Apollo Lunar Surface Experiments Package

ALSEP Familiarization Course
Handout

For Training Purposes Only

1 May 1969
Contract NAS9-5829

BSR 2264-B

Prepared for
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

by
Bendix Aerospace Systems Division
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APOLLO LUNAR SURFACE EXPERIMENTS PACKAGE

- SYSTEM OBJECTIVES
- BACKGROUND
- EXPERIMENT SELECTION
- ORGANIZATION

ALSEP
- A PACKAGE OF SCIENTIFIC INSTRUMENTS AND SUPPORTING SUBSYSTEMS FOR USE ON THE LUNAR SURFACE
- CARRIED ON APOLLO, DEPLOYED BY ASTRONAUT
- ONE YEAR CONTINUOUS OPERATION (2 YEAR MAXIMUM)
ALSEP SYSTEM OBJECTIVES

DETERMINE LUNAR CHARACTERISTICS

• INTERNAL STRUCTURE & COMPOSITION
• STATE OF INTERIOR
• COMPOSITION OF ATMOSPHERE
• GENESIS OF SURFACE FEATURES

THIS LUNAR INFORMATION WILL PROVIDE NEW INSIGHTS INTO THE GEOLOGY & GEOPHYSICS OF THE EARTH.

SUPRATHERMAL ION DETECTOR

COLD CATHODE GAUGE

SOLAR WIND SPECTROMETER

POWER

DATA

PASSIVE SEISMIC

LUNAR SURFACE MAGNETOMETER
### ALSEP Experiments

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<td>Dr. G.V. Latham, Columbia</td>
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<td>Dr. R.L. Kovach, Stanford</td>
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<td>S059</td>
<td>Lunar Field Geology**</td>
<td>Dr. E.M. Shoemaker, USGS</td>
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* Included in Suprathermal Ion on certain flights
** Equip partially carried by ALSEP

MAY 69 5178.13
ALSEP HARDWARE DEFINITIONS

SUPPORTING SUBSYSTEMS
STRUCTURE/ THERMAL SUBSYSTEM INCLUDES ALL GENERAL STRUCTURE & THERMAL CONTROL FOR CENTRAL STATION

DATA SUBSYSTEM
V ANTENNA
RECEIVER
DIPL ExER FILTER
COMMAND DECoder (REDUNDANT)

DIPL ExER SWITCH
TRANSmitter (REDUNDANT)

ELECTRICAL POWER SUBSYSTEM
POWER SUPPLY (RTG)
POWER CONDITIONING UNIT (REDUNDANT)

POWER DISTRIBUTION UNIT

"CENTRAL STATION"
APOLLO LUNAR HAND TOOLS (CARRIED ON ALSEP STRUCTURE, PART OF LGE)

COMMANDS
DATA

EXPERIMENT SUBSYSTEMS

"CENTRAL STATION"
MAY 69 5178.1.4
**ALSEP FLIGHT ASSIGNMENTS**

- To be carried on early Apollo flights
- Three flight articles
- All 7 experiments cannot be carried simultaneously

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<td>Cold Cathode Gauge*</td>
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* Included in suprathermal ion on other flights

All configurations have similar power and data subsystems.

**APR 69 5178.1.5**
OBJECTIVE: PHYSICAL PROPERTIES; e.g., DENSITY, CHEMICAL COMPOSITION, DIELECTRIC CONSTANT, ELECTRICAL CONDUCTIVITY, MAGNETIC SUSCEPTIBILITY, ALBEDO, COSMIC RAY HISTORY.

MEASUREMENT: IN SITU EXAMINATION, RETURN SAMPLES

EQUIPMENT: ASCENT STAGE - SAMPLE RETURN CONTAINERS, CAMERA
DESCENT STAGE - APOLLO LUNAR HAND TOOLS (ALHT)
CARRIED ON ALSEP BUT NOT A PART OF THE ALSEP MISSION

 TOOL CARRIER
SAMPLING HAMMER
BRUSH
SCOOP
WEIGHING SCALE
SAMPLE COLLECTION BAGS
ETC.
# ALSEP Experiment Objectives

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PASSIVE SEISMIC
NASA No. SO31

OBJECTIVE: INTERNAL SEISMIC ENERGY & STRAIN REGIME, OVERALL PHYSICAL PROPERTIES (CORE/MANTLE, etc.), DISTANCE & DIRECTION TO EPICENTERS FOR CORRELATION WITH SURFACE FEATURES.

