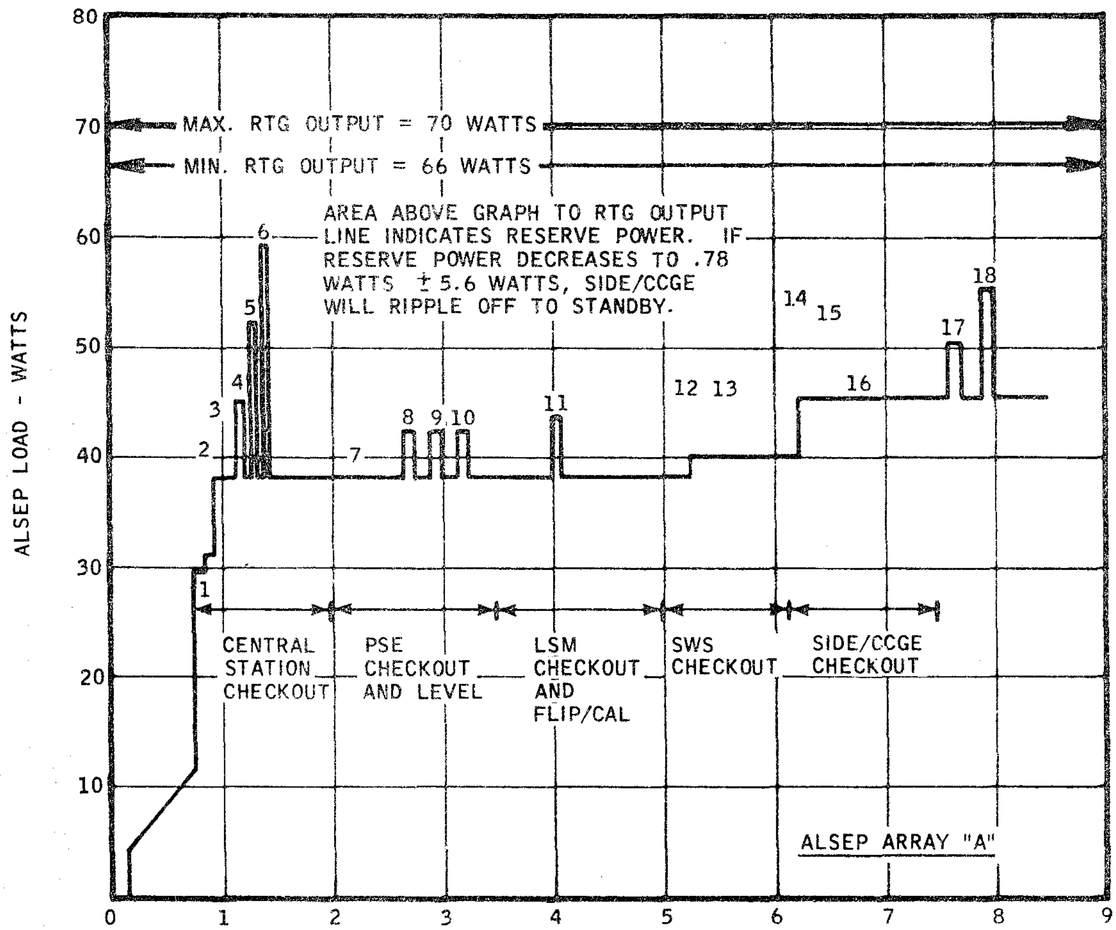
The PDU includes a Ripple-Off Sequencer which detects minimum reserve RTG power and will, by sequential turn-off of up to three experiments, adjust the total power demand to a value within the available power limit. See Table 3.2-5. If an overload condition exists for 135 ms, the SIDE/CCGE will be commanded from Operate to Standby. After 9 ms, if an overload still exists, the SWS will be commanded from Operate to Standby. If overload still exists, the PSE will be commanded from Operate to Standby. Note that the LSM is not included in the ripple-off sequence since it does not have a standby condition. When an overload is cleared, further experiment turn-off is inhibited by the Ripple-Off Sequencer. Thereafter, experiments may be ground commanded back to their Operate conditions as the available power reserve allows.

TABLE 3.2-5 RIPPLE OFF SEQUENCER ACTUATING LEVELS

1. Minimum Reserve Power to Start Experiment Turn-Off = 1.2 $\pm$ 0.5 Watts
2. Experiment Turn-Off Delay = 135 ms

If an experiment is in the Operate mode and it becomes necessary to command the experiment Off, it is first necessary to command the experiment to Standby, then command it to Off. In the Standby mode each of the ALSEP experiments is protected by a 500 milliamp fuse. If one of the fuses should open the Standby capability for that experiment is permanently disabled.

The PCU automatically maintains a constant load on the RTG. To also maintain a proper level of reserve power, two Power Dissipation Resistors may be commanded in or out of the PDU circuitry. PDR #1, a 7-watt resistor, is commanded On or Off line by Commands 017 and 021 respectively. PDR #2, a 14-watt resistor, is commanded On or Off by Commands 022 and 023 respectively. The status of both PDR's must be monitored and coordinated with all experiment operational commands to assure a safe overall power profile as shown in Figures 3.2-6 and 3.2-7.



ASSUME (A) 20° SUN ANGLE AT ZERO TIME (LUNAR SURFACE TEMP 100° F)
(B) NO EXPERIMENT HEATER POWER WHEN OPERATIONAL
(C) TIMES AND EVENT SEQUENCES ARE APPROXIMATE
(D) EVENTS GROUND COMMANDED
(E) DSS HEATER 3 OFF ABOVE 0° F

EVENTS:

1 XMTR A ON
2 PSE OPERATIONAL
3 LSM OPERATIONAL
4 PDR 1 ON
5 PDR 2 ON
6 PDR 1 AND 2 ON
7 PSE UNCAGE (NO POWER REQUIRED)
8 PSE X-AXIS LEVEL MOTOR ON/OFF
9 PSE Y-AXIS LEVEL MOTOR ON/OFF
10 PSE Z-AXIS LEVEL MOTOR ON/OFF
11 LSM FLIP/CAL (TOTAL OF FOUR REQUIRED
12 SWS OPERATIONAL
13 SWS DUST COVER REMOVAL
14 SIDE OPERATIONAL
15 SIDE DUST COVER REMOVAL
16 CCGE SEAL BREAK (NO POWER REQUIRED)
17 DSS HEATER 2 ON
18 DSS HEATER 1 ON

Figure 3.2-6 LUNAR DAY POWER PROFILE

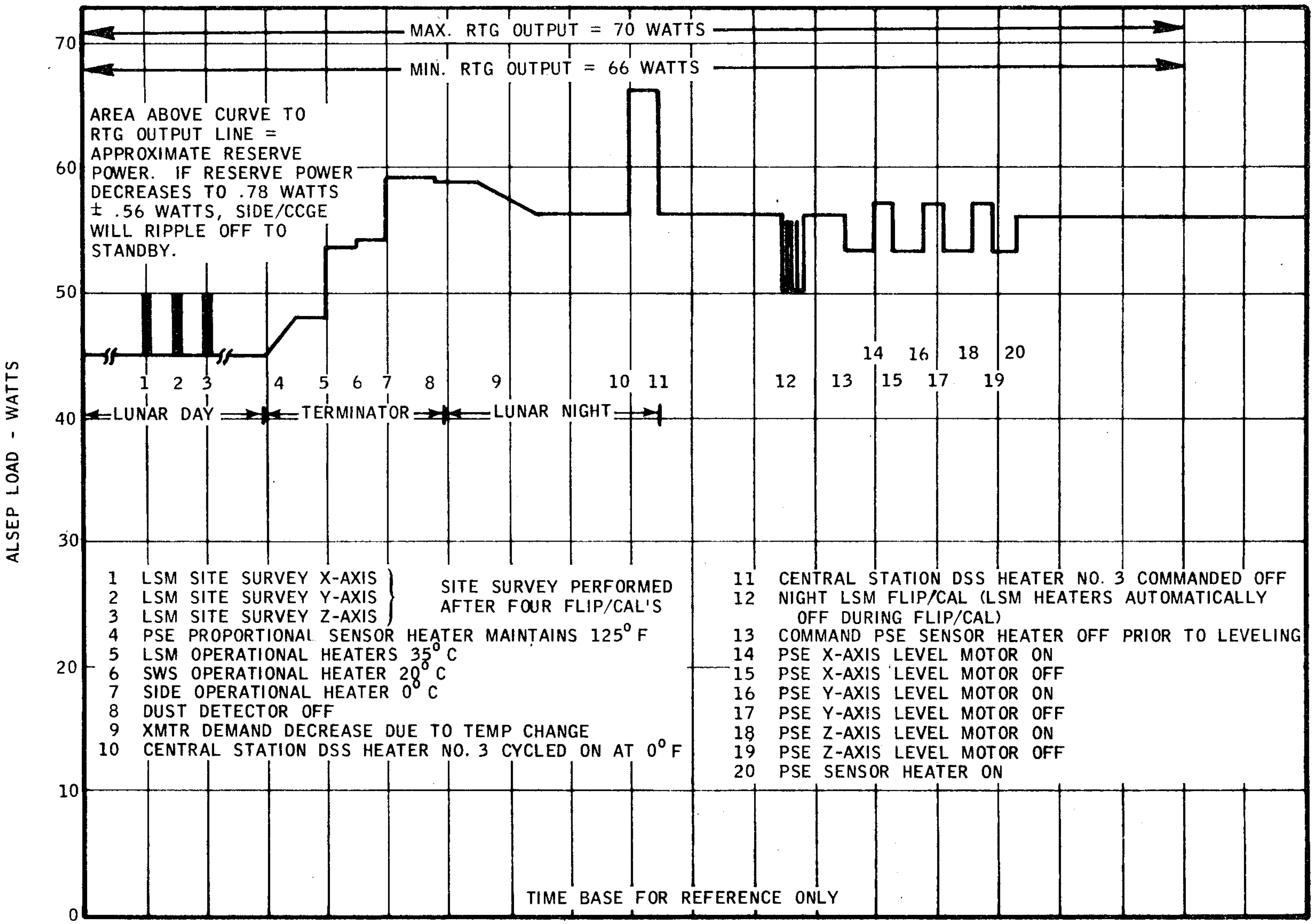


Figure 3.2-7 LUNAR NIGHT POWER PROFILE

Amendment 1
10/1/69

3.3 CENTRAL STATION

The normal operating ranges, upper and lower red-line limits of the 18 telemetered Central Station electronics measurements and 19 telemetered Central Station module temperatures are listed in Tables 3.3-1 and 3.3-2. Average Central Station radiator temperatures are illustrated in Figure 3.3-1.

3.3.1 Transmitter

ALSEP Array A transmitters A and B operate at 2278.4957 MHz and 2278.5060 MHz, respectively, with a frequency accuracy and stability of ± 0.0025 percent per year. Each transmitter has a nominal minimum power output of 1.0 watt. ALSEP Array A transmitters A and B have measured power outputs of 30.4 dbm and 30.6 dbm, respectively. The modulation index is 1.25 radians.

Transmitter A is selected during the normal lunar surface turn-on sequence. Either transmitter A or B may be selected by Command 012 or 015, respectively. Operational considerations may make it necessary to turn off the ALSEP transmitter. However, the Transmitter Off command should be sent in contingency situations only.

In the event of transmitter failure and the loss of uplink command capability during the initial turn-on sequence, the astronaut will set Astronaut Switch No. 2 which manually selects and turns on Transmitter B. A switch from one to the other of the two redundant transmitters will invariably result in a temporary loss of synchronization at the MSFN receiving sites.

The telemetered measurements of transmitter operation which must be continually monitored for optimum performance are shown in Tables 3.3-1 and 3.3-2.

TABLE 3.3-1 CENTRAL STATION ELECTRONICS MEASUREMENTS

TM MEAS. NO.	MUX CHANNEL	DESCRIPTION	NORMAL OPERATING RANGE		NOMINAL VALUE	RED-LINE LIMITS	
			LOW	HIGH		LOW	HIGH
AE-1	2	ADC Calibration 0.25V	0.24V	0.26V	0.25V	0.22V	0.28V
AE-2	3	ADC Calibration 4.75 V	4.72V	4.78V	4.75V	4.70V	4.80V
AE-3	1	Converter Input Voltage	15.4V	16.9V	16.2V	15.0V	17.5V
AE-4	5	Converter Input Current	3.9a	4.5a	4.2a	3.8a	4.6a
AE-5	8	Shunt Regulator #1 Current	0.4a	2.7a	1.1a	0.05a	3.18a
AE-6	13	Shunt Regulator #2 Current	0.4a	2.7a	1.1a	0.1a	3.18a
AE-7	20	PCU Output Voltage #1 (29V)	28.8V	29.2V	29.0V	28.59V	29.40V
AE-8	35	PCU Output Voltage #2 (15V)	14.9V	15.36V	15.0V	14.8V	15.4V
AE-9	50	PCU Output Voltage #3 (12V)	11.9V	12.05V	12.0V	11.85V	12.10V
AE-10	65	PCU Output Voltage #4 (5V)	4.9V	5.15V	5.0V	4.85V	5.25V
AE-11	79	PCU Output Voltage #5 (-12V)	-12.35V	-11.9V	-12.0V	-12.4V	-11.8V
AE-12	80	PCU Output Voltage #6 (-6V)	-6.1V	-5.9V	-6.0V	-6.15V	-5.85V
AE-13*	21	Receiver Pre-Limiting Level	-92dbm	-84dbm	-88dbm	-101dbm	-61dbm
AE-14*	36	Receiver Local Oscillator Level	2.6dbm	7.5dbm	6.1dbm	1.8dbm	7.6dbm
AE-15	51	Transmitter A AGC Voltage (Unusual Calib. Curve)	1.47V @-10°F	1.89V @+146°F	1.10V @+75°F	0.323V	5.00V
AE-16	66	Transmitter B AGC Voltage (Unusual Calib. Curve)	1.5V @-10°F	0.95V +146°F	0.61V @+75°F	0.26V	4.17V
AE-17*	81	Transmitter A Power Doubler Current	143ma @-10°F	208ma @146°F	162ma @+75°F	100ma @+77.5°	240ma @77.5°
AE-18*	22	Transmitter B Power Doubler Current	128ma @-10°F	192ma +146°F	157ma @+75°F	100ma @+77.5°	240ma @77.5°

* These measurements are temperature dependent. Refer to Calibration Curves.

TABLE 3.3-2 CENTRAL STATION MODULE TEMPERATURES

TM MEAS. NO.	MUX CHANNEL	DESCRIPTION	NORMAL OPERATING RANGE - °F		NOMINAL VALUE °F	RED-LINE LIMITS °F	
			LOW	HIGH		LOW	HIGH
AT-21	16	Local Oscillator Crystal A	-10	+165	+144	-15	+170
AT-22	17	Local Oscillator Crystal B	0	+125	+75	-15	+170
AT-23	18	Transmitter A Crystal	-10	+146	+75	-15	+165
AT-24	19	Transmitter A Heat Sink	-10	+146	+75	-15	+165
AT-25	31	Transmitter B Crystal	-10	+146	+75	-15	+165
AT-26	32	Transmitter B Heat Sink	-10	+146	+75	-15	+165
AT-27	33	Analog Data Processor Base	0	+125	+83	-25	+150
AT-28	34	Analog Data Processor Internal	0	+125	+90	-15	+163
AT-29	46	Digital Data Processor Base	0	+125	+83	-25	+150
AT-30	47	Digital Data Processor Internal	0	+125	+87	-20	+158
AT-31	48	Command Decoder Base	0	+125	+83	-25	+150
AT-32	49	Command Decoder Internal	0	+125	+86	-20	+155
AT-33	61	Command Demodulator VCO	0	+125	+86	-20	+155
AT-34	62	PDU Base	0	+140	+83	-25	+150
AT-35	63	PDU Internal	10	+150	+100	-10	+180
AT-36	64	PCU Power Oscillator #1	0	+150	+94	-20	+172
AT-37	76	PCU Power Oscillator #2	-10	+165	+94	-20	+172
AT-38	77	PCU Regulator #1	+50	+195	+103	-20	+210
AT-39	78	PCU Regulator #2	-10	+195	+103	-20	+210

