Apollo Lunar Surface Experiments Package

Apollo 17 ALSEP (ARRAY E) Familiarization Course Handout
For Training Purposes Only
BSR 3270
1 September 1972
Contract NAS 9-5829

Prepared for
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
by
Bendix Aerospace Systems Division
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APOLLO LUNAR SURFACE EXPERIMENTS PACKAGE

ALSEP
- A PACKAGE OF SCIENTIFIC INSTRUMENTS AND SUPPORTING
  SUBSYSTEMS FOR USE ON THE LUNAR SURFACE
- CARRIED ON APOLLO, DEPLOYED BY ASTRONAUT
- TWO-YEAR CONTINUOUS OPERATION (5-YEAR GOAL) FOR
  APOLLO 17. PREVIOUS ALSEP'S HAD ONE-YEAR DESIGN LIFE.

FEB 72 3270.1.1
### MISSION ASSIGNMENTS

<table>
<thead>
<tr>
<th>ALSEP EXPERIMENT</th>
<th>LOCATION</th>
<th>11</th>
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<td>LUNAR SURFACE MAGNETOMETER</td>
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<td>HEAT FLOW EXPERIMENT</td>
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<td>LASER-RANGING RETRO-REFLECTOR</td>
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FEB 72 3270.1.3
APOLLO 17 (ARRAY E) MISSION ASSIGNMENTS

• SECOND GENERATION OF LUNAR SCIENTIFIC MEASUREMENTS:

  - LUNAR SURFACE GRAVIMETER FOR INVESTIGATION OF GRAVITY FIELDS
    (PI: JOSEPH WEBER, UNIVERSITY OF MARYLAND)

  - LUNAR MASS SPECTROMETER FOR ATMOSPHERIC SPECTRUM ANALYSIS
    (PI: JOHN H. HOFFMAN, UNIVERSITY OF TEXAS)

  - LUNAR SEISMIC PROFILING EXPERIMENT FOR DETERMINATION OF SUBSURFACE PROPERTIES TO SUBSTANTIAL DEPTHS
    (PI: ROBERT KOVACH, STANDFORD UNIVERSITY)

  - LUNAR EJECTA AND METEORITES EXPERIMENT TO DETERMINE LONG-TERM COSMIC INFLUX EFFECTS
    (PI: OTTO BERG, GODDARD SPACE FLIGHT CENTER)

  - HEAT FLOW EXPERIMENT TO COMPLEMENT AND SUPPLEMENT PREVIOUS ONES
    (PI: MARK LANGSETH, LAMONT DOHERTY GEOLOGICAL OBSERVATORY)
ANTENNA POINTING CONSTRAINTS

LUNAR LIBRATION: AN APPARENT WOBBLING MOTION AS VIEWED FROM THE EARTH; CAUSES EQUIVALENT EARTH MOTION IN LUNAR COORDINATES

PRINCIPAL EFFECTS:
± 7.5° LUNAR LONGITUDE DUE TO:
  CONSTANT ANGULAR RATE OF MOON ABOUT ITS AXIS
  VARIABLE ANGULAR RATE IN ELLIPTICAL ORBIT AROUND EARTH
± 6.5° LUNAR LATITUDE DUE TO:
  INCLINATION OF MOON'S ROTATION AXIS TO ITS ORBITAL PLANE

SECONDARY EFFECTS:
  NON-SPHERICAL EARTH & MOON
  SOLAR PERTURBATIONS
  GYROSCOPE & PENDULUM COUPLING

COMBINED EFFECTS: PATTERN CHANGES
  MONTHLY & YEARLY
ALSEP ANTENNA: 22° BEAM WIDTH DOWN
  4.2 db AIMED AT MEAN CENTER OF PATTERN

FEB 72 3270.1.6
ANTENNA AND AIMING MECHANISM

LATITUDE ADJUSTMENT
LATITUDE GIMBAL
0 - 45°

LONGITUDE ADJUSTMENT
LOCK
LONGITUDE GIMBAL + 60°

TWO WAY Gnomon

SHADOW ADJUSTMENT
LOCK

SHADOW ADJUSTMENT

LEVELING ADJUSTMENTS

TUBULAR BUBBLE LEVELS
ASTRONAUT SWITCHES

ASTRO SW-1 (BACKUP ONLY)

- PURPOSE: TO ENABLE CREW TO SELECT REDUNDANT POWER CONDITIONER DELIVERED TO THE MOON IN CCW POSITION
- UPON REQUEST, THE ASTRONAUT ROTATES SW-1 FIRST CW THEN CCW (AS FAST AS HE WANTS TO).
- CW ROTATION SIMULTANEously OPENS RTG POWER LINE AND SIMULATES A COMMAND TO SELECT PCU 2.
- CCW ROTATION CLOSES RTG LINE, (APPLYING RTG PWR TO PCU 2).

ASTRO SW-2 (LSP SAFETY SWITCH)

- DELIVERED TO THE MOON IN CCW POSITION
- CLOCKWISE ROTATION OF SW-2 CW ENABLES LSP OPER PWR LINE (29 VDC)
- COUNTER-CLOCKWISE ROTATION INHIBITS LSP OPERATION

FEB 72 3270.1.8
SUBPACKAGE NO. 1 STRUCTURE

THERMAL PLATE (MOUNTING CENTRAL ELECTRONICS)

STRUCTURE

SIDE CURTAIN

SUNSHIELD

REAR CURTAIN

CURTAIN RETAINER

SIDE CURTAIN

REFLECTOR

HANDLING ASSEMBLY

ANTENNA MAST

THERMAL BAG

PRIMARY STRUCTURE
LUNAR SURFACE ACTIVITY

ALSEP DEPLOYMENT TASKS ASSOCIATED WITH LM

REMOVE PACKAGES

FUEL GENERATOR

PREPARE FOR TRAVERSE

ALSEP DEPLOYMENT TASKS AT EXPERIMENT SITE

DEPLOY CENTRAL STATION

TRAVERSE

DEPLOY ANTELLA

DEPLOY EXPERIMENTS

DEPLOYMENT DUST COVERS NOT SHOWN

FEB 72 3270.1.13
RTG FUELING

THERMAL SHIELD
RELEASE LATCH
([LANYARD OPERATED])
MOUNTING & Structure
LM INTERFACE Fittings (GRUMMAN)

REMOVAL POSITION
(ADJUSTABLE BY ASTRONAUT)

CASK IN FLIGHT POSITION

FEB 72 3270.116
RTG WARM-UP CYCLE

OPERATING DIFFERENTIAL ($\Delta T$)
(OUTPUT DEPENDS ON TEMP & $\Delta T$)

TEMPERATURE, DEG F

TIME FROM FUELING, HR

LUNAR SURFACE TEMPERATURE

FEB 72 3270.1.21
ALSEP COMMUNICATION CENTER

EARTH/MOON COMMUNICATION LINK

POWER

RTG

CENTRAL STATION

LABORATORY HOUSEKEEPING SERVICES

SCIENTIFIC SENSORS

LSG
LMS
LEAM
HFE
LSP

FEB 72 3270.1.22
CENTRAL STATION DEPLOYED CONFIGURATION

HEXICAL ANTENNA
ANTENNA ALIGNMENT MECHANISM
EXPERIMENT MOUNTING SUPPORTS
SUNSHIELD
SIDE CURTAIN
THERMAL REFLECTOR
THERMAL RADIACTOR
ASTRO HANDLE
ACTIVATION SWITCHES
RTG CONNECTOR
CONNECTORS TO DEPLOYED EXPERIMENTS

APR. 72 3270.1.23
EFFECT OF SURFACE SLOPE
ON ELECTRONICS TEMPERATURES

INCREASE IN THERMAL PLATE AVERAGE TEMPERATURE
AT LUNAR NOON - °F

CRATER SLOPE AND LUNAR SURFACE SLOPE (θ) - DEGREES
### THREE YEARS OF ALSEP OPERATION

<table>
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<tr>
<th>Deployment Data</th>
<th>Apollo 11</th>
<th>Apollo 12</th>
<th>Apollo 14</th>
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<td>NOV '69</td>
<td>FEB '71</td>
<td>JULY '71</td>
<td>APR '72</td>
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<td>Design Life (Days)</td>
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<td>Operation to Date*</td>
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<tr>
<td>- Days</td>
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<td>985</td>
<td>542</td>
<td>366</td>
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<td>- Lunations</td>
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<td>- Years</td>
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<td>14,137</td>
<td>6783</td>
<td>9822</td>
<td>1731</td>
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**Note:** Each ALSEP provides 9 million measurements per day

*As of 1 August 1972
SCIENTIFIC ACHIEVEMENTS (PSE)

- **PASSIVE SEISMIC EXPERIMENT (PSE)**
  - LUNAR OUTER STRUCTURE IS ROCK CLUMPS, BUT THERE IS A CRUST AND MANTLE (LIKE EARTH) WITH CRUST THICKNESS OF 55 TO 70 KM
  - 2-5 MOONQUAKES PER MONTH — USUALLY NEAR PERIGEE — AT DEPTHS OF 800 KM (DEEPER THAN MOST EARTHQUAKES)
  - DAILY METEOROID IMPACTS
  - UNEXPECTED STRONG "RINGING" FROM MAN-MADE IMPACTS
TYPICAL SEISMIC DATA

CHANGE OF GAIN

S-IVB IMPACT APRIL 14
LMI IMPACT NOV 20
NATURAL EVENT DEC 10
NATURAL EVENT FEB 18

0 10 20 30 40 50 60
Time In Minutes

50 NM 6 NM 6 NM

EVENT 1970 1969

FEB 72 3270.127
MOONQUAKE AND METEOROID IMPACT
SCIENTIFIC ACHIEVEMENTS (SIDE AND CCIG)

- SUPRATHERMAL ION DETECTOR EXPERIMENT (SIDE)
  - DETECTS SOLAR STORMS AND MAN-MADE IMPACTS, AS EXPECTED
  - ONE GAS CLOUD, BELIEVED TO BE CORRELATED WITH MOONQUAKE ON 7 MARCH 1971, SHOWS EVIDENCE OF WATER
  - UNEXPECTED ION CONCENTRATIONS AT LUNAR SUNRISE AND SUNSET, AND IN GEOMAGNETIC TAIL TRANSITION REGION (FLOWING DOWNSTREAM WITH SOLAR WIND)

- COLD CATHODE ION GAGE (CCIG)
  - NEUTRAL PARTICLE CONCENTRATION VARIES FROM $10^7$ ATOMS/CC DURING DAY TO $2 \times 10^5$ ATOMS/CC AT NIGHT
  - FREQUENT TRANSIENT INCREASES
  - TRANSIENTS UP TO $2 \times 10^7$ WITHIN TWO MINUTES OF SUNRISE
SCIENTIFIC ACHIEVEMENTS (SWS AND LSM)

- SOLAR WIND SPECTROMETER (SWS)
  - BASIC BEHAVIOR OF SOLAR WIND
    SAME AS FREE-SPACE OUTSIDE EARTH'S MAGNETIC TAIL
    SLIGHTLY PERTURBED IN GEOMAGNETIC TRANSITION REGION
    DOES NOT PENETRATE TO CENTER OF TAIL
  - SWS UNEXPECTEDLY DETECTED GAS CLOUD FROM APOLLO 13 S-IVB IMPACT

- LUNAR SURFACE MAGNETOMETER (LSM)
  - 38 GAMMA STEADY FIELD AT APOLLO 12 SITE; 6 GAMMA AT APOLLO 15 SITE
  - TEMPORAL CORRELATION WITH MAGNETOMETER ON EXPLORER 35 ORBITER
    INDICATES ELECTRICAL CURRENTS DEEP WITHIN MOON
  - CORRESPONDING TEMPERATURE PROFILE ESTIMATES:
    $810^\circ K$ IN SHELL AT 0.6 LUNAR RADIUS
    $1240^\circ K$ AT CORE ($3000^\circ$ TO $5000^\circ K$ AT CORE OF EARTH)
SCIENTIFIC ACHIEVEMENTS (ASE AND CPLEE)

- **ACTIVE SEISMIC EXPERIMENT (ASE)**
  - 104 METER/SEC SEISMIC VELOCITY AGREES WITH PSE DATA
  - 8.5 METER SURFACE LAYER (REGOLITH) AT APOLLO 14 SITE

- **CHARGED PARTICLE LUNAR ENVIRONMENT EXPERIMENT (CPLEE)**
  - DETECTS LARGE CHANGES IN SOLAR WIND FLUX
  - LOW ENERGY PHOTO-ELECTRONS DETECTED DURING LUNAR DAY
  - UNEXPECTED DETECTION OF ELECTRONS WITH TERRESTRIAL AURORAE BAND ENERGIES IN MAGNETOSPHERIC TAIL
SEISMIC SIGNALS PRODUCED BY APOLLO 14 THUMPER FIRINGS

Shot 20

Geophone 1  5 m

Geophone 2  41 m

Geophone 3  87 m

Shot 18

Geophone 1  14 m

Geophone 2  32 m

Geophone 3  78 m

2.4 V

Fire

1 sec

APR. 72 3270.1.32
SCIENTIFIC ACHIEVEMENTS (HFE AND LRRR)

- HEAT FLOW EXPERIMENT (HFE)
  - LIMITED PENETRATION HAS NOT COMPROMISED ACHIEVEMENT OF SCIENTIFIC OBJECTIVES
  - PROBE DATA INDICATE SURFACE LAYER IS IDEAL THERMAL BLANKET
    - NIGHT SURFACE TEMP 76°K (-320°F)
    - DAY SURFACE TEMP 358°K (+185°F)
    - SUBSURFACE AT 1.5 M VIRTUALLY CONSTANT AT 253°K (-4°F)
  - HEAT FLOW APPROX 3.3 x 10^-6 WATT/CM^2 (1/2 THAT OF EARTH)
  - CONDUCTIVITY AT 1.0 TO 1.5M DEPTH IS BETWEEN 1.4 AND 2.5 x 10^-4 WATT/CM·°K
    (7 TO 10 TIMES GREATER THAN AT SURFACE)
  - DATA SUPPORT MAGNETOMETER FINDINGS
- LASER-RANGING RETRO-REFLECTOR (LRRR)
  - PRELIMINARY RESULTS FROM THREE REFLECTORS INDICATE LARGE-SCALE LUNAR SURFACE "WARPING"
HFE PROBE EMPLACEMENT ON APOLLO 15

-320°F TO +185°F

DEPTH
CM | INCHES
---|---
0  | 0
50 | 20
100| 40
150| 60

TEMPERATURE
RANGE | CHANGE
---|---
-320°F TO +185°F | 505°F
-9°F TO -4°F | 5°F
CONSTANT TEMP. (-4°F) | 0

FEB 72 3270.1.34
POWER AND DATA SUBSYSTEMS

(CENTRAL STATION FUNCTIONS)
POWER AND DATA COMPONENTS

RADIOISOTOPE THERMOELECTRIC GENERATOR (RTG)
- Supplies all electrical power for ALSEP

POWER CONDITIONING UNIT (PCU) AND POWER DISTRIBUTION UNIT (PDU)
- Converts, regulates, and distributes power for ALSEP components and experiments with switching as commanded by MSFN
- Provides automatic power management (APM) and divides surplus power between internal heaters and external power dissipation resistors (PR) for central station thermal control

ANTENNA
- Receives and radiates uplink/downlink signals
- Mounted on antenna aiming mechanism for pointing toward the Earth

DIPLEXER FILTER
- Connects receiver and transmitter to antenna with required isolation

COMMAND RECEIVER (RCVR)
- Accepts and demodulates Earth-to-Moon uplink signal

COMMAND DECODER
- Processes received signals and issues commands to ALSEP equipment

DATA PROCESSOR
- Collects and processes scientific and engineering data in suitable format for downlink transmission; uses analog data processor (ADP) to multiplex and convert analog signals to digital; digital data processor (DDP) collects and formats the total data output
- Supplies signal conditioning to analog lines, as required

TRANSMITTER (XMTR)
- Generates Moon-to-Earth downlink signal

DIPLEXER SWITCH
- Connects one of the two redundant transmitters to the antenna
COMMAND FORMAT

A command from the MSFN consists of the following:
- Uplink frequency 2119 MHz
- A 2 kHz subcarrier phase modulated with a 1 kHz subcarrier to produce 61 serial bits (1000 bits per second)

<table>
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<tr>
<th>20 BITS</th>
<th>7 BITS</th>
<th>7 BITS</th>
<th>7 BITS</th>
<th>20 BITS</th>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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</tbody>
</table>

1. Preamble: All Ones
2. Address: 1101001 (Octal 151)*
3. Command Complement
4. True Command
5. Timing (Execution): All Ones

* Note Single Address for Array E
  (Other Alseps' each have two addresses)

Of the 128 possible combinations (7 bits) only 79 are used as functional commands on Array E

MAY 72 3270.2.4
# COMMAND INVENTORY APOLLO 17 ALSEP (ARRAY E)

## NOTES:
- (N/INV) - NOT IN INVENTORY; (*) - USED ON OTHER ALSEP's; (CRIT) - CRITICAL;
- A - DECODER A; B - DECODER B; C - COMMON DECODER

<table>
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<tr>
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<td>IN/INV (*)</td>
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<td>ADDRESS 11/15 B (N/INV)</td>
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<td>024</td>
<td>ADP X SEL</td>
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<td>ADP Y SEL (*) (ADD 14 A)</td>
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<td>COMP 17 C (N/INV)</td>
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<td>037</td>
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<td>LEAM STBY</td>
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<td>055</td>
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<td>057</td>
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<tr>
<td>060</td>
<td>PCU 1 SEL</td>
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<td>061</td>
<td>COMP 11/15 A (N/INV)</td>
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MAY 72 3270.2.5
DOWNLINK DATA FORMAT

- DOWNLINK FREQUENCY 2275.5 MHz
- NORMAL OPERATION: DATA PROCESSOR (DP) FORMAT AT 1060 BITS PER SECOND
  IS 64-WORD FRAME OF 10-BIT WORDS (640 BITS PER FRAME)
- THE SAME DP FORMAT AT 530 BITS PER SECOND CAN BE SELECTED BY COMMAND
- LSP FORMAT, SELECTED BY COMMAND, IS COMPLETELY DIFFERENT (1800 BITS PER FRAME)
  AT EITHER 3533.3 BITS PER SECOND (NORMAL) OR 1060 BITS PER SECOND (LOW)
- ALL DATA TRANSMITTED WITH MOST SIGNIFICANT BIT (MSB) FIRST
- DATA PROCESSOR FORMAT:

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**LEGEND:**
- X CONTROL WORD
- A LUNAR MASS SPECTROMETER EXPERIMENT
- CV COMMAND VERIFICATION WORD
- G LUNAR SURFACE GRAVIMETER EXPERIMENT
- HF HEAT FLOW EXPERIMENT
- J LUNAR EJECTA AND METEORITE EXPERIMENT
- HK HOUSEKEEPING (ENGINEERING) DATA
- RP RESERVE POWER
- B BLANK

MAY 72 3270.2.6
CONTROL WORDS AND COMMAND VERIFICATION

CONTROL WORDS
(ALSEP WORDS 1, 2, AND 3)

DA-05 ALSEP
CMD AS RCVD
DA-06 ALSEP CMD MAP

ONE WORD SAME AS BIT 3
SAMPLE AS EACH COMMAND IS RECEIVED AT ALSEP, AT OTHER TIMES THE SAMPLE IS ALL ZEROS

FILLER BITS (SAME AS BIT 3)

DA-02 ALSEP FRAME SynC
BARKER CODE

COMPLEMENT OF BARKER CODE

DA-01 ALSEP FRAME SYN C

FRAME MODE BIT MEANS AS FOLLOWS:
1 1 NORMAL BIT RATE
2 1 LOW BIT RATE
3 {X MSB} DATA PROC
4 {X ID NO.} DECIMAL
4 FOR APOLLO 17
5 ALSEP
6 NONE
89 NONE
0 NONE

MAY 72 3270.2.7
ANALOG DATA COMMUTATION

- ALSEP WORD 33 CONTAINS 90-CHANNEL COMMUTATED DATA, PRIMARILY ENGINEERING (HOUSEKEEPING) PARAMETERS, PROCESSED BY THE ADP
- ALSEP WORD 63 CONTAINS RESERVE POWER, ALSO PROCESSED BY THE ADP, BUT NOT COMMUTATED
- ADP OUTPUTS ARE 8-BIT BINARY (MSB FIRST) WITH TWO FILLER ZEROS AHEAD OF THE OUTPUT IN THE 10-BIT ALSEP WORD

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<tr>
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<td>HOT FRAME 1</td>
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MAY 72 3270.2.8
STRUCTURE TEMPERATURE TELEMETRY

- AT-01 Sunshield Temp 1 (Outside)
- AT-02 Sunshield Temp 2 (Inside)
- AT-03 Through
- AT-07 On Thermal Palte
- AT-11 Pwr Dmp Module
- AT-15 Rear/ST
- AT-12 Insult Int (On Wall)
- AT-13 Insult Ext (On Wall)
- AT-10 Pri/ST Bl (On Bottom)
- AT-08 Pri/ST W1
- AT-09 Pri/ST W2 (On Opposite Wall)
- AT-14 Front/ST
PCU COMMANDS

OCTAL CMD NUMBER

- **D60 PCU 1 SEL**
  - This command actuates a latching relay in the PCU to the position that applies 15.3 ± 0.5 VDC from the RTG to PCU 1 and disconnects PCU 2 from the RTG. In this position, PCU 1 provides power for the ALSEP system via PDU 1. Repeated application of CMD D60 has no further effect. In normal operation, CMD D60 should be transmitted before CMD D60, unless PC AUTO 2 SWITCH is already selected. PCU 1 is preset to be energized at initial lunar activation.

- **D62 PCU 2 SEL**
  - This command actuates a latching relay in the PCU to the position that applies 15.3 ± 0.5 VDC from the RTG to PCU 2 and disconnects PCU 1 from the RTG. In this position, PCU 2 provides power for the ALSEP system via PDU 2. In normal operation, CMD D62 should be transmitted before CMD D62, unless PC AUTO 1 SWITCH is already selected. Repeated application of CMD D62 has no further effect.

- **120 PC AUTO 1 SW SEL**
  - This command activates a relay in the PCU to the position that enables automatic switchover from PCU 2 to PCU 1, if any one of the +12 VDC, +5 VDC, or -12 VDC lines goes overvoltage longer than 5 ms or undervoltage longer than 300 ms. In this position, automatic switchover from PCU 1 to PCU 2 is inhibited. PC AUTO 1 SW SEL is preset to be energized at initial lunar activation; hence, if normal start-up occurs, CMD 121 should be transmitted as early as possible. Repeated application of CMD 120 has no further effect. In normal operation, CMD 120 should be transmitted before CMD 062, unless PC AUTO 1 SW is already selected. An internally generated PCU switchover is an abnormal condition requiring caution in the subsequent use of CMD 120.

- **121 PC AUTO 2 SW SEL**
  - This command activates a relay in the PCU to the position that enables automatic switchover from PCU 1 to PCU 2, if any one of the +12 VDC, +5 VDC, or -12 VDC lines goes overvoltage longer than 5 ms or undervoltage longer than 300 ms. In this position, automatic switchover from PCU 2 to PCU 1 is inhibited. Repeated application of CMD 121 has no further effect. In normal operation, CMD 121 should be transmitted before CMD 060, unless PC AUTO 2 SW is already selected. An internally generated PCU switchover is an abnormal condition requiring caution in the subsequent use of CMD 121.
APM COMMANDS

OCTAL CMD NUMBER

• 027  APM 1 ON

This cmd actuates a flip-flop in the PCU to the position that allows RTG input power to be diverted to a 30-watt, maximum, power dissipation resistor if (1) there is more than (2 to 4, TBD) watts of reserve power on PCU 1, and (2) the thermal plate temp is above the temp switch 1 value: 60°F close, 80°F open. The application of power to PCU 1 causes initialization in the APM 1 on configuration. Repeated application of cmd 027 has no further effect.

• 031  APM 1 OFF

This cmd actuates a flip-flop in the PCU to the position that inhibits APM 1 from dissipating RTG power. Repeated application of cmd 031 has no further effect.

• 115  APM 2 ON

This cmd actuates a flip-flop in the PCU, to the position that allows RTG input power to be diverted to a 30-watt, maximum power dissipation resistor if (1) there is more than (2 to 4, TBD) watts of reserve power on PCU 2, and (2) the thermal plate temp is above the temp switch 2 value: 60°F close, 80°F open. The application of power to PCU 2 causes initialization in the APM 2 on configuration. Repeated application of cmd 115 has no further effect.

• 113  APM 2 OFF

This cmd actuates a flip-flop in the PCU to the position that inhibits APM 2 from dissipating RTG power. Repeated application of cmd 113 has no further effect.
RTG/PCU/APM TELEMETRY

THE FOLLOWING PARAMETERS ARE SENSED IN THE RTG, WITH SIGNAL CONDITIONING IN THE DATA PROCESSOR:

AR-01 HOT FRAME 1 TEMP, DEG F
AR-02 HOT FRAME 2 TEMP, DEG F
AR-03 HOT FRAME 3 TEMP, DEG F
AR-04 COLD FRAME 1 TEMP, DEG F
AR-05 COLD FRAME 2 TEMP, DEG F
AR-06 COLD FRAME 3 TEMP, DEG F

THE FOLLOWING PARAMETERS ARE SENSED IN THE PCU/APM, WITH SIGNAL CONDITIONING IN THE DATA PROCESSOR (MEASUREMENT IS ABSENT IF PCU/APM IS OFF):

AT-38 REG 1 TEMP, DEG F (NEAR THE PCU 1 REGULATOR TRANSISTOR)
AT-39 REG 2 TEMP, DEG F (NEAR THE PCU 2 REGULATOR TRANSISTOR)
AT-41 APM 1 TEMP, DEG F (NEAR TEMP SWITCH 1)
AT-42 APM 2 TEMP, DEG F (NEAR TEMP SWITCH 2)

THE FOLLOWING ELECTRICAL PARAMETERS ARE SENSED IN THE PCU/APM:

AE-03 PCU 1 INPUT VOLTS (ESSENTIALLY RTG OUTPUT VOLTS, AT PCU 1)
AE-04 PCU INPUT CURRENT, AMPS (OR'D FROM THE SWITCHED RTG OUTPUT)
AE-21 APM 1 CURRENT, AMPS (MEASURES CURRENT TO PDR OF APM 1)
AE-22 APM 2 CURRENT, AMPS (MEASURES CURRENT TO PDR OF APM 2)
AE-23 PCU 2 INPUT VOLTS (ESSENTIALLY RTG OUTPUT VOLTS, AT PCU 2)
DA-08 RESERVE CURRENT, AMPS (OR'D FROM THE TWO PCU/APM SHUNTS)
AE-24

THE FOLLOWING ELECTRICAL PARAMETERS ARE SENSED IN THE PDU OR ADP (AFTER COMBINING OUTPUTS OF PCU 1 AND PCU 2) BUT ARE CALIBRATED TO REFLECT VALUES AT THE PCU POWER OUTPUT MONITOR:

AE-07 +29 VDC OUTPUT
AE-09 +12 VDC OUTPUT
AE-10 +5 VDC OUTPUT
AE-11 -12VDC OUTPUT

THE FOLLOWING SWITCH STATUS PARAMETERS ARE SENSED IN THE PCU:

AB-13 APM STATUS (INDICATES WHETHER THE APM OF THE ACTIVE PCU IS ENABLED OR IS INHIBITED BY CMD)
AB-16 PC AUTO SW STATUS (INDICATES WHETHER OR NOT THE INACTIVE PCU IS SELECTED FOR AUTOMATIC BACKUP)
CIRCUIT PROTECTION

• PCU AUTO SWITCH
  In case of overvoltage/undervoltage in the PCU output, automatic switchover
  from the active PCU to the alternate PCU will occur if voltage, time, and
  switch setting conditions are satisfied.
  - Voltages (as sensed by the power output monitor in the PCU)
    +12 V increases to +13.2 ± 0.25 V or decreases to +10.8 ± 0.25 V
    +5 V decreases to 0.9 V
    -12 V decreases numerically to -4.7 V
  - Time
    An increase (overvoltage) on one of these lines indicates a probable regulator
    failure and if it continues for 5 ms, a switchover signal is generated.
    A decrease (undervoltage) on one of these lines could be due to
    an overload in some component. Fuses, circuit breakers, and
    ripple-off are provided in switched lines to most components.
    To allow action of these protection features, the switchover signal
    is generated after 300 ± 50 ms of continuous undervoltage.

• Switch Setting
  Auto switchover can occur in either direction (PCU 1-to-2 or PCU 2-to-1)
  under the control of a command-selectable relay. Incorrect setting
  of the relay inhibits automatic switchover.

• Ripple-off
  In case of system overload, as sensed by marginal reserve power (nominal 0.8 W),
  an automatic sequencer in the command decoder waits 121 ms (for fuses and
  circuit breakers to relieve the overload), then switches commandable loads
  to off (or standby, for experiments), at ≈8 ms intervals.

• Fuses and Circuit Breakers
  All non-essential switchable loads are on fused lines. Other switchable loads
  have circuit breakers which are reset by application of the normal on cmd.
  There are unswitched loads (usually small) with no circuit protection.
PDU TRACKING

- WITH THE REDUNDANT PCU-PDU DESIGN, THERE ARE PROVISIONS FOR THE REDUNDANT POWER SWITCHING RELAYS TO "TRACK"; THAT IS, COMMANDS ACTUATE PDU 1 AND PDU 2 IN PARALLEL. WITH THIS TRACKING, A PCU SWITCHOVER SHOULD CAUSE NO OTHER CHANGE IN THE ALSEP OPERATIONAL CONFIGURATION.

- EXCEPTIONS MAY OCCUR WHEN POWER SWITCHING RESULTS FROM INTERNAL CAUSES INSTEAD OF UPLINK COMMANDS. THE INTERNAL CAUSES AND THEIR EFFECT ON TRACKING ARE AS FOLLOWS:
  - RIPPLE-OFF AND UPLINK SWITCH SEQUENCER OPERATE THROUGH GATES ON NORMAL COMMAND LINES; HENCE, TRACKING IS MAINTAINED.
  - CIRCUIT BREAKERS SENSE OVERLOAD ON AN ACTIVE LINE AND ACTUATE POWER SWITCHING RELAYS TO EITHER SELECT THE ALTERNATE COMPONENT OR TURN OFF THE ACTIVE COMPONENT. TRACKING DEPENDS ON THE LOCATION OF THE CIRCUIT BREAKER:
    1. IF THE CIRCUIT BREAKER OPERATES ON A "COMBINED" POWER LINE, THE SYSTEM WILL TRACK (UPLINK AND ADP)
    2. IF THE CIRCUIT BREAKER OPERATES ON AN INDIVIDUAL POWER LINE, PCU 1 OR PCU 2, THE SYSTEM WILL NOT TRACK (DDP, XMTR, AND EXPERIMENT OPERATIONAL OVERLOAD)
  - FUSES ARE SIMILAR, IN THAT "COMBINED" LINES TRACK (PDR 1 AND PDR 2) WHILE INDIVIDUAL LINES WILL NOT TRACK (EXPERIMENT STANDBY OVERLOAD)

- NOTE THAT THE APM FOR EACH PCU IS INITIALIZED TO THE ON STATE WHEN THE PCU IS SELECTED; HENCE, THE APM OFF COMMAND DOES NOT TRACK, IN TERMS OF MAINTAINING STATUS THROUGH A PCU SWITCHOVER

- THE ABNORMAL CONDITION OF "RIPPLE-OFF SEQUENCER LOCK-OUT" MAY POSSIBLY BE CLEARED BY PCU SWITCHOVER (UNPREDICTABLE TRACKING)
PDR POWER CONTROL
(NON-REDUNDANT PDU RELAYS)

NOTE: RIPPLE-OFF SEQUENCER SELECTS PDR 1, PDR 2, LMS, LEM, HFE, LSG, LSP (128 MS DELAY, THEN ~8 MS INTERVALS)
PDR COMMANDS

OCTAL CMD NUMBER

- **017 PDR 1 ON**
  
  This cmd actuates two latching relays (in series) in the non-redundant section of the PDU, to the position that applies +29 VDC to a 7-WATT power dissipation resistor, and is used as a backup means of PWR/thermal control if the APM cannot cope with the load. Repeated application of CMD 017 has no further effect.

- **021 PDR 1 OFF**
  
  This cmd actuates two latching relays (in series) in the non-redundant section of the PDU, to the position that removes +29 VDC from the 7-WATT power dissipation resistor. PDR 1 is preset to be in the off condition at initial lunar activation. Repeated application of CMD 021 has no further effect.