MEASUREMENT: NATURAL SEISMIC WAVE VELOCITY, FREQUENCY, AMPLITUDE & ATTENUATION; FREE OSCILLATIONS & TIDAL DEFORMATIONS

EQUIPMENT: ONE VERTICAL SHORT - PERIOD ELEMENT, THREE ORTHOGONAL LONG - PERIOD ELEMENTS
ACTIVE SEISMIC
NASA No. SO33

OBJECTIVE: PHYSICAL PROPERTIES TO SHALLOW DEPTHS, FORMATION PROCESSES
MEASUREMENT: ARTIFICIAL SEISMIC WAVE VELOCITY, FREQUENCY, & ATTENUATION
EQUIPMENT: ENERGY SOURCES (THUMPER & GRENADES), DETECTION EQUIPMENT (GEOPHONES & AMPLIFIERS)
LUNAR SURFACE MAGNETOMETER
NASA No. SO34

OBJECTIVE: MOON'S FIELD - SOLAR WIND, GROSS ELECTRICAL DIFFUSIVITY, EXISTENCE OF MOLTEN CORE, EARTH'S TURBULENT WAKE, LOCAL MAGNETIC ANOMALIES

MEASUREMENT: MAGNETIC FIELD VECTOR & ITS VARIATION WITH TIME; FIELD GRADIENT

EQUIPMENT: THREE FLUX-GATE SENSORS ON ORTHOGONAL 3-FT BOOMS

DEC 68 5178.1.11
SOLAR WIND SPECTROMETER
NASA No. SO35

OBJECTIVE: SOLAR WIND - MOON, RADIATION EFFECTS ON SURFACE
THROUGH SPUTTERING & CHARGING, PRESENCE OF ATMOSPHERE,
GROSS ELECTRICAL CONDUCTIVITY, EARTH'S TURBULENT WAKE

MEASUREMENT: POSITIVE ION & ELECTRON FLUX VARIATIONS WITH
ENERGY, TIME, & DIRECTION

EQUIPMENT: SEVEN
SENSORS COVERING
2\pi  STERADIANS

DEC 68 5178.1.12
SUPRATHERMAL ION DETECTOR
NASA No. SO36

OBJECTIVE: IONOSPHERE/ATMOSPHERE CHARACTERISTICS, POSSIBILITY OF VOLCANIC PROCESSES, AMBIENT ELECTRIC FIELD EFFECTS

MEASUREMENT: FLUX, COMPOSITION, ENERGY, & VELOCITY OF LOW-ENERGY POSITIVE IONS; HIGH-ENERGY SOLAR WIND FLUX; TOTAL PRESSURE

EQUIPMENT: TWO CURVED-PLATE ANALYZERS (ONE WITH VELOCITY FILTER), GROUND PLANE, COLD CATHODE ION GAUGE
HEAT FLOW
NASA No. SO37

OBJECTIVE: INTERNAL TEMPERATURE & COMPOSITION OF THE MOON.
FROM THIS, INFERENCE CAN BE MADE ON LUNAR EVOLUTION,
BULK COMPOSITION, CHEMICAL SORTING, INTERNAL ENERGY (IN-
CLUDING 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 10 - FT HOLES
CHARGED-PARTICLE LUNAR ENVIRONMENT
NASA No. SO38

OBJECTIVE: ENERGY SPECTRUM OF LUNAR ATMOSPHERE, LOW-ENERGY COSMIC RAY PARTICLES, SOLAR WIND & MAGNETOSPHERE EFFECTS

MEASUREMENT: ENERGY DISTRIBUTION & VARIATION WITH TIME OF ELECTRON & PROTON FLUX

EQUIPMENT: TWO DETECTOR PACKAGES, EACH WITH SIX DETECTORS
ALSEP AND THE FUTURE

ALSEP IS A FORERUNNER IN EQUIPMENT FOR LUNAR & SPACE EXPLORATION
CONSTRAINED BY EARLY AVAILABILITY, WEIGHT, AND SIZE

POSSIBLE FUTURE GOALS

NEW EXPERIMENTS
- METEOROID SPECTROMETER
- GRAVIMETER
- LUNAR ELECTRIC FIELD
- NEUTRAL MASS SPECTROMETER
- OPTICAL & RADAR OBSERVATORIES

MULTIPLE LOCATIONS
- LATERAL VARIATIONS OF GRAVITY, ETC.
- SEISMIC PHASE VELOCITY & DIRECTION
- MEASUREMENT REDUNDANCY

VEHICLE - BORNE EXPERIMENTS
- GEOCHEMISTRY & GEOPHYSICAL TRAVERSE
- DEEP DRILLING

OCT 67 5178.1.16
SYSTEM REQUIREMENTS AND CONSTRAINTS

- LM INSTALLATION
- MASS PROPERTIES
- PRELAUNCH OPERATIONS
- LAUNCH, FLIGHT AND LANDING
- REMOVAL FROM LM
- ASTRONAUT INTERFACE
  - LUNAR ENVIRONMENT
  - DATA TRANSMISSION AND RECEPTION
- GENERAL DESIGN CRITERIA
INSTALLATION IN LUNAR MODULE
PRELAUNCH INSTALLATION