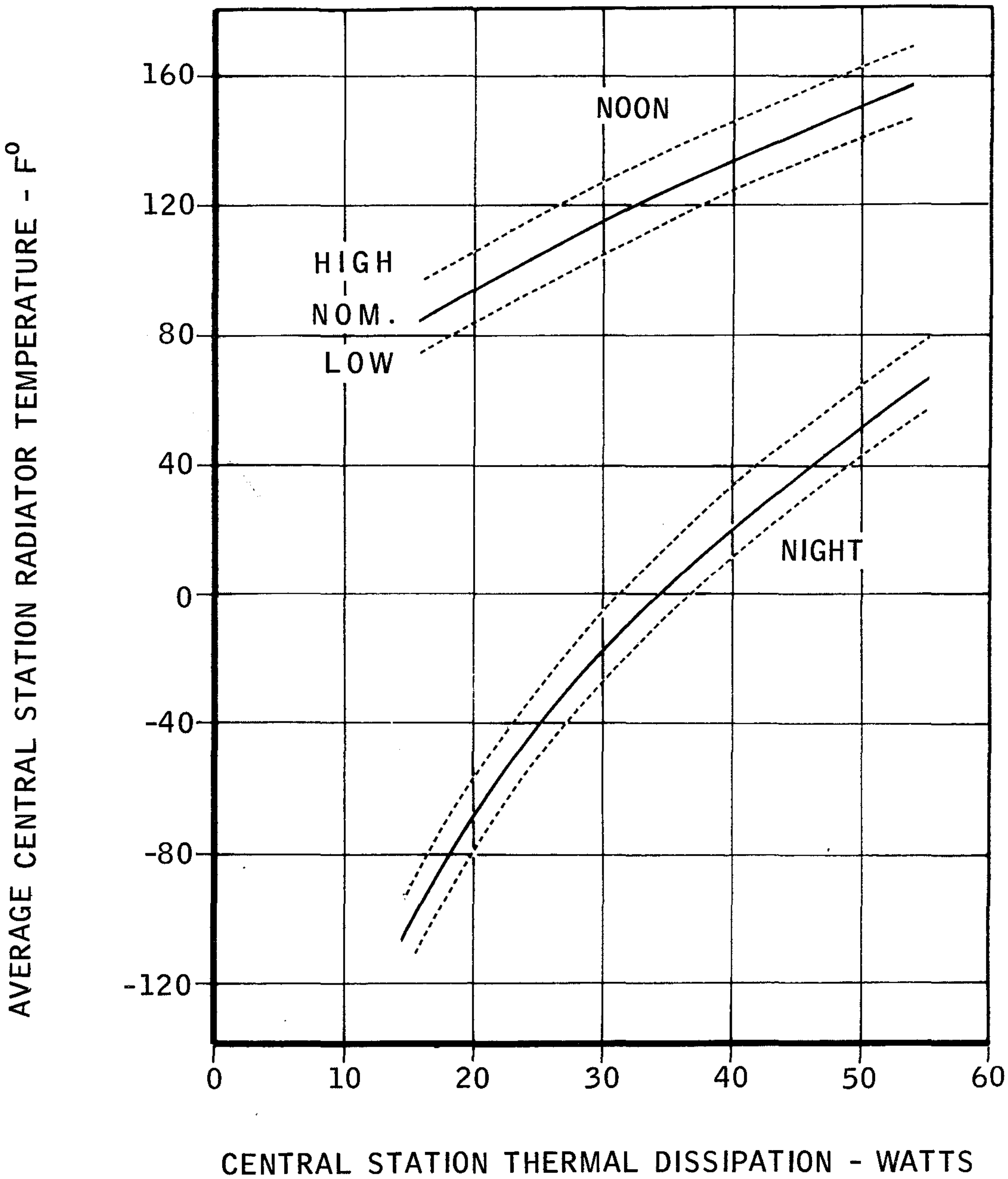


Figure 3.3-1

CENTRAL STATION RADIATOR TEMPERATURE VS THERMAL DISSIPATION FOR LUNAR SURFACE OPERATION

3.3.2 Receiver

The uplink frequency is set at 2119 MHz for all ALSEP flight systems. The unit has a frequency accuracy and stability of $\pm$ .001 percent per year. The receiver includes redundant local oscillators controlled by output power level sensors and switching logic in the Central Station receiver. There is no ground command control capability for the selection of local oscillators. However, telemetry temperature measurements AT-21 and AT-22 indicate which local oscillator, A or B respectively, is in use. The receiver is protected by a circuit breaker, CB-01, in the +12 vdc input line. If an overload occurs and the circuit breaker trips, it may be manually set by the astronaut, thereby resetting CB-01. Also, CB-01 is automatically reset every 12 hours by a recurring pulse from the timer starting at Package Elapsed Time-Zero.

The data subsystem of the Central Station can simultaneously receive commands uplink and transmit data downlink. Commands to experiments must proceed in a proper sequence to assure precise thermal control, accurate scientific data retrieval and the maintenance of a proper power profile. Proper command sequences are shown in Section 5.0. All commands referenced in this data Book are identified by their Octal Command Number.

3.3.3 Dust Detector

Dust Detector Operation is monitored by the three temperature and three output measurements shown in Table 3.3-3.

3.3.4 Timer

The Timer provides repetitive 1-minute and 12-hour pulses which are used as inputs to the delayed command sequencer. The 12-hour pulses are also routed through the PDU to generate two repetitive 12-hour commands. The Timer also provides a one-time, non repetitive pulse 720 $\pm$ 30 days after turn-on which results in an Off command to the ALSEP transmitter, thereby preventing any further transmissions.

The six delayed commands generated by the delayed command sequencer are described in Table 3.3-4. These internally generated commands would be utilized in the event of an uplink failure.

The two commands which are repetitively initiated by the 12-hour timer pulses routed through the PDU are:

a. Receiver Circuit Breaker Reset

b. PSE Short Period Calibrate. (The first two pulses will Arm and Fire the PSE Uncaging mechanism.)

These commands can be inhibited by sending Command 033, Timer Output Inhibit. However, Command 033 must be considered critical because if the command uplink should fail after Command 033 has been transmitted, all locally generated commands would be permanently inhibited.

TABLE 3.3-3 DUST DETECTOR MEASUREMENTS

TM. MEAS. NO.	MUX CHANNEL	DESCRIPTION	NORMAL OPERATING RANGE		NOMINAL VALUE	RED-LINE LIMITS	
			LOW	HIGH		LOW	HIGH
AX-1	83	#1 Cell Temperature -°C	+43	+135	+110	+33*	+160*
AX-2	30	#2 Cell Temperature -°C	+43	+135	+110	+31*	+160*
AX-3	56	#3 Cell Temperature -°C	+43	+135	+110	+32*	+160*
AX-4	84	#1 Cell Output - millivolts	20	90	80	1	163
AX-5	26	#2 Cell Output - millivolts	20	90	80	1	163
AX-6	41	#3 Cell Output - millivolts	20	90	80	1	163

Notes:

(1) Readings for AX-4, AX-5 and AX-6 will reach the low red-line limit when the Dust Detector is Off, and during lunar night.

(2) The Dust Detector is protected by two fuses, F-01 and F-02. If F-01 opens, AX-04, AX-05 and AX-06 are permanently lost. If F-02 opens, AX-01 through AX-06 are permenently lost.

(3) * Red-line limits are sensor limits.

3.3.5 Command Decoder

Within the Command Decoder redundant Digital Decoder sections are provided. A ground command may be executed by either decoder if the proper decoder address is transmitted:

ALSEP Array A Decoder A Address is Octal 130.
ALSEP Array A Decoder B Address is Octal 030.

The ALSEP command decoder is capable of accepting 128 different command messages. However, for ALSEP Array A there are only 65 valid commands which will be utilized.

The command word rate is limited by the command decoder to approximately one message per second during a normal mode of operation and to approximately one message per two seconds during the slow mode of operation.

Loss of synchronization between commands does not affect the operation of the command decoder.

If the uplink should be unavailable for any reason six delayed commands are generated within the command decoder. The six command functions and their times of execution are shown in Table 3.3-1.

TABLE 3.3-4 DELAYED COMMAND FUNCTIONS

Function	Time of Execution
1. Set CCGE Seal Break Uncage PSE	96 hr + 2 min
2. Execute CCGE Seal Break	96 hr + 3 min
3. Blow SWS Dust Cover Set SIDE Blow Dust Cover	96 hr + 4 min
4. Execute SIDE Blow Dust Cover	96 hr + 5 min
5. LSM Flip/Calibrate	108 hr + 1 min, then every 12 hr
6. Restore Power to SIDE/CCGE	108 hr + 7 min, then every 12 hr

It should be noted that these commands can be initiated either via ground command or via the delayed command sequencer. The command verification word shall be available only if the command was generated via the uplink.

3.3.6 Data Processor

Redundant data processors are included in the downlink telemetry subsystem. Data Processor X is energized during the normal lunar surface turn-on sequence. Either of the two redundant sections are selectable by ground commands. Command 034 selects Data Processor X and Command 035 selects Data Processor Y.

In the event of failure of Data Processor X and the loss of uplink command capability during the initial turn-on sequence the astronaut may set Astronaut Switch No. 2 which manually selects Data Processor Y.

Whenever there is a switch from one to the other of the redundant data processors, there will be a temporary loss of synchronization at the MSFN receiving site. If the switchover was initiated by ground command, there will also be a loss of, or error in, the command verification word.

The normal telemetry downlink bit rate of 1060 bits per second is automatically selected by the data processor during the initial turn-on sequence and can additionally be selected by Command 006 or Command 011. If the nominal allowable bit error rate of 10^{-4} is exceeded at the receiving sites, a decision will be made whether to send Command 007 to set the data processor to wht low bit rate of 530 bps in order to obtain more accurate reception of the downlink signal. However, at the 530 bps low bit rate the Lunar Surface Magnetometer data is not useable.

3.3.7 Diplexer Switch

In the normal initial condition when transmitter A is selected, the diplexer switching coil is de-energized. When transmitter B is selected the diplexer switching coil is energized by + 12 vdc and is therefore, a less reliable state for the diplexer switch. Isolation provided by the circulators is approximately 30 db.

3.3.8 Multiplexer

Although there is only one 90-channel analog multiplexer in the ALSEP TM subsystem there is redundancy of the logic gates for the first 15 channels. Selection of one or the other of the redundant channels is accomplished by commands 034 or 035 which also select Data Processor X or Y respectively. The 15 redundant channels are shown in Table 3.3-5.

TABLE 3.3-5 REDUNDANT ANALOG MULTIPLEXER CHANNELS

Multiplexer Channel	TM Meas. No.	Measurement
1	AE-3	Converter Input Voltage
2	AE-1	0.25 Vdc Calibration
3	AE-2	4.75 Vdc Calibration
4	AT-3	Thermal Plate Temp 1
5	AE-4	Converter Input Current
6	AR-1	RTG Hot Frame #1 Temp
7	AR-4	RTG Cold Frame #1 Temp
8	AE-5	Shunt Regulator #1 Current
9	AB-1	Receiver 1K Hz Subcarrier Present
10		Not Assigned
11		Not Assigned
12	AB-4	Power Distribution Exp. 1 and 2
13	AE-6	Shunt Regulator #2 Current
14	AB-5	Power Distribution Exp. 3, 4 and Data Subsystem Heater #2
15	AT-10	Primary Structure Bottom Temp 1

3.3.9 Antenna

During deployment the astronaut must adjust and align the antenna aiming mechanism. Proper alignment of the antenna in elevation and azimuth requires that the astronaut refer to accurate aiming tables and align the antenna according to values of elevation and azimuth which are compatible with the date and exact LM touch down point. Antenna aiming tables will be stowed aboard the LM for use by the astronauts. In addition, support personnel will independently determine the correct elevation and azimuth settings and confirm those chosen by the astronaut via voice communication. Antenna operational characteristics are listed in Table 3.3-6 and illustrated in Figures 3.3-2 and 3.3-3.

TABLE 3.3-6 ANTENNA OPERATIONAL PARAMETERS

FUNCTION	NOMINAL VALUE
Polarization	Right Hand Circular
Input VSWR	1.2 : 1, max.
Boresight Gain: a. Transmit b. Receive	 15.9 db, actual 14.7 db, actual
Pointing Error	1.16^{o} max.
Beamwidth	30.6 degrees, actual
Antenna Alignment: a. Azimuth b. Elevation	 $\pm 90^{o}$, max. $\mp 50^{o}$, max.

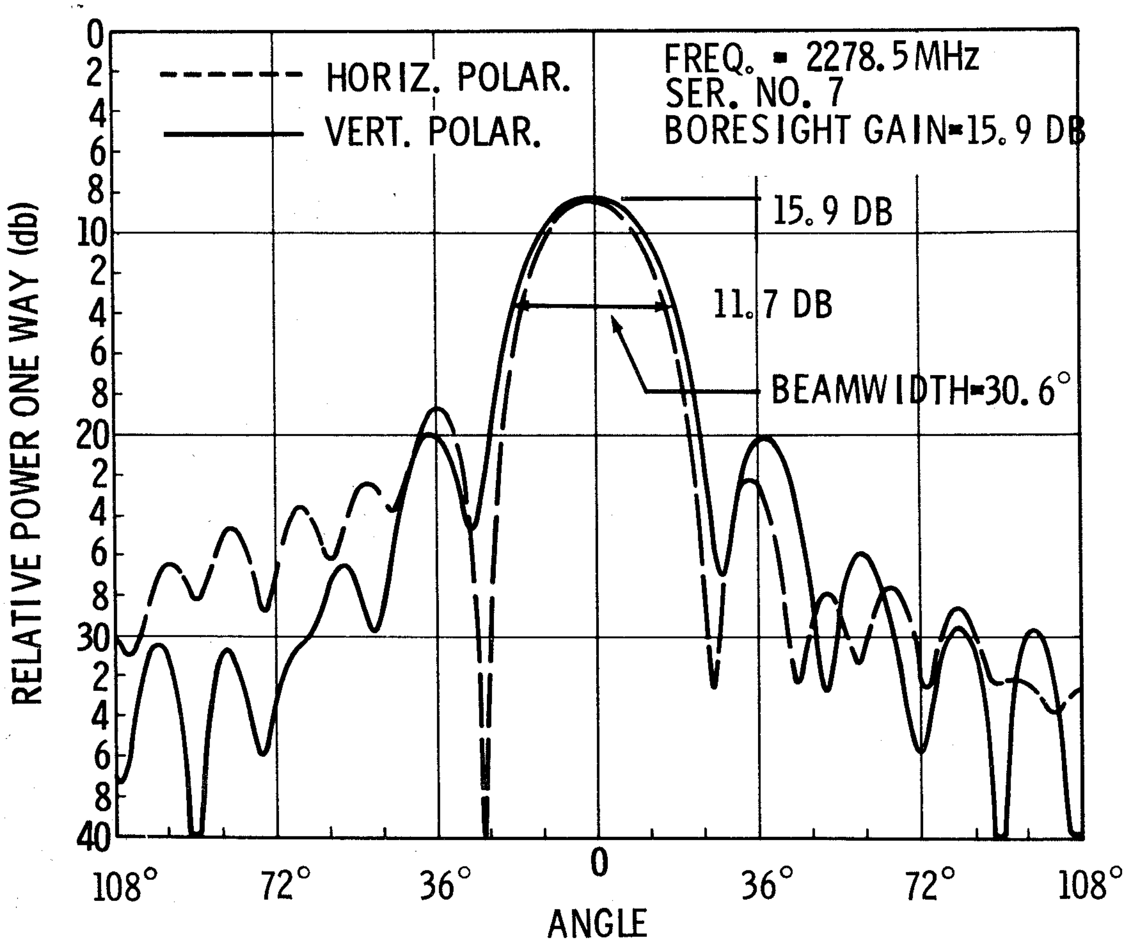


Figure 3.3-2 ANTENNA PATTERN-DOWNLINK

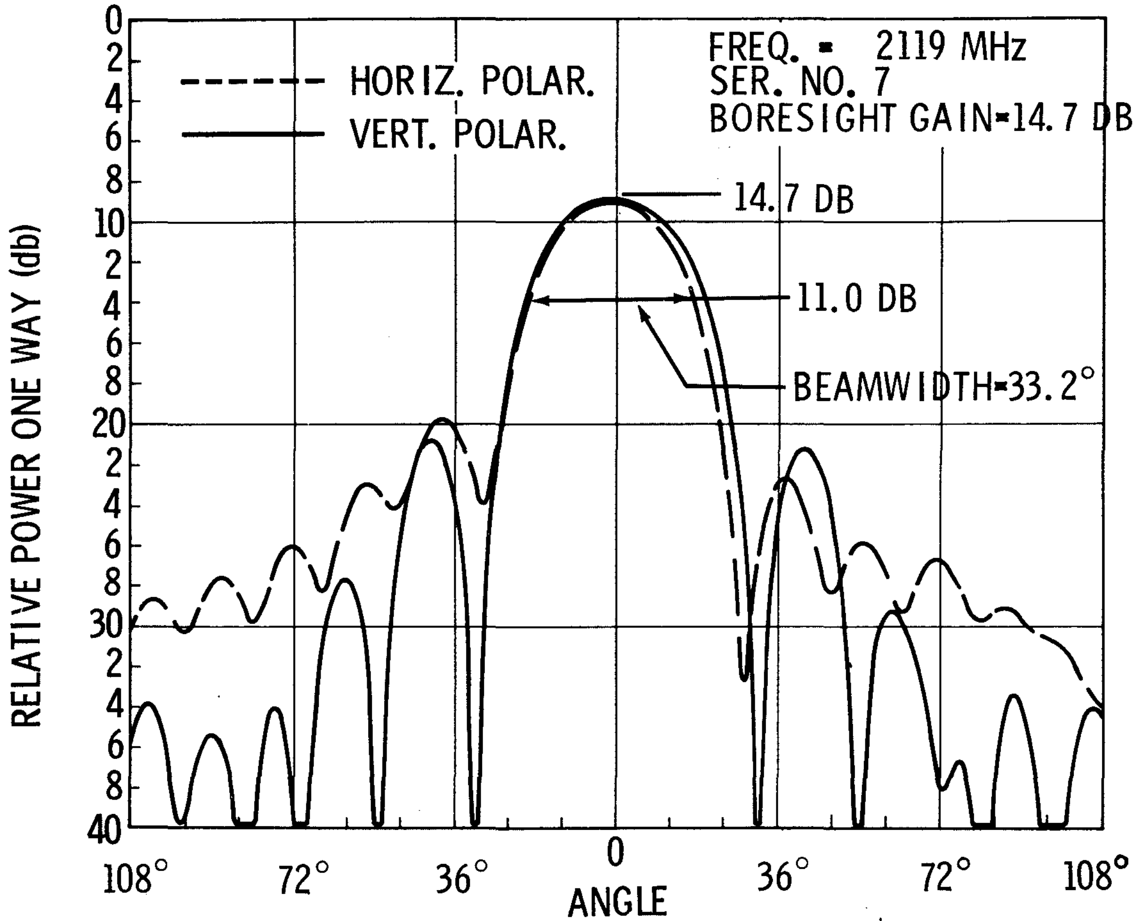


Figure 3.3-3 ANTENNA PATTERN-UPLINK

3.4 DEPLOYMENT OPERATIONS

ALSEP deployment will be performed at a time when the sun angle from the lunar horizon is 7 to 22 degrees. However, ALSEP design allows deployment at a maximum sun angle of 45 degrees.