- **022 PDR 2 ON**
  
  This cmd actuates two latching relays (in series) in the non-redundant section of the PDU, to the position that applies +29 VDC to a 14-WATT power dissipation resistor, and is used as a backup means of PWR/thermal control if the APM cannot cope with the load. Repeated application of CMD 022 has no further effect.

- **023 PDR 2 OFF**
  
  This cmd actuates two latching relays (in series) in the non-redundant section of the PDU, to the position that removes +29 VDC from the 14-WATT power dissipation resistor. PDR 2 is preset to be in the off condition at initial lunar activation. Repeated application of CMD 023 has no further effect.
PDR TELEMETRY

AT-11  PDM TEMP, DEG F (SENSED ON THE POWER DISSIPATION MODULE WITH SIGNAL CONDITIONING IN THE DATA PROCESSOR)

AB-14  PDR 1/2 STATUS (INDICATES THE ON/OFF STATUS OF BOTH PDR 1 AND PDR 2, WITH AN OFF INDICATION IN THE CASE OF A BLOWN FUSE)
DIPLEXER FILTER AND SWITCH FUNCTIONS

DIPLEXER FILTER
- Provides XMT/RCVR isolation with a common antenna
- Uses tuneable cavity bandpass filters

DIPLEXER SWITCH
- Used to couple the selected transmitter through the diplexer filter to the antenna
- Two circulators are used to provide transmitter isolation and protection (against opens or shorts), and the third circulator is reversible to serve as a switch
- +12 VDC application selects XMT B; absence of +12 VDC selects XMT A
- If both XMT's are operating, the one not selected is applied to a load.
UPLINK POWER CONTROL

- FIF initializes in state A (Circuit Breakers (C/B) actually ground relay coil rating)
- +5 VDC, 300 MA
- +12 VDC, 390 MA
- -12 VDC, 150 MA

Driver

PCU 1

RCVR 1

DECODER A

PCU 2

RCVR 8

DECODER B

CMO DECODER

AB-18 UPLINK

CMD DECODER

RCVR/DEC sw

A

RCVR/DEC sw

B

UPLINK SWITCH PULSE

7 + (N X 60 HR)

ONE TIME INHIBIT

AB-18 UPLINK SW INH

MAY 72 3270.2.22
RECEIVER FUNCTIONS

NOTE: NO CASE TEMP. TM WHEN RCVR A IS OFF

MAY 72 3270.2.23
COMMAND DECODER FUNCTIONS

- DATA DEMODULATOR
  CONVERTS THE MESSAGE INTO DIGITAL FORMAT USING A
  PHASE LOCK LOOP AND CLOCK GENERATOR, A DATA DETECTOR,
  AND THRESHOLD CIRCUITS
  - THE PHASE LOCK LOOP USES A FREE-RUNNING VOLTAGE
    CONTROLLED OSCILLATOR (VCO) AT 8 kHz WITH A DIVIDE-BY-4
    RING COUNTER TO GENERATE FOUR PHASES OF A 1 kHz
    SQUARE WAVE. ONE OF THESE IS USED TO CONTROL THE VCO.
    THE PHASES OF THE 1 kHz ARE ALSO GATED TOGETHER
    FOR THE CONTROL LOGIC CLOCKS AND DATA DETECTOR.
  - THE DATA DETECTOR HAS TWO DETECTION CHAINS, FOR ZEROS
    AND ONES, WITH "INTEGRATE AND DUMP CIRCUITS". THE
    OUTPUTS ARE USED IN THE THRESHOLD CIRCUITS AND, IF
    ACCEPTABLE, ARE CLOCKED INTO THE CONTROL LOGIC
    COMMAND REGISTER.
  - THE THRESHOLD CIRCUITS REQUIRE AT LEAST FOUR
    CONSECUTIVE VALID DATA BITS BEFORE ACCEPTING INPUTS
    FOR THE COMMAND REGISTER. IN THE EVENT OF SUBSEQUENT
    DATA DROPOUT, INPUT TO THE REGISTER IS INHIBITED AND
    THE CONTROL LOGIC IS RESET.
COMMAND DECODER FUNCTIONS (CONT’D)

- **CONTROL LOGIC**

  The control logic consists of an 8-bit shift register, two counters, and reset circuitry. Operation is as follows:

  1. Data passes through the register (1000 bits per second) and the first 7 bits are checked for the address (110100).
  2. Recognition of address starts a timing sequence. The first counter counts 7 pulses which shift the command complement into the register. As the next 7 bits (true command) are shifted into the register, an "exclusive OR" gate checks bits 3 and 8 of the register for command/complement "parity". Failure of this test sets a parity memory.
  3. After the second 7 pulses, during which the true command has been shifted into the register, there is a period of 21 pulses (21 ms) for command execution with the following logic:
     - A latch is set to time the execute gate and a second latch inhibits new data into the register (the received command is in the last 7 bits of the register).
     - The command line is selected in the decoding gates.
     - If parity is valid, the command is executed.
  4. At the end of the 21 timing pulses, a signal is sent to the data processor, indicating data availability, called verification word enable (VWE). The data processor reads out the command verification word at the proper time in the next telemetry data frame.
  5. At the end of the data processor demand pulse, the command decoder automatically returns to the address search mode (reset). In LSP mode of operation, reset occurs at execution bit 21.

- **DECODE GATES**

  Output decoding uses two-input gates, so that each individual command line is dependent on (1) the state of all 7 command bits and (2) the presence of the command execute pulse.

- **PERIODIC COMMAND AND RIPPLE-OFF SEQUENCER**

  To be described later
OCTAL CMD NUMBER

- 110  ADP/UPLINK REDUNDANT POWER ROUTING, PRIMARY SELECT

This CMD actuates a pair of latching relays in the non-redundant section of the PDU, to the position that provides the basic, redundant, routing of +5 VDC from PCU 1 and PCU 2 to the ADP/UPLINK selection relays. This CMD has the opposite effect of CMD 107 for ADP PWR routing and of a 61-HR pulse for UPLINK PWR routing. This CMD would serve to clear a malfunction in either the decoder or the ADP selection relay, if one should occur in the backup routing. The primary routing is preset to be energized at initial lunar activation. Repeated application of CMD 110 has no further effect.

- 122  RCVR/DECODER SWITCH

This CMD, through the UPLINK SWITCH FLIP-FLOP in the CMD DECODER, actuates latching relays in the non-redundant section of the PCU to remove power from whichever set of UPLINK COMPONENTS IS IN USE AND APPLY POWER TO THE ALTERNATE, REDUNDANT, COMPONENTS. THREE VOLTAGES (+5, +12 AND -12) ARE SWITCHED FOR THE CMD DECODERS AND +12 VDC FOR RCVR'S. REPEATED APPLICATION OF CMD 122 CAUSES REPEATED SELECTION, ALTERNATING BETWEEN RCVR/DECODER A AND B. TRANSMISSION OF CMD 122 DOES NOT ACTUATE THE BACKUP POWER ROUTING OF +5 VDC TO THE DECODER AS DOES AUTOMATIC SWITCHOVER. AFTER A PCU SWITCHOVER, CMD 122 MAY BE REQUIRED TWICE FOR THE NEXT SWITCHOVER (IF IT IS FROM UPLINK B TO UPLINK A). NOTE THAT CMD 122 AND CMD 174 HAVE NO EFFECT ON EACH OTHER. CMD 122 ALSO ENABLES PERIODIC CMDs.

- 174  RCVR/DECODER SWITCH DELAY

This CMD sets a one-time inhibit circuit in the CMD DECODER such that the next 61-HR PULSE DOES NOT CAUSE SWITCHOVER TO THE OPPOSITE RCVR/DECODER. REPEATED APPLICATION OF CMD 174, PRIOR TO ARRIVAL OF A 61-HR PULSE, HAS NO FURTHER EFFECTS; ONLY ONE PULSE IS INHIBITED. RESETTING TO THE NO-DELAY CONDITION OCCURS 3.5 MINUTES AFTER THE 61-HR AUTOSHUTOFF PULSE IS GENERATED, WHETHER OR NOT THE SWITCHOVER IS ACTUALLY INHIBITED OR ENABLED. THE APPLICATION OF POWER TO ALSEP CAUSES INITIALIZATION IN THE NO-DELAY CONFIGURATION. NOTE THAT CMD 174 AND CMD 122 HAVE NO EFFECT ON EACH OTHER.
UPLINK TELEMETRY

The following temperatures are sensed in the uplink components, with signal conditioning in the data processor (measurement is absent if receiver/decoder unit is off):

- AT-31 DECODER B TEMP, DEG F (sensed in the data demodulator)
- AT-32 DECODER A TEMP, DEG F (sensed in the data demodulator)
- AT-40 RCVR A CASE TEMP, DEG F (no temp when RCVR B is operating)

The following electrical parameters are sensed in the receivers:

- AE-19 RCVR A INPUT SIGNAL LEVEL, DBM (sensed in AGC)
- AE-20 RCVR B INPUT SIGNAL LEVEL, DBM (sensed in AGC)

The following status parameters are sensed in the uplink components:

- AB-06 UPLINK STATUS (A or B components plus primary or backup routing)
- AB-08 RCVR A 1 KC (present or absent)
- AB-09 RCVR B 1 KC (present or absent)
- AB-18 UPLINK SWITCH STATUS (accept or delay the 61-HR switchover signal)

The command verification word (CVW) is read out in word 7 of the ALSEP telemetry frame:

- DA-05 ALSEP COMMAND, AS RECEIVED (bits 3 through 9 of word 7)
- DA-06 ALSEP CMD MAP (MESSAGE ACCEPTANCE PULSE, IN BIT 10, INDICATES "ONE" IF COMMAND/COMPLEMENT AGREED)

Bits 1 and 2 are filler and will be the same as bit 3. The CVW appears only once, in the frame following command receipt, otherwise word 7 is all zeros. When switching by command between redundant data subsystem components, the CVW may be unavailable.

Note that component temperatures and electrical parameters are off-scale when the component is not in use.
ADP POWER SWITCHING

NON-REDUNDANT PDU RELAYS

CIRCUIT BREAKER RATINGS:
- +5 VDC: 300 mA
- +12 VDC: 150 mA
- -12 VDC: 150 mA

AB-17 GROUND RELAY COIL NOT DRIVER

ADP X SEL DRIVER

ADP Y SEL DRIVER

ADP X DRIVER

ADP Y DRIVER

PCU 1

PCU 2

MAY 72 3270.2.29
ADP FUNCTIONS

- 90-CHANNEL ANALOG MULTIPLEXER
  samples through 90 input channels of analog engineering (housekeeping) data in ascending numerical order, advancing one channel per AlSEP telemetry frame. Between each of the 90 samples, a separate sample is taken of the AlSEP reserve current which is also one of the 90 inputs. Two of the inputs are internal calibration signals and the other 88 are obtained from the central station and the experiments. Note that some of the experiment inputs are commutated, sampling a series of parameters on a single input line to the ADP.

- The multiplexer contains a self-resetting counter (1 to 90) and a 90-input matrix switch for routing the analog signals sequentially to the analog-to-digital converter (ADC).

- At the start of the 64th (final) word of each AlSEP telemetry frame, an "advance" pulse from the DDP sets the switching matrix to the next position, and one word later the DDP "frame mark" pulse applies the analog signal to the ADC.

- At AlSEP word 33, the analog-to-digital conversion is performed after which a flip-flop is reset to apply the reserve power analog signal to the ADC.

- The reserve power analog-to-digital conversion is performed during AlSEP word 63.

- During the entire period that the multiplexer is sampling channel 90, a 90-frame pulse signal is generated and supplied to the DDP. It resets the independent frame counter in the DDP which otherwise would count to 128 (7-bit counter). When switching between redundant DDP's, the frame counter indication is meaningless until receipt of the first 90-frame pulse from the ADP (that is, word 33 is out of sync). This condition will exist for less than 90 frames (54 seconds). A similar temporary out-of-sync condition for word 33 will follow an ADP switchover.

MAY 72 3270.2.30
ADP FUNCTIONS (CONT.)

- ANALOG TO DIGITAL CONVERTER (ADC)
  THE ADC ACCEPTS ANALOG SIGNALS FROM THE MULTIPLEXER AND CONVERTS THEM INTO 10-BIT DIGITAL DATA (INCLUDING TWO FILLER BITS) TO BE FORWARDED IN SERIAL FORMAT TO THE DDP.
  - THE ADC USES A RAMP GENERATOR-COMPARATOR TECHNIQUE FOR CONVERSION, IN WHICH THE INPUT ANALOG SIGNAL (VOLTAGE) IS COMPARED TO A LINEAR RAMP VOLTAGE WHILE A COUNTER ADVANCES ONE BIT PER UNIT VOLTAGE INCREMENT. THE COUNTER IS STOPPED WHEN THE RAMP VOLTAGE EXCEEDS THE INPUT VOLTAGE. THE NUMBER IN THE COUNTER IS THEN READ OUT TO A BUFFER STORAGE REGISTER AS THE BINARY EQUIVALENT OF THE MAGNITUDE OF THE INPUT ANALOG VOLTAGE. THE 8-BIT BINARY SCALE HAS A DECIMAL RANGE OF ZERO-TO-255, WITH ONE-TO-254 REPRESENTING A VOLTAGE BETWEEN ZERO AND +5 VDC. ZERO OUTPUT REPRESENTS NEGATIVE VOLTAGE INPUT AND 255 REPRESENTS GREATER THAN +5 VDC.
  - THE CONVERSION STARTS AT THE TRAILING EDGE OF A "START CONVERSION" SIGNAL FROM THE ADC CONTROL LOGIC SECTION AND IS COMPLETED WITHIN 140 MICRO-SECONDS, MAXIMUM. READOUT TO THE BUFFER REGISTER CLEARS THE COUNTER AND RESETS THE RAMP GENERATOR.
  - TIMING PULSES FOR THE COUNTER ADVANCE ARE SUPPLIED BY THE DDP AT 2.035 MHZ (± 0.005%).

- SIGNAL CONDITIONING AND CALIBRATION
  TEMPERATURE MEASUREMENTS OF THE CENTRAL STATION STRUCTURE, THE RTG, AND ONE EACH FROM LMS, LSP, AND LEAM, ARE CONDITIONED IN THE NON-REDUNDANT SECTION OF THE ADP TO PROVIDE ZERO TO +5 VDC SIGNALS FOR INPUT TO THE ANALOG MULTIPLEXERS/CONVERTERS. PRECISION SIGNALS AT 0.25 AND 4.75 VDC ARE GENERATED FOR ADC CALIBRATION, AND PCU OUTPUT VOLTAGES ARE MONITORED/CONDITIONED IN THE ADC. (PCU 1 AND PCU 2 OUTPUTS ARE COMBINED INTO ONE MEASUREMENT FOR EACH OF THE FOUR VOLTAGE LEVELS.)
ADP COMMANDS

OCTAL CMD NUMBER

- 024 ADP X SEL

This cmd actuates latching relays in the non-redundant section of the PDU to the position that applies +5 VDC, +12 VDC, and -12 VDC to the X unit of the analog data processor and removes +5 VDC, +12 VDC and -12 VDC from the Y unit. ADP X is preset to be energized at initial lunar activation. Repeated application of CMD 024 has no further effect.

- 025 ADP Y SEL

This cmd actuates latching relays in the non-redundant section of the PDU to the position that applies +5 VDC, +12 VDC and -12 VDC to the Y unit of the analog data processor and removes +5 VDC, +12 VDC and -12 VDC from the X unit. Repeated application of CMD 025 has no further effect.

- 107 ADP REDUNDANT POWER ROUTING, BACKUP SELECT

This cmd actuates a latching relay in the non-redundant section of the PDU to the position that provides an alternate, redundant routing of +5 VDC from PCU 1 and PCU 2 to the ADP selection relays. This cmd would be applied if it appeared that both ADP's were operating simultaneously. An alternative would be to switch PCU's. The 61-HR pulse does not switch ADP routing. Repeated application of CMD 107 has no further effect.
ADP TELEMETRY

THE FOLLOWING TEMPERATURES ARE SENSED AND CONDITIONED IN THE ADP:
AT-27 DP BASE TEMP, DEG F (REPRESENTS THE MOUNTING PLATE
TEMP FOR BOTH THE ADP AND DDP)
AT-28 DP INT TEMP, DEG F (SENSED IN THE ADP TO MONITOR
INTERNAL ELECTRONICS TEMP OF
THE DATA PROCESSOR

THE FOLLOWING ELECTRICAL PARAMETERS ARE SENSED IN THE ADP:
AE-01 ADC 0.25 VDC CAL (A PRECISION SOURCE OF 0.25 VDC IN THE
ADP TO VERIFY ACCURATE FUNCTIONING
OF THE ANALOG-TO-DIGITAL CONVERSION)
AE-02 ADC 4.75 VDC CAL (A PRECISION SOURCE OF 4.75 VDC IN THE
ADP TO VERIFY ACCURATE FUNCTIONING
OF THE ANALOG-TO-DIGITAL CONVERSION)

THE FOLLOWING STATUS PARAMETER IS GENERATED IN THE UPLINK
POWER CIRCUITS:
AB-17 ADP STATUS (X OR Y COMPONENT PLUS PRIMARY OR BACKUP ROUTING)

THE 90-CHANNEL ANALOG OUTPUT, WITH VARIOUS DESIGNATIONS, APPEARS IN WORD 33
OF THE ALSEP TELEMETRY FRAME AND RESERVE CURRENT (PROCESSED BY THE ADP) APPEARS
AS PARAMETER DA-08 IN ALSEP WORD 63. IN BOTH CASES, THE 10-BIT DATA WORD IS PRESENTED AS
FOLLOWS:

FILLER BITS (ZEROS)

MOST SIGNIFICANT BIT

LEAST SIGNIFICANT BIT

BIT NUMBER → 1 2 3 4 5 6 7 8 9 10

8-BIT OUTPUT OF ADC
DDP POWER COMMANDS

OCTAL CMD NUMBER

• 034  DDP X SEL

THIS CMD ACTUATES TWO LATCHING RELAYS, ONE IN EACH PDU, TO THE POSITION THAT APPLIES +5 VDC TO THE X UNIT OF THE DIGITAL DATA PROCESSOR AND REMOVES +5 VDC FROM THE Y UNIT. DDP X IS PRESET TO BE ENERGIZED AT INITIAL LUNAR ACTI-
VATION. REPEATED APPLICATION OF CMD 034 HAS NO FURTHER EFFECT. SWITCHING DDP'S IN EITHER THE DP OR LSP FORMAT, NORMAL OR SLOW DATA RATE, RESULTS IN NORMAL DATA RATE IN THE SAME FORMAT.

• 035  DDP Y SEL

THIS CMD ACTUATES TWO LATCHING RELAYS, ONE IN EACH PDU, TO THE POSITION THAT APPLIES +5 VDC TO THE Y UNIT OF THE DIGITAL DATA PROCESSOR AND REMOVES +5 VDC FROM THE X UNIT. REPEATED APPLICATION OF CMD 035 HAS NO FURTHER EFFECT. SWITCHING DDP'S IN EITHER THE DP OR LSP FORMAT, NORMAL OR SLOW DATA RATE, RESULTS IN NORMAL DATA RATE IN THE SAME FORMAT.
DDP MODE AND BIT RATE COMMANDS

OCTAL CMD NUMBER

006 NORMAL BIT RATE SEL

This cmd selects the DDP timing configuration such that in the DP format mode the downlink data rate is 1060 BPS. In the LSP format mode the downlink data rate is 3533.3 BPS. The application of PWR to ALSEP causes initialization in the normal bit rate configuration. When a change from low bit rate to normal bit rate is commanded, in either DP or LSP format, the change takes effect at the end of the 64-word data frame, following receipt of CMD 006, for whichever DDP is operational. Repeated application of CMD 006 has no further effect.

007 LOW BIT RATE SEL

This cmd selects the DDP timing configuration such that in the DP format mode the downlink data rate is 530 BPS. In the LSP format mode the downlink data rate is 1060 BPS. When a change from normal bit rate to low bit rate is commanded, in either DP or LSP format, the change takes effect at the end of the 64-word data frame, following receipt of CMD 007, for whichever DDP is operational. Repeated application of CMD 007 has no further effect.

005 DP FORMAT ON

This cmd selects the DDP configuration that inhibits inputs from the LSP to the modulator, enables inputs from the digital mux and the other experiments, and enables data demands to those experiments. When switching from LSP format to DP format by CMD 005, in either LSP normal data rate (3533.3 BPS) or LSP low data rate (1060 BPS) the resulting DP data rate will be normal (1060 BPS). CMD 005 takes effect at the end of the 64-word data frame, following receipt, for whichever DDP is operational, but is not outputting data. The application of PWR to ALSEP causes initialization in the DP format configuration. Repeated application of CMD 005 has no further effect.

003 LSP FORMAT ON

This cmd selects the DDP configuration that enables inputs from the LSP to the modulator, inhibits inputs from the digital mux and other experiments, and inhibits data demands to the experiments. When switching from DP format to LSP format by CMD 003, the resulting LSP data rate will be normal or low (3533.3 BPS or 1060 BPS) depending on whether the DP data rate was normal or low (1060 BPS or 530 BPS). CMD 003 takes effect at the end of the 64-word data frame, following receipt, for the DDP in operation at that time. Repeated application of CMD 003 has no further effect.
MODE AND BIT RATE CONFIGURATION SWITCHING

LEGEND:
- BOXES INDICATE MODE AND BIT RATE CONFIGURATIONS
- LINES INDICATE SWITCHING PATHS (NUMBERS ON LINES ARE OCTAL COMMANDS)

MAY 72 3270.2.38
DDP TELEMETRY

THE DDP COLLECTS AND FORMATS THE DATA OUTPUT OF ALL EXPERIMENTS (EXCEPT THE LSP), THE ADP OUTPUT, AND THE CVW (WHEN PRESENT), AND PROVIDES A MODULATION SIGNAL FOR DOWNLINK TRANSMISSION. IN THE DATA PROCESSOR FORMAT, THE OUTPUT IS A 640-BIT DATA FRAME (64 10-BIT DATA WORDS) AT TWO RATES:

1060 BITS PER SECOND: NORMAL BIT RATE
530 BITS PER SECOND: LOW BIT RATE

IDENTICAL FORMATS

IN THE LSP FORMAT, THE DATA COLLECTION AND FORMATTING IS PERFORMED BY THE LSP WITH ONLY TIMING AND MODULATION PERFORMED BY THE DDP. THE OUTPUT IS AN 1800-BIT MAIN DATA FRAME (60 30-BIT DATA WORDS) AT TWO DATA RATES:

3533.3 BITS PER SECOND: NORMAL BIT RATE
1060 BITS PER SECOND: LOW BIT RATE

IDENTICAL FORMATS

IN THE DATA PROCESSOR FORMAT, THE DDP GENERATES THE CONTROL WORDS (WORDS 1, 2, AND 3 IN EACH FRAME) WHICH CONTAIN:

DA-01 ALSEP FRAME SYNC (22 BITS: BARKER CODE AND COMPLEMENT)
DA-02 ALSEP FRAME CNTR (7 BITS: IDENTIFYING 90 SEQUENTIAL FRAMES)
DA-03 ALSEP BIT RATE ID (30TH BIT IN THE FIRST AND SECOND FRAME)
DA-04 ALSEP ID (30TH BIT IN FRAMES 3, 4, AND 5; BINARY 100 FOR APOLLO 17 ALSEP)

THE FOLLOWING STATUS PARAMETER IS SENSED IN THE DDP:
AB-10 DDP STATUS (X OR Y)
**DDP BASIC CLOCK LOGIC**

ADP (X OR Y) \{ CLOCK PULSES

2.0352 MHz \( \div 12 \)

169.6 KHz: BASIC CLOCK FREQUENCY \( \rightarrow \) DDP TIMING

\( \div 2 \)

84.8 KHz

\( \div 80 \)

\( \div 2 \)

\( \div 3 \)

28,266 KHz LSP SUB-BIT TIMING \( \rightarrow \) LSP

\( \div 80 \)

\( \div 8 \)

1060 BPS: DP NORMAL

530 BPS: DP LOW

3533.3 BPS: LSP NORMAL

1060 BPS: LSP LOW

CMD DECODER (RIPPLE-OFF)

DP FORMAT

LSP FORMAT

MAY 72 3270.2.40
DATA PROCESSOR TIMING/CONTROL SIGNALS

N = 1 FOR NORMAL MODE OF 1060 bps
N = 2 FOR SLOW MODE OF 530 bps
LOGIC LEVELS "ONE", + 4.0 ± 1.5 VOLTS; "ZERO", + 0.2 ± 0.2 VOLTS

*32 SEC = 640 BITS PER FRAME
53

ALL OTHER TIMES ARE ACCURATE ONLY TO THE SIGNIFICANT FIGURE SHOWN.
TRANSMITTER FUNCTIONS

SPECIFICATIONS:
- OUTPUT: 1 WATT INTO A 50-OHM LOAD
- FREQUENCY: +0.000, -0.0005% ON INITIAL SETTING
- +0.0005%, -0.0000 DRIFT OVER TWO-YEAR PERIOD
- + 0.002% DUE TO ENVIRONMENTAL EFFECTS
- MODULATION INDEX: + 1.25 RADIUS + 5%

![Diagram of transmitter functions with labels and connections for various components such as oscillators, modulators, amplifiers, filters, and power supplies.]}
TRANSMITTER POWER CONTROL

NOTES:
- CIRCUIT BREAKERS (C/B) ISSUE OFF SIGNALS AT 760 MA FOR +29 VDC AND 150 MA FOR +12 VDC
- CIRCUIT BREAKERS ACTUALLY GROUND RELAY COIL (NOT DRIVER)
- UNLIKE PREVIOUS ALSEP'S, THERE ARE NO BACKUP HEATERS PLACED ON-LINE WHEN BOTH XMTR'S ARE OFF; ALSO, THERE IS NO AUTOMATIC SWITCHOVER FROM ONE XMTR TO THE OTHER (XMTR'S ARE CONTROLLED INDEPENDENTLY)
XMTR POWER COMMANDS

OCTAL CMD NUMBERS

- 012  XMTR A ON

  THIS CMD ACTUATES A PAIR OF LATCHING RELAYS, ONE IN EACH PDU, TO THE POSITION THAT APPLIES +29 VDC TO XMTR A. XMTR A IS PRESET TO BE ENERGIZED AT INITIAL LUNAR ACTIVATION. REPEATED APPLICATION OF CMD 012 HAS NO FURTHER EFFECT.

- 013  XMTR A OFF

  THIS CMD ACTUATES A PAIR OF LATCHING RELAYS, ONE IN EACH PDU, TO THE POSITION THAT REMOVES +29 VDC FROM XMTR A. NOTE THAT THERE IS NO XMTR HEATER TO REPLACE THE LOAD IN THE CENTRAL STATION WHEN BOTH XMTR'S ARE OFF, BUT APM COMPENSATION WILL OCCUR IF NECESSARY. REPEATED APPLICATION OF CMD 013 HAS NO FURTHER EFFECT.

- 014  XMTR B OFF

  THIS CMD ACTUATES A PAIR OF LATCHING RELAYS, ONE IN EACH PDU, TO THE POSITION THAT REMOVES +29 VDC FROM XMTR B AND +12 VDC FROM THE DIPLEXER SWITCH. NOTE THAT THERE IS NO XMTR HEATER TO REPLACE THE LOAD IN THE CENTRAL STATION WHEN BOTH XMTR'S ARE OFF BUT APM COMPENSATION WILL OCCUR IF NECESSARY. XMTR B IS PRESET TO BE DEENERGIZED AT INITIAL LUNAR ACTIVATION. REPEATED APPLICATION OF CMD 014 HAS NO FURTHER EFFECT.

- 015  XMTR B ON

  THIS CMD ACTUATES A PAIR OF LATCHING RELAYS, ONE IN EACH PDU, TO THE POSITION THAT APPLIES +29 VDC TO XMTR B AND +12 VDC TO THE DIPLEXER SWITCH. IN THE ENERGIZED STATE, THE DIPLEXER SWITCH CONNECTS XMTR B TO THE ANTENNA; HENCE, IF BOTH XMTR'S ARE COMMANDED ON SIMULTANEOUSLY, THE OUTPUT OF XMTR B WILL BE RADIATED DOWNLINK. THE OUTPUT OF XMTR A WILL BE DISSIPATED IN A DUMMY LOAD IN THE DIPLEXER SWITCH. REPEATED APPLICATION OF CMD 015 HAS NO FURTHER EFFECT.
TRANSMITTER TELEMETRY

THE FOLLOWING TEMPERATURES ARE SENSED IN THE TRANSMITTERS WITH POWER SUPPLIED IN THE XMTR AND SIGNAL CONDITIONING IN THE ADP (MEASUREMENTS ABSENT IF XMTR IS OFF):

- AT-23 XMTR A POWER AMPLIFIER TEMP, DEG F
- AT-24 XMTR A CASE TEMP, DEG F
- AT-25 XMTR B POWER AMPLIFIER TEMP, DEG F
- AT-26 XMTR B CASE TEMP, DEG F

THE FOLLOWING ELECTRICAL PARAMETERS ARE SENSED IN THE TRANSMITTERS (MEASUREMENTS ABSENT WHEN XMTR IS OFF):

- AE-15 XMTR A REGULATOR CURRENT, AMPS (SENSED IN THE +17 VDC LINE)
- AE-16 XMTR B REGULATOR CURRENT, AMPS (SENSED IN THE +17 VDC LINE)
- AE-17 XMTR A +23 VDC OUTPUT, VOLTS (SENSED AT THE POWER SUPPLY REGULATOR)
- AE-18 XMTR B +23 VDC OUTPUT, VOLTS (SENSED AT THE POWER SUPPLY REGULATOR)
EXPERIMENT POWER CONTROL

(ONE OF FIVE)

NOTE: ASTRO SW IS DOWNSTREAM OF TM

CIRCUIT BREAKER (C/B) SELECTS STANDBY VIA RELAY at 560 ± 50 MA

UNSWITCHED +29 VDC

*RIPPLE-OFF SEQUENCE: PDR 1, PDR 2, LMS, LEAM, HFE, LSG, LSP

MAY 72 3270.2.46
EXPERIMENT POWER CONTROL (CONT'D)

- SELECTION COMMANDS (OCTAL):

```
<table>
<thead>
<tr>
<th></th>
<th>A OPER</th>
<th>B STBY</th>
<th>C OFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1, LMS</td>
<td>036</td>
<td>037</td>
<td>041</td>
</tr>
<tr>
<td>#2, LEAM</td>
<td>042</td>
<td>043</td>
<td>044</td>
</tr>
<tr>
<td>#3, HFE</td>
<td>045</td>
<td>046</td>
<td>050</td>
</tr>
<tr>
<td>#4, LSG</td>
<td>052</td>
<td>063</td>
<td>054</td>
</tr>
<tr>
<td>#5, LSP</td>
<td>055</td>
<td>056</td>
<td>057</td>
</tr>
</tbody>
</table>
```

- POWER SWITCHING FROM OFF TO STBY IS INHIBITED:

```
A
B
```

- NORMAL OPERATING SEQUENCES:

```
<table>
<thead>
<tr>
<th>SEQUENCE</th>
<th>RELAY CONTACT POSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF TO OPER</td>
<td>1 UP 2 UP 3 DOWN</td>
</tr>
<tr>
<td>OPER TO STBY</td>
<td>1 DOWN 2 UP 3 DOWN</td>
</tr>
<tr>
<td>STBY TO OFF</td>
<td>1 DOWN 2 DOWN 3 DOWN</td>
</tr>
<tr>
<td>OPER TO OFF</td>
<td>1 DOWN 2 DOWN 3 DOWN</td>
</tr>
</tbody>
</table>
```

- OVERLOAD (CIRCUIT BREAKER) SEQUENCE:

```
<table>
<thead>
<tr>
<th>SEQUENCE</th>
<th>RELAY CONTACT POSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPER (INITIAL)</td>
<td>1 UP 2 UP 3 DOWN</td>
</tr>
<tr>
<td>OPER TO OVERLOAD 1</td>
<td>1 UP 2 UP 3 UP</td>
</tr>
<tr>
<td>OVERLOAD 1 TO OVERLOAD 2</td>
<td>1 DOWN 2 UP 3 UP</td>
</tr>
<tr>
<td>OVERLOAD 2 TO STBY</td>
<td>1 DOWN 2 UP 3 DOWN</td>
</tr>
</tbody>
</table>
```

MAY 72 3270.2.47
EXPERIMENT POWER SWITCHING

OCTAL CMD NUMBERS

• 036  EXPER 1 OPER (LMS)

  THIS CMD ACTUATES LATCHING RELAYS, IN BOTH PDU'S, TO THE
  POSITION THAT APPLIES +29 VDC TO THE OPERATING LINE OF THE LMS. REPEATED
  APPLICATION OF CMD 036 HAS NO FURTHER EFFECT.