After insertion of the fuel capsule into the Radioisotope Thermoelectric Generator (RTG), the temperature of the RTG fin tips will increase to 250°F or higher. Because of thermal limitations on the astronaut's suit, Subpackage #2 must be deployed within 25 minutes after fuel capsule insertion.

Manual control switches are provided as a backup to permit the astronaut to start ALSEP system operation in the event of failure of the uplink command subsystem. Under normal deployment conditions, the astronaut will throw Astronaut Switch #1 before he leaves the deployment site to return to the LM.

Switch #1 overrides the power hold-off circuit in the PCU. The hold-off circuit prevents operational power from being applied to the PCU oscillator drive circuitry and the data subsystem and experiments until the RTG reaches an output open circuit voltage of about 24 volts which corresponds to an output power level of 36 watts minimum.

Switch #2 provides a manual contingency capability in the event of a data subsystem failure. The astronaut may actuate this switch to manually select Data Processor Y, turn on and select Transmitter B and reset the command receiver circuit breaker, CB-01.

Switch #3 also provides a manual contingency capability by which the astronaut may activate the experiments (Experiment Power On) sequentially in 1, 2, 4, 3 order at approximately 0.1-second intervals.

A typical deployment arrangement for Array A is illustrated in Figure 3.4-1.

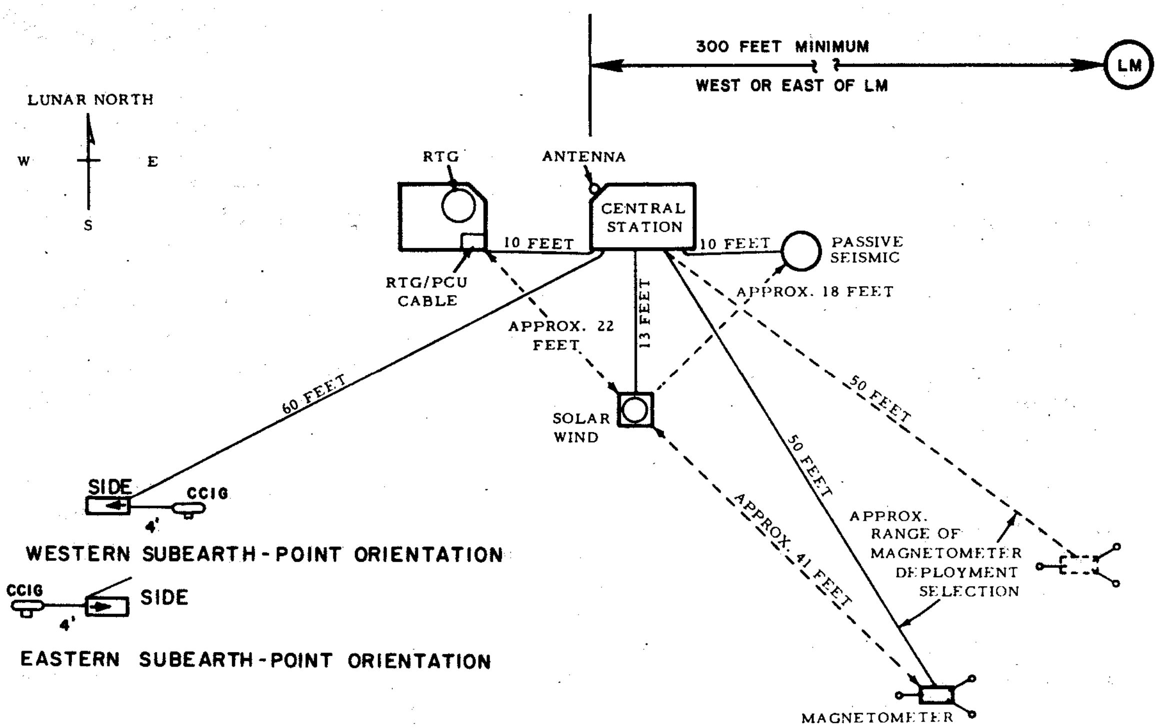


Figure 3.4-1 TYPICAL DEPLOYMENT ARRANGEMENT

3.5 PASSIVE SEISMIC EXPERIMENT (PSE)

The PSE will monitor lunar seismic activity, detect meteoroid impacts and measure tidal deformations by utilizing a set of tri-axial, orthogonal long period seismometers and a short period seismometer.

3.5.1 PSE Turn-On Sequence

In the stowed configuration the delicate PSE seismometers are protected by a caging device. To put the PSE into operation, the Uncage Arm/Fire Command 073 will be sent twice. If the uplink subsystem should fail these commands will be automatically generated by the Delayed Command Sequencer. The PSE receives a combined Uncage and Short Period Calibrate command every 12 hours from the back-up timer. The first of these commands, occurring when operational power is applied to the PSE, will Arm the Uncage circuit. The second command, 12 hours later, will Uncage the seismometer. Subsequent commands will provide a Calibrate pulse for the Short Period seismometer.

The PSE will be turned on, uncaged, leveled, calibrated and put in the scientific operational mode before the LM leaves the lunar surface. Before the PSE is uncaged, the PSE housekeeping/engineering data measurements AL-1 through AL-8 in Word 33 will be monitored to ensure that the preset states for the 15 PSE command functions are correct. Refer to Commands 063 through 103 shown in Section 5.0.

3.5.2 PSE Operational Mode

Heater power will be turned Off before a Level Motor is turned On. The order of leveling will be X-axis, Y-axis and Z-axis, sequentially.

The Feedback Filter must be switched Out for any leveling operation and switched In for the normal scientific mode.

It will not be necessary to turn a Level Motor Off before commanding a change in direction, mode or speed.

The Coarse Level Sensor will be commanded In for the initial leveling sequence only.

If the PSE needs to be turned Off, the first command to be sent would be Command 037, Standby; then Command 041, Off. The Off mode is considered highly critical because the instrument electronics are disabled, Standby heater power is disabled and there is no thermal control of the experiment.

It is undesirable to allow a Level Motor to run past its rotational stop. Although there would be no damage to the gear train, the motor might stick at the stop.

Normal operating ranges, upper and lower red-line limits for eight PSE scientific measurements and eight PSE engineering measurements are listed in Tables 3.5-1 and 3.5-2. PSE power demands are listed in Table 3.5-3 and a PSE power profile is shown in Figure 3.5-1.

3.5.3 PSE Thermal Control

The temperature of the deployed PSE is monitored as TM measurement DL-7. The PSE sensor heater thermostat provides proportional control to maintain the sensor at 125°, +2°, -0°F. Thermal control is maintained by Command 076, a four-state command which can be sequentially stepped as follows:

(1) Off : +29 vdc is disconnected from the heater
(2) Manual : +29 vdc is applied to heater. Thermostat control is disabled.
(3) Off : +29 vdc is disconnected from the heater
(4) Automatic: +29 vdc is applied to heater. Thermostat control is enabled.

Note that Command 076 does not control the heater for the PSE electronics module in the Central Station. If Command 037 is sent to put the PSE in Standby, Command 076 no longer controls the PSE sensor heater.

The temperature of the PSE sensor module affects its level characteristics. Continued operation of a Level Motor, which dissipates about 3.0 watts, could cause the PSE to overheat.

At turn-on the power transient is independent of whether it is lunar day or night, but is a function of the delta-T of the sensor with respect to the set point of 125°F.

TABLE 3.5-1 PSE SCIENTIFIC MEASUREMENTS

TM MEAS. NO.	DESCRIPTION	NORMAL OPERATING RANGE		NOMINAL VALUE	RED-LINE LIMITS	
		LOW	HIGH		LOW	HIGH
DL-1	LP Seismic X	-1 μm -0.3 μm (N) -0.1 μm -0.03 μm	+1 μm +0.3 μm (N) +0.1 μm +0.03 μm	0	Limits will be set when experience with Lunar Surface operation has been gained.	
DL-2	LP Seismic Y	-1 μm -0.3 μm (N) -0.1 μm -0.03 μm	+1 μm +0.3 μm (N) +0.1 μm +0.03 μm	0		
DL-3	LP Seismic Z	-1 μm -0.3 μm (N) -0.1 μm -0.03 μm	+1 μm +0.3 μm (N) +0.1 μm +0.03 μm	0		
DL-4	Tidal X	-25 μrad	+25 μrad	0	-20 μrad	+20 μrad
DL-5	Tidal Y	-25 μrad	+25 μrad	0	-20 μrad	+20 μrad
DL-6	Tidal Z	g_e-4 mgal	g_e+4 mgal	g_e	g_e-3.2 mgal	g_e+3.2 mgal
DL-7	Sensor Temp.	125°F	127°F	126°F	123°F	129°F
DL-8	SP Seismic Z	-1 μm at 1 Hz -0.3 μm at 1 Hz (N) -0.1 μm at 1 Hz -0.03 μm at 1 Hz	+1 μm at 1 Hz +0.3 μm at 1 Hz (N) +0.1 μm at 1 Hz +0.03 μm at 1 Hz	0	108	143

Notes: g_e Mean lunar gravity at site of ALSEP
(N) Depends on Ampl. Gain setting.

TABL 3.5-2 PSE ENGINEERING ASUREMENTS

TM MEAS. NO.	DESCRIPTION	NORMAL OPERATING RANGE		NOMINAL VALUE	RED-LINE LIMITS	
		LOW	HIGH		LOW	HIGH
AL-1	LPX, Y Gain	G_1** -0.4V	G_1*** +0.4V	G_1*	G_1** -0.4V	G_1*** +0.4V
AL-2	LPZ Gain	G_2** -0.4V	G_2*** +0.4V	G_2*	G_2** -0.4V	G_2*** +0.4V
AL-3	Level Dir./Speed	0	+0.4V	0	N.A.	+0.4V
AL-4	SPZ Gain	G_3** -0.4V	G_3*** +0.4V	G_3*	G_3** -0.4V	G_3*** +0.4V
AL-5	Level/Coarse Sens. Mode	0	+0.4V	0	N.A.	+0.4V
AL-6	Thermal Control Stat.	0	+0.4V	0	N.A.	+0.4V
AL-7	Cal. Stat. LP/SP	+2.6V	+4V	+3V	+2.6V	N.A.
AL-8	Uncage Status	N.A.	N.A.	N.A.		

Notes: * G_1, G_2 and G_3 will be selected first during initial setup and later whenever a decision is made to change the sensitivity. The possible values are 0, 1V, 2V, or 3V.

** Whenever the value selected for G_n is 0, this limit is N.A. since it is zero.

*** Whenever the value selected for G_n is 3V. the Normal Operating limit is 4V and the Red-Line limit is N.A. since it may exceed the maximum 5-volt value which can be telemetered. All values given are based on nominal instrument parameters. Actual values will deviate from nominal for each instrument and require use of Data Package Calibration Data. All values applicable for normal continuous operation. Limits are not applicable during initial setup.

TABLE 3.5-3 PSE POWER DEMANDS

COMMAND NUMBER	FUNCTION	POWER DEMAND WATTS
037	Standby Power On: (a) PSE Central Station Electronics (b) PSE Sensor Heater	4.50 3.75 0.75
036	PSE Operational Power On (sensor heater in Auto mode) Turn-On Transient (ΔT)	4.55 to 6.70 12.87 Max.
070, or 071, or 072	Level Motor On	3.05
076	Thermal Control Mode: (a) Automatic (b) Manual (c) Off	 0.20 to 2.35 2.77 -0-

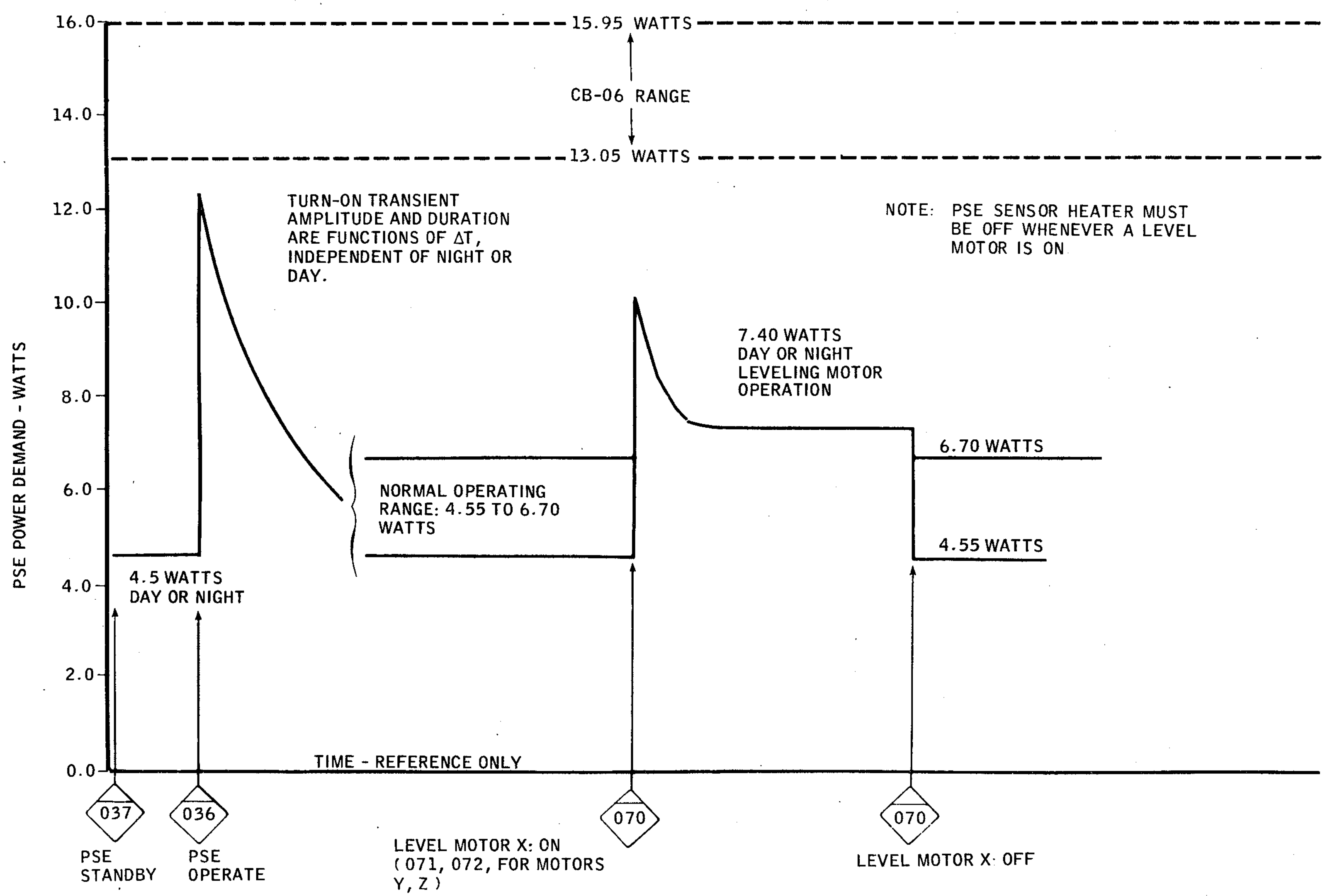


Figure 3.5-1 PSE POWER PROFILE

3.6 LUNAR SURFACE MAGNETOMETER (LSM)

The LSM will measure the magnitude and variations of the magnetic field of the lunar surface so that the electrical properties of the deep interior of the moon might be derived and the interplanetary magnetic field that diffuses through the moon might be better known. The scientific instrument portion of the LSM consists of three orthogonally oriented fluxgate magnetic sensors.

3.6.1 LSM Site Survey

A site survey, one of the three modes of LSM operation, is performed only once on receipt of ground commands after the LSM is first put into operation. A site survey is performed in each of the three axes. The purpose of the site survey is to identify and locate any magnetic influences inherent in the deployment site so that they will not affect the interpretation of the LSM data relative to the sensing of magnetic flux. The LSM site survey will be performed after the LM has left the lunar surface.

3.6.2 LSM Scientific Mode

The LSM does not have an ordinary Standby mode, only On or Off. When the LSM is commanded to Standby, the LSM is effectively Off.

The normal On condition is the scientific mode during which magnetic field sensing is accomplished.

Normal operating ranges, upper and lower red-line limits of LSM scientific and engineering measurements are listed in Table 3.6-1. LSM peak power requirements are listed in Table 3.6-2. An LSM peak power profile is shown in Figure 3.6-1.

LSM data are not transmitted at the 10600 bps high bit rate and are not useable or intelligible when the downlink telemetry data are transmitted at the 530 bps low bit rate.

3.6.3 LSM Calibration

A Flip/Cal sequence is performed automatically at 12-hour intervals, after an initial delay of 108 hours plus 1 minute, upon receipt of a command generated in the Central Station by the Delayed Command Sequencer. The Flip/Cal sequence will also be performed on receipt of ground command 131, Flip/Cal Initiate.

The purpose of the Flip/Cal mode is to determine the absolute accuracy of the flux-gate sensors and correct any drift from their laboratory calibration.