• 037  EXPER 1 STBY (LMS)

  THIS CMD ACTUATES LATCHING RELAYS, IN BOTH PDU'S, TO THE POSITION
  THAT REMOVES +29 VDC OPERATIONAL POWER FROM THE LMS, IF IT WAS IN THE
  OPERATE MODE, AND APPLIES +29 VDC TO THE STANDBY LINE. IN THE OFF MODE,
  CMD 037 DOES NOT CONTROL PWR AND THE EXPERIMENT REMAINS OFF. REPEATED
  APPLICATION OF CMD 037 HAS NO FURTHER EFFECT.

• 041  EXPER 1 OFF (LMS)

  THIS CMD ACTUATES LATCHING RELAYS, IN BOTH PDU'S, TO THE POSITION
  THAT REMOVES ALL +29 VDC PWR FROM THE LMS, WHETHER IT WAS PREVIOUSLY
  IN THE OPERATE MODE OR THE STANDBY MODE. THE EXPERIMENT RELAYS ARE
  PRESET TO BE IN THE OFF MODE AT INITIAL LUNAR ACTIVATION. REPEATED
  APPLICATION OF CMD 041 HAS NO FURTHER EFFECT.
EXPERIMENT POWER SWITCHING (CONT’D)

OCTAL CMD NUMBERS

• 042  EXPER 2 OPER (LEAM)

  This cmd actuates latching relays, in both PDU's, to the position that applies +29 VDC to the operating line of the LEAM. Repeated application of cmd 042 has no further effect.

• 043  EXPER 2 STBY (LEAM)

  This cmd actuates latching relays, in both PDU's, to the position that removes +29 VDC operational power from the LEAM, if it was in the operate mode, and applies +29 VDC to the standby line. In the off mode, cmd 043 does not control PWR and the experiment remains off. Repeated application of cmd 043 has no further effect.

• 044  EXPER 2 OFF (LEAM)

  This cmd actuates latching relays, in both PDU's, to the position that removes all +29 VDC PWR from the LEAM, whether it was previously in the operate mode or the standby mode. The experiment relays are preset to be in the off mode at initial lunar activation. Repeated application of cmd 044 has no further effect.
EXPERIMENT POWER SWITCHING (CONT'D)

OCTAL CMD NUMBERS

- **045 EXP 3 OPER (HFE)**

  This cmd actuates latching relays, in both PDU's, to the position that applies +29 VDC to the operating line of the HFE. Repeated application of cmd 045 has no further effect.

- **046 EXP 3 STBY (HFE)**

  This cmd actuates latching relays, in both PDU's, to the position that removes +29 VDC operational power from the HFE, if it was in the operate mode, and applies +29 VDC to the standby line. In the off mode, cmd 046 does not control PWR and the experiment remains off. Repeated application of cmd 046 has no further effect.

- **050 EXP 3 OFF (HFE)**

  This cmd actuates latching relays, in both PDU's, to the position that removes all +29 VDC PWR from the HFE, whether it was previously in the operate mode or the standby mode. The experiment relays are preset to be in the off mode at initial lunar activation. Repeated application of cmd 050 has no further effect.

MAY 72 3270.2.50
EXPERIMENT POWER SWITCHING (CONT’D)

OCTAL CMD NUMBERS

- **052** EXPER 4 OPER (LSG)

This cmd actuates latching relays, in both PDU's, to the position that applies +29 VDC to the operating line of the LSG. Repeated application of CMD 052 has no further effect.

- **053** EXPER 4 STBY (LSG)

This cmd actuates latching relays, in both PDU's, to the position that removes +29 VDC operational power from the LSG, if it was in the operate mode, and applies +29 VDC to the standby line. In the off mode, CMD 053 does not control PWR and the experiment remains off. Repeated application of CMD 053 has no further effect.

- **054** EXPER 4 OFF (LSG)

This cmd actuates latching relays, in both PDU's, to the position that removes all +29 VDC PWR from the LSG, whether it was previously in the operate mode or the standby mode. The experiment relays are preset to be in the off mode at initial lunar activation. Repeated application of CMD 054 has no further effect.
EXPERIMENT POWER SWITCHING (CONT'D)

OCTAL CMD NUMBERS

- **055** EXPER 5 OPER (LSP)

  This cmd actuates latching relays, in both PDU's, to the position that applies +29 VDC to the operating line of the LSP. Astro SW 2 is also in this line and TM will show oper mode regardless of the state of Astro SW 2. Repeated application of cmd 055 has no further effect.

- **056** EXPER 5 STBY (LSP)

  This cmd actuates latching relays, in both PDU's, to the position that removes +29 VDC operational power from the LSP, if it was in the oper mode, and applies +29 VDC to the standby line. The LSP has no standby mode. In the off mode, cmd 056 does not control PWR and the experiment remains off. The experiment relays are preset to be in the STBY mode at initial lunar activation. Repeated application of cmd 056 has no further effect.

- **057** EXPER 5 OFF (LSP)

  This cmd actuates latching relays, in both PDU's, to the position that removes all +29 VDC PWR from the LSP, whether it was previously in the oper mode or the standby mode. Repeated application of cmd 057 has no further effect.

MAY 72 3270.2.52
 EXPERIMENT POWER TELEMETRY

THE FOLLOWING STATUS PARAMETERS ARE GENERATED IN THE EXPERIMENT POWER CIRCUITS:

AB-04  EXPER 1/2 STATUS  (INDICATES THE OPER, STANDBY, OR OFF STATUS OF EXPERIMENT #1, LMS, AND EXPERIMENT #2, LEAM. IF THE STANDBY FUSE IS BLOWN, WILL INDICATE OFF WHEN COMMANDED TO STANDBY)

AB-05  EXPER 3/4 STATUS  (INDICATES THE OPER, STANDBY, OR OFF STATUS OF EXPERIMENT #3, HFE, AND EXPERIMENT #4, LSG. IF THE STANDBY FUSE IS BLOWN, WILL INDICATE OFF WHEN COMMANDED TO STANDBY)

AB-11  EXPER 5 STATUS  (INDICATES OPER, STANDBY, OR OFF FOR EXPERIMENT #5, LSP. THE STANDBY POWER CIRCUIT IS NOT CONNECTED TO THE LSP; FUNCTIONALLY, THE LSP IS OFF FOR BOTH OF THESE RELAY SETTINGS. FOR THE LSP TO RECEIVE OPERATIONAL POWER, THE RELAYS MUST BE IN THE OPERATE SETTING AS INDICATED BY AB-11, AND ASTRO SWITCH 2 MUST BE IN THE CW, CLOSED, POSITION)
UPLINK AND PERIODIC CMD FUNCTIONS
(NOT REDUNDANT)

DDP (X OR Y)
90-FRAME PULSE (118 MICRO SEC) EVERY 54.3396 SEC AT NORMAL BIT RATE

12 STAGE COUNTER
CLEAR AND STARTS AT APPLICATION OF POWER TO ASEP (SHORTING SWITCH ACTUATION)

GATING LOGIC
AB-15 PER CMD EN/INH
ENABLE
PERIODIC CMD LOGIC
AB-18 UPLINK SW STA
ENABLE
ENABLE 
DISABLE 
INHIBIT
INHIBIT
UPLINK SWITCHOVER (AUTO OR 122) CAUSES RESET TO PERIODIC CMD ENABLE

RCVR/DEC SW INH
UPLINK RELAYS

RCVR/DEC SW

MAY 72 3270.2.54
UPLINK AND PERIODIC CMD TIMING

START: $T = 0$ AT SHORTING SWITCH ACTUATION

ONE REVOLUTION EVERY 61 HR, 49 MIN, 35 SEC

7 HR, 38 MIN, 43 SEC TO FIRST PULSE
UPLINK SWITCH PULSE AND CMD 111
CMD 111 AND UPLINK SWITCH ENABLE
3 MIN, 37 SEC

15 HR, 27 MIN, 24 SEC
PERIODIC CMD ENABLE AND INHIBIT

OCTAL CMD NUMBER

• 104 PER CMD ENABLE

THIS CMD ACTUATES CIRCUITRY IN THE CMD DECODER TO ENABLE OUTPUT OF PERIODIC CMDS EVERY 15.46 HR EXCEPT FOR THE FIRST OUTPUT WHICH IS AT 7.65 HR. TWO OUTPUTS OCCUR WITH A 3.55-MINUTE INTERVAL, THE FIRST BEING BOTH CMD 065 (NOT USED) AND CMD 111, THE SECOND BEING COMMAND 111. THE APPLICATION OF PWR TO ALSEP CAUSES INITIALIZATION IN THE ENABLE CONFIGURATION. REPEATED APPLICATION OF CMD 104 HAS NO FURTHER EFFECT.

• 105 PER CMD INHIBIT

THIS CMD ACTUATES CIRCUITRY IN THE CMD DECODER TO INHIBIT OUTPUT OF PERIODIC CMDS. REPEATED APPLICATION OF CMD 105 HAS NO FURTHER EFFECT. A SEQUENCE OF COMMANDS 104 AND 105, ALTERNATING ENABLE/INHIBIT, DOES NOT PRODUCE SPURIOUS PER CMD PULSES.

TELEMETRY

THE FOLLOWING STATUS PARAMETER IS GENERATED IN THE PERIODIC COMMAND CIRCUIT:

AB-15 PER CMD EN/INH (INDICATES WHETHER OUTPUT PULSES FROM THE 12-STAGE COUNTER WILL BE APPLIED TO THE COMMAND LINE GATES)
RIPPLE-OFF SEQUENCER FUNCTION

- If overload exists for 121 + 1 ms, then PDR off and Exper Stby Cmds are issued sequentially for 8 counts each until overload no longer exists.
- When overload is cleared, the counter is reset to 7 automatically and no further ripple-off Cmds are issued.
- Note that experiments can not switch from off to stby; if they are off, they remain off.
- If counter runs to 192, it may be a ripple-off malfunction; therefore, a lock-out feature is provided to inhibit further counter action. Exper/PDR should be reset by Cmd and then issue Cmd 032 to check performance.
- Pcu switchover may cause initialization and clear lock-out if it exists.

MAY 72 3270.2.57
RIPPLE-OFF RESET COMMAND

OCTAL CMD NUMBER

• 032 RIPPLE-OFF RESET

This cmd resets the counter in the ripple-off sequencer, thus restoring the ripple-off capability after the counter has run to the end and locked itself out. The lock-out feature is provided in case a malfunction in the ripple-off circuitry causes erroneous ripple-off. If a reset by cmd 032 is followed by a second (erroneous) ripple-off, cmd 032 should be flagged as critical. When no malfunction exists in the ripple-off circuitry, repeated application of cmd 032 has no further effect. In normal alsep start-up, the ripple-off counter is reset by the turn-on pwr transient.
ASTRONAUT SWITCH FUNCTIONS

ASTRO SW-1 (FOR CONTINGENCY USE ONLY)

- Normally in CCW position, at launch
- Double-pole, double-throw switch (redundant contacts)
- If ALSEP fails to start up normally, astronaut rotates SW-1 back and forth (from CCW to CW and back to CCW) as fast as he wants to. It is spring-loaded CCW, but deliberate rotation is recommended.
- CW rotation opens RTG line to PCU and simultaneously applies RTG power to PCU 2 SEL relay coil causing transfer to PCU 2 setting
- CCW rotation removes RTG power from relay coil and applies RTG to PCU 2

ASTRO SW-2 (USED OPERATIONALLY)

- Normally in CCW position, at launch, which opens line and prevents +29 VDC from being applied to LSP during deployment
- After deployment of LSP explosive packages, astronaut rotates SW-2 CW to enable command application of +29 VDC operational power to the LSP

Note: Direction of rotation for enable/inhibit is the reverse of SW-5 on earlier ALSEP's with ASE.
LUNAR SURFACE GRAVIMETER
(LSG)
LSG EXTERNAL CONFIGURATION

DEPLOYED

STOWED

JUNE 72 3270.3.2
LSG OBJECTIVES AND MEASUREMENTS

OBJECTIVES:

- SEARCH FOR GRAVITATIONAL RADIATION FROM COSMIC SOURCES, WHICH MAY EXCITE LOW-FREQUENCY FREE OSCILLATIONS OF THE MOON, IN THE FREQUENCY RANGE UPWARD FROM ONE CYCLE EVERY 15 MINUTES

- OBTAIN INFORMATION ON THE INTERNAL STRUCTURE OF THE MOON BY OBSERVATION OF LUNAR TIDES

- OBTAIN VERTICAL AXIS SEISMIC DATA UP TO FREQUENCIES OF 16 HZ

- DETERMINE THE RATIO OF LUNAR GRAVITATIONAL FORCE TO EARTH GRAVITY WITH A PRECISION OF 1 PART IN $10^5$

MEASUREMENTS:

- USE THE LACOSTE-ROMBERG TYPE OF SPRING-MASS SUSPENSION TO SENSE CHANGES IN THE VERTICAL COMPONENT OF LOCAL GRAVITY

- BASIC INSTRUMENT SENSITIVITY TO CHANGES IN THE LUNAR GRAVITATIONAL FORCE IS 1 PART IN $10^{10}$

- SHORT-PERIOD CHANGES (FREQUENCIES UP TO 16 HZ) ARE RECORDED AS SEISMIC DATA WHILE LONG-PERIOD CHANGES MEASURE TIDAL EFFECTS

- THE LOWEST FREQUENCIES (LONGEST PERIODS) ARE ASSOCIATED WITH FREE OSCILLATIONS OF THE MOON

JUNE 72 3270.3.3
LSG COMPONENTS AND ELECTRICAL INTERFACE

ALSEP
CENTRAL STATION

DATA SUBSYSTEM

PDU (1 OR 2)

LSG DEPLOYED EQUIPMENT

STRUCTURE/ THERMAL

COMMANDS (7 LINES)
FRAME MARK
90 FRAME MARK
DATA DEMAND
DATA GATE
DATA SHIFT CLOCK
DIGITAL DATA
ANALOG DATA (10 LINES)

+29 VDC OPER PWR (5 LINES)
+29 VDC OPER RTN (5 LINES)
+29 VDC STBY PWR (2 LINES)
+29 VDC STBY RTN (2 LINES)
**LSG OPERATIONS SUMMARY**

**DEPLOYMENT**

- LOCATE 25 FT FROM CENTRAL STATION
- RAISE AND TILT SUNSHADE
- SET INSTRUMENT ON FIRM SURFACE WITH APPROXIMATE ORIENTATION
- LEVEL ± 3° WRT BUBBLE AND ALIGN ± 3° WRT SHADOW
- PERFORM INITIAL UNCAGING
- REPORT LEVEL AND ALIGNMENT

APPROX TIME, 3 MIN

**POST DEPLOYMENT**

- UNCAGE AND ACTIVATE BY CMD
- PERFORM INITIAL SET-UP/CHECK-OUT CMD SEQUENCE
- MAKE SUBSEQUENT ADJUSTMENTS BY CMD AS REQUIRED

JUNE 72 3270.3.6
LSG COMMUNICATIONS SUMMARY

COMMANDS

- POWER OPER/STBY/OFF
- 7 SPECIAL cmds FOR:
  INSTRUMENT HOUSING HEATER ON/OFF (2)
  LSG CMD DECODER ON/OFF (2)
  LSG CMD REGISTER UP/DOWN (2)
  LSG CMD REGISTER EXECUTE (1)
- THE LSG CMD REGISTER PROVIDES
  FOR 30 ENCODED CMDS WHICH
  PERFORM VARIOUS INTERNAL
  ADJUSTMENTS AND FUNCTIONAL
  CHANGES IN LSG OPERATION

DATA

- 36 TEN-BIT DIGITAL WORDS
  IN EACH 64-WORD ALSEP
  DATA FRAME, WITH TWO
  DIFFERENT WORD ASSIGNMENTS
  SELECTABLE BY CMD:
  - NORMAL SCIENTIFIC DATA
  - SHAFT ENCODER DATA
- DIGITAL DATA RATE, 60 BITS PER
  SEC (AVERAGE AT NORMAL BIT RATE)
- ONE COMPLETE UPDATE OF
  SCIENTIFIC DATA IN EACH
  ALSEP FRAME (0.6-SEC REP RATE
  AT ALSEP NORMAL BIT RATE)
- SHAFT ENCODER DATA ARE READ
  OUT AS OFTEN AS 12 TIMES IN
  EACH ALSEP FRAME AND REPEATED
  FOR 90 FRAMES (NO CHANGE IN
  READINGS)
- 10 ANALOG ENGINEERING
  PARAMETERS EACH SAMPLED
  ONCE EVERY 90 ALSEP DATA
  FRAMES (54 SEC AT NORMAL
  BIT RATE)

JUNE 72 3270.3.7
LSG DESIGN PARAMETERS

MECHANICAL

SENSITIVITY: DEVIATIONS IN LUNAR SURFACE ACCELERATION OF ONE PART IN 10^10 OR BETTER

ACCURACY: LUNAR TIDES, 0.1% OR BETTER
RESOLUTION FOR INDIVIDUAL MEASUREMENTS, 2 MICROGALS
RATIO OF LUNAR G TO EARTH G, 1 PART IN 10^5

THERMAL

SHORT TERM STABILITY: ± 0.001°C (FOR PERIODS UP TO 30 MIN.) AT AN INVERSION TEMPERATURE NEAR 50°C

LONG TERM DRIFT: 0.1°C PER MONTH

ABSOLUTE TEMPERATURE: 0.001°C

ELECTRICAL

PREAMP GAIN: 40
POSTAMP GAIN: 1 TO 90 IN STEPS OF 6
SEISMIC AMPLIFIER GAIN WITH SOFT LIMITING: 500
FREE MODES AMP GAIN: 500
INTEGRATOR TIME CONSTANT: 50 SEC
BIAS VOLTAGE: 13V ± 1V
ANALOG STATUS DATA: 0 TO 5V TO CENTRAL STATION
SCIENCE DATA: 10 BINARY BITES PER WORD

JUNE 72 3270.3.8
NOTE:
SCALE MODIFIED FOR CLARITY

LSG SENSOR DETAILS

FINE SCREW
FIXED CAPACITOR PLATES (DETECTOR)

OPPOSITE ROTATION OF SCREW
LIFTS MASS OFF PAN, THEN MASS FOR FINE TRIM OF LUNAR MASS

NOTE:
CUP HAS GUIDE TO PREVENT ROTATION WHEN SCREW TURNS

CONDITIONS:
PAN AND BEAM MAKE UP EARTH MASS
TO CAGE, FINGERS CLAMP ON MASS AND PAN, RAISING PAN (SLACK IN WIRE)
FULL ROTATION OF SCREW INTO CUP PLACES ALL 3 MASSES ON PAN

JUNE 72 3270.3.9
LSG STOWED CROSS SECTION

CAGING FEATURES:
1. HOUSING, HANGING ON UNIVERSAL JOINT, IS CAGED BY DOWNWARD RESTRAINT AND RELEASED BY ASTRONAUT (LANYARD). DIFFICULT TO RECAGE.
2. MASS CHANGING MECHANISM IS CAGED BY CALIPER-TYPE FINGERS CLAMPING ON MASS 1 AND PAN, RAISING PAN. RELEASED AND RECAGED BY COMMAND.
3. SENSOR BEAM IS CAGED BY CLAMPING BEAM AGAINST STOP. RELEASED AND RECAGED BY COMMAND.
LSG PHYSICAL PARAMETERS

SIZE, WEIGHT, AND POWER

STOWED

SIZE, IN.

10.9 LENGTH

15.1 HEIGHT

PLUS 3 X 3 (DIAM)

CABLE REEL

EARTH WT. LB: 28

POWER, W: 9.3 (APPROX, MAX)

JUNE 72 3270.3.11
LSG SENSOR ELECTRONICS

NOTE:
- IDENTIFIES ENCODED CMD WITH BINARY CODE IN PARENTHESES

- (00011) BIAS IN SEL
- (00100) BIAS OUT SEL
- (11101) POST AMP GAIN STEP
- (11110) POST AMP GAIN RESET
- (00101) INTEGRATOR NORMAL SEL
- (00110) INTEGRATOR SHORT SEL
- (00111) SEISMIC LOW GAIN SEL
- (01000) SEISMIC HIGH GAIN SEL

FIXED PREAMP (40 DB) -> DC BRIDGE AND AC COUPLING
DIGITAL GAIN CONTROL (15 STEPS) -> POST GAIN AMPLIFIER (0 TO 39 DB)
PHASE SENSITIVE DEMODULATOR
AMPLITUDE STABILIZED OSCILLATOR
INTEGRATOR
SEISMIC AMPLIFIER AND FILTER
SEISMIC BUFFER

AG-07 LSG OSC AMP
AG-01 LSG SEISMIC
AG-02 LSG TIDE
AG-03 LSG FREE MODE
FREE MODE FILTER
DIGITAL FILTER

TIDE FREE MODE LSG ANALOG LINE BUFFERS
ELECTROSTATIC FEEDBACK SIGNAL
SEISMIC PROCESSING

JUNE 72 3270.3.15
LSG BEAM CAGING CONTROL

NOTE:
IDENTIFIES ENCODED CMD WITH BINARY CODE IN PARENTHESES
LSG MASS CHANGING CONTROL

- Switched +15 VDC
- Switched +5 VDC
- Mass Change Mtr On
- Tilt, Mass Change, and Screw Servo Off
- Mass Change Increment
- 5-Bit Counter
- Digital to Analog Converter
- Mass State Comparator
- Mass Change Motor Drive
- DC Motor
- In Sensor
- I-S-G Pressure Transducer
- Screw Servo
- Tilt Servo
- Power Relay
- Power Converter
- +15 VDC
- +5 VDC
- -15 VDC
- Relay Pwr
- Reg
- Pot Voltage Ref

NOTE:
- Indicates Encoded Cmd with Binary Code in Parentheses

JUNE 72 3270.3.17
LSG SCREW SERVO CONTROL

NOTE: Indicates encoded CMD with binary code in parentheses

JUNE 72 3270.3.18
LSG SHAFT ENCODERS

NOTE:

INDICATES ENCODED CMD WITH BINARY CODE IN PARENTHESES

LSG POWER CONVERTER (0000) READ SHAPT ENCODERS

LSG TIMING AND CONTROL

90-FRAME MARK DATA DEMAND FRAME MARK

COUNTER

ENCODER SELECTOR

COARSE ENCODER ENABLE RETARD BRUSHES 1-10

ADVANCE BRUSHES 1-10

ADVANCE BRUSHES 11-19

RETARD BRUSHES 11-19

FINE ENCODER ENABLE RETARD BRUSHES 1-10

ADVANCE BRUSHES 1-10

ADVANCE BRUSHES 11-19

RETARD BRUSHES 11-19

LSG DIGITAL MULTIPLEXER

DG-07 COARSE ENCODER MSB DG-08 COARSE ENCODER LSB DG-09 FINE ENCODER MSB DG-10 FINE ENCODER LSB

10-BIT (PARALLEL) DATA: APPEARS IN ALL LSG WORDS IN ALSEP DATA FRAME

BRUSH SELECTION LOGIC BITS 1-10

BRUSH SELECTION LOGIC BITS 11-19

TO DIGITAL MULTIPLEXER CONTROL TO SHAPT ENCODER LOGIC

SWITCHED +5 VDC

POWER ON/OFF CONTROL

TRANSMITOR SWITCH

+5 VDC

ENERGIZED ON AT FIRST 90-FRAME MARK AFTER CMD AND OFF AT NEXT 90-FRAME MARK

JUNE 72 3270.3.19
LSG TILT SERVO CONTROL

NOTE:

- INDICATES ENCODED CMD WITH BINARY CODE IN PARENTHESES

- (10100) NORTH/SOUTH TILT SERVO ON
- (10101) EAST/WEST TILT SERVO ON
- (01100) TILT, MASS CHANGE, AND SCREW SERVO OFF

TO

MASS CHANGE
SCREW SERVO
PRESSURE TRANSDUCER

LSG POWER CONVERTER

PWR AND RTN

DC-14 TILT SERVO STA

UP/DOWN CMD STORE AND TILT SERVO SYST RESET

START

TIMEOUT COUNTER CLOCK GATE

GATED PULSES

TO SCREW SERVO

TIMEOUT GENERATOR

RESET

PULSE

TILT SERVO POWER SWITCHES

MOTOR SELECTION RELAYS

MOTOR

PULSE

NORTH/SOUTH

EAST/WEST

DATA GATE PULSES (CLOCK INPUT)

JUNE 72 3270.3.20
LSG TEMPERATURE CONTROL

+29 VDC STANDBY PWR
PDU
+29 VDC HTR RTN
+29 VDC HTR PWR
HEATER POWER SUPPLY
HEATER LATCHING RELAY
SWITCHING AMPLIFIER
INTEGRATOR
LINEAR AMPLIFIER
BRIDGE CIRCUIT
POWER DRIVER
OUTPUT POWER STAGE
FINE HEATER
LINER AMPLIFIER
BRIDGE CIRCUIT
SIX RELAYS (64 STEPS)
DG-11 TEMP RELAY STA
HEATER BOX
HEATER OUTPUT
HEATER POWER BOX
HEAT BOX TEMPERATURE CONTROL
THERMOSTAT OPENS 105°F
CLOSES 95°F (100° RANGE BUT +5° TOLERANCE)
SURVIVAL HEATER
JUNE 72 3270.3.23

NOTE:
- INDICATES ENCODED CMD WITH BINARY CODE IN PARENTHESES

- (10110) TEMPERATURE INCREMENT LOAD 1
- (10111) TEMPERATURE INCREMENT LOAD 2
- (11000) TEMPERATURE INCREMENT LOAD 3
- (11001) TEMPERATURE INCREMENT LOAD 4
- (11010) TEMPERATURE INCREMENT LOAD 5
- (11011) TEMPERATURE INCREMENT LOAD 6
- (11100) TEMPERATURE RESET
### LSG POWER SUMMARY

<table>
<thead>
<tr>
<th>ITEM</th>
<th>POWER, WATTS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>INCREMENT</td>
<td>TOTAL</td>
</tr>
<tr>
<td>BASIC SYSTEM</td>
<td>2.09</td>
<td>2.09 INCLUDES 0.5 W HEATER BOX HTR</td>
</tr>
<tr>
<td>COMMAND DECODER</td>
<td>0.41</td>
<td>2.50</td>
</tr>
<tr>
<td>TILT SERVO ELECTRONICS</td>
<td>0.09</td>
<td>2.59</td>
</tr>
<tr>
<td>TILT MOTOR</td>
<td>1.00</td>
<td>3.59 WITH MOTOR RUNNING</td>
</tr>
<tr>
<td>SCREW SERVO ELECTRONICS</td>
<td>0.15</td>
<td>2.65</td>
</tr>
<tr>
<td>SCREW MOTOR</td>
<td>1.00</td>
<td>3.65 WITH MOTOR RUNNING</td>
</tr>
<tr>
<td>MASS CHANGE MOTOR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAXIMUM</td>
<td>4.00</td>
<td>6.50</td>
</tr>
<tr>
<td>MINIMUM</td>
<td>1.70</td>
<td>4.20</td>
</tr>
<tr>
<td>SHAFT ENCODER ELECTRONICS</td>
<td>0.21</td>
<td>2.30 CMD DECODER NOT ON</td>
</tr>
<tr>
<td>UNCAGE/RECAGE MOTOR</td>
<td>2.00</td>
<td>4.50 WITH MOTOR RUNNING</td>
</tr>
<tr>
<td>INSTRUMENT HOUSING HEATER</td>
<td>6.70</td>
<td>8.79 CMD DECODER NOT ON</td>
</tr>
<tr>
<td>MAXIMUM</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SURVIVAL HEATER (STANDBY PWR) IS 4.20 WATTS WITH ON/OFF THERMOSTAT CONTROL
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Priority</th>
<th>Indicator</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from Central Station</td>
<td>25 ± 5 ft</td>
<td>Visual</td>
<td>Avoid craters &amp; rubble</td>
</tr>
<tr>
<td>Direction from Central Station</td>
<td>West</td>
<td>Visual</td>
<td>Visual</td>
</tr>
<tr>
<td>Site Selection</td>
<td></td>
<td></td>
<td>Central Station Cable Length 30 ± 1 ft</td>
</tr>
<tr>
<td>Rough Alignment</td>
<td></td>
<td>Circular Dial</td>
<td>Dial marked in degrees of latitude</td>
</tr>
<tr>
<td>Sunshade Tilt Setting</td>
<td></td>
<td>Bubble Level</td>
<td>Off-level condition degrades alignment accuracy</td>
</tr>
<tr>
<td>Level, WRT Indicator</td>
<td></td>
<td>Within ± 3°</td>
<td>Marking on sunshade panel on inside of lower west panel</td>
</tr>
<tr>
<td>Shadow</td>
<td></td>
<td></td>
<td>Shadow of upper east panel</td>
</tr>
</tbody>
</table>

**Notes**
- Stable on 15° slope with sunshade deployed and fully tilted
- Re-check level and alignment after lanyard release of instrument housing caging restraint

**LSG Emplacement Criteria**
LSG ALIGNMENT MARKINGS

1. SUNSHADE TILT DIAL - MARKED IN DEGREES OF LATITUDE
2. BUBBLE LEVEL - WITHIN ±3° WHEN BUBBLE IS FREE OF CASE
3. SHADOW ALIGNMENT - LIMITS OF ±3° ARE MARKED ON INSIDE OF LOWER SUNSHADE PANELS
**LSG COMMAND SUMMARY**

### OCTAL COMMANDS

<table>
<thead>
<tr>
<th>OCTAL</th>
<th>COMMAND DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>063</td>
<td>LSG HTR ON</td>
</tr>
<tr>
<td>064</td>
<td>LSG HTR OFF</td>
</tr>
<tr>
<td>067</td>
<td>LSG CMD EX</td>
</tr>
<tr>
<td>070</td>
<td>LSG DECODER ON</td>
</tr>
<tr>
<td>071</td>
<td>LSG DECODER OFF</td>
</tr>
<tr>
<td>072</td>
<td>LSG STEP UP</td>
</tr>
<tr>
<td>074</td>
<td>LSG STEP DN</td>
</tr>
</tbody>
</table>

### ENCODED COMMANDS (BINARY)

<table>
<thead>
<tr>
<th>BINARY</th>
<th>COMMAND DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>00001</td>
<td>READ SHAFT ENCODERS</td>
</tr>
<tr>
<td>00010</td>
<td>MASS CHANGE MOTOR ON</td>
</tr>
<tr>
<td>00011</td>
<td>BIAS IN SELECT</td>
</tr>
<tr>
<td>00100</td>
<td>BIAS OUT SELECT</td>
</tr>
<tr>
<td>00101</td>
<td>INTEGRATOR NORMAL MODE SELECT</td>
</tr>
<tr>
<td>00110</td>
<td>INTEGRATOR SHORT MODE SELECT</td>
</tr>
<tr>
<td>00111</td>
<td>SEISMIC LOW GAIN SELECT</td>
</tr>
<tr>
<td>01000</td>
<td>SEISMIC HIGH GAIN SELECT</td>
</tr>
<tr>
<td>01001</td>
<td>SENSOR BEAM CAGE</td>
</tr>
<tr>
<td>01010</td>
<td>SENSOR BEAM UN Cage</td>
</tr>
<tr>
<td>01011</td>
<td>COARSE SCREW SERVO ON</td>
</tr>
<tr>
<td>01100</td>
<td>TILT, MASS CHANGE, AND SCREW SERVO OFF</td>
</tr>
<tr>
<td>01101</td>
<td>PRESSURE TRANSDUCER ON</td>
</tr>
<tr>
<td>01110</td>
<td>MASS CHANGE INCREMENT</td>
</tr>
<tr>
<td>01111</td>
<td>GROSS SLEW UP/ TILT INCREMENT UP</td>
</tr>
<tr>
<td>10000</td>
<td>GROSS SCREW DOWN/ TILT INCREMENT DOWN</td>
</tr>
<tr>
<td>10001</td>
<td>VERNIER SLEW UP</td>
</tr>
<tr>
<td>10010</td>
<td>VERNIER SLEW DOWN</td>
</tr>
<tr>
<td>10011</td>
<td>FINE SCREW SERVO ON</td>
</tr>
<tr>
<td>10100</td>
<td>NORTH/SOUTH TILT SERVO ON</td>
</tr>
<tr>
<td>10101</td>
<td>EAST/WEST TILT SERVO ON</td>
</tr>
<tr>
<td>10110</td>
<td>TEMPERATURE INCREMENT LOAD 1</td>
</tr>
<tr>
<td>10111</td>
<td>TEMPERATURE INCREMENT LOAD 2</td>
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<td>11000</td>
<td>TEMPERATURE INCREMENT LOAD 3</td>
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<td>11001</td>
<td>TEMPERATURE INCREMENT LOAD 4</td>
</tr>
<tr>
<td>11010</td>
<td>TEMPERATURE INCREMENT LOAD 5</td>
</tr>
<tr>
<td>11011</td>
<td>TEMPERATURE INCREMENT LOAD 6</td>
</tr>
<tr>
<td>11100</td>
<td>TEMPERATURE RESET</td>
</tr>
<tr>
<td>11101</td>
<td>POST AMP GAIN STEP</td>
</tr>
<tr>
<td>11110</td>
<td>POST AMP GAIN RESET</td>
</tr>
</tbody>
</table>