TABLE 3.6-1 LSM MEASUREMENTS

TM MEAS. NO.	DESCRIPTION		NORMAL OPERATING RANGE		NOMINAL VALUE	RED-LINE LIMITS	
			LOW	HIGH		LOW	HIGH
	Scientific Measurements:						
DM-25	X-axis Field	Decimal Counts	-511	+511	0	-511*	+511*
DM-26	Y-axis Field	Decimal Counts	-511	+511	0	-511*	+511*
DM-27	Z-axis Field	Decimal Counts	-511	+511	0	-511*	+511*
	Engineering Measurements:						
DM-1	Temp. #1 - X Sensor	°C	+30	+50	+40	-50	+85
DM-2	Temp. #2 - Y Sensor	°C	+30	+50	+40	-50	+85
DM-3	Temp. #3 - Z Sensor	°C	+30	+50	+40	-50	+85
DM-4	Temp. #4 - Base	°C	-40	+60	+20	-50	+85
DM-5	Temp. #5 - Internal	°C	-40	+60	+20	-50	+85
DM-6	Level Sensor #1	Degrees	-15	+15	0	-15 *	+15 *
DM-7	Level Sensor #2	Degrees	-15	+15	0	-15 *	+15 *
DM-8	Supply Voltage	Volts	0	+ 6	+ 5	0	+ 6

Notes:

Normal limits and red-line limits for some of the above measurements will be identical until experience has been gained in actual lunar surface operation.

* Red-line limits are sensor limits.

TABLE 3.6-2 LSM PEAK POWER REQUIREMENTS

Operational Mode	Average Power Watts	Peak Power Watts
Scientific - without heaters-day	3.45	5.8
- with heaters-night	9.1	10.85
Flip/Cal: Motor Off		
- without heaters	4.95	6.9
- with heaters	NA	11.5
Site Survey: Motor Off		
- without heaters	5.2	7.2
- with heaters	NA	12.0
Motor On	7.45	9.8
Turn-On Transient - Day	NA	10.2
Turn-On Transient - Night	NA	12.0

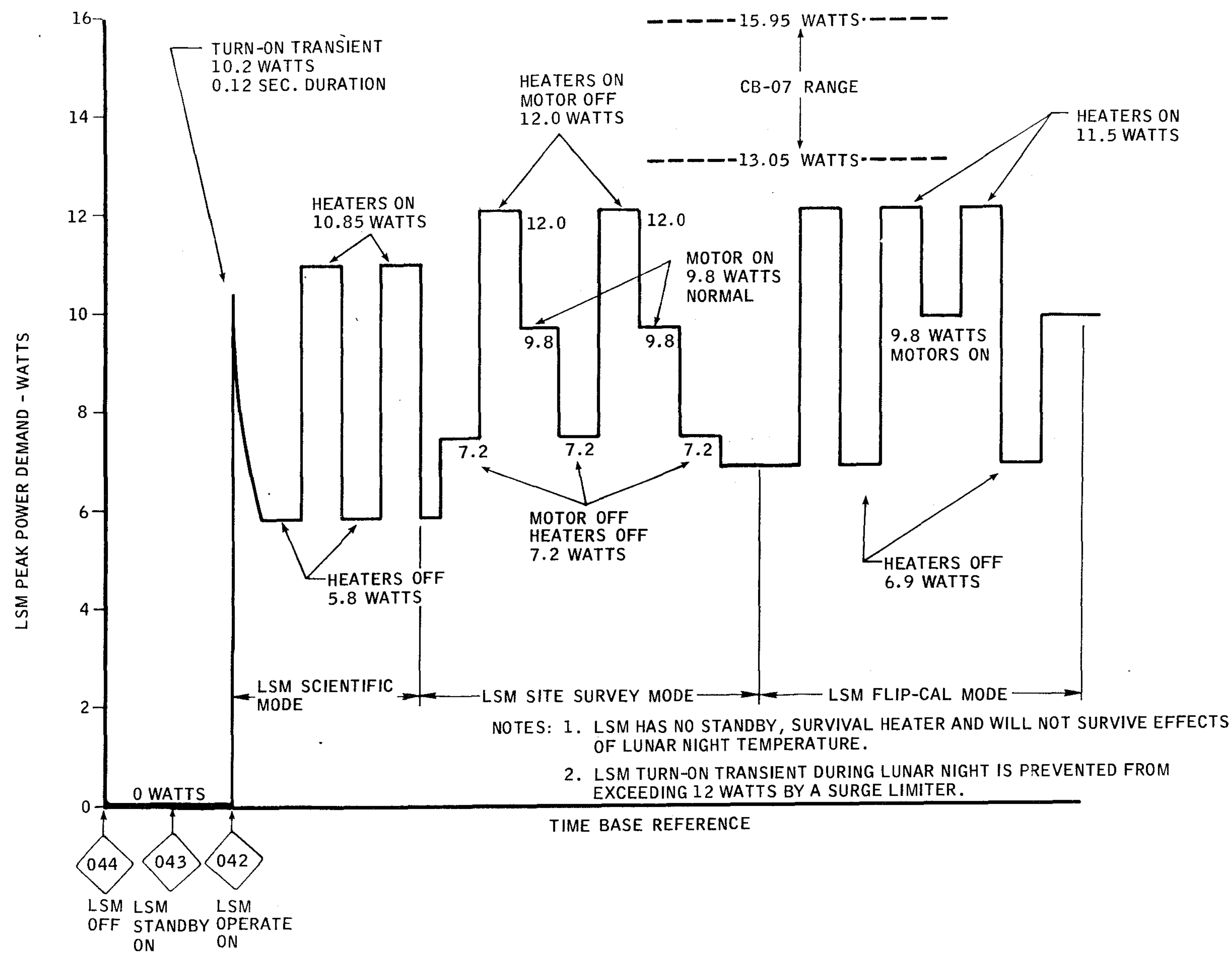


Figure 3.6-1 LSM PEAK POWER PROFILE

3.7 SOLAR WIND SPECTROMETER (SWS)

The SWS will measure energies, densities, incidence angles and temporal variations of the electron and proton components of solar wind on the lunar surface. The sensor assembly consists of seven modified Faraday cups arranged in a hexagonal cupola configuration. One cup is mounted on each of the six sides and one cup on the top of the cupola.

3.7.1 SWS Operation

The SWS is fully automatic in its operation except for the removal of the dust covers and the change of gain in the modulation amplifier.

Command 122, SWS Dust Cover Removal, will be sent after the LM has left the lunar surface and after the PI has examined at least a one-hour record of telemetered SWS data.

When Command 122 is sent three times within 10 seconds, after the SWS Dust Cover has been removed, this constitutes a Gain Change command for the SWS modulation amplifier by increasing the high voltage. A reset to the lower voltage level (low gain) is accomplished by commanding the SWS to Standby (Command 046) and then back to On (Command 045).

3.7.1 SWS Operation (Continued)

The SWS main counter is totally asynchronous with respect to the ALSEP telemetry data subystem and can be in any state when power is first applied. As a result, there is no control over what SWS data will be presented to the TM subsystem when it first samples the SWS. SWS data that is sampled during the first 28 seconds should be disregarded. Within 28 seconds after the SWS is put into operation, the proper synchronization between the SWS and TM subsystems will be achieved and SWS data can be accepted.

Normal operating ranges, upper and lower red-line limits for critical SWS telemetry measurements are shown in Table 3.7-1. The SWS power profile is illustrated in Figure 3.7-1.

3.7.2 Thermal Control

The thermal control system will maintain the temperature of the electronics between -10° and 75°C over the extreme variations in ambient lunar temperature. The nighttime heater which maintains the internal power dissipation at 6.0 watts, is activated by a temperature sensor whenever the temperature drops below 25°C. In the Standby condition the Standby heater will maintain the electronics temperature above -40°C during the night. Four telemetry measurements give the temperatures of the three electronic modules (DW-11, DW-12, DW-13) and of the sensor assembly (DW-14). See Table 3.7.1.

TABLE 3.7-1 SWS MEASUREMENTS

TM MEAS. NO.	DESCRIPTION	NORMAL OPERATING RANGE		NOMINAL VALUE	RED-LINE LIMITS	
		LOW	HIGH		LOW	HIGH
DW-3	9 mv A/D Conv. Calib.	8mv	10mv	9mv	1mv	20mv
DW-4	90mv A/D Conv. Calib.	80mv	100mv	90mv	50mv	150mv
DW-5	900mv A/D Conv. Calib.	800mv	1000mv	900mv	500mv	1500mv
DW-6	3000mv A/D Conv. Calib.	2650mv	3300mv	3000mv	1650mv	5000mv
DW-7	9000mv A/D Conv. Calib.	8000mv	9800mv	9000mv	5000mv	10,500mv
DW-11	Temp. Mod 100	-10°C	80°C	25°C	-25°C	100°C
DW-12	Temp. Mod 200	-10°C	80°C	25°C	-25°C	100°C
DW-13	Temp. Mod 300	-10°C	80°C	25°C	-25°C	100°C
DW-14	Temp. Sensor Cup Assembly	-101°C	93°C	25°C	-150°C	120°C
DW-15	Sun Angle Sensor	-0.1V	5.0V	0.0V	-1.0V	9.8V
DW-16	Programmer Voltage	4.6V	5.1V	4.95V	4.0V	6.0V
DW-17	Step Generator Voltage	0.85V	0.91V	0.88V	0.60V	1.2V
DW-18	Modulation Monitor	1.0V	1.4V	1.2V	0.60V	2.5V

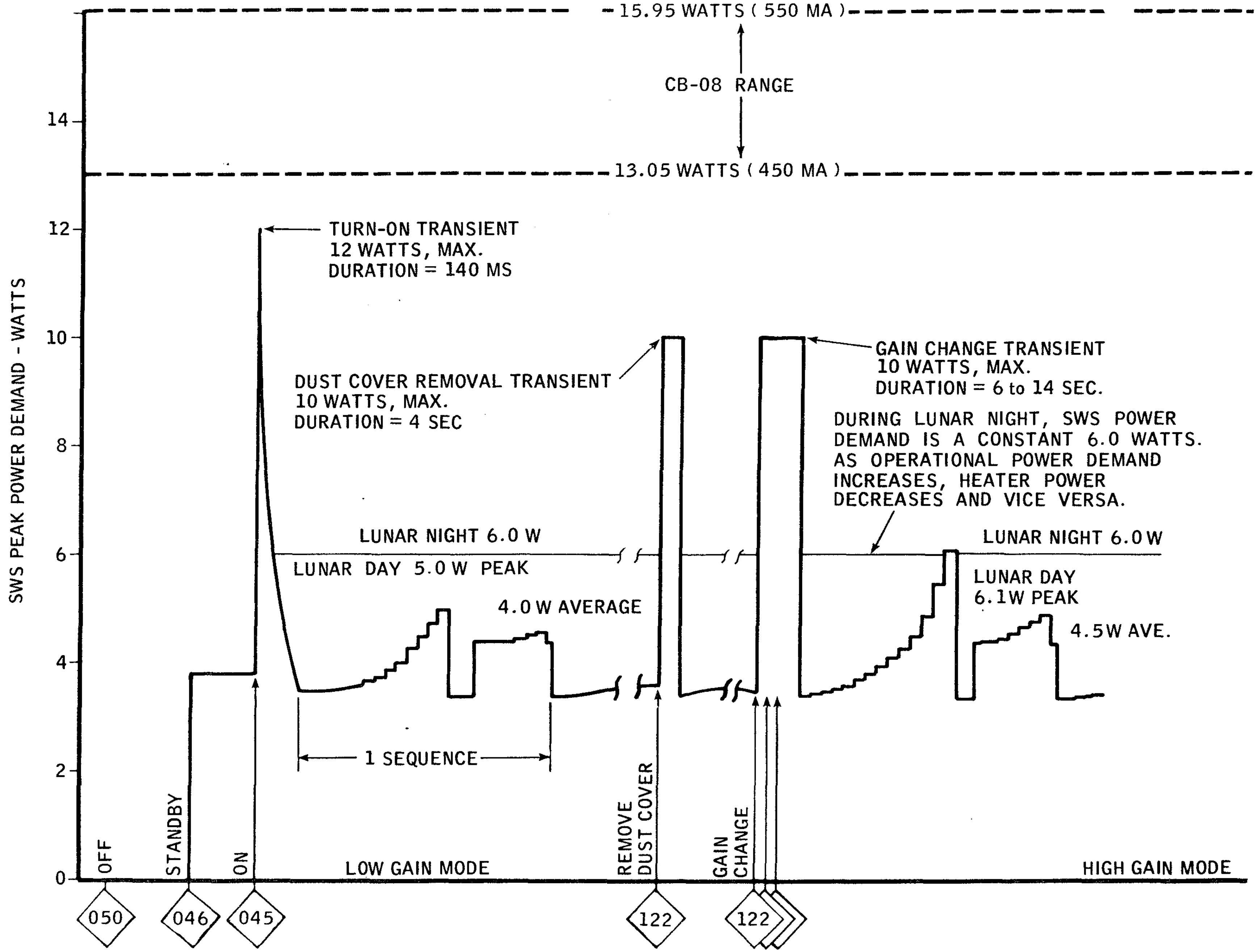


Figure 3.7-1 SWS POWER PROFILE

3.8 SUPRATHERMAL ION DETECTOR EXPERIMENT/COLD CATHODE GAUGE EXPERIMENT (SIDE/CCGE)

In the ALSEP Array A configuration, the instrument comprising the SIDE has been integrated with the instrument comprising the CCGE to constitute one combined SIDE/CCGE experiment subsystem.

The purpose of the experiment is to measure the ionic environment of the moon by detecting the ions resulting from the ultraviolet ionization of the lunar atmosphere and the free streaming and thermalized solar wind. The SIDE will measure the flux, number density, velocity, and energy per unit charge of positive ions in the vicinity of the lunar surface. The CCGE will determine the density of the lunar ambient atmosphere, including temporal variations, either of a random character or associated with lunar local time or solar activity. In addition, the rate of loss of contaminants left in the landing area by the LM and its crew will be measured by the CCGE.

The SIDE/CCGE hardware consists of a velocity filter, a low-energy curved plate analyzer ion detector, a high-energy curved plate analyzer ion detector, a cold cathode ion gauge, a wire-mesh ground plane, and associated electronics.

3.8.1 SIDE/CCGE Turn-On Sequence

Two one-time-only command sequences establish operation for the SIDE/CCGE. Details are found in Section 5.0, Command Descriptions. The first command sequence will cause the seal to be removed from the aperture of the CCGE. The second sequence will cause the SIDE dust cover to be removed. These one-time turn-on procedures will be commanded after the LM has left the lunar surface, with direction from the PI.

3.8.2 SIDE/CCGE Operation

There are five basic commands which are encoded by the SIDE/CCGE into the two one-time commands mentioned above plus fifteen operational commands. The five basic commands are:

104	SIDE Load 1
105	SIDE Load 2
106	SIDE Load 3
107	SIDE Load 4
110	Side Execute

The fifteen operational SIDE commands are listed and described in Section 5.0, ALSEP Array A Command Descriptions.

The timing for the SIDE/CCGE downlink TM data is as follows:

5 SIDE words/ALSEP main frame	= 0.604 second
2 ALSEP main frames/SIDE frame	= 1.208 seconds
128 SIDE frames/SIDE cycle	= 2.57 minutes
24 SIDE cycles/SIDE field	= 1.038 hours

Normal operating ranges, upper and lower red-line limits for critical SIDE/CCGE telemetry measurements are shown in Tables 3.8-1, 3.8-2, 3.8-3 and 3.8-4. Peak power requirements are listed in Table 3.8-5. Figure 3.8-1 shows the power profile and Figure 3.8-2 shows the programmed sensor voltage variations.

TABLE 3.8-1 SIDE/CCGE SCIENTIFIC AND ENGINEERING MEASUREMENTS

TM MEAS. NO	DESCRIPTION	NORMAL OPERATING RANGE		NOMINAL VALUE	RED-LINE LIMITS (a)	
		LOW	HIGH		LOW	HIGH
	Scientific Measurements:					
DF-5	Low Energy Data - MSD Counts per SIDE Frame	000	999	N/A	N/A	N/A
DF-6	Low Energy Data - LSD Counts per SIDE Frame	000	999	N/A	N/A	N/A
AI-1	Low Energy Detector Count Rate Counts per second	0	10^6	N/A	N/A	N/A
AI-2	High Energy Detector Count Rate Counts per second	0	10^6	N/A	N/A	N/A
DI-61	High Energy Data - MSD Counts per SIDE Frame	000	999	N/A	N/A	N/A
DI-62	High Energy Data - LSD Counts per SIDE Frame	000	999	N/A	N/A	N/A
DI-3	CCGE Output-Volts DC	$<$.015	15	N/A	N/A	15
	Engineering Measurements:					
DI-2	+5 volts analog - volts	4.5	5.3	4.9	4.4	5.5
DI-4	Temp. #1 - °K	133	413	N/A	133	413
DI-5	Temp. #2 - °C	-20	+80	N/A	-40	+85(b)
DI-6	Temp. #3 - °C	-20	+80	N/A	-40	+85(b)
DI-7	4.5 KV supply - Kilovolts	3.7	5.4	4.5	3.6(c)	5.6(c)
DI-8	CCGE Range - Count (d)	188	234	(d)	188	235
DI-9	Temp. #4 - °C	-21	+80	N/A	-40	+85(b)
DI-10	Temp. #5 - °C	-21	+80	N/A	-40	+85(b)
DI-12	Solar Cell - Volts DC(e)	$<$.015	1.02	(e)	N/A	1.03
DI-13	+60 volt supply - volts	55	65	60	53	66
DI-14	+30 volt supply - volts	27	32	29	26	33

TABLE 3.8-1 SIDE/CCGE SCIENTIFIC AND ENGINEERING MEASUREMENTS

TM MEAS NO.	DESCRIPTION	NORMAL OPERATING RANGE		NOMINAL VALUE	RED-LINE LIMITS (a)	
		LOW	HIGH		LOW	HIGH
DI-15	+ 5 volt digital supply - volts	4.5	5.3	4.9	4.4	5.5
DI-16	Ground - Volts DC	<.015	.018	<.015	N/A	.019
DI-17	- 5 volt Supply - volts	-4.5	-5.3	-4.9	-4.4	-5.5
DI-18	-30 volt supply - volts	-27	-32	-29	-26	-33
DI-19	Temp. #6 - °C	-21	+80	N/A	-40	+85(b)
DI-20	-3.5 KV supply - kilovolts	-3.37	-3.82	-3.57	-3.35(f)	-3.85(f)
DI-21	+1.0 volt Calibration - volts	0.94	1.04	0.99	0.91	1.07
DI-22	+30 MV Calibration - millivolts	24	36	30	24	37
DI-23	+A/D Reference Voltage - volts	5.8	7.6	6.6	5.6	7.8
DI-24	Dust Cover and Seal - Count (g)	000	218	(g)	N/A	219
DI-25	-A/D Reference Voltage - volts	-5.8	-7.6	-6.6	-5.6	-7.8
DI-26	-1.0 volt Calibration - volts	-0.94	-1.04	-0.99	-0.91	-1.07
DI-27	-12.0 volt Calibration - volts	-11.1	-12.4	-11.7	-10.8	-12.7
DI-28	+12.0 volt Calibration - volts	11.1	12.4	11.7	10.8	12.7
DI-29	Pre Reg. Duty Factor - volts	31.5	26.0	28.5	32.0	25.5
DI-30	-30 MV Calibration - Millivolts	-20	-37	-30	-20	-38
DF-29	One Time Command Register	000	218	(h)	N/A	219

NOTES:

(a) If Low or High Red-Line Limit is Reached, Notify PI.