*JUNE 72 3270.3.28*
LSG COMMANDS

OCTAL CMD NUMBER

• 063  LSG HTR ON
  
  **THIS CMD ACTUATES A LATCHING RELAY IN THE LSG TO THE POSITION THAT APPLIES +29 VDC SLAVE HEATER POWER TO THE LSG INSTRUMENT HOUSING. THIS HEATER IS SLAVED TO THE TEMPERATURE OF THE HEATER BOX BY TWO SENSORS, ONE ON THE INSTRUMENT HOUSING, USING A DIFFERENTIAL OUTPUT BY MEANS OF A BRIDGE CIRCUIT. REPEATED APPLICATION OF CMD 063 HAS NO FURTHER EFFECT. THE SLAVE HEATER IS PRESET TO BE IN THE 00000 CONDITION AT INITIAL LUNAR ACTIVATION.**

• 064  LSG HTR OFF
  
  **THIS CMD ACTIVATES A LATCHING RELAY IN THE LSG TO THE POSITION THAT REMOVES +29 VDC SLAVE HEATER POWER FROM THE LSG INSTRUMENT HOUSING. REPEATED APPLICATION OF CMD 064 HAS NO FURTHER EFFECT. THE SLAVE HEATER IS PRESET TO BE IN THE 00000 CONDITION AT INITIAL LUNAR ACTIVATION.**

• 067  LSG CMD EX
  
  **THIS CMD CAUSES EXECUTION OF ONE OF THE 30 ENCODED LSG CMDS AS CONTAINED IN ITS 5-STAGE CMD REGISTER WHICH IS SHIFTED UP/DOWN BY OCTAL CMDS 072/074. EXECUTION DOES NOT CLEAR THE REGISTER. REPEATED APPLICATION OF CMD 067 WILL CAUSE REPEATED EXECUTION OF THE SELECTED ENCODED CMD.**

• 070  LSG DECODER ON
  
  **THIS CMD ACTUATES A LATCHING RELAY IN THE LSG TO THE POSITION THAT APPLIES +5 VDC POWER TO THE CMD COUNTER AND THE ASSOCIATED CMD DECODING CIRCUITRY WITHIN THE LSG, ALLOWING THE 5-STAGE CMD REGISTER COUNTER TO BE STEPPED UP/DOWN AND ENABLING THE LSG ENCODED CMD EXECUTION FUNCTION. APPLICATION OF CMD 070 ALWAYS RESETS THE REGISTER COUNTER TO 00000. REPEATED APPLICATION OF CMD 070 HAS NO FURTHER EFFECT. THE COMMAND DECODER IS PRESET TO BE IN THE OFF CONDITION AT INITIAL LUNAR ACTIVATION.**

• 071  LSG DECODER OFF
  
  **THIS CMD ACTUATES A LATCHING RELAY IN THE LSG TO THE POSITION THAT REMOVES +5 VDC POWER FROM THE CMD DECODER WITHIN THE LSG. REPEATED APPLICATIONS OF CMD 071 HAS NO FURTHER EFFECT. THE CMD DECODER IS PRESET TO BE IN THE OFF CONDITION AT INITIAL LUNAR ACTIVATION.**

• 072  LSG STEP UP
  
  **THIS CMD ADVANCES THE 5-STAGE CMD REGISTER COUNTER OF THE LSG TO THE NEXT HIGHER BINNARY VALUE, THIS REPRESENTING A NEW ENCODED CMD FUNCTION, IF EXECUTED. OF THE 32 POSSIBLE STATES, 30 ARE USED (EXCLUDING 00000 AND 11111), AND THE REGISTER STATE IS READ OUT IN THE TM. REPEATED APPLICATION OF CMD 072 ADVANCES THE COUNTER SETTING UNTIL IT REACHES 11111, AFTER WHICH CMD 072 SETS THE COUNTER TO 00000, ETC.**

• 074  LSG STEP ON
  
  **THIS CMD REDUCES THE VALUE IN THE 5-STAGE CMD REGISTER COUNTER OF THE LSG TO THE NEXT LOWER BINARY VALUE, THIS REPRESENTING A NEW ENCODED CMD FUNCTION, IF EXECUTED. OF THE 32 POSSIBLE STATES, 30 ARE USED (EXCLUDING 00000 AND 11111), AND THE REGISTER STATE IS READ OUT IN THE TM. REPEATED APPLICATION OF CMD 074 REDUCES THE COUNTER SETTING UNTIL IT REACHES 00000, AFTER WHICH CMD 074 SETS THE COUNTER TO 11111, ETC.**
**LSG ENCODED COMMANDS**

**BINARY COUNT**

00000 and 11111 have no functional effect.

00001 Read Shaft Encoders

This CMD inhibits all other signals to the LSG Digital Multiplexer and activates continuous readout of the shaft encoders on the Coarse and Fine Screw Servo Shafts. These two encoders are read out in the AlSEP data words assigned to LSG as 19-bit readings, alternating in the following manner, starting at the AlSEP frame mark:

<table>
<thead>
<tr>
<th>1st Word</th>
<th>Coarse Encoder</th>
<th>Last 10 Bits (LSB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd Word</td>
<td>Coarse Encoder</td>
<td>First 9 Bits (MSB)</td>
</tr>
<tr>
<td>3rd Word</td>
<td>Fine Encoder</td>
<td>Last 10 Bits (LSB)</td>
</tr>
<tr>
<td>4th Word</td>
<td>Fine Encoder</td>
<td>First 9 Bits (MSB)</td>
</tr>
<tr>
<td>5th Word</td>
<td>Coarse Encoder</td>
<td>Last 10 Bits (LSB)</td>
</tr>
<tr>
<td>Etc.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the MSB words a filler bit (Binary One) is inserted as the first bit of the 18-bit AlSEP word. There are two brushes (Advance/Retard) on each encoder. These brushes also alternate in the data readout. The shaft encoder data readout starts at the first AlSEP 90-frame mark following receipt of CMD 00000 (Binary) and continues until the next AlSEP 90-frame mark after which normal LSG Scientific data readout is reactivated. Repeated applications of CMD 00000 (Binary) will cause shaft encoder data readout for additional blocks of 90 frames provided that the sequential CMD applications occur before and after an AlSEP 90-frame mark. Application of operational power to the LSG causes initialization in the normal data mode.

00010 Mass Change Motor On (Cont'd)

- There are 10 functional states controlled by the increment CMD, 01110 (Binary).
- The counter status is read out in the TM as an analog voltage value and the zero counter setting is defined as state 1.
- At turn-on, the mechanism always drives to state 1 which is against the stop.
- State 2 of the increment counter is provided to cage the mass changing mechanism during transportation and state 10 is used on Earth for calibration.
- The mass change motor uses servo feedback and, when activated, only operates until the state called for by the counter is achieved.
- Turn-off of the control, by CMD 01100 (Binary), causes the mechanism state to be retained until the next turn-on.
- Since turn-on clears the register, repeated application of CMD 00010 (Binary) causes no further change provided that no increment CMDs are executed between turn-on CMDs.

00011 Bias In Sel

This CMD actuates a latching relay to the position that applies +13 VDC fixed bias to the sensor bridge drive circuit of the LSG Sensor Electronics. Repeated application of CMD 00011 (Binary) has no further effect. The Bias Relay is preset to be in the TBD condition at initial Lunar activation.

00100 Bias Out Sel

This CMD actuates a latching relay to the position that removes the +13 VDC fixed bias from the sensor bridge drive circuit of the LSG Sensor Electronics. Repeated application of CMD 00100 (Binary) has no further effect. The Bias Relay is preset to be in the TBD condition at initial Lunar activation.
LSG ENCODED COMMANDS (CONT'D)

**Binary Count**

<table>
<thead>
<tr>
<th>Binary Count</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00000</td>
<td>Tilt, Mass Change, and Screw Servo Off</td>
</tr>
<tr>
<td>00010</td>
<td>Sensor Beam Uncage</td>
</tr>
<tr>
<td>00100</td>
<td>Tilt, Pressure Transducer</td>
</tr>
<tr>
<td>00101</td>
<td>Coarse Servo On</td>
</tr>
<tr>
<td>00110</td>
<td>Seismic Low Gain Sel</td>
</tr>
<tr>
<td>01000</td>
<td>Seismic High Gain Sel</td>
</tr>
<tr>
<td>01001</td>
<td>Sensor Beam Cage</td>
</tr>
<tr>
<td>01010</td>
<td>Encoder Command Selection</td>
</tr>
<tr>
<td>01011</td>
<td>Encoder Command Selection</td>
</tr>
<tr>
<td>01100</td>
<td>Encoder Command Selection</td>
</tr>
<tr>
<td>01101</td>
<td>Encoder Command Selection</td>
</tr>
</tbody>
</table>

**Encoder Command Selection**

<table>
<thead>
<tr>
<th>Binary Count</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00010</td>
<td>Encoder Command Selection</td>
</tr>
<tr>
<td>00011</td>
<td>Encoder Command Selection</td>
</tr>
<tr>
<td>00100</td>
<td>Encoder Command Selection</td>
</tr>
<tr>
<td>00101</td>
<td>Encoder Command Selection</td>
</tr>
<tr>
<td>00110</td>
<td>Encoder Command Selection</td>
</tr>
<tr>
<td>00111</td>
<td>Encoder Command Selection</td>
</tr>
<tr>
<td>01000</td>
<td>Encoder Command Selection</td>
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<td>01001</td>
<td>Encoder Command Selection</td>
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<tr>
<td>01010</td>
<td>Encoder Command Selection</td>
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<tr>
<td>01011</td>
<td>Encoder Command Selection</td>
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<tr>
<td>01100</td>
<td>Encoder Command Selection</td>
</tr>
<tr>
<td>01101</td>
<td>Encoder Command Selection</td>
</tr>
</tbody>
</table>

**Encoder Command Actions**

<table>
<thead>
<tr>
<th>Binary Count</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>00010</td>
<td>Sensor Beam Uncage</td>
</tr>
<tr>
<td>00011</td>
<td>Coarse Servo On</td>
</tr>
<tr>
<td>00100</td>
<td>Tilt, Pressure Transducer</td>
</tr>
<tr>
<td>00101</td>
<td>Seismic Low Gain Sel</td>
</tr>
<tr>
<td>00110</td>
<td>Seismic High Gain Sel</td>
</tr>
<tr>
<td>01000</td>
<td>Sensor Beam Cage</td>
</tr>
<tr>
<td>01001</td>
<td>Encoder Command Selection</td>
</tr>
<tr>
<td>01010</td>
<td>Encoder Command Selection</td>
</tr>
<tr>
<td>01011</td>
<td>Encoder Command Selection</td>
</tr>
<tr>
<td>01100</td>
<td>Encoder Command Selection</td>
</tr>
<tr>
<td>01101</td>
<td>Encoder Command Selection</td>
</tr>
</tbody>
</table>

**Notes**

- **Binary Count**: This column lists the binary codes for various actions.
- **Description**: The actions are described in detail, including their effects and parameters.
- **Encoder Command Actions**: These actions are for the encoder and are used to control various operations of the LSG sensor system.
LSG ENCODED COMMANDS (CONT’D)

**Binary Count**

01101 **Pressure Transducer On**

This command activates a thermal conductivity type of pressure transducer to measure the LSG instrument housing internal pressure via the ALSEP housekeeping, AG-05. Repeated application of CMD 01101 (BINARY) has no further effect. Turn-off of the pressure transducer is accomplished by CMD 01100 (BINARY). The pressure transducer is preset to be in the off condition at initial lunar activation.

01110 **Mass Change Increment**

This CMD steps the 5-bit counter of the LSG mass changing servo control circuitry, when the circuit has been activated by CMD 00110 (BINARY). When the circuit is activated, the counter automatically resets to zero (state 0) and each increment CMD steps it one step up to the next higher state; states 1 through 10 are functional states of the counter and control the mass changing servo. State 7 is provided to gate the mass changing system during transportation and state 10 is used on Earth for calibration. Repeated application of CMD 01110 (BINARY) causes repeated steps and the tenth increment CMD will select state 1 again.

01111 **Gross Slew Up/Tilt Increment Up (cont.)**

This command causes operation in the up direction of one of the two LSG screw servo motors or one of the two tilt motors, if they have been previously enabled by one of the individual binary CMDs as follows:

- Coarse Screw Servo On: 01011
- Fine Screw Servo On: 10011
- North/South Tilt Servo On: 10100
- East/West Tilt Servo On: 10101

For the screw servos, execution of CMD 01111 (BINARY) sets a 15-bit counter to a count of 32,768 after which data gate pulses step the counter down to zero; a period of 308 seconds corresponding to 16,384 steps of the stepping motor, in the down direction. A relay which controls the direction of motor drive is actuated by execution of the CMD.

For the tilt servos, execution of CMD 01111 (BINARY) enables data gate pulses to step a timeout counter clock which was also reset by the CMD. The timeout of the clock corresponds to 2 revolutions of the tilt motor, in the up direction.

Repeated application of CMD 01111 (BINARY) causes repeated increments of gross slew up or tilt up; however, the proper time interval between CMDs must be observed.

10000 **Gross Slew Down/Tilt Increment Down**

This CMD causes operation in the down direction of one of the two LSG screw servo motors or one of the two tilt motors, if they have been previously enabled by one of the individual binary CMDs as follows:

- Coarse Screw Servo On: 01011
- Fine Screw Servo On: 10011
- North/South Tilt Servo On: 10100
- East/West Tilt Servo On: 10101

For the screw servos, execution of CMD 10000 (BINARY) sets a 15-bit counter to a count of 32,768 after which data gate pulses step the counter down to zero; a period of 308 seconds corresponding to 16,384 steps of the stepping motor, in the down direction. A relay which controls the direction of motor drive is actuated by execution of the CMD.

For the tilt servos, execution of CMD 10000 (BINARY) enables data gate pulses to step a timeout counter clock which was also reset by the CMD. The timeout of the clock corresponds to 2 revolutions of the tilt motor, in the down direction.

Repeated application of CMD 10000 (BINARY) causes repeated increments of gross slew down or tilt down; however, the proper time interval between CMDs must be observed.

June 72 3270.3.32
LSG ENCODED COMMANDS (CONT’D)

**Binary Count**

**10001 Vernier Slew Up**

This command causes operation in the up direction of one of the two LSG screw servo motors, if they have been previously enabled by one of the individual binary CMDs as follows:

- Coarse Screw Servo On: 01011
- Fine Screw Servo On: 10011

Execution of CMD 10001 (Binary) sets a 13-bit counter to 256 after which data gate pulses step the counter down to zero; a period of 2.5 seconds corresponding to 128 steps of the stepper motor, in the up direction. A relay which controls the direction of motor drive is actuated by execution of the CMD.

Repeated application of CMD 10001 (Binary) causes repeated Vernier slew up of whichever screw servo motor has been enabled.

**10010 Vernier Slew Down**

This command causes operation in the down direction of one of the two LSG screw servo motors, if they have been previously enabled by one of the individual binary CMDs as follows:

- Coarse Screw Servo On: 01011
- Fine Screw Servo On: 10011

Execution of CMD 10010 (Binary) sets a 13-bit counter to 256 after which data gate pulses step the counter down to zero; a period of 2.5 seconds corresponding to 128 steps of the stepper motor, in the down direction. A relay which controls the direction of motor drive is actuated by execution of the CMD.

Repeated application of CMD 10010 (Binary) causes repeated Vernier slew down of whichever screw servo motor has been enabled.

**10011 Fine Screw Servo On**

This command activates LSG screw servo circuits to enable acceptance of up and down slew commands, either gross or Vernier. Screw servo activation is inhibited when the tilt servo control is on and vice versa. Initiation of CMD 10011 (Binary) also selects a relay position such that the drive power, when applied, will be fed to the fine screw of the LSG sensor. Repeated application of CMD 10011 (Binary) has no further effect. Turn-off of the screw servo circuits is accomplished by CMD 01100 (Binary). The servo power control is preset to be in the off condition at initial lunar activation.

**10100 North/South Tilt Servo On**

This command activates LSG tilt servo circuits to enable acceptance of an up or down tilt increment command. Tilt servo activation is inhibited when the screw servo control is on and vice versa. Initiation of CMD 10100 (Binary) also selects a relay position such that the drive power, when applied, will be fed to north/south tilt motor. Repeated application of CMD 10100 (Binary) has no further effect. Turn-off of the tilt servo circuits is accomplished by CMD 01100 (Binary). The servo power control is preset to be in the off condition at initial lunar activation.

**10101 East/West Tilt Servo On**

This command activates LSG tilt servo circuits to enable acceptance of an up or down tilt increment command. Tilt servo activation is inhibited when the screw servo is on and vice versa. Initiation of CMD 10101 (Binary) also selects a relay position such that the drive power, when applied, will be fed to the east/west tilt motor. Repeated application of CMD 10101 (Binary) has no further effect. Turn-off of the tilt servo circuits is accomplished by CMD 01100 (Binary). The servo power control is preset to be in the off condition at initial lunar activation.
LSG ENCODED COMMANDS (CONT’D)

10101 TEMPERATURE INCREMENT LOAD 1

This CMD is one of six used by the LSG to load a register consisting of six relays. The state of the register is read out in the TM and each of the 64 states, through a thermistor bridge circuit, controls the temperature of the heater box around the LSG sensor through 64 steps of 0.06°C. Thus, the temperature can be adjusted within a range of ±1.6°C around the nominal operating point to find the sensor inversion point on the lunar surface and maintain operation at this point. Repeated application of CMD 10101 (BINARY) has no further effect until the register is cleared by the reset CMD 11000 (BINARY). The temperature register relays are preset to be in the (TBD) condition at initial lunar activation. These relays may reset when LSG operational power is removed and reapplied.

10111 TEMPERATURE INCREMENT LOAD 2

This CMD is one of six used by the LSG to load a register consisting of six relays. The state of the register is read out in the TM and each of the 64 states, through a thermistor bridge circuit, controls the temperature of the heater box around the LSG sensor through 64 steps of 0.06°C. Thus, the temperature can be adjusted within a range of ±1.6°C around the nominal operating point to find the sensor inversion point on the lunar surface and maintain operation at this point. Repeated application of CMD 10111 (BINARY) has no further effect until the register is cleared by the reset CMD 11100 (BINARY). The temperature register relays are preset to be in the (TBD) condition at initial lunar activation. These relays may reset when LSG operational power is removed and reapplied.

11000 TEMPERATURE INCREMENT LOAD 3

This CMD is one of six used by the LSG to load a register consisting of six relays. The state of the register is read out in the TM and each of the 64 states, through a thermistor bridge circuit, controls the temperature of the heater box around the LSG sensor through 64 steps of 0.06°C. Thus, the temperature can be adjusted within a range of ±1.6°C around the nominal operating point to find the sensor inversion point on the lunar surface and maintain operation at this point. Repeated application of CMD 11000 (BINARY) has no further effect until the register is cleared by the reset CMD 11100 (BINARY). The temperature register relays are preset to be in the (TBD) condition at initial lunar activation. These relays may reset when LSG operational power is removed and reapplied.

11001 TEMPERATURE INCREMENT LOAD 4

This CMD is one of six used by the LSG to load a register consisting of six relays. The state of the register is read out in the TM and each of the 64 states, through a thermistor bridge circuit, controls the temperature of the heater box around the LSG sensor through 64 steps of 0.06°C. Thus, the temperature can be adjusted within a range of ±1.6°C around the nominal operating point to find the sensor inversion point on the lunar surface and maintain operation at this point. Repeated application of CMD 11001 (BINARY) has no further effect until the register is cleared by the reset CMD 11100 (BINARY). The temperature register relays are preset to be in the (TBD) condition at initial lunar activation. These relays may reset when LSG operational power is removed and reapplied.
LSG ENCODED COMMANDS (CONT’D)

BINARY COUNT

11100  TEMPERATURE RESET

This cmd resets the six relays used in the register of the LSG heater box temperature control circuit. Repeated application of cmd 11100 has no further effect. The temperature register relays are preset to be in the (TBD) condition at initial lunar activation. These relays may reset when LSG operational power is removed and reapplied.

11101  POST AMP GAIN INCREMENT

This cmd advances the count of a 4-stage register controlling the gain of the post-amplifier of the LSG sensor. The status of this register is not read out in the TM. Repeated application of cmd 11101 (binary) causes the counter setting to advance in repeated increments until it reaches 15, after which it resets to zero and continues in the same sequence. When operational power is applied to the LSG, the initial gain setting is unpredictable.

11110  POST AMP GAIN RESET

This cmd resets the counter of the 4-stage register controlling the gain of the post-amplifier of the LSG sensor, resulting in the lowest gain setting. Repeated application of cmd 11110 (binary) has no further effect.
<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
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<th>5</th>
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</tbody>
</table>

**ALSEP Data Frame Contains 64 10-bit Data Words**

**C** = ALSEP Control Words (3 per frame)

**G** = LSG Seismic Data (31 words per frame)

**H. K.** = Housekeeping (Including 10 LSG Parameters)

Commutated once every 90 ALSEP Frames

**LGS Digital Data Formats**

**Shaf Encoder Mode**

**Normal Mode**
### LSG Status and Engineering Data

**Housekeeping Parameters are Read Out Once Every 90 AlSEP Frames (Once Every 54 Seconds at Normal Data Rate)**

<table>
<thead>
<tr>
<th>ALSEP Frame No.</th>
<th>Code</th>
<th>Parameter</th>
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</thead>
<tbody>
<tr>
<td>10</td>
<td>AG-02</td>
<td>LSG Tide *</td>
</tr>
<tr>
<td>23</td>
<td>AG-03</td>
<td>LSG Free Mode *</td>
</tr>
<tr>
<td>24</td>
<td>AG-07</td>
<td>LSG Oscillator Amplitude</td>
</tr>
<tr>
<td>38</td>
<td>AG-08</td>
<td>LSG +15 Volts</td>
</tr>
<tr>
<td>39</td>
<td>AG-01</td>
<td>LSG Seismic *</td>
</tr>
<tr>
<td>53</td>
<td>AG-09</td>
<td>LSG -15 Volts</td>
</tr>
<tr>
<td>54</td>
<td>AG-06</td>
<td>LSG Mass Change Position</td>
</tr>
<tr>
<td>68</td>
<td>AG-04</td>
<td>LSG Sensor Temperature</td>
</tr>
<tr>
<td>69</td>
<td>AG-10</td>
<td>LSG +5 Volts</td>
</tr>
<tr>
<td>89</td>
<td>AG-05</td>
<td>LSG Pressure</td>
</tr>
</tbody>
</table>

* Science Data Read Out in Analog Housekeeping Channels

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**Status 1 (ALSEP Word 35)**
- DG-14 Tilt Motor STA
- DG-13 Screw Motor STA
- DG-12 Mass Change Motor STA
- DG-11 Temperature Relays STA

**Status 2 (ALSEP Word 37)**
- DG-19 CMD Counter (Bit 5 is always one and Bits 6 through 10 contain the counter readout)
- DG-18 Seismic Gain Hi/low
- DG-17 Press Transducer On/Off
- DG-16 Inst Housing HTR On/Off
- DG-15 CMD Decoder On/Off
# LSG Initial Lunar Operations

<table>
<thead>
<tr>
<th>Function</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Instrument Turn-On</td>
<td>Application of LSG operational power</td>
</tr>
<tr>
<td>2. Initial Temperature Set Up</td>
<td>Reset register to lowest increment</td>
</tr>
<tr>
<td>3. Pressure Transducer Check</td>
<td>1.5 minutes for stabilization, then turn off</td>
</tr>
<tr>
<td>4. Initialize Electrostatic Loop</td>
<td>Set bias out, integrator short mode, and minimum gain</td>
</tr>
<tr>
<td>5. Uncage Mass Change Mechanism</td>
<td></td>
</tr>
<tr>
<td>6. Uncage Sensor Beam</td>
<td></td>
</tr>
<tr>
<td>7. Initial Mass Adjustment</td>
<td>Actuate mass change motor</td>
</tr>
<tr>
<td>8. Initial Beam Adjustment</td>
<td>Operate screw motors, read shaft encoders</td>
</tr>
<tr>
<td>9. Temperature Stabilization</td>
<td>May take several hours</td>
</tr>
<tr>
<td>10. NJLL Sensor Beam</td>
<td>Actuate screw motors</td>
</tr>
<tr>
<td>11. Adjust Tilt</td>
<td>Actuate tilt motors</td>
</tr>
<tr>
<td>12. Obtain Spring Inversion Temp</td>
<td>Adjust temp in increments, stabilizing each time</td>
</tr>
<tr>
<td>13. Re-Null Sensor Beam</td>
<td>Actuate screw motors</td>
</tr>
<tr>
<td>14. Adjust Electrostatic Loop</td>
<td>Set bias in, integrator normal, and increase gain</td>
</tr>
<tr>
<td>15. Stability Check</td>
<td>Re-adjust as necessary</td>
</tr>
<tr>
<td>16. Operational Mode</td>
<td>Follows completion of the operations above</td>
</tr>
</tbody>
</table>

JUNE 72 3270.3.38
LUNAR MASS SPECTROMETER (LMS)
LMS SCIENCE SUMMARY

OBJECTIVES

• TO IDENTIFY AND DETERMINE THE DENSITY OF CONSTITUENTS OF THE LUNAR ATMOSPHERE

• TO DETERMINE THE TEMPORAL VARIATIONS OF THE ATMOSPHERIC CONSTITUENTS

METHODS

• DETECT AND COLLECT IONS IN MASS RANGE 1 THROUGH 4 AMU AND 12 THROUGH 110 AMU

RESULTS

• STRUCTURE AND COMPOSITION OF LUNAR ATMOSPHERE
  • GLOBAL DISTRIBUTION
  • DIURNAL VARIATIONS
  • GAS RELEASE AT DAWN TERMINATOR
  • TEST THEORIES OF PLANETARY EXOSPHERE DYNAMICS

• ORIGIN OF ATMOSPHERE
  • SOLAR WIND ACCRETION
  • NEON DISTRIBUTION
  • VOLCANISM

• TRANSIENT PHENOMENA
  • LOCATION OF GAS VENTING
  • PHYSICAL PROCESSES CAUSING GAS RELEASE

• RESIDUAL CONTAMINATION
  • DIFFUSION RATES OF GAS CLOUDS
  • OUTGASSING RATE OF SURFACE
LMS OPERATIONS SUMMARY

DEPLOYMENT
- OPEN VENT VALVE
- REMOVE 3 TIE-DOWN FASTENERS
- ROTATE 90° TO UPRIGHT POSITION
- PLACE 45 FT NORTHWEST OF CENTRAL STATION
- LEVEL
- BREAK HERMETIC SEAL ON SENSOR
- RECHECK LEVEL

POST DEPLOYMENT
- CMD OPERATIONAL POWER FOR LOW VOLTAGES
- REMOVE DUST COVER AFTER LM ASCENT
- PERFORM BAKEOUT
- TURN ON ION PUMP, READ PRESSURE
- APPLY HIGH VOLTAGES FOR FULL OPERATION

CONSIDERATIONS
- HERMETICALLY SEALED ON EARTH
- REQUIRES UNOBSERVED UPWARD HEMISPHERE VIEW
- PLACE AS FAR AS POSSIBLE FROM EQUIPMENT THAT MIGHT OUTGAS
- CONTAINS PERMANENT MAGNETS
- USES HIGH VOLTAGES
- USES SECOND SURFACE MIRRORS ON TOP THERMAL CONTROL SURFACE
LMS COMMUNICATIONS SUMMARY

COMMANDS
- POWER ON/STANDBY/OFF
- 7 CMD LINES TO PROVIDE 15 ENCODED CMDS
  (2 LOAD AND 1 EXECUTE, EACH) INCLUDING:
  - DUST COVER REMOVAL
  - HIGH VOLTAGES ON/OFF
  - ION PUMP ON/OFF
  - FILAMENT 1 OR 2 SELECT/OFF
  - HIGH VOLTAGE STEPS
  - SWEEP LOCK/STEP MODE SELECT
  - BAKEOUT MODE SELECT
  - ELECTRON MULTIPLIER VOLTAGE SELECT
  - DISCRIMINATOR LEVEL SELECT

DATA
- 4 DIGITAL 10-BIT WORDS PER ALSEP FRAME
  - 1 INSTRUMENT/CMD STATUS DATA
  - 3 SCIENCE DATA (3 SENSORS SAMPLED ONCE PER FRAME)
- 3 ANALOG CHANNELS IN ALSEP WORD 33,
  READ OUT ONCE EVERY 90 ALSEP FRAMES
  (ONCE EVERY 54 SECONDS AT NORMAL DATA RATE)
  - 1 MULTIPLEXED 16-CHANNEL HOUSEKEEPING DATA
  - 1 SWEEP VOLTAGE
  - 1 ELECTRONICS TEMPERATURE
    (READS OUT IN OPERATIONAL, STANDBY, AND OFF CONDITIONS)
LMS PERFORMANCE CHARACTERISTICS

- MODE OF OPERATION: AUTOMATIC CONTINUOUS SWEEP WITH COMMANDABLE LOCK AT ANY AMU
- SCAN TECHNIQUE: VARY ACCELERATING VOLTAGE FROM 320 TO 1420 VOLTS IN A SERIES OF 1350 STEPS
- MEASUREMENT: THREE DETECTORS DETERMINE THE DENSITY (ABUNDANCE) OF EACH CONSTITUENT IN THE LUNAR ATMOSPHERE BY COUNTING PARTICLES AT EACH STEP FOR A PERIOD OF 0.6 SECONDS
- RESOLUTION: 10%
- SENSITIVITY: $1.0 \times 10^{-5}$ TORR
- DYNAMIC RANGE: $1 \times 10^{5}$
- TYPICAL RECORD FOR ONE SWEEP IS SHOWN BELOW

![Mass Range Diagram]

JUNE 72 3270.4.7
LMS EXPLODED ASSEMBLY

SECOND SURFACE MIRROR (IN MOUNTING PLATE)

ELECTRONICS

THERMAL INSULATION BAG

ANALYZER

ANALYZER COVER

DUST COVER (OPEN)

ELECTRONICS COVER

JUNE 72 3270.4.8
LMS DETECTION SYSTEM

- 90° MAGNETIC SECTOR FIELD MASS ANALYZER
- NIER-TYPE THERMIONIC ELECTRON BOMBARDMENT ION SOURCE
- GAS IONIZATION AND ACCELERATION (ION SOURCE)

SENSOR TYPE

HI MASS SENSOR TYPE

GAS MOLECULE INLET

DRIFT TUBE

MAGNET

H1 MASS

ION SOURCE TEMP

LO MASS

MID MASS

ELECTRON MULTIPLIERS

JUNE 72 3270.4.9
LMS DECODER AND DATA PROCESSOR

**PURPOSE**
- Receives individual cmds from ALSEP. Decodes the multiplexed combinations, conditions them and routes them to the proper circuits.
- Provides tm on cmds received from ALSEP.
- Gates scientific digital data and LMS operating status digital data to ALSEP DDP in the proper sequence.

**INPUTS**
- Digital cmd and timing from ALSEP.
- Digital housekeeping status data from LMS analog multiplexer.
- Digital scientific data from the three sensors via the LMS counting and data compression.

**OUTPUTS**
- CMDS to LMS circuits.
- Timing to LMS data and sweep control.
- Digital scientific and status data to the ALSEP digital data processor.