(b) Command the SIDE/CCGE to Standby and Notify PI.

(c) Command the CCGE High Voltage Off and Notify PI.

TABLE 3.8-1 SIDE/CCGE SCIENTIFIC AND ENGINEERING MEASUREMENTS

NOTES: (Cont'd)

(d) CCGE Range - Count:

Range 1 = 215 to 234
Range 2 = 194 to 202
Range 3 = 189 to 194

(e) Solar Cell - Volts, DC:

Fully Dark Solar Cell = $<$ .015 vdc
Fully Lighted Solar Cell = 1.03 vdc

(f) Command the Channeltron High Voltage Off and Notify PI.

(g) Dust Cover and Seal-Count:

Dust Cover and Seal not Activated	= 197 to 218
Seal Activated	= 178 to 197
Dust Cover Activated	= 138 to 178
Dust Cover and Seal Activated	= 000 to 138

(h) One Time Command Register - Count:

One Time Command Register Preset	= 000 to 138
Octal Command 105 Received by SIDE	= 138 to 178
Octal Command 107 Received by SIDE	= 178 to 197
Octal Commands 105 and 107 Received by SIDE	= 197 to 218

TABLE 3.8-2 SIDE CURVED PLATE ANALYZER STEPPER VOLTAGES

TM. MEAS. NO.	NORMAL OPERATING RANGE - VOLTS		NOMINAL VALUE VOLTS	RED-LINE LIMITS - VOLTS	
	LOW	HIGH		LOW	HIGH
Low Energy Curved Plate Analyzer Stepper Voltages:					
DJ-98	11.24	13.24	12.20	10.94	13.60
DJ-99	3.59	4.46	4.00	3.49	4.58
DF-0	1.21	1.59	1.39	1.18	1.63
DF-1	0.356	0.58	0.455	0.345	0.595
DF-2	0.105	0.22	0.155	0.105	0.225
DF-3	0.045	0.099	0.050	N/A	0.102
DF-4	0.045	0.054	0.045	N/A	0.056
High Energy Curved Plate Analyzer Stepper Voltages:					
DI-40	398	464	432	388	469
DI-41	377	444	409	367	456
DI-42	348	409	377	338	420
DI-43	320	377	348	312	388
DI-44	287	338	312	279	348
DI-45	265	303	280	251	312
DI-46	231	272	250	225	280
DI-47	201	238	219	196	244
DI-48	171	202	186	167	207
DI-49	142	167	153	138	171
DI-50	114	134	124	111	138
DI-51	84.5	99.5	91.6	82.2	102
DI-52	57.7	68.0	62.7	56.2	69.8
DI-53	28.5	33.5	30.9	27.7	34.4
DI-54	11.43	13.45	12.40	11.12	13.82
DI-55	8.02	9.45	8.71	7.81	9.71
DI-56	5.79	6.82	6.28	5.64	7.00
DI-57	3.45	4.07	3.75	3.36	4.18
DI-58	2.29	2.70	2.49	2.24	2.78
DI-59	1.16	1.37	1.26	1.13	1.41
DI-60	0.014	0.018	0.014	N/A	0.019

Note: All Measurements are Plate-to-Ground Voltages.

TABLE 3.8-3 VELOCITY FILTER VOLTAGES

TM MEAS. NO.	NORMAL OPERATING RANGE-VOLTS		NOMINAL VALUE	RED-LINE LIMITS VOLTS	
	LOW	HIGH	VOLTS	LOW	HIGH
DI-72	13.6	16.0	14.95	13.3	16.5
DI-73	12.2	14.35	13.3	11.9	14.8
DI-74	10.95	12.9	11.9	10.7	13.2
DI-75	9.80	11.6	10.7	9.55	11.9
DI-76	8.80	10.4	9.55	8.55	10.7
DI-77	7.90	9.30	8.55	7.70	9.55
DI-78	6.70	7.90	7.30	6.55	8.10
DI-79	6.00	7.10	6.55	5.85	7.30
DI-80	5.25	6.20	5.70	5.10	6.35
DI-81	4.58	5.40	4.97	4.45	5.55
DI-82	3.89	4.58	4.23	3.79	4.71
DI-83	3.40	4.00	3.69	3.31	4.11
DI-84	2.97	3.49	3.22	2.89	3.59
DI-85	2.09	3.31	2.59	2.32	2.89
DI-86	1.92	2.39	2.14	1.87	2.45
DI-87	1.59	1.97	1.77	1.55	2.03
DI-88	1.35	1.63	1.50	1.31	1.72
DI-89	1.09	1.35	1.21	1.06	1.39
DI-90	0.92	1.15	1.03	0.895	1.18
DI-91	0.825	1.03	0.92	0.805	1.06
DI-92	7.45	8.80	8.10	7.30	9.05
DI-93	7.10	8.35	7.30	6.90	8.55
DI-94	6.35	7.45	6.90	6.20	7.70
DI-95	5.70	6.70	6.20	5.55	6.90
DI-96	5.10	6.00	5.55	4.97	6.20
DI-97	4.46	5.25	4.84	4.34	5.40
DI-98	4.00	4.71	4.34	3.89	4.84
DI-99	3.49	4.11	3.79	3.40	4.23
DJ-0	2.97	3.69	3.31	2.89	3.79
DJ-1	2.59	3.22	2.89	2.52	3.31
DJ-2	2.20	2.74	2.45	2.14	2.81
DJ-3	1.87	2.32	2.08	1.82	2.39
DJ-4	1.68	2.08	1.87	1.63	2.14
DJ-5	1.35	1.68	1.50	1.31	1.72
DJ-6	1.09	1.35	1.21	1.055	1.39
DJ-7	0.92	1.15	1.03	0.895	1.18
DJ-8	0.72	0.945	0.825	0.700	0.970
DJ-9	0.61	0.805	0.700	0.595	0.825
DJ-10	0.52	0.680	0.595	0.505	0.70
DJ-11	0.465	0.610	0.535	0.455	0.63
DJ-12	4.46	5.25	4.84	4.34	5.40
DJ-13	4.00	4.76	4.34	3.89	4.84

NOTE: All Measurements are Plate-to-Ground Voltages.

TABLE 3.8-3 VELOCITY FILTER VOLTAGES

TM MEAS. NO.	NORMAL OPERATING RANGE-VOLTS		NOMINAL VALUE	RED-LINE LIMITS VOLTS	
	LOW	HIGH	VOLTS	LOW	HIGH
DJ-14	3.59	4.23	3.89	3.49	4.34
DJ-15	3.31	3.89	3.59	3.22	4.00
DJ-16	2.97	3.49	3.22	2.89	3.59
DJ-17	2.52	3.13	2.81	2.45	3.22
DJ-18	2.14	2.66	2.39	2.08	2.74
DJ-19	1.97	2.45	2.20	1.92	2.52
DJ-20	1.77	2.20	1.97	1.72	2.26
DJ-21	1.50	1.87	1.68	1.46	1.92
DJ-22	1.28	1.59	1.42	1.24	1.63
DJ-23	1.09	1.35	1.21	1.06	1.39
DJ-24	0.945	1.18	1.06	0.920	1.21
DJ-25	0.740	0.970	0.850	0.610	1.00
DJ-26	0.610	0.805	0.700	0.595	0.825
DJ-27	0.505	0.665	0.580	0.495	0.680
DJ-28	0.420	0.550	0.480	0.410	0.565
DJ-29	0.335	0.465	0.395	0.330	0.480
DJ-30	0.285	0.420	0.345	0.280	0.430
DJ-31	0.265	0.385	0.320	0.255	0.395
DJ-32	2.39	3.13	2.74	2.32	3.22
DJ-33	2.17	2.89	2.52	2.14	2.97
DJ-34	2.03	2.66	2.32	1.97	2.74
DJ-35	1.82	2.39	2.08	1.77	2.45
DJ-36	1.59	2.08	1.82	1.55	2.14
DJ-37	1.42	1.87	1.63	1.39	1.92
DJ-38	1.21	1.59	1.39	1.18	1.63
DJ-39	1.12	1.46	1.28	1.09	1.50
DJ-40	0.970	1.28	1.12	0.945	1.31
DJ-41	0.850	1.12	0.970	0.825	1.15
DJ-42	0.700	0.970	0.825	0.680	1.00
DJ-43	0.595	0.825	0.700	0.580	0.850
DJ-44	0.525	0.720	0.610	0.505	0.740
DJ-45	0.420	0.580	0.495	0.410	0.595
DJ-46	0.335	0.495	0.410	0.330	0.505
DJ-47	0.270	0.420	0.335	0.265	0.430
DJ-48	0.230	0.345	0.280	0.220	0.355
DJ-49	0.175	0.300	0.230	0.170	0.310
DJ-50	0.150	0.270	0.200	0.145	0.280
DJ-51	0.135	0.245	0.180	0.130	0.250
DJ-52	1.46	1.815	1.63	1.42	1.87
DJ-53	1.31	1.63	1.46	1.28	1.68
DJ-54	1.18	1.46	1.31	1.15	1.50
DJ-55	1.085	1.345	1.21	1.06	1.39
DJ-56	0.945	1.24	1.09	0.920	1.28

NOTE: All Measurements are Plate-to-Ground Voltages

TABLE 3.8-3 VELOCITY FILTER VOLTAGES

TM MEAS. NO.	NORMAL OPERATING RANGE-VOLTS		NOMINAL VALUE	RED-LINE LIMITS VOLTS	
	LOW	HIGH	VOLTS	LOW	HIGH
DJ-57	0.825	1.09	0.945	0.805	1.12
DJ-58	0.680	0.945	0.805	0.665	0.970
DJ-59	0.610	0.85	0.720	0.610	0.870
DJ-60	0.550	0.760	0.645	0.535	0.780
DJ-61	0.465	0.645	0.550	0.455	0.665
DJ-62	0.410	0.565	0.480	0.395	0.580
DJ-63	0.335	0.495	0.410	0.330	0.505
DJ-64	0.300	0.440	0.365	0.295	0.455
DJ-65	0.220	0.355	0.280	0.210	0.365
DJ-66	0.185	0.300	0.235	0.180	0.310
DJ-67	0.140	0.255	0.190	0.135	0.260
DJ-68	0.110	0.210	0.155	0.110	0.220
DJ-69	0.090	0.200	0.135	0.085	0.205
DJ-70	0.075	0.170	0.115	0.075	0.175
DJ-71	0.065	0.170	0.105	0.065	0.175
DJ-72	0.780	1.090	0.920	0.760	1.120
DJ-73	0.700	0.970	0.825	0.680	1.000
DJ-74	0.645	0.895	0.760	0.630	0.920
DJ-75	0.580	0.805	0.680	0.565	0.825
DJ-76	0.505	0.740	0.610	0.493	0.760
DJ-77	0.455	0.665	0.550	0.440	0.680
DJ-78	0.385	0.565	0.465	0.375	0.580
DJ-79	0.335	0.495	0.410	0.330	0.505
DJ-80	0.295	0.455	0.365	0.285	0.465
DJ-81	0.255	0.395	0.320	0.250	0.410
DJ-82	0.220	0.335	0.270	0.210	0.345
DJ-83	0.185	0.300	0.235	0.180	0.310
DJ-84	0.155	0.265	0.200	0.150	0.270
DJ-85	0.120	0.220	0.160	0.115	0.225
DJ-86	0.090	0.190	0.135	0.090	0.195
DJ-87	0.075	0.160	0.110	0.075	0.165
DJ-88	0.060	0.145	0.090	0.055	0.150
DJ-89	0.045	0.130	0.075	N/A	0.135
DJ-90	0.045	0.115	0.065	N/A	0.120
DJ-91	0.045	0.110	0.060	N/A	0.110
DJ-92	8.80	45.0	14.8	8.55	45.0
DJ-93	8.80	45.0	13.3	8.55	45.0
DJ-94	8.80	45.0	11.9	8.55	45.0
DJ-95	8.80	45.0	10.7	8.55	45.0
DJ-96	8.80	45.0	9.55	8.55	45.0
DJ-97	8.80	45.0	16.5	8.55	45.0

NOTE: All Measurements are Plate-to-Ground Voltages

TABLE 3.8-4 SIDE GROUND PLANE VOLTAGES

GROUND PLANE STEP NUMBER TM MEAS. NO. DI-63	GROUND PLANE VOLTAGE TM MEAS. NO. DI-11 NORMAL OPERATING RANGE -VDC LOW	 HIGH	 NOMINAL VALUE VDC
000	-2.73	+2.099	-0.415
001	-1.98	+2.98	+0.400
002	-1.21	+3.89	+1.238
003	-0.415	+4.83	+2.099
004	+0.400	+4.79	+2.98
005	+1.24	+6.77	+3.89
006	+2.099	+7.79	+4.83
007	+4.83	+11.00	+7.79
008	+8.83	+15.71	+12.13
009	+13.29	+20.96	+16.97
010	+15.71	+23.81	+19.60
011	+23.81	+30.00	+26.82
016	-2.73	+2.099	-0.415
017	-3.46	+1.238	-1.21
018	-4.18	+0.400	-1.98
019	-4.87	-0.415	-2.73
020	-4.87	-0.415	-2.73
021	-5.54	-1.21	-3.46
022	-7.46	-3.46	-5.54
023	-9.78	-6.20	-8.06
024	-11.86	-8.65	-10.32
025	-17.27	-15.01	-16.18
026	-20.56	-18.89	-19.72
027	-28.29	-26.55	-27.57

TABLE 3.8-5 SIDE/CCGE PEAK POWER REQUIREMENTS

COMMAND NUMBER	FUNCTION	POWER DEMAND
105, 110	Remove CCIG Seal	No Change in Power Demand
107, 110	Blow SIDE Dust Cover	11.2 watts for 2.5 seconds
053	Standby Power On: (a) Above +8°C (b) Below +8°C	 2.0 watts 6.0 watts
052	Operational Power On: (a) Turn-On Transient (b) Above +8°C (c) Below +8°C	 13.3 watts for 0.120 seconds 6.0 watts 10.0 watts

0 - 5V

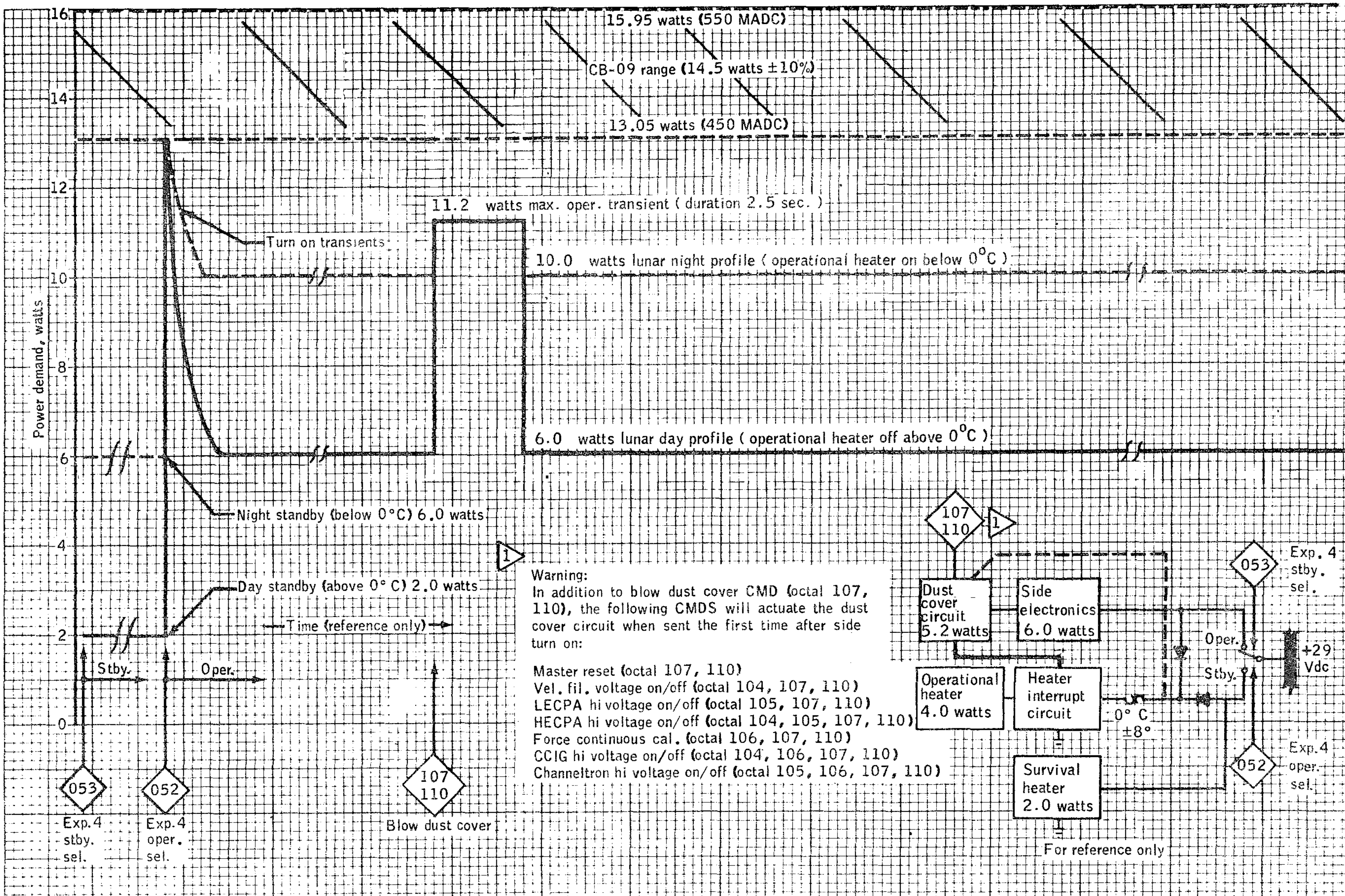


Figure 3.8-1 SIDE POWER PROFILE

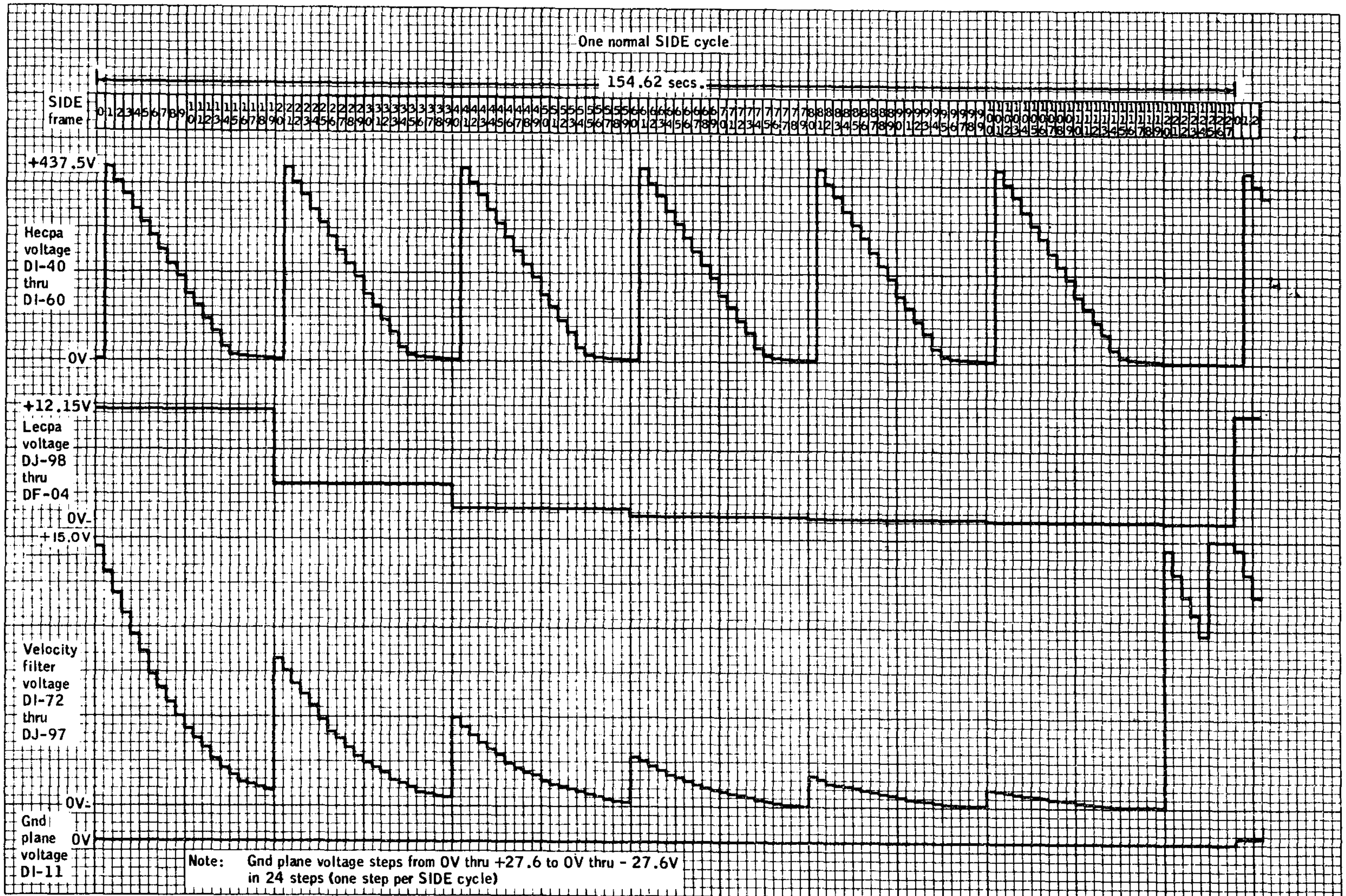


Figure 3.8-2 Programed sensor voltage variations.

4.0 CONSTRAINTS AND LIMITATIONS

This section presents constraints and limitations which must be considered in ALSEP mission planning and operations. The constraints are intended to assure that planned procedures do not conflict with ALSEP capabilities. The associated operational limitations are parameter bounds, both nominal and red-line, which apply to ALSEP Array A operation. If the restrictions are not observed, system degradation or failure may result.

The constraints and limitations are discussed in this section under individual subsystem headings. Complementary performance and operational data are presented under similar headings in Section 3.0.

4.1 STRUCTURAL/THERMAL CONTROL SUBSYSTEM

4.1.1 Thermal Control

Upon removal from the LM SEQ Bay, Subpackages #1 and #2 must not be shaded from the sun more than absolutely necessary prior to deployment.

The temperature of the Central Station radiator must not exceed the limits shown in Figure 3.3-1. The normal operating ranges, upper and lower red-line limits of the 13 structural-thermal temperature measurements on the Central Station are shown in Table 3.1-1.

Astronaut handling constraints based on the thermal control limitations on the RTG Fuel Cask have been omitted from this document because they are so intimately crew-related and will be defined in a Flight Crew Operations Directorate document entitled, "Lunar Surface Operations Plan."

4.2 ELECTRICAL POWER SUBSYSTEM (EPS)

Experiment commands and operations must be coordinated in order to avoid power overloads which could cause ripple-off of an experiment. Specific EPS constraints are defined in the text and tables of Section 4.2 while normal, operating power characteristics are shown in Section 3.2.

4.2.1 Radioisotope Thermoelectric Generator (RTG)

Thermal equilibrium and stabilized electrical power output of the RTG are not achieved until approximately 1.5 hours after the fuel capsule has been placed in the RTG. Full scale operation of the ALSEP via ground commands should not be attempted until after this stabilization period. Prior to the time when the astronaut connects the cable from the RTG to the Central Station, the RTG output is shorted by means of the astronaut connector.

In order to prevent overheating and possible damage to the RTG, a constant load must be maintained on the RTG at all times after fueling. The current drawn from the generator by this load reduces the generator "hot side" temperature and thus prevents the generator from overheating and causing a degradation effect on the thermoelectric couples. The RTG is a power limited device. Attempts to draw system power in excess of rated maximum generator power will cause the Power Conditioning Unit (PCU) output voltages to drop out of tolerance. For normal, operating RTG parameters, see Section 3.2. RTG temperatures must not exceed the red-line limits shown in Table 3.2-3. Constraints on the deployment and emplacement of the RTG are shown in Table 4.2-1.

4.2.2 Power Conditioning Unit (PCU)

After the ALSEP has been deployed and the cable connected from the RTG to the Central Station, the PCU starts automatically. The PCU has a hold-off circuit which prevents PCU turn-on until the output power is about 36 watts. Thereafter, no command must be sent which will cause an increase in load greater than the reserve power as shown by the calculations illustrated in Table 3.2-2.

If an automatic switchover from PCU #1 to PCU #2 has occurred, Command 060, PCU #1 Select, must be flagged as highly critical because there was obviously a malfunction in PCU #1.

Command 062 selects PCU #2. Since there is no automatic switchover from PCU #2 to PCU #1, this command is highly critical and should be executed only after determining that PCU #1 is on the verge of failing.

The astronaut must throw Astronaut Switch #1, which overrides the PCU power hold-off circuit before he leaves the ALSEP deployment site to return to the LM.

TABLE 4.2-1 RTG DEPLOYMENT CONSTRAINTS

Parameter	Constraint
Separation between RTG and Central Station	9 to 13 feet. Limited by 13-foot cable. Hot RTG should be away from Subpackage #1 to avoid contact with astronaut, and to provide maximum heat radiation to free space.
RTG Orientation from Central Station	East or West of Subpackage #1 $\pm$ 20° as eyeballed by astronaut to minimize thermal load on Subpackage #1.
RTG Deployment Site	Horizontal site. Pallet must be horizontal $\pm$ 10°, as eyeballed by astronaut. No mechanical provisions for astronaut to level RTG. Astronaut will avoid craters and slopes which impede dissipation of heat from RTG.
RTG Alignment	No critical constraint: Astronaut will align so as to favor RTG cable exit toward Subpackage #1.
Interrelation	RTG requires maximum view of space to maximize heat radiation. Astronaut will read ammeter on shorting switch box, connect RTG to Central Station, actuate switch.

4.2.3 Power Distribution Unit (PDU)

If the Ripple-Off Sequencer has detected minimum reserve power as described in Section 3.2.3, one or more experiments will have been automatically commanded to Standby. The experiments in Standby can only be put back in the Operate condition by ground commands if an adequate power reserve is available. Refer to Table 3.2-5.

In the Standby mode, each of the four ALSEP Array A experiments is protected by a 500 milliamp fuse. If one of these fuses should open, the Standby capability for that experiment is permanently disabled. See Table 4.2-2.

The two Power Dissipation Resistors must be commanded In or Out of the PDU circuitry as necessary to maintain a proper level of reserve power. Reserve power calculations are shown in Table 3.2-2. PDR #1, a 7-watt resistor, is commanded On or Off line by Commands 017 and 021 respectively. PDR #2, a 14-watt resistor, is commanded On or Off by Commands 022 and 023 respectively. The status of both PDR's must be monitored and coordinated with all experiment operational commands to assure a safe overall power profile.

A listing of the PDU circuit breakers, their application and the effect if a circuit breaker should trip are shown in Table 4.2-3.

TABLE 4.2-2 ALSEP ARRAY A FUSE TABULATION

SYMBOL NUMBER	RATING IN MILLIAMPS	CIRCUIT VOLTAGE	ALSEP SUBSYSTEM	EFFECT
F-01	250	-12	Dust Detector	If F-01 opens, TM measurements of photoelectric cell voltages, AX-04, AX-05, and AX-06 are lost.
F-02	250	+12	Dust Detector	If F-02 opens, all 6 Dust Detector TM Measurements, AX-01 through AX-06, are lost.
F-03	500	+29	PSE	If F-03 opens, PSE Standby capability is lost.
F-04	500	+29	LSM	If F-04 opens, LSM reverts to Power Off mode since the LSM Standby condition is essentially the Off mode.
F-05	500	+29	SWS	If F-05 opens, SWS Standby capability is lost.
F-06	500	+29	SIDE/CCGE	If F-06 opens, SIDE/CCGE Standby capability is lost.

SYMBOL NUMBER	RATING IN MILLIAMPS	CIRCUIT VOLTAGE	ALSEP SUBSYSTEM	EFFECT
CB-01	110 to 225	+12	Command Receiver	If overload trips CB-01, 1.25-watt receiver heater is switched into circuit. CB-01 is reset every 12 hours by the 12-hour timer pulse.
CB-02	110 to 225	+12	Transmitter A	If CB-02 trips, Transmitter B is switched on.
CB-03	560 to 840	+29	Transmitter A	If CB-03 trips, Transmitter B is switched On.
CB-04	110 to 225	+12	Transmitter B	If CB-04 trips, Transmitter A is switched On.
CB-05	560 to 840	+29	Transmitter B	If CB-05 trips, Transmitter A is switched On.
CB-06	450 to 550	+29	PSE	If overload trips CB-06, PSE goes into Standby.
CB-07	450 to 550	+29	LSM	If CB-07 trips, LSM goes into a Power Off mode, which is the condition which the LSM Standby mode represents.
CB-08	450 to 550	+29	SWS	If overload trips CB-08, SWS goes into Standby.
CB-09	450 to 550	+29	SIDE/CCGE	If overload trips CB-09, SIDE/CCGE goes into Standby.

NOTE: CB-02 through CB-08 are self-resetting circuit breakers.

4.3 CENTRAL STATION

The red-line limits of Central Station operation are shown in the measurement tables of Section 3.3. Table 4.3-1 lists the Central Station deployment constraints. Central Station power limitations are shown in Table 4.3-2.

4.3.1 Transmitter

Referencing Transmitter A and B Power Doubler Current measurements shown in Table 3.3-1, note that if the 250 milliamp power doubler current is exceeded, maximum transistor junction temperature will also be exceeded and a catastrophic failure is imminent. Normally there will be a minimum of switching from one transmitter to another. However, if there is a choice, Transmitter A, serial number 12 should be utilized during the lunar night operations because power doubler current is higher, more heat is dissipated and temperature will be a little higher. Transmitter B, serial number 14 should be utilized for lunar day operation since it is a little cooler running. If there is a rising trend in power doubler current, the transmitters should be switched.

A maximum of four different scientific packages will transmit simultaneously from the lunar surface. The ALSEP telemetry subsystem includes redundant transmitters, A and B. Transmitter A is selected during the normal lunar surface turn-on sequence. Either Transmitter A or B may be selected by Command 012 and 015, respectively. In the event of transmitter failure and the loss of uplink command capability during the initial turn-on sequence, the astronaut will set Astronaut Switch No. 2 which manually selects and turns on Transmitter B. A switch from one to the other of the two redundant transmitters will result in a temporary loss of synchronization at the MSFN receiving sites.

Transmitter Off Command 014 will be sent in contingency situations only.

TABLE 4.3-1 CENTRAL STATION DEPLOYMENT CONSTRAINTS

PARAMETER	CONSTRAINT
Central Station - LM Separation	300 to 1000 ft. At minimum distance, the LM ascent engine blast should not harm ALSEP. At maximum distance, astronaut is limited by PLSS, safety rules.
Central Station Orientation from LM	Due West or East of LM, preferably West. Must not be deployed in shadow of LM.
Central Station Deployment Site	Approximately horizontal, as visually determined by astronaut to provide stable base for antenna. Must avoid craters and slopes which would degrade thermal control of unit.
Central Station Leveling	Within 5° of horizontal as noted by astronaut on bubble level. Leveling procedure interacts with alignment procedure.
Central Station Alignment	$\pm 5^{\circ}$ of East-West as aligned by astronaut using partial compass rose. Alignment affects thermal control capability of Subpackage #1. Closed or curtained sides of Central Station must face East-West.
Interrelation	Central Station, as with most ALSEP subsystems, requires clear field-of-view for both thermal control and scientific data reasons. Central Station must not be shaded from the sun more than absolutely necessary prior to deployment. ALSEP design allows deployment when sun angle is between 7 and 45 degrees. ALSEP may be removed from LM when bottom of SEQ Bay is from 18 to 60 inches from lunar surface and with a 15 degree tilt in any direction.

TABLE 4.3-2 CENTRAL STATION POWER LIMITATIONS

FUNCTION	RED-LINE LIMITS
PCU #1 Shunt Regulator	50.9 watts, max. 0.11 watts, min.
PCU #2 Shunt Regulator	50.9 watts, max. 0.093 watts, min.
Power Dissipation Resistor #1	6.65 watts
Power Dissipation Resistor #2	13.3 watts
PCU #1 Central Station Load	18.4 watts, min. 22.4 watts, max.
PCU #2 Central Station Load	17.4 watts, min. 22.4 watts, max.
Commandable Central Station Heaters	Standby: 5.2 watts Operate: 10.2 watts
PCU #1 Load Prior to Ripple-off	46.54 watts, max.
PCU #2 Load Prior to Ripple-Off	46.75 watts, max.

4.3.2 Receiver

If the input signal level to the ALSEP uplink command receiver should drop below -101 dbm, the allowable bit error rate of 10^{-9} will be exceeded and overall performance of the uplink subsystem will be degraded.

There is no ground command control capability for the selection of local oscillators. However, telemetry temperature measurements AT-21 and AT-22 indicate which local oscillator, A or B respectively, is in use.