**JUNE 72 3270.4.12**
LMS SWEEP HVPS
(HIGH VOLTAGE POWER SUPPLY)

1. Switched Power (+27.5 VDC Nom.)
2. LMS LVPS
3. Power RTN
4. Referenced to ALSEP PWR RTN
5. Referenced to Signal Ground

- Chopper
- Transformer
- Voltage Multiplier (Quadrupler)
- Buffer
- Breaker
- Bleeder Resistor Chain
- Operational Amplifier
- Control Voltage (Reference)
- Pedestal Voltage
- Digital Sweep Control

- AMP-44
- AM-44
- SWEEP VOLTS
- SWEEP HIGH VOLTAGE OUTPUT (320 TO 1420 VDC)
- ION SOURCE AND EMISSION CONTROL

JUNE 72 3270.4.15
LMS ELECTRON MULTIPLIER HVPS
(HIGH VOLTAGE POWER SUPPLY)

OUTPUT RANGE
-2200 TO -3000 VDC
WITH 600 VDC INCREMENT BETWEEN HIGH AND LOW

NOTE:
* INDICATES ENCODED CMDS WITH TWO LOAD CMDS (OCTAL) IN PARENTHESES; FOLLOWED BY 134 (OCTAL) FOR EXECUTION

JUNE 72 3270.4.16
LMS PREAMPS AND DISCRIMINATORS

- Signal A
- Signal B
- Signal C
- Preamp Discriminator Pulse Shaper A
- Preamp Discriminator Pulse Shaper B
- Preamp Discriminator Pulse Shaper C
- 2 MHz Calibration Oscillator
- DM-13 Discrim H/Low
- (124/123) Discriminator High
- (125/127) Discriminator Low
- Discriminator Threshold Control
- Inhibit
- Enable
- J-Plate Sequencer
- Note: Indicates encoded CMDs with two load CMDs (octal) in parentheses; followed by 134 (octal) for execution
- Counting and Data Compression
- Output A
- Output B
- Output C
- DM-03 Low Mass A Counts
- DM-04 Mid Mass B Counts
- DM-05 High Mass C Counts

JUNE 72 3270.4.17
LMS COUNTING AND DATA COMPRESSION

IONs ARE DETECTION IN EACH OF THE THREE ELECTRON MULTIPLIERS AND COUNTED IN A 21-BIT BINARY COUNTER (12,097,152 CAPACITY) FOR ONE FRAME MARK INTERVAL; 0.604 SEC AT NORMAL DATA RATE.

THE COUNTS ARE TRANSFERRED (AND COUNTER CLEARED) TO A 21-BIT SHIFT REGISTER.

THE COUNTS ARE SHIFTED TOWARD THE MSB END OF THE REGISTER AND EACH BIT-SHIFT IS RECORDED IN A 4-BIT SHIFT COUNTER.

THE SHIFTING STOPS WHEN A LOGICAL ONE IS DETECTED IN THE 21ST BIT OR WHEN 14 SHIFTS HAVE OCCURRED.

IF 14 SHIFTS HAVE OCCURRED AND THE 21ST BIT IS STILL A LOGICAL ZERO, THE 4-BIT SHIFT COUNTER IS ADVANCED TO 15 WITH NO CHANGE IN THE 21-BIT REGISTER.

IF 14, ADVANCE 4-BIT COUNTER TO 15 AND TRANSFER DATA TO 10-BIT REGISTER.

SIX REGISTER BITS (20 THROUGH 15) ARE TRANSFERRED TO THE 10-BIT OUTPUT REGISTER PLUS THE FOUR BITS FROM THE SHIFT COUNTER.

JUNE 72 3270.4.18
LMS ION PUMP HVPS
(HIGH VOLTAGE POWER SUPPLY)

• ION PUMP SERVICES TO MONITOR THE INSTRUMENT PRESSURE AND DETERMINE WHETHER IT HAS OUTGASSED SUFFICIENTLY TO ALLOW TURN-ON OF HIGH-VOLTAGE CIRCUITS (PROBABLY FIRST LUNAR NIGHT).

NOTES:
- INDICATES ENCODED COMMANDS WITH TWO LOAD CMDS (OCTAL) IN PARENTHERSES; FOLLOWED BY 134 (OCTAL) FOR EXECUTION.
- INHIBIT ACTUALLY OCCURS IN CMD DECODER.

OPERATION
- POWER (27.5 VDC NOMINAL)
- POWER RTN
- MULTIPLIER AND SWEEP HVPS ON
- MULTIPLIER AND SWEEP HVPS OFF
- ENABLE INHIBIT
- SWEEP HVPS MULTIPLIER HVPS
- LMS CMD DECODER
  - (127/133) ION PUMP ON
  - (132/133) ALL HVPS OFF
- LMS LVPS
  - POWER RTN
  - MULTIPLIER AND SWEEP HVPS ON
  - MULTIPLIER AND SWEEP HVPS OFF
- POWER ON/OFF RELAY
- CHOPPER
- TRANSFORMER
- VOLTAGE MULTIPLIER
- AM-03 ION PUMP CURRENT
- LOGARITHMIC AMPLIFIER
- CURRENT SENSOR
- AM-04 ION PUMP CURRENT
- HIGH VOLTAGE OUTPUT (+3500 VDC)
- LMS ION PUMP VOLTS
- LMS ANALOG MULTIPLEXER
- OUTPUT SIGNAL

JUNE 72 3270.4.19
LMS DUST COVER AND THERMAL DESIGN

DUST COVER DESIGN
- Dust cover in open position
- Hinges and torsion spring
- Nichrome burn wire
- Guide pin
- Tie down cord
- Housing
- Dust cover
- Thermal shield

THERMAL DESIGN
- Radiator with second surface mirrors
- Thermal isolator
- Masking
- Thermal bag
- Fiberglass liner
- Aluminized surfaces
- Nylon ties
- Lunar surface
- Electronics
- Analyzer
- External structure painted white
- Flat ribbon cable

JUNE 72 3270.4.22
LMS DEPLOYMENT

1. ENGAGE UHT HANDLE IN LMS VENT PULL RING.
2. RELEASE LMS VENT PULL RING.
3. OPEN LMS VENT (PULL LMS VENT LANYARD UPWARD).
4. RELEASE 3 BOYDBOLTS SECURING LMS TO SUBPACKAGE #1.
5. ENGAGE UHT IN LMS SWIVEL SOCKET.
6. REMOVE LMS FROM SUBPACKAGE #1 AND TRANSFER TO DEPLOYMENT SITE (45 FEET NORTHEAST OF CENTRAL STATION) USING UHT.
7. ROTATE LMS 90° USING SWIVEL SOCKET AND INSURE THAT SWIVEL SOCKET IS LOCKED.
8. EMPLACE LMS ON LUNAR SURFACE USING UHT (SITE SHOULD BE RELATIVELY FLAT, I.E. WITHIN ±15°).
9. VERIFY THAT LMS IS LEVEL WITHIN ±15°. IF LMS IS NOT LEVEL WITHIN ±15° DO NOT EMBED THE EXPERIMENT; REPOSITION IT ON A MORE LEVEL SPOT.
10. REMOVE UHT FROM LMS SWIVEL SOCKET.
11. ENGAGE UHT IN LMS BREAKSEAL SOCKET.
12. BREAK BREAKSEAL USING UHT (LEVER UHT IN DIRECTION OF ARROW TO SNAP BREAKSEAL).
13. REMOVE BREAKSEAL, USING UHT, AND DISCARD.
14. VERIFY THAT LMS IS LEVEL WITHIN ±15° AND IS NOT EMBEDDED IN LUNAR SURFACE.
15. VERIFY THAT ION SOURCE DUST COVER IS COVERING THE INLET.
<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>REQUIREMENT</th>
<th>PRIORITY</th>
<th>INDICATOR</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISTANCE FROM SUBPACKAGE 1</td>
<td>45 ± 5 FT FROM CENTRAL STATION</td>
<td>RACING, CABLE LENGTH</td>
<td>VISUAL</td>
<td>AVOID SLOPES, OUT-CROPPINGS, AND RUBBLE, +15° IS OBTAINED WHEN BUBBLE IS FREE FROM CASE</td>
</tr>
<tr>
<td>DIRECTION FROM SUBPACKAGE 1</td>
<td>CENTRAL STATION</td>
<td>VISUAL</td>
<td>BUBBLE LEVEL</td>
<td>SEE NOTE</td>
</tr>
<tr>
<td>SITE SELECTION</td>
<td>NORTH-EAST OF CENTRAL STATION</td>
<td>HORIZONTAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LEVEL, WRIT</td>
<td>+15°</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>ALIGNMENT</td>
<td></td>
<td></td>
<td>THE FLAT CABLE SHALL GO DIRECTLY TO THE CENTRAL STATION (NOT WRAPPED AROUND THE LMS)</td>
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</tr>
<tr>
<td>NOTE</td>
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LMS ENSACEMENT CRITERIA

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<thead>
<tr>
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<td>NOTE</td>
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</table>
LMS ALIGNMENT FEATURES

NOTE: NO ALIGNMENT REQUIREMENT OTHER THAN CABLE
# LMS Command Summary

<table>
<thead>
<tr>
<th>OCTAL COMMAND</th>
<th>COMMAND NOMENCLATURE</th>
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<tbody>
<tr>
<td>123</td>
<td>LMS Load Command #1</td>
</tr>
<tr>
<td>124</td>
<td>LMS Load Command #2</td>
</tr>
<tr>
<td>125</td>
<td>LMS Load Command #3</td>
</tr>
<tr>
<td>127</td>
<td>LMS Load Command #4</td>
</tr>
<tr>
<td>132</td>
<td>LMS Load Command #5</td>
</tr>
<tr>
<td>133</td>
<td>LMS Load Command #6</td>
</tr>
<tr>
<td>134</td>
<td>LMS Execute and Clear</td>
</tr>
</tbody>
</table>

OCTAL CMD 123, 124, 125, 127, 132, 133, AND 134 ARE ENCODED IN SPECIFIC SEQUENCES TO PROVIDE 15 DISCRETE CMDS FOR THE LMS AS LISTED BELOW:

## Function Sequence

<table>
<thead>
<tr>
<th>STEP, MULT, SWEEP HV ON</th>
<th>123</th>
<th>124</th>
<th>125</th>
<th>127</th>
<th>132</th>
<th>133</th>
<th>134</th>
</tr>
</thead>
<tbody>
<tr>
<td>&amp; BACKUP HTR OFF</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

LOCK (SWEEP HOLD), J-PLATE VOLTAGE STEP, & FIXED MODE SELECT

ONE-STEP (SWEEP ADVANCE) X X X

*EMISSION/FILAMENTS OFF & MODE SELECT ENABLE X X X

FILAMENT #1 ON & MODE SELECT INHIBIT X X X

FILAMENT #2 ON & MODE SELECT INHIBIT X X X

MULT HIGH & BACKUP HTR ON X X X

*MULT LOW X X X

DISC HIGH, J-PLATE VOLTAGE STEP ENABLE, & CYCLIC MODE SELECT X X X

*DISC LOW & J-PLATE VOLTAGE STEP INHIBIT X X X

BAKEOUT ENABLE (2) X X X

*BAKEOUT BYPASS X X X

DUST COVER REMOVAL X X X

ION PUMP ON (1) X X X

*ION PUMP, MULT, AND SWEEP HV OFF X X X

### Notes
- *PRESET TURN-ON OPERATING MODE; ALL ARE LATCHING RELAYS EXCEPT DISCRIMINATOR (FLIP-FLOP) BUT INITIALIZING PULSE ALSO DRIVES RELAYS
- (1) THIS CMD IS INHIBITED IF HIGH VOLTAGES ARE ON; THE OPPOSITE IS NOT INHIBITED
- (2) AFTER THIS CMD, THE LMS MUST BE COMMANDED TO STANDBY TO PERFORM BAKEOUT
LMS commands

Octal CMD Number

- 123 LMS Load 1
  This CMD is one of six used by the LMS to load a 6-stage CMD register in the LMS and provide 15 encoded CMOS. Each encoded CMD consists of two loads in the register and is executed by receipt of CMD 134 which also clears the register. Repeated application of CMD 123 has no further effect prior to execution.

- 124 LMS Load 2
  This CMD is one of six used by the LMS to load a 6-stage CMD register in the LMS and provide 15 encoded CMOS. Each encoded CMD consists of two loads in the register and is executed by receipt of CMD 134 which also clears the register. Repeated application of CMD 124 has no further effect prior to execution.

- 125 LMS Load 3
  This CMD is one of six used by the LMS to load a 6-stage CMD register in the LMS and provide 15 encoded CMOS. Each encoded CMD consists of two loads in the register and is executed by receipt of CMD 134 which also clears the register. Repeated application of CMD 125 has no further effect prior to execution.

- 127 LMS Load 4
  This CMD is one of six used by the LMS to load a 6-stage CMD register in the LMS and provide 15 encoded CMOS. Each encoded CMD consists of two loads in the register and is executed by receipt of CMD 134 which also clears the register. Repeated application of CMD 127 has no further effect prior to execution.

- 132 LMS Load 5
  This CMD is one of six used by the LMS to load a 6-stage CMD register in the LMS and provide 15 encoded CMOS. Each encoded CMD consists of two loads in the register and is executed by receipt of CMD 134 which also clears the register. Repeated application of CMD 132 has no further effect prior to execution.

- 133 LMS Load 6
  This CMD is one of six used by the LMS to load a 6-stage CMD register in the LMS and provide 15 encoded CMOS. Each encoded CMD consists of two loads in the register and is executed by receipt of CMD 134 which also clears the register. Repeated application of CMD 133 has no further effect prior to execution.

- 134 LMS CMD EX
  This CMD causes execution of one of the 15 encoded LMS CMOS as contained in its 6-stage CMD register which is loaded by receipt of two of the six CMOS 123, 124, 125, 127, 132, and 133. Execution also clears the register. Repeated application of CMD 134 has no further effect.

- Application of operational power to the LMS causes initialization of the 6-stage CMD register in the clear state (0000000).
- If an incorrect CMD load is received by the register, it will not affect the instrument unless executed by CMD octal 134. Incorrect loads may be cleared by sending additional CMOS to fill the register (111111) and then executing by sending CMD 134.
- If an incorrect load consisting of three CMOS (for example) is inadvertently executed by CMD 134, there are three combinations of load pairs, each corresponding to an encoded LMS CMD. The response of the LMS to this invalid input is unpredictable, depending on switching times (signal race) and whether or not some of the three encoded CMOS are mutually exclusive.
LMS ENCODED COMMANDS

OCTAL CMD LOADS:

- **123 & 124 STEP, MULT, SWEEP HV ON & BACKUP HEATER OFF**
  - This combination ofcmds, when followed by the execute cmd (octal 134):
    - Applies power to the electron multiplier HV power supply
    - Enables the digital sweep control and sweep HV power supply
    - Removes power from the backup heater circuit
    - Inhibits turn-on of the ion pump HV power supply
  - Note that the ion pump interlock is a one-way inhibit; operation of cmd 123/124/134 is never inhibited.
  - The digital sweep control is locked (sweep hold) by the cmd combination 123/125; the two HV power supplies are commanded off by 122/133; and the backup heater is energized by 124/127 each combination executed by cmd 134.
  - Repeated execution of 123/124/134 has no further effect. Application of operational power to the LMS causes initialization in the lock mode and with the HV power supplies off. The initial state of the backup heater may be on or off (unpredictable).

- **123 & 127 ONE STEP (SWEEP ADVANCE)**
  - This combination of cmds, when followed by the execute cmd (octal 134), causes the LMS digital sweep control to advance one step if it has been previously locked by 123/125/134. Repeated application of 123/127/134 causes repeated stepping of the digital sweep control through its 1350 steps, or more if desired.

- **123 & 132 EMISSION/FILAMENTS OFF, & MODE SELECT ENABLE**
  - This combination of cmdds, when followed by the execute cmd (octal 134), deactivates a portion of the LMS emission control power supply to remove power from the LMS ion source filaments. It also enables the mode select portion of the emission control circuit. After sending 123/132/134, either the fixed mode emission or cyclic mode emission may be selected as follows:
    - **Fixed Mode**: 123/125/134
    - **Cyclic Mode**: 124/133/134

  - Repeated application of cmd 123/132/134 has no further effect. Application of operational power to the LMS causes initialization in the filament-off mode corresponding to cmd 123/132/134. Turn-on of the filaments (including emission control) is accomplished by one of the two cmds:
    - **Filament #1 On**: 123/133/134
    - **Filament #2 On**: 124/132/134

- **123 & 135 FILAMENT #1 ON & MODE SELECT INHIBIT**
  - This combination of/cmds, when followed by the execute cmd (octal 134), causes power to be applied to filament #1 of the LMS ion source and selects relay positions such that the filament bias voltages are applied to the correct filaments. This cmd combination (123/135/134) has no effect unless the emission filaments are off by prior execution of cmds 123/132/134. Specifically, filament #1 cannot be turned on if filament #2 is on. Also, this cmd combination inhibits the mode select circuitry; specifically, the mode of emission not being used cannot be selected without first going to the filament-off and mode select state (cmd 123/132/134). Repeated application of cmd 123/135/134 has no further effect. Application of operational power to the LMS causes initialization in the filament-off and mode select enable state.

- **123 & 125 LOCK (SWEEP HOLD), J-PLATE VOLTAGE STEP, & FIXED MODE SELECT**
  - This combination of cmdds, when followed by the execute cmd (octal 134), causes the following changes in LMS:
    - Deactivates the digital sweep control, to lock its stepping function and hold the sweep HV output at the existing value
    - Advances the J-plate voltage sequencer of the ion source emission control by one step if the sequencer has been enabled by 124/133/134
    - Selects the fixed mode of operation of the emission control circuit if it has been enabled by 123/132/134.

  - Reactivation of automatic sweep stepping is performed by 123/124/134. The sweep remains locked until the next 90-frame mark at which time it resets and starts at the beginning of the counter sequence (back ground).

  - Application of operational power to the LMS causes initialization in the lock mode, with J-plate stepping inhibited at the last command level but with power applied to the J-plate sequencer circuit. Repeated execution of 123/125/134 causes repeated stepping of the J-plate voltage sequencer throughout its four states, the nominal voltages +1 volt, as a function of temperature for the two J-plates (J-1 and J-2) are:

<table>
<thead>
<tr>
<th>PLATE</th>
<th>STATE 1</th>
<th>STATE 2</th>
<th>STATE 3</th>
<th>STATE 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>J-1</td>
<td>1092V</td>
<td>1076V</td>
<td>1070V</td>
<td>1068V</td>
</tr>
<tr>
<td>J-2</td>
<td>1060V</td>
<td>1059V</td>
<td>1032V</td>
<td>1035V</td>
</tr>
</tbody>
</table>

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LMS ENCODED COMMANDS (CONT'D)

OCTAL CMD LOADS

• 124 & 125 FILAMENT #2 ON & MODE SELECT INHIBIT

  THIS COMBINATION OF CMOS, WHEN FOLLOWED BY THE EXECUTE CMD (OCTAL 134), CAUSES POWER TO BE APPLIED TO FILAMENT #2 OF THE LMS ION SOURCE AND SELECTS RELAY POSITIONS SUCH THAT THE FILAMENT BIAS VOLTAGES ARE APPLIED TO THE CORRECT FILAMENTS. THIS CMD COMBINATION (124/125/134) HAS NO EFFECT UNLESS THE EMISSION FILAMENTS ARE OFF BY PRIOR EXECUTION OF CMDS 123/123/134; SPECIFICALLY, FILAMENT #1 CANNOT BE TURNED ON IF FILAMENT #1 IS ON. ALSO, THIS CMD COMBINATION INHIBITS THE MODE SELECT CIRCUITRY; SPECIFICALLY, THE MODE OF EMISSION NOT BEING USED CANNOT BE SELECTED WITHOUT FIRST GOING TO THE FILAMENT OFF AND MODE SELECT STATE (CMD 123/123/134). REPEATED APPLICATION OF CMD 124/125/134 HAS NO FURTHER EFFECT. APPLICATION OF OPERATIONAL POWER TO THE LMS CAUSES INITIALIZATION IN THE FILAMENT-OFF AND MODE SELECT ENABLE STATE.

• 124 & 127 MULTIPLIER HIGH & BACKUP HEATER ON

  THIS COMBINATION OF CMOS, WHEN FOLLOWED BY THE EXECUTE CMD (OCTAL 134), STEPS THE LMS ELECTRON MULTIPLIER HV POWER SUPPLY FROM ITS NORMAL (LOW) VALUE TO ITS HIGH VALUE, A STEP OF 600 VDC (TWO OPERATIONAL VALUES IN THE OUTPUT RANGE OF -2200 TO -3000 VDC). THIS VOLTAGE IS SUPPLIED TO ALL THREE ELECTRON MULTIPLIER TUBES. CMD 124/127/134 ALSO APPLIES POWER TO THE LMS BACKUP HEATER. SELECTION OF THE ALTERNATE CONDITIONS BY CMD IS AS FOLLOWS:

  MULTIPLIER LOW: 124/132/134
  BACKUP HEATER OFF: 123/120/134

  REPEATED APPLICATION OF CMD 124/127/134 HAS NO FURTHER EFFECT. APPLICATION OF OPERATIONAL POWER TO THE LMS CAUSES INITIALIZATION IN THE MULTIPLIER-LOW STATE. THE INITIAL STATE OF THE BACKUP HEATER MAY BE ON OR OFF (UNPREDICTABLE).

• 124 & 132 MULTIPLIER LOW

  THIS COMBINATION OF CMOS, WHEN FOLLOWED BY THE EXECUTE CMD (OCTAL 134), STEPS THE LMS ELECTRON MULTIPLIER HV POWER SUPPLY FROM ITS HIGH VALUE (IF PREVIOUSLY COMMANDED HIGH BY 124/127/134) TO ITS NORMAL LOW VALUE, A STEP OF 600 VDC (TWO OPERATIONAL VALUES IN THE OUTPUT RANGE OF -2200 TO -3000 VDC). THIS VOLTAGE IS SUPPLIED TO ALL THREE ELECTRON MULTIPLIER TUBES. REPEATED APPLICATION OF CMD 124/132/134 HAS NO FURTHER EFFECT. APPLICATION OF OPERATIONAL POWER TO THE LMS CAUSES INITIALIZATION IN THE MULTIPLIER-LOW STATE.

• 124 & 133 DISCRIMINATOR HIGH, J-PLATE VOLTAGE STEP ENABLE, & CYCLIC MODE SELECT

  THIS COMBINATION OF CMOS, WHEN FOLLOWED BY THE EXECUTE CMD (OCTAL 134), CAUSES THE FOLLOWING CHANGES IN LMS:

  • SELECTS THE HIGHER OF THE TWO LEVELS FOR THE PREAMP DISCRIMINATOR THRESHOLD CONTROL
  • ENABLES THE J-PLATE VOLTAGE SEQUENCER OF THE ION SOURCE EMISSION CONTROL SO THAT IT CAN ACCEPT THE STEP CMD (123/125/134)
  • SELECTS THE CYCLIC MODE OF EMISSION IF IT HAS BEEN ENABLED BY CMDS 123/132/134

  REPEATED APPLICATION OF CMD COMBINATION 124/133/134 HAS NO FURTHER EFFECT. THE HIGHER OF THE TWO LEVELS FOR THE PREAMP DISCRIMINATOR THRESHOLD CONTROL IS SELECTED, AND J-PLATE VOLTAGE STEP IS INHIBITED. CMDS 124/127/134 APPLICATION OF OPERATIONAL POWER TO THE LMS CAUSES INITIALIZATION IN THE LATTER LOW/INHIBIT MODE.

• 125 & 127 DISCRIMINATOR LOW & J-PLATE VOLTAGE STEP INHIBIT

  THIS COMBINATION OF CMOS, WHEN FOLLOWED BY THE EXECUTE CMD (OCTAL 134), CAUSES THE FOLLOWING CHANGES IN LMS:

  • SELECTS THE LOWER OF THE TWO LEVELS FOR THE PREAMP DISCRIMINATOR THRESHOLD CONTROL
  • INHIBITS THE J-PLATE VOLTAGE SEQUENCER OF THE ION SOURCE EMISSION CONTROL SO THAT IT CANNOT ACCEPT THE STEP CMD (123/125/134)

LMS ENCODED COMMANDS (CONT’D)

OCTAL CMD LOADS

• 125 & 132 BAKEOUT ENABLE

This combination of CMOS, when followed by the execute cmd (octal 134), selects a relay position such that a subsequent command of the LMS to standby power will perform bakeout of the LMS sensor and bypass the LMS survival heater. To discontinue bakeout after it is in process, the LMS must be commanded either to operational power on/off. Prior to an LMS standby cmd, repeated execution of CMOS 125/132/134 has no further effect. To cancel this command, prior to LMS standby, the bakeout bypass command (126/133/134) must be executed. When operational power is applied to the LMS, from either standby or off, it is possible for the relay to receive signals driving it to the opposite position. At LMS turn-on, the bypass state is assured by transmitting CMD 134 with no load in the LMS register; that is, a binary reading of 00000.

• 125 & 133 BAKEOUT BYPASS

This combination of CMOS, when followed by the execute cmd (octal 134), selects a relay position such that a subsequent command of the LMS to standby power will not perform bakeout of the LMS sensor and will operate the survival heater. Repeated application of CMD 125/133/134 has no further effect. If there has been no bakeout enable CMD in between, when operational power is applied to the LMS, from either standby or off, it is possible for the relay to receive signals driving it to the opposite position. At LMS turn-on, the bypass state is assured by transmitting CMD 134 with no load in the LMS register; that is, a binary reading of 00000.

• 127 & 132 OUST COVER REMOVAL

This combination of CMOS, when followed by the execute cmd (octal 134), activates the circuits of a burn-wire device for a period of 12 to 20 seconds to release the dust cover which protects the LMS thermal control mirror. This burn-wire severs a cord causing minimum release of gas which could contaminate the LMS science measurements. Repeated execution of CMOS 127/132/134 causes repeated activation of the burn-wire. Removal of the mirror cover is scheduled after LMS ascent. Prior to removal, the extent of LMS operations is constrained by thermal control limitations.

• 127 & 133 ION PUMP ON

This combination of CMOS, when followed by the execute cmd (octal 134), energizes the LMS ion pump which applies a high-vacuum pumping action to the LMS gas analyzer (sensor). Repeated application of CMOS 127/133/134 has no further effect. If the HV power supplies are on CMOS 123/124/134, the ion pump on cmd, 127/133/134, is inhibited and, to turn on the pump, the HV power supply off cm, 132/133/134, must be executed first. Turn-off of the ion pump is accomplished by CMOS 132/133/134. Application of operational power to the LMS causes initialization in the pump-off mode.

• 132 & 133 ION PUMP, MULTIPLIER, AND SWEEP HV OFF

This combination of CMOS, when followed by the execute cmd (octal 134), removes power from the following LMS circuits:

- ION PUMP
- ELECTRON MULTIPLIER HV POWER SUPPLY
- SWEEP HV POWER SUPPLY

The ion pump is turned on by 127/133, and the two HV power supplies are turned on by 123/124 (each combination executed by CMD 134).

Repeated application of 132/133/134 has no further effect. Application of operational power to the LMS causes initialization in the pump and HV off mode corresponding to CMOS 130/131/134.

SEQUENCE OF CMS CMDS

123/132/134
124/133/134
125/127/134
123/133/134
124/125/134
123/124/134

*Required only if a filament is on

This sequence of CMS CMDS activates a cyclic mode operation of the emission control circuit in which the 1350 sweep steps are programmed to occur with four different values, in succession, of the filament bias, as follows:

<table>
<thead>
<tr>
<th>FILAMENT BIAS</th>
<th>SWEEP STEPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>-70 VDC</td>
<td>FIRST</td>
</tr>
<tr>
<td>-18 VDC</td>
<td>SECOND</td>
</tr>
<tr>
<td>-25 VDC</td>
<td>THIRD</td>
</tr>
<tr>
<td>-20 VDC</td>
<td>FOURTH</td>
</tr>
<tr>
<td>-70 VDC</td>
<td>FIFTH</td>
</tr>
</tbody>
</table>

ETC.

The sequence can start at any of the bias voltages depending on prior operation of the LMS. To return to the fixed mode of operation of the emission control circuit requires the following sequence of CMOS: 123/132/134, 123/125/134, 123/133/134 (or 124/125/134), and 123/124/134.

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LMS DIGITAL DATA

ALSEP WORD ASSIGNMENT

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
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<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
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</tr>
<tr>
<td>17</td>
<td>LMS</td>
<td>18</td>
<td>LMS</td>
<td>19</td>
<td>LMS</td>
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<td>LMS</td>
<td>21</td>
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<td>59</td>
<td>60</td>
<td>61</td>
<td>62</td>
<td>63</td>
<td>64</td>
<td></td>
</tr>
</tbody>
</table>

Each box represents one 10-bit word in the 640-bit ALSEP frame.

C - ALSEP control words
CV - ALSEP command verification
LMS flag & CV - Status flags & cmd reg status
LMS ch. A - Low mass range count
LMS ch. B - Intermediate mass range count
LMS ch. C - High mass range count
HK - ALSEP and experiments housekeeping multiplexed to sample each source once every 90 ALSEP frames (every 54 seconds at normal data rate)

ALSEP WORD 5, EVEN FRAME

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM-20 FIL ON/OFF</td>
<td>DM-19 HVPS ON/OFF</td>
<td>DM-18 BAKEOUT HTR</td>
<td>DM-17 DUST COVER STA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM-16 ION PUMP ON/OFF</td>
<td>DM-15 AUTO/Lock STA</td>
<td>DM-14 BGICAL OR SWEEP</td>
<td>DM-13 DISCRIM H/L/LOW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| DM-12 MULT H/L/LOW STA | DM-11 FRAME ID (1 indicates even frame)

ALSEP WORD 5, ODD FRAME

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
</table>
| DM-01 CMD REG STA | NOT USED (FILLER ZEROS) | DM-11 FRAME ID (0 indicates odd frame)

ALSEP WORDS 17 (DM-03), 19 (DM-04), AND 21 (DM-05)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
</table>
| 4-BIT SHIFT COUNTER | 6-BIT SCIENCE REGISTER DATA

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LMS ANALOG DATA

IN THE ALSEP HOUSEKEEPING WORD (WORD 33 OF THE ALSEP FRAME) THREE CHANNELS ARE ASSIGNED TO THE LMS. THEY ARE CHANNELS 40, 41, AND 44, READ OUT DURING THOSE THREE FRAMES OF THE ALSEP 90-FRAME SEQUENCE (ONCE EVERY 54 SECONDS AT THE NORMAL DATA RATE).

• CHANNEL 40 (THIS CHANNEL IS MUL-TIPLEXED TO PRESENT 16 PARAMETERS)

<table>
<thead>
<tr>
<th>MULTIPLEXED SEQUENCE</th>
<th>CODE</th>
<th>PARAMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AM-01</td>
<td>MARKER ID (EIGHT ONES)</td>
</tr>
<tr>
<td>2</td>
<td>AM-02</td>
<td>EXPERIMENT CURRENT</td>
</tr>
<tr>
<td>3</td>
<td>AM-03</td>
<td>ION PUMP CURRENT</td>
</tr>
<tr>
<td>4</td>
<td>AM-04</td>
<td>ION PUMP VOLTS</td>
</tr>
<tr>
<td>5</td>
<td>AM-05</td>
<td>BASEPLATE TEMP</td>
</tr>
<tr>
<td>6</td>
<td>AM-06</td>
<td>ION SOURCE TEMP</td>
</tr>
<tr>
<td>7</td>
<td>AM-07</td>
<td>+12 VDC LVPS</td>
</tr>
<tr>
<td>8</td>
<td>AM-08</td>
<td>+5 VDC LVPS</td>
</tr>
<tr>
<td>9</td>
<td>AM-09</td>
<td>-12 VDC LVPS</td>
</tr>
<tr>
<td>10</td>
<td>AM-10</td>
<td>-15 VDC LVPS</td>
</tr>
<tr>
<td>11</td>
<td>AM-11</td>
<td>EMISSION CURRENT</td>
</tr>
<tr>
<td>12</td>
<td>AM-12</td>
<td>FIL. #1 CURRENT</td>
</tr>
<tr>
<td>13</td>
<td>AM-13</td>
<td>FIL. #2 CURRENT</td>
</tr>
<tr>
<td>14</td>
<td>AM-14</td>
<td>MULT. HIGH VOLTAGE</td>
</tr>
<tr>
<td>15</td>
<td>AM-15</td>
<td>LVPS TEMP</td>
</tr>
<tr>
<td>16</td>
<td>AM-16</td>
<td>SPARE (APPROX. ZERO)</td>
</tr>
</tbody>
</table>

• CHANNEL 41 READS AM-41, ELECTRONICS TEMP, NOT ONLY WHEN THE LMS IS OPERATIONAL BUT ALSO IN STANDBY AND OFF

• CHANNEL 44 READS AM-44, LMS SWEEP HIGH VOLTAGE
# LMS Initial Lunar Setup

## Functions and Comments

<table>
<thead>
<tr>
<th>Functions</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrument Turn-On</td>
<td>CMD operational PWR with preset high voltages off, monitor TM</td>
</tr>
<tr>
<td>Dust Cover Removal</td>
<td>CMD dust cover removal after LM ascent; may be delayed until after LSP detonation</td>
</tr>
<tr>
<td>Bakeout Operation</td>
<td>Execute bakeout enable CMD and switch LMS to standby (subsequent turn-on for TM check); will be repeated for total of 12 hours</td>
</tr>
<tr>
<td>Ion Pump Operation</td>
<td>CMD ion pump on to determine when pressure is acceptable for high-voltage operation</td>
</tr>
<tr>
<td>Filament #1 On</td>
<td>CMD filament on and monitor filament current</td>
</tr>
<tr>
<td>Step, Mult, and Sweep On</td>
<td>CMD full operation and monitor science/TM data (make adjustments as necessary)</td>
</tr>
<tr>
<td>Full Instrument Operation</td>
<td>Follows any adjustments, above</td>
</tr>
</tbody>
</table>

June 72 3270.4.34
LUNAR SEISMIC PROFILING EXPERIMENT (LSP)
LSP EQUIPMENT

- Geophone Module - Mounted on Subpackage 1
- Remote Transmitting Antenna - Mounted on Subpackage 1
- Central Electronics - Mounted inside Subpackage 1
- RF Cable
- Explosive Packages (8) - Mounted four on each Transport Module
- HFE Subpallet
- Receiving Antenna (8)
- Transport Modules (2) carried in LM and on LRV

JULY 72 3270.5.2
Determining Lunar Surface and Near-Surface Response to Artificially Induced Seismic Energy and Natural Seismic Phenomena

Objectives

- Determine Lunar surface and near-surface response to artificially induced seismic energy and natural seismic phenomena.