The receiver is protected by a circuit breaker, CB-01, in the +12 vdc input line. If an overload occurs and the circuit breaker trips, it may be reset by two methods. Astronaut Switch No. 2 on the Central Station may be manually set by the astronaut, thereby resetting CB-01. Also, CB-01 is automatically reset every 12 hours by a recurring pulse from the timer starting at Package Elapsed Time-Zero.

4.3.3 Dust Detector

Dust Detector operation is controlled by On and Off ground Commands 027 and 031 respectively. The Dust Detector must not be commanded On unless there are at least 0.5 watts of reserve power available.

4.3.4 Timer

If necessary, the delayed command functions initiated by the Timer may be inhibited by sending Command 033, Timer Output Inhibit. Transmission of this command results in the generation of a 12-hour output pulse.

In the event of an uplink failure the timer will repetitively initiate the generation of the following commands every 12 hours. See paragraph 3.3.4 and Table 3.3-4.

a. Receiver Circuit Breaker Reset
b. PSE Short Period Calibrate/PSE Uncage
c. LSM Flip/Calibrate Initiate
d. SIDE/CCGE Operational Power On

The Timer also provides a one-time non-repetitive pulse 720 $\pm$ 30 days after turn-on which results in an Off command to the ALSEP transmitter, thereby preventing any further transmissions.

4.3.5 Command Decoder

There are 65 functional commands which will be accepted by the ALSEP Array A command decoder. See Section 5.0, ALSEP Array A Command Descriptions.

Command word rate is limited by the command decoder to approximately one message per second during a normal mode of operation and to approximately one message per two seconds during the slow mode of operation.

If the uplink should be unavailable for any reason, six delayed commands are generated within the command decoder. The six command functions and their times of execution are shown in Table 3.3-4.

4.3.6 Data Processor

In the event of failure of Data Processor X and the loss of uplink command capability during the initial turn-on sequence the astronaut may set Astronaut Switch No. 2 which manually selects Data Processor Y.

Whenever there is a switch from one to the other of the redundant data processors, there will be a temporary loss of synchronization at the MSFN receiving site. If the switchover was initiated by ground command, there will also be a loss of, or error in, the command verification word.

The normal telemetry downlink bit rate of 1060 bits per second is automatically selected by the data processor during the initial turn-on sequence and can additionally be selected by Command 006. If the nominal allowable bit error rate of 10^{-4} is exceeded at the receiving sites, a decision will be made whether to send Command 007 to set the data processor to the low bit rate of 530 bps in order to obtain more accurate reception of the downlink signal. However, at the 530 bps low bit rate the Lunar Surface Magnetometer data is not useable.

4.3.7 Diplexer Switch

In the normal initial condition when transmitter A is selected, the diplexer switching coil is de-energized. When transmitter B is selected the diplexer switching coil is energized by + 12vdc and is therefore, a less reliable state for the diplexer switch. Isolation provided by the circulators is approximately 30 db.

4.3.8 Multiplexer

Channels 37 and 82 of the 90-channel multiplexer no longer contain valid temperature measurements of the Hot Frame and Cold Frame for the ALSEP Array A RTG. Instead, a fixed resistor has been substituted for the sensor in these two TM channels. See Table 3.2-3.

4.3.9 Antenna

Antenna deployment constraints are listed in Table 4.3-3. Ground support personnel must independently determine antenna azimuth and elevation settings and confirm the settings chosen by the astronaut via voice communication.

TABLE 4.3-3 ANTENNA DEPLOYMENT CONSTRAINTS

Parameter	Constraint
Site Selection	Attached to Subpackage #1
Antenna Leveling	Within 0.55° of vertical. Astronaut will use bubble level to adjust. Level adjustment interacts with alignment.
Antenna Alignment	± 0.50° of East-West line, With reference to sun line. Astronaut will use sun dial to align.
Antenna Azimuth Setting	Astronaut will set dial to value indicated on Antenna Aiming Tables for landing site chosen.
Antenna Elevation Setting	Astronaut will set dial to value indicated on Antenna Aiming Tables for landing site chosen.
Special Requirements	1. Maximum Allowed Errors for Astronaut Alignment: a. Scale Setting: 0.25° b. Leveling: 0.50° c. Shadow Alignment: 0.70° d. Overall Mean: 1.16°

4.4 PASSIVE SEISMIC EXPERIMENT (PSE)

4.4.1 PSE Turn-On Constraints

Constraints on the deployment of the PSE are listed in Table 4.4-1.

The normal turn-on sequence for the PSE automatically puts certain command functions into a preset state. However, before leveling, the following prerequisite modes must be verified:

(a) Feedback Filter: Out. Command 101
(b) Coarse Level Sensor: In. Command 102. Check word 33, channel 24.
(c) Level Mode: Automatic. Command 103. Check word 33, channel 24.
(d) Thermal Control Mode: Off. Command 076. Check word 33, channel 39.
(e) Reserve Power: Adequate per PSE Power Profile, Figure 3.5-1.

Note for mode (a) that the verification of Feedback Filter Out is a comparison of the long period seismic and long period tidal data on the recorders. However, if the PSE is initially off level, this check cannot be made.

Survival thermal control power must be provided to the PSE within 90 minutes after removal of the ALSEP from the LM. Activation of the functional portion of the PSE may be delayed as long as 5 days after removal from the LM.

4.4.2 PSE Thermal Constraints

The temperature of the PSE must be maintained at $125 \pm 18^{\circ}F$. Normally, this is accomplished by the automatic PSE thermal control subsystem consisting essentially of a proportional heater and a superinsulating thermal shroud. The backup capability consists of manual and automatic command operation of the PSE heater. Heater power demand, in the Auto mode, is a function of the sensor temperature deviation from the control set point of $125^{\circ}F$. While it is true that more power will be drawn during the lunar night, it is not expected that the heater power will fluctuate over the total available span of 0.20 watts to 2.35 watts between day and night. However, during deployment and initial operation, the sensor temperature is expected to be below the set point regardless of the solar angle. This will result in a maximum available power demand of 2.35 watts for several hours after initial turn-on of the PSE.

The PSE sensor heater must be turned Off every time a leveling motor is activated. Simultaneous operation of the heater and a leveling motor should be considered only in a contingency situation. Only one leveling motor must be operated at a time. The order of leveling is X-axis, Y-axis, and Z-axis, sequentially. A leveling motor should not be allowed to run past its stop.

If command 037 is sent to put the PSE in Standby, then Command 076 will no longer control the sensor heater. Note that at no time does Command 076 control the heater for the PSE electronics module in the Central Station.

The PSE must not be commanded Off during lunar night. Instead, survival capability is ensured in the Standby mode which activates a separate heating element.

Red-line limit constraints on the operation of the PSE were listed in Tables 3.5-1, 3.5-2 and 3.5-3.

TABLE 4.4-1 PSE DEPLOYMENT CONSTRAINTS

PARAMETER	CONSTRAINT
PSE - to - Central Station Separation	8 to 10 feet. Limited by 10-foot cable. 8-feet minimum separation due to thermal heat from RTG.
PSE Orientation from Central Station	Due East or West of Central Station as eyeballed by astronaut. Must be out of field-of-view of Central Station radiator.
PSE Deployment Site	Approximately level spot, free from loose material. Should be a "quiet" location as chosen by astronaut.
PSE Leveling	Must be coarse leveled by astronaut within ± 5 degrees of vertical because 5 degrees is the limit of the automatic, fine-leveling gimbal system.
PSE Alignment	Astronaut must rough align within ± 20 degrees of lunar East, before opening PSE shroud, by pointing arrow on the sensor girdle towards the sun. Fine alignment will be performed by the astronaut after removing girdle and spreading the thermal shroud. Astronaut will read and record, to the nearest degree, the intersection of the shadow of the gnomon on the compass rose. Final azimuth alignment must be known within ± 5 degrees accuracy with reference to lunar North or South.
Interrelation	PSE must be no less than 10 feet from other units to minimize pickup of stray vibrations by PSE.

4.5 LUNAR SURFACE MAGNETOMETER (LSM)

4.5.1 LSM Turn-On Constraints

The LSM will be commanded to perform a site survey sequence only once after the LSM is first put into operation on the lunar surface. The site survey must be preceded by exactly four Flip/Cal sequences. One Flip/Cal sequence should be performed prior to LM ascent.

There must be exactly four Flip/Calibrate cycles before a Site Survey is performed. The LSM Site Survey must not be performed while the astronauts are still on the lunar surface.

One of the delayed command functions initiated by the timer is LSM Flip/Calibrate which is triggered at 108 hours plus one minute and every 12 hours thereafter. This sequence can be initiated only after the Site Survey has been completed. Command 127, Flip/Cal Inhibit will prevent any execution of the delayed command if four Flip/Cal's have been completed but the Site Survey has not been completed.

Constraints on the deployment of the LSM are shown in Table 4.5-1.

4.5.2 LSM Operational Constraints

LSM data is not intelligible when the downlink telemetry data is transmitted at the low data rate of 530 bps.

Command 127, Flip/Cal Inhibit, must be considered highly critical because of the possibility of loss of uplink command capability. Command 127 inhibits not only Command 131, Flip/Cal Initiate, but also the automatically generated Flip/Cal Initiate command from the Delayed Command Sequencer.

The LSM does not have a Standby mode, only On and Off. Command 044 which turns the LSM Off should be given only in a contingency situation. If the LSM is commanded Off and its temperature drops as low as -50°C, the LSM may be permanently disabled. The LSM has no Standby/Survival heater and will not survive the effects of lunar night temperatures. When the LSM is commanded to Standby, the LSM is actually Off.

Red-line limits for selected LSM measurements are shown in Table 3.6-1.

TABLE 4.5-1 LSM DEPLOYMENT CONSTRAINTS

Parameter	Constraint
Separation between LSM and Central Station	40 to 55 feet. Limited by 55-foot cable. Separation required to minimize EMI effects on LSM sensors.
LSM Orientation from Subpackage #1	On opposite side of Subpackage #1 from LM $\pm 20^{\circ}$ as eyeballed by astronaut. Required to minimize magnetic and EMI influences on LSM.
LSM Deployment Site	Approximately horizontal site free from loose material. Astronaut will eyeball site for maximum stability for experiment.
LSM Leveling	$\pm 3^{\circ}$ of vertical. Support legs adjusted by astronaut using bubble level on LSM. Leveling procedure interacts with alignment. LSM includes Level Sensors #1 and #2. Sensor data is telemetered as TM measurements DM-6, DM-7.
LSM Alignment	$\pm 3^{\circ}$ of East-West sun line. Set by astronaut using color-coded leg towards East, then Shadowgraph. Astronaut must read Shadowgraph within $\pm 1^{\circ}$. Alignment is critical because thermal control is critical and because exact alignment is required to interpret LSM scientific data.
Interrelation	LSM must be 80 feet, preferably 100 feet from SIDE/CCGE which contains strong magnet. Magnet could perturbate LSM scientific data if closer. LSM Site Survey must not be performed while astronauts are still on lunar surface.

4.6 SOLAR WIND SPECTROMETER (SWS)

4.6.1 SWS Turn-On Constraints

Deployment constraints are listed in Table 4.6-1.

Command 122, SWS Dust Cover Removal must not be sent until after the LM has left the lunar surface and the PI has examined at least a one-hour record of SWS data.

4.6.2 SWS Operational Constraints

Except for the removal of the dust covers and the change of modulator gain, the SWS is fully automatic in its operation. To command a gain change from low to high, Command 122 must be sent three times within 10 seconds. A reset from high gain/high voltage to low gain/low voltage can only be accomplished by commanding the SWS from On to Standby to On. SWS power control commands for On, Off and Standby are 045, 050 and 046 respectively.

SWS data that is received during the first 28 seconds after the SWS is commanded On must be disregarded because it takes almost 28 seconds for the SWS main counter to come into synchronization with the ALSEP telemetry counter.

SWS input power requirements must not exceed 6.5 watts except during starting transients and dust cover removal. Starting transients must not exceed 12 watts except during the first 30 microseconds and must not exceed 6.5 watts longer than 50 milliseconds. Total power during dust cover removal must not exceed 10 watts and shall not exceed 6.5 watts longer than 5 seconds. SWS Standby power requirement is 3.8 watts at 131 milliamps. The survival heaters in modules 100 and 200 draw 1.2 watts each, and that in module 300 draws 1.4 watts to comprise the 3.8 watt total. Each of the two redundant heaters to remove the dust covers draws only 0.6 watts. See Figure 3.7-1. Red-line limit constraints for telemetered SWS measurements are listed in Table 3.7-1.

TABLE 4.6-1 SWS DEPLOYMENT CONSTRAINTS

Parameter	Constraint
SWS - to - Central Station Separation	12 to 13.5 feet. Limited by 15-ft. cable.
SWS Orientation from Central Station	Approximately due North or South. Less than 30° from N-S line. Astronaut must eyeball direction.
SWS Deployment Site	Approximately horizontal site to avoid thermal perturbations. Astronaut must eyeball site.
SWS Leveling	± 5° of vertical about its E-W hinge axis. Due to A-frame construction, there is a pendulum effect about E-W axis. SWS should swing freely. If not, the Astronaut may nudge it with handling tool. No leveling about N-S axis is necessary since N-S orientation is determined from sun sensor TM data. Astronaut can estimate level of instrument by observing shadows cast by triangular surfaces on the sensor mounting plate.
SWS Alignment	± 5° of East-West. Rough align by making arrow point E or W with respect to sun line. Fine align by setting N-S orange triangular faces equally in shade. Louvered side (radiator) must be away from RTG and Subpackage #1 due to thermal control requirement.
Interrelation	No other subsystem may subtend a solid angle greater than 0.03 steradian at the SWS site (total solid angle = 4π steradians). SWS location should be in an area of reduced susceptibility to seismic activity.

4.7 SUPRATHERMAL ION DETECTOR EXPERIMENT/COLD CATHODE GAUGE EXPERIMENT (SIDE/CCGE)

4.7.1 SIDE/CCGE Turn-On Constraints

Deployment constraints for the SIDE/CCGE are listed in Table 4.7-1.

Survival heater power must be provided to the experiment no later than 90 minutes after removal of the ALSEP from the LM. Operating power must be provided no later than 6 days after removal of ALSEP from the LM. The SIDE must survive with the dust cover in place for a maximum of four days after deployment, while consuming not more than 6.0 watts of thermal control survival power.

The one-time command sequences establish operational capability for the SIDE/CCGE. Command 105 followed by Command 110 will cause seal removal from the aperture of the CCIG. This procedure will be commanded after the turn-on sequence and before the second EVA. Similarly, Command 107 followed by Command 110 will cause SIDE dust cover removal. This procedure will be commanded no sooner than 30 minutes after LM ascent. Neither of these one-time sequences are to be commanded until specifically directed by the PI.

4.7.2 SIDE/CCGE Operational Constraints

Red-line limit constraints for the SIDE/CCGE telemetered measurements are shown in various tables in Section 3.8. Peak power demands are listed in Table 3.8-5 and illustrated in Figure 3.8-1.

TABLE 4.7-1 SIDE/CCGE DEPLOYMENT CONSTRAINTS

Parameter	Constraint
SIDE - to - Central Station Separation	50 to 60 feet. Limited by 60-foot cable. Minimum 50 feet needed to minimize EMI on LSM experiment.
SIDE Orientation from LSM	$110^{\circ} \pm 10^{\circ}$ from LSM site. SIDE - LSM separation must be 80 feet minimum, preferably 100 feet.
SIDE Site Selection	Smooth as eyeballed by astronaut to allow ground screen and SIDE emplacement.
SIDE Leveling	Must be $\pm 5^{\circ}$ of vertical. Astronaut will utilize bubble level during emplacement.
SIDE Alignment	$\pm 5^{\circ}$ of East-West line, with respect to sun line to satisfy SIDE thermal and scientific data - gathering requirements. Astronaut will align unit utilizing direction marking which indicates which end of the experiment must face the sub-earth point. The large side areas of the experiment must face in a N-S direction for proper thermal control. Final alignment by astronaut utilizing shadows on long sides of SIDE.
CCGE - SIDE Separation	3.5 to 4 feet, limited by cable. CCGE must be off the SIDE ground screen.
CCGE Alignment	Orifice must be $\pm 20^{\circ}$ of North-South line, oriented so it has a clear field of view, away from all other subsystems and the LM.
Interrelation	CCGE includes a strong magnet which would affect LSM if separation is not at least 80 feet.

5.0 ARRAY A COMMAND DESCRIPTIONS

5.1 COMMAND SUMMARY

5.1.1 Central Station Command Summary

There are a total of 36 Central Station commands, three of which control the Data Processor; 33 commands control the Power Distribution Unit.

5.1.2 Experiment Command Summary

There are a total of 29 experiment commands. Of these, 15 control the Passive Seismic Experiment, one controls the Solar Wind Spectrometer, eight control the Lunar Surface Magnetometer and five control the Suprathermal Ion Detector/Cold Cathode Gauge Experiment. The five octal commands to the SIDE/CCGE are further encoded to execute two one-time-only commands and perform 15 operational functions. See Table 5.2-4.

5.2 COMMAND DESCRIPTIONS

5.2.1 Central Station Command Descriptions

Central Station commands are described in Tables 5.2-1 (Central Station Data Processor Command Descriptions) and 5.2-2 (Central Station Power Distribution Unit Command Descriptions).

5.2.2 Experiment Command Descriptions

The experiment commands are described in Tables 5.2-3 through 5.2-7 as follows:

Table 5.2-3	Passive Seismic Experiment Command Descriptions
Table 5.2-4, 5.2-5	Suprathermal Ion Detector/Cold Cathode Gauge Experiment Command Summary Sequences
Table 5.2-6	Solar Wind Spectrometer Command Descriptions
Table 5.2-7	Lunar Surface Magnetometer Command Descriptions

TABLE 5.2-1 CENTRAL STATION DATA PROCESSOR COMMAND DESCRIPTIONS

Octal Command Number	Command Title	Command Description	Remarks
006	Normal Bit Rate	Sets Data Processor to 1060 bps, normal bit rate, at the end of the word frame in progress.	Preset condition: 1060 bps
007	Low Bit Rate	Sets Data Processor to 530 bps, low bit rate, at the end of the word frame in progress.	Preset condition: 1060 bps
011	Normal Bit Rate Reset	Resets Data Processor to normal bit rate from either the high or low bit rate. Command is effective immediately, not delayed until the end of the word frame in progress.	May lose sync at ground station or cause error in command verification word.

TABLE 5.2-2 CENTRAL STATION POWER DISTRIBUTION UNIT COMMAND DESCRIPTIONS

Octal Command Number	Command Title	Command Description	Remarks
012	Transmitter A Select	Selects Transmitter A	Preset condition: Transmitter A
013	Transmitter On	Turns selected Transmitter On and turns Transmitter heater Off	Preset condition: Transmitter Off
014	Transmitter Off	Turns selected Transmitter Off and turns Transmitter heater On	Preset condition: Transmitter Off
015	Transmitter B	Selects Transmitter B	Preset condition: Transmitter A
017	Power Dissipation Resistor #1 On	Applies power to 7-watt resistor to optimize load on PCU.	Actuates relay K-16, applies +29 vdc.
021	Power Dissipation Resistor #1 Off	Removes power from 7-watt resistor to optimize load on PCU.	Actuates relay K-16, removes +29 vdc.
022	Power Dissipation Resistor #2 On	Applies power to 14-watt resistor to optimize load on PCU.	Actuates relay K-17, applies +29 vdc.
023	Power Dissipation Resistor #2 Off	Removes power from 14-watt resistor to optimize load on PCU.	Actuates relay K-17, removes +29 vdc.
024	Data Subsystem Heater #3 On	Applies power to thermostat-controlled, 10-watt heater on Central Station thermal plate.	Preset condition programmed in during final checkout.
025	Data Subsystem Heater #3 Off	Removes power from thermostat-controlled, 10-watt heater on Central Station thermal plate.	Programmed during final checkout to On.
027	Dust Detector On	Activates Dust Detector.	
031	Dust Detector Off	Deactivates Dust Detector.	One-state command.
032	Timer Output Acceptance	Gates the timer output pulses, thus enabling the Delayed Command Sequencer	Timer generates 12-hour and one-minute pulses.

TABLE 5.2-2 CENTRAL STATION POWER DISTRIBUTION UNIT COMMAND DESCRIPTIONS (Continued)

Octal Command Number	Command Title	Command Description	Remarks
033	Timer Output Inhibit	Inhibits gating of the timer output pulses, thus inhibiting the Delayed Command Sequencer.	This command must be considered highly critical.
034	Data Processor X Select	Applies power to Data Processor X; removes power from Data Processor Y. At turn-on, Data Processor is set to 1060 bps.	Transmission of Command 034 and 035 may cause loss of sync or error in Command Verification Word. Preset condition programmed in during final checkout.
035	Data Processor Y Select	Applies power to Data Processor Y; removes power from Data Processor X.	At turn-on, Data Processor is set to 1060 bps.
036	PSE Operational Power On	Applies power to PSE and to sensor heater. Removes power from PSE standby heater in Central Station.	
037	PSE Standby Power On	Applies power to PSE standby heaters in Central Station and PSE sensor assembly. Deactivates PSE.	Preset condition programmed in during final checkout.
041	PSE Standby Off	Removes power from both PSE standby heaters in Central Station and sensor assembly.	Command 041 has no effect if PSE is On. Command 037 must be sent first.
042	LSM Operational Power On	Applies power to LSM.	
043	LSM Standby Power On	Deactivates LSM. LSM has no standby heater.	LSM is effectively Off in this mode. Preset condition programmed in during final checkout.
044	LSM Standby Off		If LSM is On, Command 044 has no effect. Command 044 must be preceded by Command 043.
045	SWS Operational Power On	Applies power to SWS; deactivates SWS Standby heater.	
046	SWS Standby Power On	Deactivates SWS and applies voltage to SWS Standby heater.	Preset condition programmed in during final checkout.

TABLE 5.2-2 CENTRAL STATION POWER DISTRIBUTION UNIT COMMAND DESCRIPTIONS (Continued)

Octal Command Number	Command Title	Command Description	Remarks
050	SWS Standby Off	Removes power from SWS Standby heater.	If the SWS is On, Command 050 has no effect. Command 050 must be preceded by Command 046.
052	SIDE/CCGE Operational Power On	Applies power to SIDE/CCGE and to the SIDE heater.	052 is also generated by Delayed Command Sequencer.
053	SIDE/CCGE Standby Power On	Deactivates SIDE/CCGE; applies voltage to SIDE heater.	Preset condition programmed in during final checkout.
054	SIDE/CCGE Standby Off	Removes power from SIDE heater.	If SIDE/CCGE is On, Command 054 has no effect. Command 054 must be preceded by 053.
055	Data Subsystem Heater #1 Select	Applies power to 10-watt heater to maintain thermal balance.	10-watt heater and 5-watt heater (Commands 055 and 056) cannot be energized simultaneously.
056	Data Subsystem Heater #2 Select	Applies power to 5-watt heater to maintain thermal balance.	5-watt heater and 10-watt heater (Commands 056 and 055) cannot be energized simultaneously.
057	Data Subsystem Heater #2 Off	Removes power from 5-watt heater #2.	If Heater #1 is On, Command 057 has no effect. Command 057 must be preceded by 056. Preset condition programmed in during final checkout.
060	PCU #1 Select	Applies power to PCU #1 and de-energizes PCU #2.	Preset condition: PCU #1. If automatic switchover to PCU #2 has occurred, this command is highly critical.
062	PCU #2 Select	Applies power to PCU #2 and de-energizes PCU #1.	This command is highly critical since there is no automatic switch-back from PCU #2 to PCU #1.

TABLE 5.2-3 PASSIVE SEISMIC EXPERIMENT COMMAND DESCRIPTIONS

Octal Command Number	Command Title	Command Description	Remarks
063	Gain Change: Long Period-X, Long Period-Y: (LP-X),(LP-Y)	Four-state command attenuates PSE signal into Long Period-X and -Y amplifiers to provide gain control of LP-X and LP-Y axis signals.	Preset condition: -30 db attenuation. Stepping sequence is -30, 0, -10, -20 db.
064	Gain Change: LP-Z	Four-state command attenuates PSE signal into Long Period-Z amplifier to provide gain control signal.	Preset condition: -30 db attenuation. Stepping sequence is -30, 0, -10, -20 db.
065	Calibration: Short Period (SP) On/Off	Two-State command to turn On or Off the Short Period calibration circuitry.	Preset condition: Off
066	Calibration: LP On/Off	Two-state command to turn On or Off the Long Period calibration circuitry.	Preset condition: Off
067	Gain Change: SP-Z	Four-state command attenuates PSE signal into Short Period-Z amplifier to provide gain control signal.	Preset condition: -30 db attenuation. Stepping sequence is -30, 0, -10, -20 db.
070	Leveling Power: X-Motor On/Off	Two-state command turns X-axis motor On or Off.	Only one (X, Y, or Z) motor must be operated at a time.
071	Leveling Power: Y-Motor On/Off	Two-state command turns Y-axis motor On or Off.	Only one (X, Y or Z) motor must be operated at a time.
072	Leveling Power: Z-Motor On/Off	Two-state command turns Z-axis motor On or Off.	Only one (X, Y or Z) motor must be operated at a time.
073	Uncage Arm/Fire	Two-state command. First transmission arms PSE actuator circuit. Second transmission fires actuator circuit and uncages all spring mass systems.	073 is also generated by Delayed Command Sequencer.
074	Leveling Direction Plus/Minus	Two-state command to control direction of rotation of X-axis, Y-axis and Z-axis leveling motors.	Preset Condition: Plus.

TABLE 5.2-3 PASSIVE SEISMIC EXPERIMENT COMMAND DESCRIPTIONS (Continued)

Octal Command Number	Command Title	Command Description	Remarks
075	Leveling Speed: Low/High	Two-state command to control speed of X-axis, Y-axis and Z-axis leveling motors.	Preset at Low speed.
076	Thermal Control Mode: Auto/Manual	Four-state command. Sequentially steps through the following modes to control the PSE sensor heater: (a) +29 volts is removed from heater. (b) +29 volts is applied to heater; thermostat control is disabled. (c) +29 volts is removed from heater. (d) +29 volts is applied to heater; thermostat control is enabled.	Preset to Auto. Has no effect when PSE is in Standby.
101	Feedback Filter In/Out	Two-state command inserts or removes feedback loop filters from LP-X, LP-Y and LP-Z axes.	Preset condition: Out
102	Coarse Level Sensor In/Out	Two-state command inserts or removes coarse level sensors controlling X-axis and Y-axis leveling motors.	Preset condition: Out
103	Leveling Mode: Auto/Manual	Two-state command, controls the operational mode X-axis, Y-axis and Z-axis leveling motors.	Preset condition: Automatic leveling.

TABLE 5.2-4 SIDE/CCGE COMMAND SUMMARY

The SIDE/CCGE Commands consist of 2 discrete, one-time command sequences and 15 operational command sequences, 17 total. Each of the 17 commands is effected by transmission of a unique combination of octal commands 104, 105, 106 and 107; and by 110, the execute code. All of the 17 SIDE/CCGE Commands require use of the octal code 110 for execution. Note that operational command #15, Reset Command Register, utilizes all five of the octal combinations and is effectively a "clear" command which can be used in the event of an error during the command transmission sequence. The commands are encoded as follows:

Type Command		Command Description	Octal Command Sequence				
One-Time Commands	A.	Break CCIG Seal	105	110			
	B.	Blow SIDE Dust Cover	107	110			
Operational Commands	1.	Ground Plane Step Programmer On/Off	104	110			
	2.	Reset SIDE Frame Counter at 10	105	110			
	3.	Reset SIDE Frame Counter at 39	104	105	110		
	4.	Reset Velocity Filter at 9	106	110			
	5.	Reset SIDE Frame Counter at 79	104	106	110		
	6.	Reset SIDE Frame Counter at 79 and Velocity Filter Counter at 9	105	106	110		
	7.	X10 Accumulation Interval On/Off	104	105	106	110	
	8.	Master Reset	107	110			
	9.	Velocity Filter Voltage On/Off	104	107	110		
	10.	Low Engergy CPA High Voltage On/Off	105	107	110		
	11.	High Energy CPA High Voltage On/Off	104	105	107	110	
	12.	Force Continuous Calibration	106	107	110		
	13.	CCIG High Voltage On/Off.	104	106	107	110	
	14.	Channeltron High Voltage On/Off	105	106	107	110	
	15.	Reset Command Register	104	105	106	107	110

TABLE 5.2-5 SIDE/CCGE COMMAND SEQUENCES

Octal Command Number	Command Title	Command Description	Remarks
	<u>One-Time Commands</u>		
105, 110	Break CCGE Seal	Irreversibly breaks CCGE Seal and simultaneously resets the SIDE Frame counter at Frame 10.	Also generated by the Delayed Command Sequencer at hour 96.
107, 110	Blow SIDE Dust Cover	Irreversibly blows SIDE Dust Cover and simultaneously activates the SIDE master reset.	Also generated by the Delayed Command Sequencer at hour 96.
	<u>Operating Commands</u>		
1. 104, 110	Ground Plane Step Programmer On/Off	Two-state command turns programmer On or Off to start or stop stepping sequence.	Steps through 24 voltage levels; one step per SIDE cycle. See Figure 3.8-2. Preset condition: On.
2. 105, 110	Reset SIDE Frame Counter at 10.	Mode command that steps SIDE Frame Counter to frame 10, then resets to zero.	Activated by same code that breaks CCIG Seal.
3. 104, 105	Reset SIDE Frame Counter at 39.	Mode command that steps SIDE Frame Counter to frame 39, then resets to zero.	
4. 106, 110	Reset Velocity Filter at 9.	Mode command that causes the Velocity Filter to execute only 10 of the normal 20-step programs.	
5. 104, 106, 110	Reset SIDE Frame Counter at 79.	Mode command that steps SIDE frame counter to frame 79, then resets to zero.	
6. 105, 106, 110	Reset SIDE Frame Counter at 79, Velocity Filter Counter at 9.	Mode command that simultaneously performs operations normally performed separately by commands 106, 110 and 104, 106, 110.	

TABLE 5.2-5 SIDE/CCGE COMMAND SEQUENCES (Continued)

Octal Command Number	Command Title	Command Description	Remarks
7. 104, 105, 110	X10 Accumulation Interval On/Off	A two-state command which selects one of two accumulation time periods. The On command selects X10 (12 seconds) and the Off command selects X1 (1.2 seconds).	The time period is the interval for accumulation of the high and low energy curved plate analyzer output pulses at each analyzer.
8. 107, 110	Master Reset	Mode command to return SIDE to the normal operational mode.	Activated by same commands that blow dust cover (i.e., 107, 110).
9. 104, 107, 110	Velocity Filter Voltage On/Off	Two-state command to connect or remove Velocity Filter step voltages. On connects; Off removes. Preset condition: On.	Upon retransmitting the command, the Velocity Filter assumes the voltage level of the SIDE frame in progress.
10. 105, 107, 110	Low Energy CPA High Voltage On/Off	Two-state command to connect or remove Low Energy Curved Plate Analyzer (LECPA) step voltages. On connects; Off removes. Preset condition: On	Upon retransmitting the command, the LECPA assumes the voltage level of the SIDE frame in progress.
11. 104, 105, 107, 110	High Energy CPA High Voltage On/Off	Two-state command to connect or remove High Energy Curved Plate Analyzer (HECPA) step voltages. On connects; Off removes.	Upon retransmitting the command, the HECPA assumes the voltage level of the SIDE frame in progress.
12. 106, 107, 110	Force Continuous Calibration (Reset to 120)	Mode command causes a reset to SIDE frame 120, then steps through to frame 127 before repeating.	No scientific data can be transmitted during calibration.
13. 104, 106, 107, 110	Cold Cathode Ion Gauge High Voltage On/Off	Two-state command to connect or disconnect high voltage to the CCGE sensor, turning On or Off all CCGE scientific data.	Preset to On.

TABLE 5.2-5 SIDE/CCGE COMMAND SEQUENCES (Continued)

Octal Command Number	Command Title	Command Description	Remarks
14. 105, 106, 107, 110	Channeltron High Voltage On/Off	Two-state command to connect or disconnect high voltage from SIDE sensor, thereby turning On or Off all SIDE scientific data.	Preset to On.
15. 104, 105, 106, 107, 110	Reset Command Register	This command clears command register of any SIDE command awaiting execution.	Can be used anytime prior to transmission of 110 execute code to nullify previous transmission code errors.

TABLE 5.2-6 SOLAR WIND SPECTROMETER COMMAND DESCRIPTIONS

Octal Command Number	Command Title	Command Description	Remarks
122	SWS Dust Cover Removal	Blows Dust Cover on SWS.	To be sent only after LM ascent, and after the P.I. has examined at least a one-hour record of data. Dust cover removal command is also initiated at hour 96 by Delayed Command Sequencer
122	Gain Change	If, after Dust Cover removal, this same command 122 is sent three times in succession within a 10-second period, a high voltage gain change occurs in the SWS modulation amplifier.	Two-state command 122 switches sequentially from low particle energy range to high particle energy range. No other commands alter the SWS operational mode.

TABLE 5.2-7 LUNAR SURFACE MAGNETOMETER COMMAND DESCRIPTIONS

Octal Command Number	Command Title	Command Description	Remarks
123	LSM Range Select	Three-state command sequentially steps through three ranges - 400, 100 and 200 gammas; one step per command.	Preset to 400 gammas.
124	Steady Field Offset	Controls field offset of X-, Y- and Z-axis sensors by stepping through a sequence of the following seven values, at one step per command: 0, +25, +50, +75, -75, -50 and -25 percent of full scale.	Preset to 0 percent, repeats in the same sequence. Desired axis is selected by command 125, Steady Field Offset Address.
125	Steady Field Offset Address	Controls axis for steady field command, by stepping through four states, in the following order: Neutral, X-axis, Y-axis and Z-axis.	Preset to the Neutral state; command repeats stepping the same sequence.
127	Flip/Cal Inhibit In/Out	Enables or inhibits the LSM Flip/Calibrate sequence. Command activates one of two states, Inhibit or Enable.	Preset to Inhibit. Command is highly critical because of the possibility of Uplink loss.
131	Flip/Cal Initiate	Initiates the Flip/Cal cycle, by means of a one-state command. LSM returns to the normal scientific mode after Flip/Cal sequence has been completed.	This function is also activated by Delayed Command Sequencer every 12 hours after hour 108.
132	LSM Filter Failure In/Out Bypass	Two-state command to insert or remove digital filter in or out of circuit.	Preset condition: Filter In.
133	LSM Site Survey	Activates Site Survey sequence generator to the X-, Y-, and Z-axis sequentially; one axis survey per command.	Preset to X-axis survey.
134	Temperature Control	Selects one of two LSM sensor heater thermostats. This is a three-state command that operates sequentially in the order X, Y and Off. In the Off position, sensor heater power is removed.	Preset to the X-axis thermostat.