Method

- Explosive packages deployed by crew and detonated by combination of timer and RF fire pulses. Locations must be known for data reduction.
- Geophone array of four geophones placed by crew.
- Data includes precision timing of fire pulses from which detonation time is obtained.

Analysis

- Seismic wave train data in terms of velocity, frequency spectra, and attenuation.

Results

- Degree of induration and bearing strength of lunar surface.
- Type and character of surface and near-surface rocks.
- Relationship between mare and highland areas.
- Understanding of origin of primordial lunar surface.
- Meteorite impact data.
- Microquake data.
LSP OPERATIONS SUMMARY

DEPLOYMENT
- PLACE EXPLOSIVE TRANSPORT MODULES IN SUN
- PLACE GEOPHONE MODULE 30 FT SOUTH OF CENTRAL STATION
- DEPLOY FOUR GEOPHONES, ONE AT A TIME, FROM GEOPHONE MODULE; TWO ALONG SUN LINE AND TWO PERPENDICULAR TO SUN LINE
- ERECT LSP TRANSMITTING ANTENNA 37 FT NW OF CENTRAL STATION

EVA 1
- PLACE TRANSPORT MODULE #1 ON LRV
- AT EACH OF FOUR PRESCRIBED LOCATIONS, PLACE APPROPRIATE EXPLOSIVE PACKAGE ON LUNAR SURFACE WITH RECEIVING ANTENNA EXTENDED AND PULL (FOUR PINS) THREE PULL-RINGS
- REPEAT STEPS OF EVA 2 FOR TRANSPORT MODULE #2 USING APPROPRIATE PACKAGES/LOCATIONS

EVA 2

EVA 3

POST-DEPLOYMENT
- COMMAND LSP OPERATIONAL POWER AND DATA FORMAT
- INITIATE LSP FIRING SIGNALS (TRANSMITTER PULSES) BY COMMAND AT TIME DEPENDING ON DEPLOYMENT HISTORY
- TRANSMIT COMMANDS FOR GEOPHONE CALIBRATION
- OTHER COMMANDS AS NECESSARY

JULY 72 3270.5.4
LSP COMMUNICATIONS SUMMARY

COMMANDS

- POWER ON/STANDBY/OFF (STANDBY IS EFFECTIVELY OFF FOR LSP)
- LSP DATA FORMAT
- DATA RATE (3533.3 BITS PER SEC IS NORMAL FOR LSP; LOW RATE OF 1060 BITS PER SEC USED ONLY FOR LISTENING MODE BECAUSE PROPER FIRE PULSES CANNOT BE GENERATED - NETWORK HAS NO PROVISION FOR THROUGHPUT OF LOW RATE TO MCC)
- 5 SPECIAL LSP CONTROL COMMANDS USED FOR:
  - LSP XMTR PULSES ON
  - LSP XMTR PULSES OFF
  - AMPLIFIER GAIN NORMAL
  - AMPLIFIER GAIN LOW
  - GEOPHONE CALIBRATE
- WHENEVER LSP IS ACTIVATED BY POWER ON CMD, XMTR FIRE AND AGC PULSES INITIALIZE OFF AND AMPLIFIER GAIN Initializes NORMAL

DATA

- IN THE ALSEP DATA PROCESSOR FORMAT, LSP ELECTRONICS TEMPERATURE (PARAMETER AP-O1) IS OBTAINED ONCE EVERY 90 ALSEP FRAMES, REGARDLESS OF LSP ON/STANDBY/OFF STATUS
- IN THE LSP FORMAT, ALL SCIENCE DATA FROM OTHER EXPERIMENTS IS BY-PASSED, AND A SPECIAL DOWNLINK FORMAT IS GENERATED BY THE LSP
- THIS FORMAT CONSISTS OF AN 1800-BIT MAIN FRAME MADE UP OF THREE 600-BIT SUBFRAMES, EACH HAVING TWENTY 30-BIT WORDS
- IN EACH LSP MAIN FRAME, THERE ARE SIX CRITICAL ALSEP HOUSEKEEPING PARAMETERS (8 BITS EACH), THE REMAINDER IS EITHER LSP DATA (SCIENCE AND HOUSEKEEPING) OR SYNCHRONIZATION
- AT THE NORMAL LSP DATA RATE, EACH SEISMIC DATA CHANNEL IS SAMPLED 118 TIMES PER SECOND

JULY 72 3270.55
# LSP Physical Parameters

<table>
<thead>
<tr>
<th>Size</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Central Electronics:</td>
<td>6.755 x 6.505 x 2.8 in.</td>
</tr>
<tr>
<td>Geophone Module:</td>
<td>9.84 x 8.665 x 6.85 in.</td>
</tr>
<tr>
<td>Explosive Packages (on Transport Frame):</td>
<td>18.39 x 11.12 x 10.88 in.</td>
</tr>
<tr>
<td>Transmitting Antenna Length:</td>
<td>13 in. stowed, 62 in. deployed</td>
</tr>
<tr>
<td>Transport Module No. 1:</td>
<td>20.10 LB</td>
</tr>
<tr>
<td>Transport Module No. 2:</td>
<td>18.66 LB</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Earth Weight</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Electronics:</td>
<td>3.70 LB</td>
</tr>
<tr>
<td>Antenna and Cable:</td>
<td>5.00 LB</td>
</tr>
<tr>
<td>Geophone Module:</td>
<td>8.95 LB</td>
</tr>
<tr>
<td>Anchor, Flags, etc.:</td>
<td>2.90 LB</td>
</tr>
<tr>
<td><strong>Total</strong>:</td>
<td><strong>59.31 LB</strong></td>
</tr>
</tbody>
</table>

Operational Power: 6.8 W  
Survival Power: ZERO
LSP PERFORMANCE CHARACTERISTICS

EXPLOSIVE PACKAGES
- PLACED AT RANGES OF 500 FT TO 3.5 KM
- LARGER EXPLOSIVE CHARGES AT LONG-RANGE LOCATIONS

GEOPHONES (SENSORS)
- ELECTROMAGNETIC TYPE

LOGARITHMIC COMPRESSION AMPLIFIERS
- DYNAMIC RANGE: 64 DB TO 78 DB

GEOPHONE/AMPLIFIER
- SENSITIVITY: THE RMS VALUE OF A 6 MILLIMICRON (μm) PEAK-TO-PEAK SIGNAL AT 10 Hz WILL BE A MINIMUM OF 18 DB ABOVE THE RMS NOISE
- BANDWIDTH: 3 TO 20 Hz WITH RESPECT TO VELOCITY (GEOPHONES SENSE RATE OF CHANGE IN VERTICAL POSITION)
- DYNAMIC RANGE: 64 TO 78 DB

BASIC DATA WORD
- 7-BIT READOUT FROM EACH OF FOUR SEISMIC DATA CHANNELS (GEOPHONE/AMPLIFIER)
- 1.28-DB RESOLUTION PER BIT

SHOT TIME
- DETERMINED BY CORRELATING SEISMIC RESPONSE FROM DETONATION OF EXPLOSIVE PACKAGE WITH TIME OF FIRE PULSE SETS; TIMING OF EACH FIRE PULSE SET IS SYNCHRONIZED IN DATA FORMAT AS WELL AS DETECTED FOR VERIFICATION IN TM

NOTES:
(1) ACCURATE DETERMINATION OF SHOT TIME AND RANGE IS FUNDAMENTAL IN THE ANALYSIS OF GEOPHONE DATA
(2) THE VARIETY OF RANGES AND EXPLOSIVE CHARGES ALLOWS INVESTIGATION OF SEISMIC WAVE PENETRATION THROUGH SEVERAL LAYERS OF SUBSURFACE MATERIAL DOWN TO DEPTHS OF 3 OR 4 KM

JULY 72 3270.5.7
LSP EXPLOSIVE PACKAGE DESIGN

- Receiving Antenna
- Slide Position Indicator
- Safe/Arm Slide Timer
- Shorting Plug
- Handle
- Ganged Pull Pins
  - Thermal Battery Timer
  - Thermal Battery Firing Pin
- S/A Timer Pull Ring
- S/A Slide Pull Ring
- Thermal Battery Timer
- Receiver & Signal Processor
- Thermal Battery
- Firing Pulse Generator
- Test Connector
- Pull Pin (4 Pins on 3 Rings)
- Safe/Arm Slide Assy
- Housing and Charge Assy
- End Denoting Cartridge

JULY 72 3270.5.9
LSP EXPLOSIVE PACKAGE FUNCTIONS

- **Safe/Arm Timer**
  - Arms explosive package = 90 hours after deployment

- **Thermal-Battery**
  - Timer activates battery to supply power to receiver, signal processing, and firing circuit
  - $\approx$ 91 hours after deployment

- **Explosive Package**
  - Detonates upon receiving coded RF signal from LSP central electronics if safe/arm slide plate is in position and thermal battery is activated
  - Shorting switch on end detonating cartridge is opened by roller engagement with safe/arm slide plate

$T_n$ = Preset time (90, 91, 92, or 93 hours)

**Diagram Description**

- Astronaut pull ring no. 3
- Timing mechanism
- Firing-pin mechanism
- Thermal battery (w/ primer)
- Receiver
- Signal processor
- Firing-pulse generator
- Cutter
- Receiver
- Astronaut pull ring no. 1
- Astronaut pull ring no. 2
- Explosive charge
- Explosive lead
- Safe/arm plate
- Tension spring
- Open: $T_n + 2$ hours
- Close: $T_n + 2$ hours
- $T_n + 1$ hour
- 2-minute life

July 72 3270.5.10
LSP EXPLOSIVE PACKAGE SAFETY FEATURES

- THREE INDEPENDENT EVENTS OCCUR FOR DETONATION
  - RUN-OUT OF SAFE/ARM SLIDE TIMER
  - RUN-OUT OF BATTERY TIMER
  - RADIO RECEPTION OF CODED FIRING SIGNAL (PROPERLY GENERATED ONLY AT 3533.3-BPS DATA RATE)
- TIMER PULL PINS WILL PERMANENTLY LOCK IN PLACE IF TIMER STARTS PREMATURELY
- FIRING PIN SAFING PULL PIN WILL PERMANENTLY LOCK IN PLACE, PREVENTING THERMAL BATTERY INITIATION, IF THE BATTERY FIRING PIN RELEASES PRIOR TO DEPLOYMENT
- SAFE/ARM SLIDE PULL PIN WILL PERMANENTLY LOCK IN PLACE, PREVENTING THE SLIDE FROM MOVING TO THE ARM POSITION, IF THE SAFE/ARM SLIDE PLATE RELEASES PRIOR TO DEPLOYMENT
- SAFE/ARM SLIDE IN SAFE POSITION
  - PREVENTS PROPAGATION OF EXPLOSIVE TRAIN DETONATION
  - SHORTS END DETONATING CARTRIDGE
- BATTERY TIMER, PRIOR TO RUN-OUT, OPEN CIRCUITS THE SIGNAL PROCESSOR AND FIRING PULSE GENERATOR POWER LINE
- THERMAL BATTERY HAS A ONE-TIME OPERATIONAL LIFETIME OF THREE MINUTES MAXIMUM
- TIMEOUT OF TIMERS MUST COINCIDE WITHIN LIMITS SUCH THAT THE SAFE/ARM SLIDE PLATE IS IN THE ARM POSITION WHEN THE THERMAL BATTERY IS ACTIVATED
- FIRING CAPACITORS DISCHARGE THROUGH LEAK RESISTORS IF FIRING SIGNAL IS NOT RECEIVED WITHIN THREE MINUTES OF THERMAL BATTERY ACTIVATION
- IF EXPLOSIVE PACKAGE IS NOT DETONATED WITHIN THE TWO-HOUR SAFE/ARM SLIDE FIRING WINDOW, THE SLIDE WILL MOVE TO THE RESAFE POSITION (VISUAL INDICATOR SHOWS STATUS)
LSP SAFE/ARM SLIDE PULL PIN

PULL RING

UNLOCKED POSITION

PULL RING RETAINER

EXPLOSIVE PACKAGE

EDC HOUSING

BASE PLATE

SAFE/ARM SLIDE

PULL RING STEM (ROTATED 180°)

PULL RING SPRING

JULY 72 3270.5.12
LSP EXPLOSIVE TRAIN SAFE POSITION

- EDC
- EDC HOUSING
- SAFE/ARM SLIDE
- EXPLOSIVE CHARGE 6 POUNDS (MAXIMUM)
- LEAD
- BASE PLATE
LSP EXPLOSIVE PACKAGE ELECTRONICS DIAGRAM

- **ANTENNA**
- **RF AMPL**
- **AM DETECTOR**
- **AGC AMPL**
- **PEAK DETECTOR**
- **BANDPASS FILTER**
- **THRESHOLD DETECTOR**
- **SIGNAL PROCESSOR**
  - **DELAY MV-2**
  - **NOISE FF**
  - **ENABLE**
  - **COUNTER (2 BIT)**
  - **BIT 1**
  - **BIT 2**
- **INTEGRATOR**
- **LEVEL SENSOR**
- **GATING AMPL**
- **SCR**
- **EDC**
- **THERMAL BATTERY Timer**
- **THERMAL BATTERY**
- **ENERGY STORAGE CAPACITORS**
- **DC VOLTAGES**

**NOTE:**

1. **THRESHOLD DETECTOR OUTPUT**
2. **NOISE GATE**
3. **PULSE GATE (LOGIC ENABLE)**
4. **NOISE INHIBIT LATCH**
5. **BIT 1 COUNT**
6. **BIT 2 COUNT**
7. **FIRE PULSE**

**DATA:**

- **T' 0.283 MILLISEC**
- **T = 0.283 MILLISEC**

**JULY 72 3270.5.16**
LSP TRANSMITTER PULSE TIMING

- **Start of Frame**
- **Main Frame (1800T)**
- **End of Frame**

**Subframe 3**
- **Subframe 1** (600T)
- **Subframe 2** (600T)
- **Subframe 3** (600T)

**Fire Pulse Set**
- **AGC Pulse**

**AGC Pulse Set**
- **AGC Pulse**

**Notes:**
1. **Fire Pulse Sets Occur Once Every 58 Frames (174 Subframes)**
   (58 Frames = 29.55 sec)
2. **AGC Pulse Occurs Once Per Subframe**
   (169.8-millisecond intervals)
3. **Timing Shown Applies Only to 3533, 3 BPS Clock Rate**

**T** = 0.283 Millisecond = 1 Clock Pulse Width
**2T** = 0.566 Millisecond
**3T** = 0.849 Millisecond
**12T** = 3.40 Millisecond
**8T** = 23.49 Millisecond
**359T** = 101.6 Millisecond
**600T** = 169.8 Millisecond
**1800T** = 504.4 Millisecond

**Figure A**
- **Figure Pulse Set**

**Figure B**
- **AGC Pulse**

**Figure**

- **JULY 72 3270.5.17**
LSP TRANSMITTER

OPERATION

- USES A PULSED CARRIER-WAVE (CW) TYPE TRANSMISSION
- WHENEVER OPERATIONAL POWER IS APPLIED TO THE LSP, THE CRYSTAL OSCILLATOR IS ON BUT OUTPUT IS NOT MODULATED UNTIL COMMAND TO RF PULSE MODE
- EXECUTION OF THE "PULSES ON" CMD CAUSES A CONTINUOUS SERIES OF TRIGGER SIGNALS, UNTIL THE "PULSES OFF" CMD IS RECEIVED WITH THE FOLLOWING TIMING:
  - ONE PULSE FOR 0.283 MILLISEC, COINCIDING WITH THE 359TH BIT IN EVERY LSP SUBFRAME (EVERY 169.3 MILLISECONDS)
  - A FIRE PULSE SET CONSISTING OF THREE PULSES OF 0.566 MILLISEC EACH SPACED 0.849 MILLISEC APART, COINCIDING WITH THE FOLLOWING BIT PAIRS IN THE LSP FRAME (AT 58-FRAME INTERVALS): 84-85, 89-90, AND 94-95
- THE ONE-BIT PULSES SET RECEIVER AGC THRESHOLD
- TRANSMISSION OF FIRE PULSE SETS ARE INDICATED IN "M, DP-20," (BITS 89-90) THROUGH A DIODE DETECTOR AT THE TRANSMITTER OUTPUT
- DETONATION OCCURS ON THE LEADING EDGE OF THE THIRD PULSE

RF LINK PARAMETERS (WORST CASE)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FREQUENCY, MHz</td>
<td>41.2</td>
</tr>
<tr>
<td>PEAK XMTR POWER, WATTS</td>
<td>10 (MINIMUM)</td>
</tr>
<tr>
<td>XMTR FIRING PULSE, MILLISEC</td>
<td>0.566</td>
</tr>
<tr>
<td>XMTR AGC PULSE, MILLISEC</td>
<td>0.283</td>
</tr>
<tr>
<td>RCVR NOISE FIGURE, DB</td>
<td>7</td>
</tr>
<tr>
<td>RCVR BANDWIDTH, kHz</td>
<td>10</td>
</tr>
<tr>
<td>SIG PROC BANDWIDTH, kHz</td>
<td>5</td>
</tr>
<tr>
<td>XMTR ANTENNA GAIN, DB</td>
<td>0</td>
</tr>
<tr>
<td>RCVR ANTENNA GAIN, DB</td>
<td>0</td>
</tr>
<tr>
<td>XMTR ANTENNA HEIGHT, IN.</td>
<td>63</td>
</tr>
<tr>
<td>RCVR ANTENNA HEIGHT, IN.</td>
<td>60</td>
</tr>
<tr>
<td>XMTR ANT PROXIMITY LOSS, DB</td>
<td>3</td>
</tr>
<tr>
<td>RCVR ANT PROXIMITY LOSS, DB</td>
<td>7</td>
</tr>
<tr>
<td>RANGE, KM</td>
<td>3.5</td>
</tr>
</tbody>
</table>
LSP GEOPHONE/AMPLIFIER RESPONSE

EXPECTED RESPONSE

FREQUENCY, Hz

RESPONSE, DB

+6 DB

+2 DB

0 DB

-4 DB

-40 DB
LSP ANALOG MULTIPLEXER/CONVERTER

ANALOG GATES 2, 3, AND 4 ARE IDENTICAL TO 1 AND 5

SEISMIC | GEOPHONE OUTPUT 1 | ANALOG GATE 1
---|---|---
AMPLIFIER | DP-02 | 
ENG DATA INPUTS | DP-03 | 
| AE-24 | 

SEISMIC | GEOPHONE OUTPUT 2 | ANALOG GATE 2
---|---|---
AMPLIFIER | DP-05 | 
ENG DATA INPUTS | AE-03 | 
| AT-16 | 

SEISMIC | GEOPHONE OUTPUT 3 | ANALOG GATE 3
---|---|---
AMPLIFIER | DP-10 | 
ENG DATA INPUTS | AE-04 | 
| AB-04 | 

SEISMIC | GEOPHONE OUTPUT 4 | ANALOG GATE 4
---|---|---
AMPLIFIER | DP-14 | 
ENG DATA INPUTS | SPARE | 
| AB-05 | 

CONTROL AND DIGITAL DATA PROCESSOR

MUX ADDRESS SIGNALS (16)

AID START

GATING LOGIC

COMPARATOR

RAMP GENERATOR

GATE

SYNC

CLOCK

COUNTER

8-BIT DIGITAL OUTPUT

DIGITAL DATA PROCESSOR

JULY 72 3270.5.26
LSP CONTROL AND DIGITAL DATA PROCESSING

CLOCK 1
(OUTPUT DATA RATE)
3533.3 OR 1060 BPS

CLOCK 2
(SUB-BIT TIMING)
28.266 KHz

ALSEP
DDP

BIT WORD SUBFRAME FRAME

COUNTERS

DECODERS

BIT WORD SUBFRAME FRAME

DATA ROUTING LOGIC

TRANSMITTER DATA REGISTER

GEOPHONE DATA REGISTER

DATA HOLD REGISTER

TRIGGER SIGNAL

LSP TRANSMITTER

LSP PULSES ON

156

LSP PULSES OFF

162

LSP GAIN NORMAL SEL

163

LSP GAIN LOW SEL

164

LSP GEOPHONE CALIBRATE

170

CMD LOGIC

TRIGGER SIGNAL

LSP TRANSMITTER

NORMAL GAIN SEL SIGNAL

162

LOW GAIN SEL SIGNAL

164

CAL ENABLE SIGNAL

170

LSP SEISMIC AMPLIFIERS

JULY 72 3270.5.27
<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>POWER, WATTS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASIC EXPERIMENT</td>
<td>5.3</td>
<td>STARTUP TRANSIENT OF LESS THAN 13 WATTS FOR LESS THAN 2 MILLI SEC</td>
</tr>
<tr>
<td>PASSIVE LISTENING MODE</td>
<td>5.3</td>
<td>SAME AS BASIC EXPERIMENT</td>
</tr>
<tr>
<td>GEOPHONE CALIBRATION PULSE</td>
<td>0.8</td>
<td>CAL PULSE OPERATES FOR APPROX 1.5 SEC FOLLOWING EXECUTION OF COMMAND</td>
</tr>
<tr>
<td>TRANSMITTER FIRE PULSES (NOT</td>
<td>0.8</td>
<td>ENERGY STORAGE (CAPACITORS) REQUIRE 0.6 TO 0.8 WATT</td>
</tr>
<tr>
<td>CALIBRATING)</td>
<td></td>
<td>APPROX 1.5 SEC EACH TIME</td>
</tr>
<tr>
<td>TRANSMITTER FIRE PULSES (WITH</td>
<td>0.8</td>
<td>NOTE: THERE IS NO STANDBY POWER (SURVIVAL HEATER) FOR THE LSP</td>
</tr>
<tr>
<td>GEOPHONE CALIBRATION)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Increment Total**: 5.3 5.3 0.8 6.1 6.0 6.8
LSP ANTENNA AND GEOPHONE DEPLOYMENT

**ANTENNA**
- Release antenna and cable reel from subpackage 1
- Carry 37 ft northwest of central station
- Extend antenna to full length
- Attach to heat flow subpallet to provide baseplate
- Align vertical and check stability (press on subpallet with boot if necessary)

**GEOPHONES**
- Release geophone module from subpackage 1 and engage UHT with carry socket
- Carry 30 ft south of central station, place on surface, and engage UHT handle with cover pull ring
- Remove cover, retain stake/flags, and discard cover
- Secure module with stake/flag, retain one flag (insert UHT through flag ring), and engage UHT with geophone No. 1 reel
- Carry 150 ft east, insert geophone in surface, discard reel, and install flag securing geophone
- Repeat geophone/flag installation for geophone No. 2 150 ft west of module
- Repeat geophone/flag installation for geophone No. 3 88 ft south of module
- Repeat geophone/flag installation for geophone No. 4 260 ft south of module

Photograph array

JULY 72 32705.31
# LSP Emplacement Criteria

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>PARAMETER</th>
<th>REQUIREMENT</th>
<th>PRIORITY</th>
<th>INDICATOR</th>
<th>COMMENTS</th>
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</thead>
<tbody>
<tr>
<td>REMOTE</td>
<td>LOCATION AND SITE</td>
<td>37 + 7 FT NORTHWEST</td>
<td>CABLE</td>
<td>LENGTH AND VISUAL</td>
<td>45-FT CABLE SURFACE MAY BE Packed OR SMOOTHED WITH BOOT</td>
</tr>
<tr>
<td></td>
<td>AND OF CENTRAL STATION</td>
<td>OF CENTRAL STATION ON HORIZONTAL SURFACE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LEVEL</td>
<td>STABILITY</td>
<td>VISUAL</td>
<td></td>
<td>ON HFE SUBPALLET</td>
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<tr>
<td></td>
<td>ALIGN</td>
<td>NONE</td>
<td></td>
<td></td>
<td>OMNIDIRECTIONAL</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GEOPHONE</td>
<td>LOCATION AND SITE</td>
<td>30 + 5 FT SOUTH</td>
<td>PACING,</td>
<td></td>
<td>MIDDLE OF BASELINE FOR GEOPHONE TRIANGLE, PACK SURFACE, AVOID CRATERS,</td>
</tr>
<tr>
<td>MODULE</td>
<td>AND OF CENTRAL STATION</td>
<td>OF CENTRAL STATION ON HORIZONTAL SURFACE</td>
<td>CABLE</td>
<td></td>
<td>SLOPES, AND ROCKY MATERIAL</td>
</tr>
<tr>
<td></td>
<td>LEVEL</td>
<td>STABILITY</td>
<td>VISUAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ALIGN</td>
<td>ALONG SUN LINE</td>
<td></td>
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<tr>
<td>GEOPHONES</td>
<td>LOCATION WRT GEOPHONE MODULE</td>
<td>1 150 FT EAST</td>
<td>CABLE</td>
<td></td>
<td>PLACE A FLAG WITH EACH GEOPHONE; MAKES 300-FT TRIANGULAR ARRAY WITH ONE</td>
</tr>
<tr>
<td></td>
<td>AND GEOPHONE MODULE</td>
<td>2 150 FT EAST</td>
<td>LENGTH</td>
<td></td>
<td>GEOPHONE IN CENTER</td>
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<tr>
<td></td>
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<td>3 88 FT SOUTH</td>
<td>AND VISUAL</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>4 260 FT SOUTH</td>
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<td>SITE</td>
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<tr>
<td></td>
<td>LEVEL</td>
<td>VERTICAL + 70°</td>
<td>VISUAL</td>
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<td>PACK SURFACE FOR STABILITY</td>
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<td>ALIGN</td>
<td>NONE</td>
<td></td>
<td></td>
<td>PHOTOGRAPH ARRAY</td>
</tr>
</tbody>
</table>

**NOTES:**
1. SEPARATE CRITERIA FOR EXPLOSIVE PACKAGES
2. GEOPHONE CABLE AND LSP ANTENNA CABLE SHOULD NOT BE DEPLOYED PARALLEL TO EACH OTHER OR TOUCH
LSP EXPLOSIVE PACKAGE INTERIM STOWAGE

• LM WILL LAND WITH SUN AT AN ANGLE BETWEEN 15° AND 75° FROM THE NORMAL TO QUAD III

NOTE

LM RIGHHAND PALLET AND LSP TRANSPORT FRAMES CAN NOT BE EXPOSED TO DIRECT SUNLIGHT WHILE REMAINING IN QUAD III BECAUSE

- WITH THE SUN 15° FROM THE NORMAL, THE LSP TRANSPORT FRAMES WILL REACH A TEMPERATURE 267° OR GREATER. AT 75°, THE TEMPERATURE WILL BE 121°F OR GREATER

- IF THE RIGHHAND PALLET WERE TO BE SHADED BY QUAD III SIDE CURTAIN, THE TEMPERATURE OF THE LSP TRANSPORT FRAMES WOULD RANGE BETWEEN 32°F AND 21°F BETWEEN EVA 1 AND EVA 2

• THE RIGHHAND PALLET MUST BE REMOVED FROM QUAD III AND PLACED ON THE LUNAR SURFACE IN THE SUN, WITH LSP PACKAGES FACING THE SUN, AT LEAST 10 HOURS PRIOR TO THE LRV STOWAGE

• THE LSP TRANSPORT FRAME REMAINING FOR DEPLOYMENT DURING EVA 3 MUST REMAIN ON THE LUNAR SURFACE IN DIRECT SUNLIGHT UNTIL ITS STOWAGE ABOARD LRV
LSP THERMAL CONSTRAINTS ON LRV

- The safe-arm and thermal-battery timers must be +40°F when timers are activated.

- Since timer activation may occur any time during LRV mission, high-explosive baseplate temperatures must never drop below +40°F during an EVA.

- Because LSP transport frames are conductively isolated from the tool pallet, transport frame equilibrium temperatures tend to be independent of tool pallet temperatures.

- The LSP high-explosive baseplate interfaces with LSP transport frame through stainless steel spring pins which resist heat leak to transport frame. This design allows 45 minutes of LRV shade exposure with no additional means of high-explosive package isolation.

- LSP transport frame assembly temperatures must be between +90°F and +185°F at the time of stowage aboard LRV in order to meet the LRV shade requirement.
LSP EXPLOSIVE PACKAGE DEPLOYMENT

PREPARATION
- REMOVE EXPLOSIVE PACKAGE TRANSPORT MODULE, ON LM PALLET, FROM LM AND PLACE IN SUN PRIOR TO DEPLOYING GEOPHONES AND REMOTE ANTENNA
- USE UHT TO ROTATE ASTRO SW-2 CW TO OPERATIONAL POSITION AFTER DEPLOYING GEOPHONES

INSTALLATION ON LRV
- RELEASE PULL RING FOR TRANSPORT FRAME
- REMOVE PULL PIN SECURING TRANSPORT FRAME TO LM PALLET
- REMOVE TRANSPORT FRAME, WITH FOUR EXPLOSIVE PACKAGES, AND TRANSFER TO LRV
- ENGAGE LATCH TO SECURE FRAME ON LRV

PACKAGE EMLACEMENT (TYPICAL)
- TRAVERSE TO EXPLOSIVE PACKAGE DEPLOYMENT SITE (LOCATIONS ARE 160 TO 3500 METERS FROM ALSEP CENTRAL STATION)
- REMOVE CAMLOCK SECURING EXPLOSIVE PACKAGE TO TRANSPORT FRAME BY ROTATING CAMLOCK CW (DISCARD CAMLOCK)
- GRASP EXPLOSIVE PACKAGE HANDLE AND LIFT FROM FRAME
- EXTEND ANTENNA, REMOVE PULL RING NO. 1 (SAFE/ARM TIMER), ROTATE AND REMOVE PULL RING NO. 2 (SAFE/ARM SLIDE), AND REMOVE PULL RING NO. 3 (BATTERY TIMER AND FIRING PIN)
- GRASP ANTENNA AND LOWER EXPLOSIVE PACKAGE TO SURFACE IN STABLE POSITION
- AVOID LARGE ROCKS OR SLOPES THAT WOULD SHADOW PACKAGE
- REPEAT FOR OTHER THREE PACKAGES ON THIS TRANSPORT FRAME AND FOR THE OTHER TRANSPORT FRAME DURING EVA 1, 2, AND 3

JULY 72 3270.5.35
LSP COMMANDS

OCTAL CMD NUMBER

156 LSP PULSES ON

This cmd is required to activate the pulse function of the 41.2-MHz LSP XMT which transmits time-coded fire pulse sets (3 per set) at 29.55-sec intervals and AGC pulses once per LSP subframe (169.8 millisecond). One fire pulse set will trigger detonation of an explosive package provided that timer-controlled functions in the explosive package are in the proper configuration to accept, arm, and execute the firing input. AGC pulses desensitize the explosive package receiver to ambient noise and EMI. CMD 156 is to be transmitted to switch the LSP XMT pulse function on from a time 90 minutes before the first normal arm time through the detonation of the last explosive package in each group of four. Presence of LSP XMT pulse function is read out in the LSP TM. Repeated application of CMD 156 has no further effect.

162 LSP PULSES OFF

This cmd deactivates the pulse function of the LSP XMT. If the function was activated by application of a CMD 156. Repeated application of CMD 162 has no further effect. When the LSP is activated by application of operational power, the LSP XMT pulse function will be in the deactivated mode.

163 LSP GAIN NORM

This cmd switches the four LSP geophone amplifier channels back to the normal, high-gain mode, if the amplifier had been switched to the low gain mode by application of a CMD 164. The ratio of normal to low gain is nominally 10 but may vary from 8 to 12.5 (20 ± 2 db). Repeated application of CMD 163 has no further effect. When the LSP is activated by application of operational power, the LSP will be in the geophone amp normal gain mode.

164 LSP GAIN LOW

This cmd is required to switch the four LSP geophone amplifier channels to the low-gain mode of operation. The ratio of normal to low gain is nominally 10 but may vary from 8 to 12.5 (20 ± 2 db). Repeated application of CMD 164 has no further effect.

170 LSP GEO CAL

This cmd causes the seismic detection system to switch to the calibration mode for approximately 1.5 sec. This produces a relative calibration of all four geophone channels for comparison to an absolute preflight calibration, to detect any changes in such parameters as geophone resonant frequency and system sensitivity. The calibration signal is fixed, showing lower response at low gain. Repeated application of CMD 170 causes repeated switchovers to the calibration mode.
### LSP Digital Data Format

#### LSP Word and LSP Bit Position

<table>
<thead>
<tr>
<th>LSP Word</th>
<th>LSP Bit Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DP-17</td>
</tr>
<tr>
<td>2</td>
<td>DP-01</td>
</tr>
<tr>
<td>3</td>
<td>DP-06</td>
</tr>
<tr>
<td>4</td>
<td>DP-11</td>
</tr>
<tr>
<td>5</td>
<td>DP-16</td>
</tr>
</tbody>
</table>

#### Subframes

**Subframe 1**

- 1: DP-17, DP-01, DP-06, DP-11, DP-16, DP-18, DP-19
- 2: DP-01, DP-06, DP-11, DP-16, DP-18, DP-19
- 3: DP-01, DP-06, DP-11, DP-16, DP-18, DP-19
- 4: DP-01, DP-06, DP-11, DP-16, DP-18, DP-19
- 5: DP-01, DP-06, DP-11, DP-16, DP-18, DP-19

**Subframe 2**

- 1: DP-17, DP-01, DP-06, DP-11, DP-16, DP-18, DP-19
- 2: DP-01, DP-06, DP-11, DP-16, DP-18, DP-19
- 3: DP-01, DP-06, DP-11, DP-16, DP-18, DP-19
- 4: DP-01, DP-06, DP-11, DP-16, DP-18, DP-19
- 5: DP-01, DP-06, DP-11, DP-16, DP-18, DP-19

**Subframe 3**

- 1: DP-17, DP-01, DP-06, DP-11, DP-16, DP-18, DP-19
- 2: DP-01, DP-06, DP-11, DP-16, DP-18, DP-19
- 3: DP-01, DP-06, DP-11, DP-16, DP-18, DP-19
- 4: DP-01, DP-06, DP-11, DP-16, DP-18, DP-19
- 5: DP-01, DP-06, DP-11, DP-16, DP-18, DP-19

#### Geophones

- **Geophone 1**
- **Geophone 2**
- **Geophone 3**
- **Geophone 4**
- **Engineering Data and Status Flags**

*JULY 72 3270.5.37*
LSP DIGITAL DATA

• IDENTICAL FORMATS (1800 BITS-PER-MAIN-FRAME) IN EITHER OF TWO DATA RATES:
  3533-3-BPS (NORMAL) OR 1060-BPS (LOW); 1060 IS NOT THROUGHPUT BY MSFN TO HOUSTON

• EACH SUBFRAME (600 BITS) CONTAINS THE FOLLOWING PARAMETERS:
  DP-17; FRAME SYNC, (000011101) MODIFIED BARKER CODE IN FIRST 10 BITS
  DP-01, DP-06, DP-11, AND DP-15; GEOPHONE DATA (TRUNCATED TO 5 MOST SIGNIFICANT
  BITS IN LSP WORD 1 OF EACH SUBFRAME AND TO 7
  MOST SIGNIFICANT BITS IN WORDS 2 THROUGH 20)
  DP-18; GEOPHONE CALIBRATION PULSE ON/OFF (IN BIT 59 OF EACH SUBFRAME)
  DP-19; GEOPHONE AMPLIFIER_GAIN NORMAL/LOW (IN BIT 60 OF EACH SUBFRAME)
  DP-20; RF FIRE PULSE STATUS (1) IN BITS 89 AND 90 OF THE FIRST SUBFRAME IF
  FIRE PULSES ARE BEING TRANSMITTED, 00 IF NOT, AND ALWAYS 00 IN SUBFRAMES 2 AND 3
  NOTE: FIRE PULSES, AND THEIR TM, OCCUR ONCE
  IN EACH 58 MAIN FRAMES (174 SUBFRAMES)
  DP-21; SUBFRAME IDENTIFICATION (B I TS 599 AND 600 OF EACH SUBFRAME; C ODED 11
  FOR SUBFRAME 1, 01 FOR SUBFRAME 2, AND 10 FOR
  SUBFRAME 3)

• EACH MAIN FRAME (1800 BITS) CONTAINS THE FOLLOWING 8-BIT ENGINEERING PARAMETERS:
  DP-02; LSP 1.25-VOLT ADC CAL
  DP-03; LSP +12-VOLT OUTPUT
  AE-24; ALSEP RESERVE CURRENT
  DP-06; LSP 3.75-VOLT ADC CAL
  AE-03; ALSEP PCU 1 INPUT VOLTS
  AT-16; ALSEP THERMAL PLATE 6
  DP-10; LSP GEO CAL VOLTS
  AE-04; ALSEP PCU INPUT AMPS
  AB-04; ALSEP EXPER 1/2 STA
  DP-14; LSP ELECT TEMP
  AB-05; ALSEP EXPER 3/4 STA

  THESE PARAMETERS, PLUS ONE SPARE CHANNEL,
  ARE ALLOCATED LOCATIONS IN THE LSP FORMAT
  IN PIECES: THAT IS, THE LAST 2 BITS OF AN LSP
  30-BIT WORD FOR 4 CONSECUTIVE WORDS (MOST
  SIGNIFICANT BITS FIRST)
THE FOLLOWING LSP ENGINEERING PARAMETER IS READ OUT VIA THE ALSEP ADP (ALSEP WORD 33, CHANNEL 25):

AP-01; LSP ELECTRONICS TEMPERATURE

THIS PARAMETER IS AVAILABLE IN THE ALSEP DATA PROCESSOR FORMAT REGARDLESS OF WHETHER THE LSP POWER IS ON OR OFF (NO STANDBY MODE)
LUNAR EJECTA AND METEORITES
(LEAM)
LEAM SCIENTIFIC SUMMARY

OBJECTIVES

• MEASURE LONG-TERM VARIATIONS IN COSMIC DUST INFLUX RATES ON THE LUNAR SURFACE
• DETERMINE THE DIRECTIONS, FLUX DENSITY, AND SPEED OF PARTICLES IN METEOR STREAMS
• DETERMINE THE EXTENT AND NATURE OF LUNAR EJECTA PRODUCED BY METEORITE IMPACTS ON THE MOON
• PERFORM A CONTROLLED EXPERIMENT ON THE RELIABILITY OF THE ACOUSTICAL SENSOR AS A COSMIC DUST SENSOR
• CORRELATE THE ABOVE MEASUREMENTS IN AN EFFORT TO ANSWER CURRENT QUESTIONS ON THE ORIGIN AND NATURE OF LUNAR SOIL

METHODS

• METEORITE AND EJECTA IMPACT ON FILM/GGRID ASSEMBLIES CAUSES IONIZED PLASMA WHICH IS SENSED IN MAGNITUDE AND LOCATION
• DETERMINE VELOCITY FROM TIMING BETWEEN FRONT AND REAR FILM/GGRID RESPONSES
• PARTICLE MOMENTUM INDICATED BY RESPONSE OF PIEZOELECTRIC ELEMENT
LEAM OPERATIONS SUMMARY

DEPLOYMENT

- Connect cable to central station (Astromate connector) and remove instrument from subpallet
- Locate 25 ft southeast of central station
- Release Leam legs and gnomon
- Place instrument on surface, level within \( \pm 5^\circ \), and align gnomon shadow within \( \pm 5^\circ \) of alignment index on sun dial

POST-DEPLOYMENT

- Turn on, by command, for initial checkout
- Remove dust cover from thermal control mirror by command after LM ascent
- Remove sensor covers by command after detonation of LSP explosive packages and at least two days of background data
- Other operational commands (including calibration) as required

JULY 72 3270.6.4
LEAM COMMUNICATIONS SUMMARY

COMMANDS

- POWER OPERATIONAL, STANDBY, AND OFF
- FOUR INDIVIDUAL COMMAND LINES FOR
  - DUST COVERS (2)
  - HEATER CONTROL
  - CALIBRATION

DATA

- TWO 10-BIT SCIENCE DATA WORDS IN EACH ALSEP DATA FRAME
  (TEN WORDS, IN FIVE FRAMES, MAKE UP ONE COMPLETE LEAM READOUT)
- THREE ANALOG LINES, PROCESSED IN THE ALSEP ADP (ALSEP WORD 33), ARE
  MULITPLEXED TO PROVIDE READOUT OF 11 LEAM ENGINEERING PARAMETERS
  - EACH LINE IS SAMPLED ONCE EVERY 90 ALSEP DATA FRAMES
  (ONCE EVERY 54 SECONDS AT NORMAL DATA RATE)
  - TWO OF THE LINES ARE MULITPLEXED FOR FIVE PARAMETERS EACH;
    HENCE, EACH PARAMETER IS SAMPLED ONCE EVERY 450 FRAMES
  - THE THIRD LINE IS LEAM TEMPERATURE, WHICH OPERATES REGARDLESS
    OF THE EXPERIMENT STATUS (ON, STANDBY, OR OFF)
LEAM PHYSICAL PARAMETERS

MIRROR DUST COVER

STRUCTURE AND THERMAL

SENSOR DUST COVERS (2)

RELEASE

COMMAND LINES (4)

+29 VDC OPER PWR
+29 VDC OPER RTN
+29 VDC STANDBY PWR
+29 VDC STANDBY RTN
+12 VDC TEMP SUPPLY
DATA DEMAND
DATA SHIFT PULSES
FRAME MARK
90-FRAME MARK
DIGITAL OUTPUT DATA
ANALOG DATA LINES (3)

LEAM ELECTRONICS

LEAM SENSORS (3)
UP (METEORITES)
EAST WEST (EJECTA)

SIZE, WEIGHT, AND POWER

STOWED
SIZE: 12.7 X 12.0 X 7.8 IN.
EARTH WEIGHT: 16.3 LB
POWER: 6.60 W

JULY 72 3270.6.6
LEAM SENSOR CHARACTERISTICS

- Dual sensors (East and Up) have two film/grid assemblies
- Single sensor (West) has one film/grid assembly
- Each film/grid assembly has collector and suppressor grids
- Each sensor has an impact plate with microphone (isolated microphone behind single West sensor to register noise effects)

MEASUREMENT PARAMETERS

- Particle velocity range: 1 to 75 km-per-second
- Particle energy range: 1 to 1000 ergs
- Particle momentum range: $2.5 \times 10^{-5}$ to $7 \times 10^{-4}$ dyne-second

FREQUENCY OF MEASUREMENT

- Primary particle: $10^{-4}$ impacts/square-meter/second
- Ejecta: $10^{-1}$ impacts/square-meter/second

Angular resolution of radiant: $\pm 26^\circ$ (function of grid/film design)

Sensor field of view: $\pm 60^\circ$

GRID/FILM MATERIALS

- Grid: Beryllium copper, 97% transparent, 0.006-inch thickness
- Film substrate: Paralene C, 2800- to 3300-angstrom units thickness
- Film deposition: Aluminum, 650- to 750-angstrom units thickness
- Film outer layer: Silicon oxide, 3000- to 3500-angstrom units thickness

JULY 72 3270.6.7
LEAM SENSOR GEOMETRY

SOUTH REFERENCE

THERMAL RADIATOR MIRROR (HORIZONTAL REFERENCE)

WEST SENSOR

4 IN. (TYPICAL)

EAST SENSOR

SHIELDS PRECLUDE HITS AND PROVIDE BACKGROUND DATA CHECK

UP SENSOR

1 2 3 4 5 6 7 8

4 IN.
LEAM ELECTRONICS FUNCTIONS

DIGITAL STATUS INPUTS
ANALOG HOUSEKEEPING INPUTS

ANALOG DATA LINES (2)
90-FRAME MARK
DATA DEMAND PULSES
DATA PULSES (CLOCK)
FRAME MARK
DIGITAL DATA OUTPUT

CENTRAL ELECTRONICS AND DIGITAL DATA CONTROL

DUAL SENSOR ELECTRONICS
DUAL SENSOR ELECTRONICS
SINGLE SENSOR ELECTRONICS

ALSEP CENTRAL STATION

LEAM CAL (INC. PERIODIC)
LEAM MIR CVR GO
LEAM SNSR CVR GO
LEAM HTR STEP

+12 VDC EXCITATION
ANALOG LINE (1)
+29 VDC STANDBY PWR
+29 VDC STANDBY RTN
+29 VDC OPER PWR
+29 VDC OPER RTN

TEMP MONITOR
HEATER CONTROL
HEATER
POWER SUPPLY

CALIBRATION EXECUTE
COMMAND BUFFERS
MIRROR COVER RELEASE
SENSOR COVERS RELEASE
HTR STEP

HEATER
SQUIBS (2)
SQUIBS (2)

NOTE:
-7 VDC AND -3.5 VDC BIAS VOLTAGES ARE DERIVED IN SENSOR ELECTRONICS FROM -7.5 VDC INPUT

+24 VDC, +12 VDC, +5 VDC, -5 VDC, -7.5 VDC (-7 AND -3.5)
+3 VAC (ZERO TO PEAK)

ENVIRONMENTAL INPUTS

UP SENSOR (DUAL)
EAST SENSOR (DUAL)
WEST SENSOR (SINGLE)

+29 VDC STANDBY PWR
+29 VDC STANDBY RTN

JULY 72 3270.6.12
LEAM POWER SUPPLY

- BIAS VOLTAGES MONITOR IS BASED ON A COMBINATION OF +24 VDC AND -7.5 VDC
- BIAS VOLTAGES MONITOR IS BASED ON A COMBINATION OF +24 VDC AND -7.5 VDC (FOR SQUIB FIRING)

NOTES:
- POWER SUPPLY MONITOR IS BASED ON A COMBINATION OF +12 VDC, +5 VDC and -5 VDC
- BIAS VOLTAGES MONITOR IS BASED ON A COMBINATION OF +24 VDC AND -7.5 VDC

+29 VDC OPER PWR

+12 VDC, +5 VDC and -5 VDC

+24 VDC BIAS

RECTIFIER AND FILTER

-7.5 VDC

FOR SQUIB FIRING

3 VAC (ZERO-TO-PeAK)

+24 VDC

+5 VDC

-5 VDC

-7.5 VDC

POWER SUPPLY MONITOR IS BASED ON A COMBINATION OF +12 VDC, +5 VDC and -5 VDC

NOTES:
- POWER SUPPLY MONITOR IS BASED ON A COMBINATION OF +24 VDC AND -7.5 VDC

- BIAS VOLTAGES MONITOR IS BASED ON A COMBINATION OF +24 VDC AND -7.5 VDC (FOR SQUIB FIRING)

NOTES:
- POWER SUPPLY MONITOR IS BASED ON A COMBINATION OF +12 VDC, +5 VDC and -5 VDC
- BIAS VOLTAGES MONITOR IS BASED ON A COMBINATION OF +24 VDC AND -7.5 VDC

NOTES:
- POWER SUPPLY MONITOR IS BASED ON A COMBINATION OF +12 VDC, +5 VDC and -5 VDC
- BIAS VOLTAGES MONITOR IS BASED ON A COMBINATION OF +24 VDC AND -7.5 VDC (FOR SQUIB FIRING)
LEAM DUAL SENSOR ELECTRONICS

- FROM DUAL SENSOR (UP OR EAST)
  - FRONT FILM SIGNALS
  - REAR FILM SIGNALS
  - MICROPHONE SIGNALS

- BUFFER AMPS
- ID AMPS
- AMPLIFIER, THRESHOLD, AND PEAK DETECTOR
- LOG A/D CONVERTER
- CENTRAL ELECTRONICS AND DIGITAL DATA CONTROL

- FRONT COLLECTOR SIGNALS
- REAR COLLECTOR SIGNALS
- CALIBRATION OUTPUT

- DIGITAL DATA CONTROL
  - CALIBRATION SIGNAL
  - CALIBRATION MODE
  - CALIBRATION DRIVER

- NOTE:
  - CALIBRATION CHARACTERISTICS ALTERNATE BETWEEN TWO TYPES (CAL 1 AND CAL 2) ON SUCCESSIVE EXECUTIONS
  - INITIAL STATUS IS UNPREDICTABLE
  - CALIBRATION MODE SELECTS PAIRS OF FILM STRIPS (1-2 AND 3-4) ON SUCCESSIVE EXECUTIONS

JULY 72 3270.6.14
LEAM SINGLE SENSOR ELECTRONICS

CODE:
UFF - UPPER FRONT FILM
URF - UPPER REAR FILM
URC - UPPER FRONT COLLECTOR
Umm - UPPR MAIN MICROPHONE
URC - UPPER REAR COLLECTOR
U - UPPER SENSOR
EFF - EAST FRONT FILM
ERF - EAST REAR FILM
EFC - EAST FRONT COLLECTOR
EMM - EAST MAIN MICROPHONE
ERC - EAST REAR COLLECTOR
E - EAST SENSOR
WF - WEST FILM
WC - WEST COLLECTOR
WSM - WEST SECONDARY MICROPHONE
WMM - WEST MAIN MICROPHONE
ID - IDENTIFICATION
PHA - PULSE HEIGHT ANALYSIS
ACC - ACCUMULATOR
ET - ELAPSED TIME
TEMP - TEMPERATURE

JULY 72 3270.6.15
LEAM DIGITAL DATA OPERATION

Sensor electronics interface with each of the sensor elements through channels of dedicated circuitry allows any combination of events to occur without mutual interference.

Internal cross-checks ensure the validity of an event before final processing.

Data inhibiting is used to ensure that an event is processed without ensuing events altering or erasing the data.

The processing operation starts on either a film or a main microphone event (above zero threshold); thus, a collector event without a film event is not recorded.

Film events, if valid, will usually produce confirming collector events and, if large enough, rear film and collector events (for dual sensors), plus microphone events; if there is no collector event, the PI will subtract it during data analysis.

The combined film and collector ID's indicate the area of impact, while front and rear data give the angle of impact; the elapsed time is translated into particle velocity.

Film pulses resulting from a front film event are summed and the sum is peak-detected for encoding on a logarithmic scale; the same is true for rear film events.

Main microphone outputs are applied to narrow bandpass filters because the crystal microphones produce a 100-kHz sine wave in their primary mode; the outputs are inhibited after approximately 75 microseconds (for a period of 30 milliseconds) to avoid recording reflected wave motion in the quartz plate.

Film and collector ID circuits include an inhibit function to suppress cross-talk signals; this inhibit is bypassed during calibration.

The secondary (noise) microphone on the west sensor is mechanically isolated and provides a check against false events.

Data readout to the ALSEP DDP, on demand, consists of ten 10-bit words (two words per ALSEP frame) synchronized to start at an ALSEP 90-frame mark; hence, 18 complete sets of LEAM digital data in 90 ALSEP frames.

When data from one sensor are being read out (4 ALSEP words in two ALSEP frames for a dual sensor), a transfer inhibit causes data from a new event to be held in the buffer storage; it is transferred to the output register when the existing data have been read out once.

If there are no new events, successive sets of LEAM data are identical (register does not clear on readout).

Initial readings are random (meaningless) and will be repeated until there is a valid hit or a calibration.
LEAM ANALOG DATA MULTIPLEXER

**NOTES:**
- **DJ-28** indicates a logical one in the LEAM digital data during the 90 ALSEP frames when AJ-01 and AJ-06 are input to the ALSEP ADP. During the intervening 360 ALSEP frames, it indicates a logical zero (digital encoding produces the logical one 18 times in 90 successive ALSEP frames).
- **Multiplexer initializes to any one of the five steps but both 1 and 2 will be at the same step.**
- Each LEAM parameter appears in the ALSEP downlink data once every 450 ALSEP frames (every 4.5 minutes at normal data rate).

---

*Diagram showing connections and labels for multiplexer and ALSEP inputs.*
LEAM SQUIRB AND TEMPERATURE CONTROL

**NOTES:**

- **FIRST RELAY DRIVER OPERATES FOR**
  DURATION OF THE CMD (20 MILLISEC)
- **WHEN THE CMD PULSE ENDS, THE FALLING**
  EDGE TRIGGERS THE SECOND RELAY WHICH
  IS HELD ON FOR APPROXIMATELY 35 MILLISEC
  BY A CAPACITOR DISCHARGE CIRCUIT
- **FIRING OF EITHER SQUIRB RELEASES COVER**
- **TM MONITORS INTEGRITY OF EACH SQUIRB**
  PAIR BY +5 VDC VIA THE SQUIRBs
- **ONCE FIRED, TM GOES TO ZERO AND**
  RELAY POWER IS INHIBITED

**JULY 72 3270.6.19**
LEAM POWER PROFILE

NOTE:
AFTER COMPLETION OF DUST COVER RELEASE, THESE COMMANDS WILL HAVE NO FURTHER EFFECT.

TYPICAL TURN-ON TRANSIENT

TYPICAL DUST COVER RELEASES

MIRROR SENSOR

0.24 INCREASE FOR AUTOMATIC HEATER LOGIC

LUNAR DAY

LUNAR NIGHT

STANDBY

POWER, WATTS

TIME

JULY 72 3270.6.20
# LEAM EMPLACEMENT CRITERIA

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>REQUIREMENT</th>
<th>PRIORITY</th>
<th>INDICATOR</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOCATION</td>
<td>25 ± 5 FT SOUTHEAST OF CENTRAL STATION ON A MOUND (LEVEL AREA ON TOP)</td>
<td></td>
<td>PACING, CABLE LENGTH, AND VISUAL</td>
<td>30-FT CABLE; AVOID CRATERS, SLOPES, AND ROCKY SURFACES (PACK SURFACE WITH BOOT).</td>
</tr>
<tr>
<td>LEVEL, WRT INDICATOR</td>
<td>WITHIN ± 5°</td>
<td></td>
<td>BUBBLE LEVEL</td>
<td>LEGS MAY PENETRATE SURFACE TO DIFFERENT DEPTHS TO ACHIEVE LEVELING</td>
</tr>
<tr>
<td>ALIGN, WRT INDICATOR</td>
<td>WITHIN ± 5° OF PRESCRIBED SETTING</td>
<td></td>
<td>GNOMON AND SUN COMPASS GRADUATIONS</td>
<td>REPORT FINAL INDICATION AND TAKE PHOTOGRAPHS</td>
</tr>
</tbody>
</table>

**NOTE:** LEVEL IS WITHIN ± 5° WHEN BUBBLE IS FREE FROM OUTER CASE EDGE.
LEAM DEPLOYMENT OPERATIONS

SUBPACKAGE 2 IN VERTICAL POSITION
- RELEASE AND REMOVE SUBPALLET PULL PIN

SUBPACKAGE 2 IN HORIZONTAL POSITION
- RELEASE 2 BOYDBOLTS TO FREE THE LEAM SUBPALLET FROM SUBPACKAGE 2
- ENGAGE UHT IN SUBPALLET CARRY SOCKET
- REMOVE SUBPALLET FROM SUBPACKAGE, AND RELOCATE 10 FT SOUTHEAST OF CENTRAL STATION
- RELEASE ASTROMATE CONNECTOR PULL RING AND REMOVE PULL PIN TO FREE THE CONNECTOR FROM THE SUBPALLET
- WHILE SUPPORTING SUBPALLET ON UHT, REMOVE ASTROMATE CONNECTOR
- RETAIN CONNECTOR, AND MATE CONNECTOR WITH CENTRAL STATION (ENGAGE LOCK)
- RETAIN CONNECTOR, SET SUBPALLET ON SURFACE, REMOVE CONNECTOR DUST CAP (DISCARD), AND MATE CONNECTOR WITH CENTRAL STATION (ENGAGE LOCK)
- RELEASE 4 BOYDBOLTS TO FREE LEAM FROM SUBPALLET
- ENGAGE UHT IN LEAM SWIVEL SOCKET, REMOVE LEAM FROM SUBPALLET

AT FINAL LOCATION
- GRASP PULL RING ON DUST COVER BAG AND REMOVE BAG FROM LEAM
- CARRY TO FINAL LOCATION
- RELEASE SWIVEL SOCKET PULL RING, REMOVE PULL PIN, AND ROTATE LEAM UNTIL SWIVEL SOCKET LOCKS
- RELEASE LEG/GNOMON PULL RING AND PULL IN THE DIRECTION INDICATED BY STRIPE ON THE SIDE OF LEAM TO SEQUENTIALLY RELEASE LEGS AND GNOMON (DISCARD RING AND LANYARDS)
- PLACE LEAM ON SURFACE (USING UHT), LEVEL AND ALIGN, AND REMOVE UHT FROM SWIVEL SOCKET
LEAM COMMANDS

OCTAL CMD NUMBER

111  LEAM CAL

This is a two-state cmd to select alternately, upon successive transmission, the two LEAM calibration levels called mode one and mode two. Each activation of the calibration circuits produces a single input pulse to the LEAM sensor buffer amplifiers to calibrate the overall sensor electronics and data storage system. The response of LEAM to cmd 111 is delayed until previously recorded data has been transmitted to ALSEP.

Mode one provides signal pulses to each:
- Front film amplifiers 3 and 4 (4)
- Main microphone amplifiers (3)
- Secondary microphone amplifier (1)
- Rear film and all collector amplifiers (28)**

Mode two provides signal pulses to each:
- Front film amplifiers 1 and 2 (4)
- Main microphone amplifiers (3)
- All rear film amplifiers (10)**

112  LEAM MIR CVR GO

This cmd activates the circuits of a redundant firing mechanism to release the dust cover which protects the LEAM thermal control mirror. After cover release, cmd 112 has no further effect. Removal of the mirror dust cover is scheduled after LM ascent. Prior to removal, the extent of LEAM operation is constrained by thermal control limitations.

114  LEAM SEN CVR GO

This cmd activates the circuits of a redundant firing mechanism to release the dust covers which protect the LEAM sensors. After cover release, cmd 114 has no further effect. Removal of the sensor dust covers are scheduled after LM ascent and after detonation of the LSP explosive packages, and after at least two days of background data.

117  LEAM HTR STEP

This is a three-state cmd which, upon successive transmission, steps repetitively through three LEAM heater control modes: on, off, and automatic. In the automatic (normal) mode, a circuit controls the heater operation to maintain LEAM above a minimum temperature. The on and off modes bypass the automatic control circuit and cause the heater to remain on or off regardless of temperature. The heater on/off status is read out in the TM, along with temperature data. Application of operational power to the LEAM causes initialization in the automatic mode.

When standby (survival) power is applied to the LEAM:
- The automatic circuit is energized and controls operation of the 3.2-watt heater; there is an additional 1.6-watt constant standby heater
- Cmd 117 has no effect
- Temperature is read out in the ALSEP central station TM.

NOTES:
* The calibration level of mode two is higher than mode one
** Rear film signals are delayed to verify elapsed-time circuitry; delay is longer in mode two.

JULY 72 3270.6.24
LEAM DIGITAL DATA FORMAT

ALSEP WORD 31

2^9 2^8 2^7 2^6 2^5 2^4 2^3 2^2 2^1 2^0

- DJ-03, UFF ACC
- DJ-02, UFF PHA
- DJ-01, UFF ID

ALSEP FRAME NUMBER

1, 6, 11 ETC.

ALSEP WORD 39

2^9 2^8 2^7 2^6 2^5 2^4 2^3 2^2 2^1 2^0

- DJ-06, URF ACC
- DJ-05, URF PHA
- DJ-04, URF ID
- DJ-09, UMM ACC
- DJ-08, UMM PHA
- DJ-07, UFC ID

BIT POSITION

2, 7, 12, ETC.

ALSEP WORD 31

2^9 2^8 2^7 2^6 2^5 2^4 2^3 2^2 2^1 2^0

- DJ-14, EFF ACC
- DJ-13, EFF PHA
- DJ-12, EFF ID

ALSEP FRAME NUMBER

3, 8, 13, ETC.

ALSEP WORD 31

2^9 2^8 2^7 2^6 2^5 2^4 2^3 2^2 2^1 2^0

- DJ-20, EMM ACC
- DJ-19, EMM PHA
- DJ-18, EFC ID

ALSEP FRAME NUMBER

4, 9, 14, ETC.

ALSEP WORD 31

2^9 2^8 2^7 2^6 2^5 2^4 2^3 2^2 2^1 2^0

- DJ-25, WF ACC
- DJ-24, WF PHA
- DJ-23, WF ID

ALSEP FRAME NUMBER

5, 10, 15, ETC.

ALSEP FRAME NUMBER

1, 6, 11 ETC.

ALSEP FRAME NUMBER

2, 7, 12, ETC.

ALSEP FRAME NUMBER

3, 8, 13, ETC.

ALSEP FRAME NUMBER

4, 9, 14, ETC.

ALSEP FRAME NUMBER

5, 10, 15, ETC.

JULY 72 3270.6.25
LEAM ANALOG DATA

ALSEP WORD 33, CHANNEL 83, MULTIPLEXED 5 TIMES IN THE FOLLOWING SEQUENCE:
AJ-01, LEAM +5 VOLTS (MEASURED AT OUTPUT OF LEAM POWER SUPPLY)
AJ-02, SNSR CVR STATUS (INDICATES THAT SQUIBS HAVE OR HAVE NOT FIRED)
AJ-03, MIR CVR STATUS (INDICATES THAT SQUIBS HAVE OR HAVE NOT FIRED)
AJ-04, POWER SUPPLY MON (BASED ON COMBINED +12 VDC +5 VDC AND -5 VDC OUTPUT)
AJ-05, BIAS VOLTAGES MON (BASED ON COMBINED +24 VDC AND -7.5 VDC OUTPUT)

ALSEP WORD 33, CHANNEL 84, MULTIPLEXED 5 TIMES IN THE FOLLOWING SEQUENCE:
AJ-06, UP MAIN MIC TEMP (MEASURES UP SENSOR TEMP NEAR MICROPHONE)
AJ-07, EAST MAIN MIC TEMP (MEASURES EAST SENSOR TEMP NEAR MICROPHONE)
AJ-08, WEST MAIN MIC TEMP (MEASURES WEST SENSOR TEMP NEAR MAIN MICROPHONE)
AJ-09, CENT ELECT TEMP (MEASURES TEMP IN SENSOR CENTRAL ELECTRONICS)
AJ-10, LEAM -5 VOLTS (MEASURED AT OUTPUT OF LEAM POWER SUPPLY)

ALSEP WORD 33, CHANNEL 85:
AJ-11, LEAM ELECT TEMP (MEASURES INTERNAL STRUCTURE TEMP NEAR THERMAL PLATE; POWERED FROM ALSEP CENTRAL STATION TO READ INDEPENDENT OF LEAM ON/STANDBY/OFF STATUS)
HEAT FLOW EXPERIMENT (HFE)
HEAT FLOW EXPERIMENT

ELECTRONICS PACKAGE

PROBE CARRYING PACKAGE (CONTAINS 2 PROBES & EMPLACEMENT TOOL)

CABLE REEL

CABLE CONNECTOR

SUNSHIELD

REFLECTOR

LENGTH WIDTH HEIGHT

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ELECTRONICS PACKAGE</td>
<td>PROBE PACKAGE</td>
<td>TOTAL</td>
</tr>
<tr>
<td>10</td>
<td>9.55</td>
<td>25.5</td>
</tr>
<tr>
<td>11</td>
<td>4.5</td>
<td>11.8</td>
</tr>
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</table>

*EXCEPT HANDLES (8.5)
HEAT FLOW
NASA No. SO37

OBJECTIVE: INTERNAL TEMPERATURE & COMPOSITION OF THE MOON. FROM THIS, INFERENCES CAN BE MADE ON LUNAR EVOLUTION, BULK COMPOSITION, CHEMICAL SORTING, INTERNAL ENERGY (INCLUDING RADIOACTIVITY), & NEAR-SURFACE MATERIAL PROPERTIES

MEASUREMENT: TEMPERATURE GRADIENT & THERMAL CONDUCTIVITY TO DETERMINE AVERAGE OUTWARD HEAT FLUX AT THE SURFACE

EQUIPMENT: APOLLO LUNAR SURFACE DRILL; TWO PROBES, 1-IN. DIAM X 43 IN. LONG, WITH HEATING ELEMENTS & TEMPERATURE SENSORS; PROBES PLACED AT BOTTOM OF 8 - FT HOLES
HEAT FLOW CHARACTERISTICS

KEY FEATURES
SENSOR CALIBRATION ON EARTH REQUIRES SPECIAL FACILITY
AVOID DISTURBING LUNAR SURFACE REFLECTIVE PROPERTIES AROUND PROBES
REQUIRES RADIATIVE THERMAL COUPLING BETWEEN PROBE & HOLE PLUS
NO THERMAL SHORT-CIRCUIT TO SURFACE
"THERMOSTATICALLY"CONTROLLED HEATER IN ELECTRONICS PACKAGE

PHYSICAL PARAMETERS
(NOT INC DRILL)
\[ \text{ELECTRONICS } 11 \times 9.5 \times 10 \]
\[ \text{PROBES } 25.5 \times 3.8 \times 8.5 \] (IN PACKAGE)
EARTH WT, LB: 12.2 LB (TOTAL)
POWER, W: 3.9 TO 10.7

OPERATIONS

POST DEPLOYMENT
• TURN ON (OPER) PRE-ASCENT
• READ GRADIENT DATA CONTINUOUSLY EXCEPT DURING CONDUCTIVITY TESTS
• MAKE CONDUCTIVITY TESTS - TIMES FOR UP TO 48 HRS EACH TIME

COMMUNICATIONS

COMMANDS:
• POWER OPER/STBY/OFF
• 10 SPECIAL CNDS FOR:
  • SELECT GRADIENT, HI CONDUCTIVITY, OR LO CONDUCTIVITY MODES (3)
  • SELECT MEASUREMENT SEQUENCE (6)
  • SELECT & ACTIVATE CONDUCTIVITY HTRS (1)

DATA:
• 1 DIGITAL WORD PER ALSEP FRAME (FOR 16 OUT OF EVERY 90 FRAMES)
  • 3.0 BPS (APPROX)
• 65% SCIENCE, 35% HK
• 435 SEC REP RATE (FULL SEQUENCE)
• 6 ANALOG ENG PARAMETERS SAMPLED ONCE PER 54 SEC ALSEP SEQUENCE

DISPLAY: PRINT (REQUIRES DATA ANALYSIS)

DEPLOYMENT
• LOCATE ELECTRONICS 25-30 FT FROM CENTRAL STATION
• LEVEL ± 5°
• ALIGN ±5° WRT SHADOW (THERMAL)
• DRILL HOLES (2) 2.5 METERS DEEP & PLACE PROBES IN BOTTOM OF HOLES USING TOOL
• HOLES 30 FT APART & 18 FT FROM ELECTRONICS
APPROX TIME, 9 MIN, PLUS 30 MIN FOR DRILLING

OPERATIONS

POST DEPLOYMENT
• TURN ON (OPER) PRE-ASCENT
• READ GRADIENT DATA CONTINUOUSLY EXCEPT DURING CONDUCTIVITY TESTS
• MAKE CONDUCTIVITY TESTS - TIMES FOR UP TO 48 HRS EACH TIME

COMMUNICATIONS

COMMANDS:
• POWER OPER/STBY/OFF
• 10 SPECIAL CNDS FOR:
  • SELECT GRADIENT, HI CONDUCTIVITY, OR LO CONDUCTIVITY MODES (3)
  • SELECT MEASUREMENT SEQUENCE (6)
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  • 3.0 BPS (APPROX)
• 65% SCIENCE, 35% HK
• 435 SEC REP RATE (FULL SEQUENCE)
• 6 ANALOG ENG PARAMETERS SAMPLED ONCE PER 54 SEC ALSEP SEQUENCE

DISPLAY: PRINT (REQUIRES DATA ANALYSIS)

FEB 72 3270.7.4
HEAT FLOW SENSORS

NOTE: FOR ILLUSTRATION, NOT ACTUAL DATA

TEMP

DIURNAL VARIATION
WITH SUPERIMPOSED
HI-ORDER EFFECTS

ANNUAL VARIATION
(DUE TO MOON’S ORBIT AROUND THE SUN)

• PROBLEM: TO FIND THE SMALL DC COMPONENT IN A POSSIBLY LARGE AC WAVE

MODES OF OPERATION: MODE/G, MODE/LK, & MODE/HK PLUS MANY MEASUREMENT SEQUENCES

BASIC DATA WORD: 13-BIT OUTPUT OF ADC IN 2 ALSEP WORDS (PLUS 1D)

TYPICAL BRIDGE READING
(8 ALSEP WORDS)

1. + EXCITATION
2. + OUTPUT
3. - EXCITATION
4. - OUTPUT

SENSOR TYPE: PLATINUM RESISTOR
SENSOR CIRCUITS:
• SETS OF FOUR SENSORS
• TWO COMBINATIONS (DIFFERENCE & AMBIENT)
• SELECTED BY INTERNAL LOGIC

DYNAMIC RANGE:
• TEMP DIFFERENCE (BRIDGE)
  HI SENSITIVITY ± 2° K (200° K TO 250° K)
  LO SENSITIVITY ± 20° K (200° K TO 250° K)
• AMBIENT TEMP (RESISTANCE)
  200°K TO 250°K
• CABLE THERMOCOUPLES (ALONG PROBE CABLES)
  90°K TO 350°K (ACCURACY 0.3°C)
• THERMOCOUPLE REF JUNCTION (IN ELECTRONICS)
  -20° C TO +60° C (ACCURACY 0.1°C)
• CONDUCTIVITY RANGE: 5 x 10⁻⁶ TO 1 x 10⁻³ CAL/CM-SEC-°C

FEB 72 3270.7.6
HFE PROBE DETAILS

- Radial Shield
- Lunar Surface
- Borestem
- Top of Probe
- Probe Stop
- Upper Section
- Lower Section
- Flexible Spring
- Cable to Electronics
- Thermocouple (TC 1)
- Thermocouple (TC 4)
- Thermocouple (TC 3)
- Thermocouple (TC 2)
- Gradient Sensor (Inside)
- Ring Sensor (4/Probe)
- Heater Coils (Outside)
## HFE Modes of Operation

<table>
<thead>
<tr>
<th>Measurement Sequences</th>
<th>Mode</th>
<th>Mode</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. FULL (ALL MEAS)</td>
<td></td>
<td>SAME AS GRADIENT</td>
<td>DIFFERENTIAL &amp; AMBIENT TEMP FOR ONE BRIDGE (DEPENDING ON SELECTED HEATER)</td>
</tr>
<tr>
<td>B. PROBE 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROBE 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. DIFFERENTIAL TEMP (HI EXCITATION)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIFFERENTIAL TEMP (LO EXCITATION)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AMBIENT TEMP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REF JUNCTION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEMP &amp; CABLE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>THERMOCOUPLES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. COMBINATIONS OF B &amp; C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BRIDGE SENSORS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRADIENT</td>
<td>GRADIENT</td>
<td>RING (OR &quot;REMOTE&quot;)</td>
<td></td>
</tr>
<tr>
<td>HEATERS</td>
<td>NONE</td>
<td>0.002W</td>
<td>0.5W</td>
</tr>
</tbody>
</table>

*These modes used primarily for tests*

FEB 72 3270.7.9
## HFE Command Summary

<table>
<thead>
<tr>
<th>CMD NUMBERS</th>
<th>OCTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFE</td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>135</td>
</tr>
<tr>
<td>C2</td>
<td>136</td>
</tr>
<tr>
<td>C3</td>
<td>140</td>
</tr>
<tr>
<td>C4</td>
<td>141</td>
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<tr>
<td>C5</td>
<td>142</td>
</tr>
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<td>C6</td>
<td>143</td>
</tr>
<tr>
<td>C7</td>
<td>144</td>
</tr>
<tr>
<td>C8</td>
<td>145</td>
</tr>
<tr>
<td>C9</td>
<td>146</td>
</tr>
<tr>
<td>C10</td>
<td>152</td>
</tr>
</tbody>
</table>

Input buffer holds commands for execution at 90-frame mark.

*Initialized to these conditions at power turn-on*
HFE DIGITAL DATA FORMAT

ALSEP FRAME 90,8

MEASUREMENT (SEQUENCE) REGISTER

HFE SCIENCE DATA (TYPICAL)

MODE REGISTER

HEATER REGISTER

CONDUCTIVITY HEATER REGISTER

SUBSEQUENCE REGISTER (WORD 10)

FEB 72 3270.7.11
HFE MODE REGISTER

THE MODE REGISTER IS PART OF THE HFE CMD DECODER AND RESPONDS TO CMDs 135, 136 AND 140. THE STATE OF THIS REGISTER IS READ OUT VIA TM

<table>
<thead>
<tr>
<th>OCTAL</th>
<th>ABBR</th>
<th>HFE</th>
<th>MODE</th>
<th>TM (M₁M₂M₃)</th>
</tr>
</thead>
<tbody>
<tr>
<td>135</td>
<td>MODE/G</td>
<td>MODE1</td>
<td>NORMAL GRADIENT</td>
<td>100</td>
</tr>
<tr>
<td>136</td>
<td>MODE/LK</td>
<td>MODE2</td>
<td>LOW CONDUCTIVITY</td>
<td>010</td>
</tr>
<tr>
<td>140</td>
<td>MODE/HK</td>
<td>MODE3</td>
<td>HIGH CONDUCTIVITY</td>
<td>001</td>
</tr>
</tbody>
</table>

THE MODE SELECTED BY CMD AFFECTS THE DATA AS FOLLOWS:

MODE/G AND MODE/LK HAVE IDENTICAL TM (FORMATTED BY THE MEASUREMENT SEQUENCE PROGRAMMER AND SUBSEQUENCE PROGRAMMER) BUT IN MODE/LK THE PROBE HEATER CURRENT SUPPLY IS TURNED ON AND HEATERS RESPOND TO CMD 152.

MODE/HK BYPASSES THE MEASUREMENT SEQUENCE PROGRAMMER AND PRODUCES A SPECIAL TM OUTPUT FORMATTED BY THE SUBSEQUENCE PROGRAMMER AND HEATER SEQUENCE PROGRAMMER.
HFE MEASUREMENT SEQUENCE PROGRAMMER

THE MEASUREMENT SEQUENCE PROGRAMMER (MSP) IS A 16-STATE BINARY COUNTER USING 4 FLIP-FLOPS. ITS OPERATION CAN BE MODIFIED BY CMD TO PERFORM 8-STATE, 4-STATE, AND 2-STATE PROGRAMS. THE FLIP-FLOPS HAVE DUAL FUNCTIONS:

- FORMAT HFE DATA BY CONTROLLING GATES TO THE OUTPUT REGISTER
- SUPPLY MSP STATUS DATA FOR TM (P-BITS)

NOTE THAT EXECUTION OF A MEASUREMENT CMD (141 THROUGH 146) DOES NOT RESET MSP. OPERATION CONTINUES FROM PREVIOUS STATE.

IN DIAGRAM, THE SET (S) AND CLEAR (C) POSITIONS OF THE FLIP-FLOPS CORRESPOND TO ONE AND ZERO IN THE TM.
HFE MSP DIAGRAM

0 = UPPER SECTION
1 = LOWER SECTION

0 = PROBE 1
1 = PROBE 2

NOTE
SET, S = 1
CLEAR, C = 0

00 DTH
01 DTL
10 T
11 TC

01 ADV
10 ADV
00 ADV

01 BYPASS Pp
10 BYPASS Pp
00 BYPASS Pp

(C5) (C6) (C4) (C7) (C8) (C9)
HFE SUBSEQUENCE PROGRAMMER

THE SUBSEQUENCE PROGRAMMER IS A 4-STATE COUNTER HAVING DUAL FUNCTIONS:

- CONTROLS GATING OF DATA, WITHIN A SUBSET, TO THE OUTPUT REGISTER (WHERE THE TYPE OF SUBSET IS CONTROLLED BY THE MSP)
- SUPPLIES SUBSEQUENCE REGISTER STATUS DATA FOR TM (R-BITS)

THE STATE OF R₂R₁ CHANGES EVERY OTHER ALSEP FRAME (ONE 10-BIT WORD OF HFE DATA IN EACH ALSEP FRAME)
STARTING WITH A RESET AT THE 90-FRAME MARK

THE TRANSITION FROM 11 TO 00 BETWEEN 7 AND 8 MARKS THE 90 + 8 FRAME. THIS ADVANCES P₁ FROM ZERO TO ONE

FROM ALSEP FRAME 16 TO 89 THERE IS NO HFE DATA AND REGISTER CHANGES ARE INHIBITED

<table>
<thead>
<tr>
<th>R₂ R₁</th>
<th>ALSEP</th>
<th>FRAME NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>90, 1</td>
<td>8, 9</td>
</tr>
<tr>
<td>01</td>
<td>2, 3</td>
<td>10, 11</td>
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<td>10</td>
<td>4, 5</td>
<td>12, 13</td>
</tr>
<tr>
<td>11</td>
<td>6, 7</td>
<td>14, 15</td>
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</table>

R₂R₁ READ OUT AS FIRST TWO BITS IN EVEN NUMBERED ALSEP FRAME

FEB 72 3270.7.16
# HFE Gradient Measurement Index

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>ABBR</th>
<th>P-BITS</th>
<th>DATA SOURCE</th>
<th>PROBE/BRIDGE</th>
<th>EXCITATION (SENSITIVITY)</th>
<th>((R_2R_1)) SUBSET DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>DH-01</td>
<td>GDT 11H</td>
<td>0000</td>
<td>1/UPPER</td>
<td>HIGH VOLTAGE</td>
<td>((00) + BRIDGE EXCITATION)</td>
<td></td>
</tr>
<tr>
<td>DH-02</td>
<td>GDT 12H</td>
<td>0001</td>
<td>1/UPPER</td>
<td>HIGH VOLTAGE</td>
<td>((01) + BRIDGE EXCITATION)</td>
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</tr>
<tr>
<td>DH-03</td>
<td>GDT 21H</td>
<td>0010</td>
<td>1/LOWER</td>
<td>HIGH VOLTAGE</td>
<td>((10) - BRIDGE EXCITATION)</td>
<td></td>
</tr>
<tr>
<td>DH-04</td>
<td>GDT 22H</td>
<td>0011</td>
<td>2/UPPER</td>
<td>HIGH VOLTAGE</td>
<td>((11) - BRIDGE OUTPUT)</td>
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<tr>
<td>DH-05</td>
<td>GDT 11L</td>
<td>0100</td>
<td>1/UPPER</td>
<td>LOW VOLTAGE</td>
<td>((00) + BRIDGE CURRENT)</td>
<td></td>
</tr>
<tr>
<td>DH-06</td>
<td>GDT 12L</td>
<td>0101</td>
<td>1/UPPER</td>
<td>LOW VOLTAGE</td>
<td>((01) + BRIDGE CURRENT)</td>
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<tr>
<td>DH-07</td>
<td>GDT 21L</td>
<td>0110</td>
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<td>LOW VOLTAGE</td>
<td>((10) - BRIDGE CURRENT)</td>
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<tr>
<td>DH-08</td>
<td>GDT 22L</td>
<td>0111</td>
<td>2/LOWER</td>
<td>LOW VOLTAGE</td>
<td>((11) - BRIDGE OUTPUT)</td>
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<tr>
<td>DH-09</td>
<td>GT 11</td>
<td>1000</td>
<td>1/UPPER</td>
<td>HIGH VOLTAGE</td>
<td>((00) + BRIDGE EXCITATION)</td>
<td></td>
</tr>
<tr>
<td>DH-10</td>
<td>GT 12</td>
<td>1001</td>
<td>1/UPPER</td>
<td>HIGH VOLTAGE</td>
<td>((01) + BRIDGE EXCITATION)</td>
<td></td>
</tr>
<tr>
<td>DH-11</td>
<td>GT 21</td>
<td>1010</td>
<td>1/LOWER</td>
<td>HIGH VOLTAGE</td>
<td>((10) - BRIDGE EXCITATION)</td>
<td></td>
</tr>
<tr>
<td>DH-12</td>
<td>GT 22</td>
<td>1011</td>
<td>2/LOWER</td>
<td>HIGH VOLTAGE</td>
<td>((11) - BRIDGE CURRENT)</td>
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<tr>
<td>DH-13</td>
<td>REF T1</td>
<td>1100</td>
<td>REF JUNCTION BR</td>
<td>HV</td>
<td>SAME AS DH-01 TO DH-04</td>
<td></td>
</tr>
<tr>
<td>DH-14</td>
<td>TC1 GROUP</td>
<td>1101</td>
<td>THERMOCOUPLES IN CABLE OF PROBE 1 WRT REF T1</td>
<td></td>
<td>((00) REF T1-TC1 (1))</td>
<td></td>
</tr>
<tr>
<td>DH-15</td>
<td>REF T2</td>
<td>1110</td>
<td>SAME AS DH-13</td>
<td>HV</td>
<td>SAME AS DH-01 TO DH-04</td>
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<td>DH-16</td>
<td>TC2 GROUP</td>
<td>1111</td>
<td>THERMOCOUPLES IN CABLE OF PROBE 2 WRT REF T2</td>
<td></td>
<td>((00) REF T2-TC2 (1))</td>
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</table>

FEB 72 3270.7.18
HFE HEATER SEQUENCE PROGRAMMER

- 16-STATE BINARY COUNTER USING 4 FLIP-FLOPS
- STATUS TRANSMITTED IN TM AS H-BITS (ALL 3 MODES)
- EFFECT ON OPERATION AND DATA:
  - MODE/G – NO EFFECT (CAN BE ADVANCED VIA CMD 152 BUT PROBE HEATER CURRENT SUPPLY IS OFF)
  - MODE/LK – CONTROLS ON/OFF STATUS OF 8 HEATERS (4/PROBE) IN LOW MODE OF PROBE HEATER CURRENT SUPPLY
  - MODE/HK – CONTROLS DATA OUTPUT AND ON/OFF STATUS OF 8 HEATERS IN HIGH MODE OF PROBE HEATER CURRENT SUPPLY
- PROBE HEATER ON/OFF STATUS IN ANALOG TM (ALSEP WORD 33)
**HFE HEATER SELECT CODE**

- **H4**: 0 = PROBE 1, 1 = PROBE 2
- **H3**: 0 = LOWER HEATER, 1 = UPPER HEATER (IN PROBE SECTION)
- **H2**: 0 = UPPER SECTION, 1 = LOWER SECTION (IN PROBE)
- **H1**: 0 = HEATER OFF, 1 = HEATER ON

### Example

When H-BITS = 1011, HEATER H24 is on (where H24 indicates fourth heater in probe 2).

### Table

<table>
<thead>
<tr>
<th>H3 H2</th>
<th>HTR NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>2</td>
</tr>
<tr>
<td>01</td>
<td>4 (BOTTOM)</td>
</tr>
<tr>
<td>10</td>
<td>1 (TOP)</td>
</tr>
<tr>
<td>11</td>
<td>3</td>
</tr>
</tbody>
</table>

**Note:** This code applies to heater control in both MODE/LK and MODE/HK.

_FEB 72 3270.7.20_
### HFE Measurements in Mode/HK

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Abbr</th>
<th>Probe</th>
<th>Bridge</th>
<th>H₂H₃H₄</th>
<th>Symbol</th>
<th>Abbr</th>
<th>Probe</th>
<th>Bridge</th>
<th>H₂H₃H₄</th>
</tr>
</thead>
<tbody>
<tr>
<td>DH-50</td>
<td>RDT 11</td>
<td>1</td>
<td>1</td>
<td>0000</td>
<td>DH-70</td>
<td>RDT 21</td>
<td>2</td>
<td>1</td>
<td>1000</td>
</tr>
<tr>
<td>DH-51</td>
<td>RT 11</td>
<td>1</td>
<td>1</td>
<td>0000</td>
<td>DH-71</td>
<td>RT 21</td>
<td>2</td>
<td>1</td>
<td>1000</td>
</tr>
<tr>
<td>DH-52</td>
<td>RDT 11</td>
<td>1</td>
<td>1</td>
<td>0001</td>
<td>DH-72</td>
<td>RDT 21</td>
<td>2</td>
<td>1</td>
<td>1001</td>
</tr>
<tr>
<td>DH-53</td>
<td>RT 11</td>
<td>1</td>
<td>1</td>
<td>0001</td>
<td>DH-73</td>
<td>RT 21</td>
<td>2</td>
<td>1</td>
<td>1001</td>
</tr>
<tr>
<td>DH-60</td>
<td>RDT 12</td>
<td>1</td>
<td>2</td>
<td>0010</td>
<td>DH-80</td>
<td>RDT 22</td>
<td>2</td>
<td>2</td>
<td>1010</td>
</tr>
<tr>
<td>DH-61</td>
<td>RT 12</td>
<td>1</td>
<td>2</td>
<td>0010</td>
<td>DH-81</td>
<td>RT 22</td>
<td>2</td>
<td>2</td>
<td>1010</td>
</tr>
<tr>
<td>DH-62</td>
<td>RDT 12</td>
<td>1</td>
<td>2</td>
<td>0011</td>
<td>DH-82</td>
<td>RDT 22</td>
<td>2</td>
<td>2</td>
<td>1011</td>
</tr>
<tr>
<td>DH-63</td>
<td>RT 12</td>
<td>1</td>
<td>2</td>
<td>0011</td>
<td>DH-83</td>
<td>RT 22</td>
<td>2</td>
<td>2</td>
<td>1011</td>
</tr>
<tr>
<td>DH-54</td>
<td>RDT 11</td>
<td>1</td>
<td>1</td>
<td>0100</td>
<td>DH-74</td>
<td>RDT 21</td>
<td>2</td>
<td>1</td>
<td>1100</td>
</tr>
<tr>
<td>DH-55</td>
<td>RT 11</td>
<td>1</td>
<td>1</td>
<td>0100</td>
<td>DH-75</td>
<td>RT 21</td>
<td>2</td>
<td>1</td>
<td>1100</td>
</tr>
<tr>
<td>DH-56</td>
<td>RDT 11</td>
<td>1</td>
<td>1</td>
<td>0101</td>
<td>DH-76</td>
<td>RDT 21</td>
<td>2</td>
<td>1</td>
<td>1101</td>
</tr>
<tr>
<td>DH-57</td>
<td>RT 11</td>
<td>1</td>
<td>1</td>
<td>0101</td>
<td>DH-77</td>
<td>RT 21</td>
<td>2</td>
<td>1</td>
<td>1101</td>
</tr>
<tr>
<td>DH-58</td>
<td>RDT 11</td>
<td>1</td>
<td>1</td>
<td>0101</td>
<td>DH-78</td>
<td>RDT 21</td>
<td>2</td>
<td>1</td>
<td>1101</td>
</tr>
<tr>
<td>DH-59</td>
<td>RT 11</td>
<td>1</td>
<td>1</td>
<td>0101</td>
<td>DH-79</td>
<td>RT 21</td>
<td>2</td>
<td>1</td>
<td>1101</td>
</tr>
<tr>
<td>DH-66</td>
<td>RDT 12</td>
<td>1</td>
<td>2</td>
<td>0110</td>
<td>DH-86</td>
<td>RDT 22</td>
<td>2</td>
<td>2</td>
<td>1110</td>
</tr>
<tr>
<td>DH-67</td>
<td>RT 12</td>
<td>1</td>
<td>2</td>
<td>0110</td>
<td>DH-87</td>
<td>RT 22</td>
<td>2</td>
<td>2</td>
<td>1110</td>
</tr>
<tr>
<td>DH-68</td>
<td>RDT 12</td>
<td>1</td>
<td>2</td>
<td>0111</td>
<td>DH-88</td>
<td>RDT 22</td>
<td>2</td>
<td>2</td>
<td>1111</td>
</tr>
<tr>
<td>DH-69</td>
<td>RT 12</td>
<td>1</td>
<td>2</td>
<td>0111</td>
<td>DH-89</td>
<td>RT 22</td>
<td>2</td>
<td>2</td>
<td>1111</td>
</tr>
</tbody>
</table>

- Data alternates between difference (bridge) and ambient (resistance) measurements for the set of ring sensors nearest the selected heater.

<table>
<thead>
<tr>
<th>Alsep Frames</th>
<th>P₁ (a)</th>
<th>Meas Type (b)</th>
<th>Abbr (c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 to 7</td>
<td>0</td>
<td>Difference</td>
<td>RDTN</td>
</tr>
<tr>
<td>8 to 15</td>
<td>1</td>
<td>Ambient</td>
<td>RTN</td>
</tr>
</tbody>
</table>

- Notes:
  (a) P1-bits, other than P₁, are meaningless in Mode/HK.
  (b) Measurement content:

<table>
<thead>
<tr>
<th>R₂ R₁</th>
<th>Difference</th>
<th>Ambient</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>+ Bridge excitation volts</td>
<td></td>
</tr>
<tr>
<td>01</td>
<td>+ Bridge output</td>
<td>+ Bridge current</td>
</tr>
<tr>
<td>10</td>
<td>- Bridge excitation volts</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>- Bridge output</td>
<td>- Bridge current</td>
</tr>
</tbody>
</table>

- NN identifies sensor (bridge) location.

FEB 72 3270.7.21
### HFE Command Details

#### OCTAL CMD NUMBER

<table>
<thead>
<tr>
<th>OCTAL CMD NUMBER</th>
<th>HEX</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>135</td>
<td>HFE</td>
<td>MODE/G SEL</td>
</tr>
<tr>
<td>140</td>
<td>HFE</td>
<td>MODE/LK SEL</td>
</tr>
<tr>
<td>141</td>
<td>HFE</td>
<td>SEQUENTIAL SEL</td>
</tr>
<tr>
<td>142</td>
<td>HFE</td>
<td>S/C SEL</td>
</tr>
<tr>
<td>143</td>
<td>HFE</td>
<td>SEQ/P2 SEL</td>
</tr>
<tr>
<td>144</td>
<td>HFE</td>
<td>LOAD 1</td>
</tr>
<tr>
<td>145</td>
<td>HFE</td>
<td>LOAD 2</td>
</tr>
<tr>
<td>146</td>
<td>HFE</td>
<td>LOAD 3</td>
</tr>
</tbody>
</table>

**MODE/G SEL**: This command (135) is a 1-state command. If the HFE is in the gradient, or normal, mode of operation in which measurements are obtained from the gradient sensors and cable thermocouples under the control of the MSP, CMD 135 also turns off the probe heater current supply. Different measurement sequences in MODE/G may be selected by transmitting subsequent CMDs. At power-on, the HFE initializes in MODE/G. If the HFE is in MODE/G, transmission of CMD 135 has no effect. Note that the HFE input buffer holds CMDs for execution at the 10-frame mark; thus, sequential CMDs must be transmitted at least 54 sec apart.

**MODE/LK SEL**: This CMD (140) is a 1-state CMD. It places the HFE in the low conductivity or ring source mode of operation in which measurements and sequences are identical to MODE/G. It also turns on the probe heater current supply in the low-ring source mode allowing heaters to be activated by CMD 152. If the HFE is in MODE/LK, transmission of CMD 136 has no effect.

**SEQUENTIAL SEL**: This CMD (141) is a 1-state CMD. It places the HFE in the high conductivity or heat pulse mode of operation in which measurements are obtained from the ring or remote sensors under the control of the heater sequence programmer. Note that CMD 141 (1C7) must also be transmitted before valid data will be obtained in MODE/LK. Either CMD may be transmitted first. CMD 140 also turns on the probe heater current supply in the high or heat pulse mode allowing heaters to be activated by CMD 152. If the HFE is in MODE/LK, transmission of CMD 140 has no effect.

**S/C SEL**: This CMD (142) is a 1-state CMD. It cancels the effect of CMD 142 through 146 causing the MSP to perform its full 16-state cycle of operation in MODE/G or MODE/LK. If transmitted during MODE/G operation, this CMD will cause invalid operation until CMD 144 is executed. At power-on, the HFE initializes in S/C FULL. If the HFE is in MODE/G or MODE/LK and in S/C FULL, transmission of CMD 144 has no effect.

**LOAD 1**: This CMD (143) is a 1-state CMD and alternates with CMD 144 to select only one probe for measurement. It has the same characteristics as CMD 144 except that flip-flop P2 is located in the SET state.

**LOAD 2**: This CMD (145) is a 1-state CMD and is used alone or in combination with CMD 146 to position and lock two flip-flops (Q1, P1) of the MSP. CMD 146 places P2, P3 in the CLEAR position 1001 and bypasses those steps. The MSP then acts as a 4-state counter if CMD 144 was previously executed and as a 2-state counter if CMD 142 or 143 was previously executed. This applies to MODE/G and MODE/LK in MODEM. CMD 146 must be executed to obtain valid data. CMDs 143 or 146 may be used in MODE/G or MODE/LK. Following CMD 144, to lock P2, P3 in the 10 or 01 state respectively, the effect of CMD 144 is cleared by subsequent execution of CMD 146.

**LOAD 3**: This CMD (146) is a 1-state CMD and is used in combination with either CMD 144 (preceding 146) or CMD 146 (following 146) to position and lock P2, P3 in the SET state. Therefore, 146-145 yields ILOW EXCITATION DIFFERENTIAL TEMPERATURE DATA ONLY. While 145-146 yields ILOW EXCITATION CABLE THERMOCOUPLE DATA ONLY. Execution of this CMD in MODEM yields invalid data until CMD 146 is executed. The effect of CMD 146 is cleared by subsequent execution of CMD 146.

**HFE STEPS**: This CMD (142) is a 16-state CMD which advances the heater excitation programmer in MODE/LK. The MSP advances both there is another effect since the probe heater current supply is off. In MODEM, the excitation of CMD 142 alternates the heater status between on and off, simultaneously stepping through the 8 heaters (current supply is on full time and heater elements are switched in and out of circuit). In MODEM, the heater excitation programmer advances by CMD 152 also selects the data to be sampled.
HFE ANALOG DATA

AH-01  HFE +5V SUPPLY
AH-02  HFE -5V SUPPLY
AH-03  HFE +15V SUPPLY
AH-04  HFE -15V SUPPLY
AH-05  (DELETED)
AH-06  HFE HTR/HK ON/OFF
AH-07  HFE HTR/LK ON/OFF

EACH SAMPLED ONCE
EVERY 54 SEC ALSEP
SEQUENCE

FEB 72 3270.7.23
HFE THERMAL CONTROL

NOTE: ADDITIONAL THERMOSTAT TURNS A PORTION OF INSTRUMENT ELECTRONICS OFF DURING FRAMES 16 THROUGH 89 WHEN TEMP. IS ABOVE 30°C NOMINAL
HFE POWER PROFILE

CONDUCTIVITY HEATERS TURNED ON & OFF BY GROUND CMD

THERMAL CONTROL RANGE

NM = NIGHT MAX
DM = DAY MAX
DA = DAY AVERAGE

MODE/HK (NO NIGHT OPERATION)
MODE/LK
MODE/G

FEB 72 3270.7.25
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement Details</th>
<th>Priority</th>
<th>Indicator</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from Subpackage 1</td>
<td>(30 ft cable) greater than 80 ft from RTG</td>
<td>2</td>
<td>Visual</td>
<td>Interacts with probes</td>
</tr>
<tr>
<td>Direction from Subpackage 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level</td>
<td>Align with North</td>
<td>2</td>
<td>Visual</td>
<td></td>
</tr>
<tr>
<td>Upright Shadow</td>
<td>Align with Upright Shadow at Decal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance from Electronics</td>
<td>180° apart</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direction from Electronics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance from Probes (2)</td>
<td>100° apart</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical Alignment</td>
<td>Within ±15°</td>
<td>2</td>
<td>Visual</td>
<td>Objective for drilling</td>
</tr>
<tr>
<td>Experiment Interrelation</td>
<td>Separation distance from RTG: 40 ft minimum, avoid major disturbances (trampling, etc.) and shadows in 17 ft circle around probe.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
HFE ALIGNMENT MARKINGS

SOCKET FOR UHT

DEPTH

INDICATION

EMPLACEMENT

TO PROBE 1

TO PROBE 2

FEB 72 3270.7.28

FLAT CABLE TO CENTRAL STATION

DEPTH INDICATION ON PROBE EMPLACEMENT TOOL
APOLLO LUNAR SURFACE DRILL

- Earth weight, lb: 29.54 (total)
- Stowed size, in.: 22.7 x 9.6 x 7
  (not inc drill string & caps)
- Drill operated by self-contained battery
- Battery installed 5 days prelaunch
- Battery shelf life: dry: 2 yr, activated: 30 days
- Drilling principle: rotary-percussion
- Torque reaction system: none
  (minimal vertical & rotary reaction, even in rock)
- Drilling time: 5 to 15 min/hole
  (depending on material)