INSTALLATION FIXTURE
SUPPLIED BY GRUMMAN
ALSEP/LM GEOMETRY

FORWARD
+Z

-Y

AFT
-Z

DESCENT STAGE

SEQ BAY
HEIGHT = 21"

COMPARTMENT 1

COMPARTMENT II

RTG FUEL CASK

OCT 67 5178.2.4
LM HARD POINTS

BULLET PINS (4) ON LM IN REAR OF SEQ BAY

TABS (4) ON SIDES OF ALSEP (ENGAGE BY RAISING ALSEP)

PIP PINS (4)
MASS PROPERTIES

RESTRICTIONS

MAX WT IN DESCENT STAGE = 210 LB
LOADING IN BOTH COMPARTMENTS:
  MINIMUM WT = 50 LB
  MAXIMUM WT = 215 LB
  (EXTERNAL CASK NOT INC)

EXPERIMENTS 50.7 LB
POWER (GFE ONLY) 68.2
LM ALLOWANCE 5.0
ALHT 18.0
ALL OTHER (CFE) 140.8
TOTAL 282.7 LB

C G DISTANCE FROM GEOMETRIC CENTER OF COMPARTMENT (INCHES)

WEIGHT, LB

JAN 69 5178.2.7
PRELAUNCH OPERATIONS

- STORAGE UP TO 2 YRS IN CONTROLLED ENVIRONMENT
- CHECKOUT PRIOR TO LM INSTALLATION (INC MSFN TESTS)
- LM INSTALLATION IN LANDING GEAR CHECK FIXTURE (BEFORE ≈ F-60 DAYS)
- OPERATIONS AFTER S/C STACKING
  FUEL CASK INSTALLATION ON LM
  BATTERY INSTALLATION FOR ALSD, IF CARRIED
  FUEL CAPSULE INSTALLATION IN CASK
- HEAT REMOVAL FROM CASK VIA CONDITIONED AIR (1500 WATTS, NOMINAL)
GROUND SUPPORT EQUIPMENT

SYSTEM TEST SET

PROVIDES COMPLETE UPLINK, DOWNLINK & CHECKOUT FUNCTIONS FOR FACTORY, KSC & DURING MSFN TEST

EXPERIMENT AUXILIARIES

MOST SENSORS CANNOT BE OPERATED IN EARTH ENVIRONMENT. THEREFORE, FLUX TANKS & VACUUM CHAMBERS ARE PROVIDED FOR LIMITED END-TO-END TESTS

MECH HANDLING EQUIP

LM INSTALLATION FIXTURE SPECIAL EQUIPMENT FOR RTG FUEL CAPSULE

APR 69  5178.2.9
LAUNCH, FLIGHT AND LANDING
(STOWED IN SEQ BAY)

- ALSEP INACTIVE (NO ELECTRICAL INTERFACE)
- LAUNCH SHOCK & VIBRATION (TYPICAL SPACECRAFT ENVIRONMENTS)
- SEA LEVEL PRESSURE TO SPACE VACUUM
- TEMPERATURE CONTROLLED BY LM: 0°F TO 160°F (MAXIMUM VALUE OCCURS POST - TOUCHDOWN)
- HEAT LOADS FROM CASK TO LM <100 BTU/HR [TENTATIVE]
- TOUCHDOWN DYNAMIC LOADS: 8g FOR 10 - 20 MS (ANY AXIS)  
  PLUS 14 RAD/SEC² ROTATION ACCEL (AROUND LATERAL AXIS)
REMOVAL FROM LUNAR MODULE

- BOTTOM OF SEQ BAY 18 IN. TO 60 IN. FROM SURFACE & ± 15° TILT (ANY DIRECTION)
- CLOSE LM DOOR FOR THERMAL INTEGRITY
- LANDING LOCATION WITHIN ± 5° FROM EQUATOR & ± 45° E - W
- LM PROBABLY LANDS FACING NW OR SW
- SUN ANGLE 7° TO 20° (POSSIBLE 45°) ABOVE HORIZON AND RISING
- ALHT REMOVAL SEPARATELY OR ATTACHED TO ALSEP
ASTRONAUT INTERFACE

SAFETY
BIOMED: WITHIN EXERTION AND LIFE SUPPORT LIMITATIONS
TEMPERATURES: NO CONTACT WITH EXTREMELY HOT SURFACES
PUNCTURES: NO SHARP EDGES, ETC.; NO HAZARDOUS PYROTECHNICS

CAPABILITY
MOBILITY: LIMITATIONS ON REACH (UP & DOWN), KNEELING, TWISTING, ETC.
DEXTERITY: KNOBS & HANDLES SIZED TO FIT GLOVES, MINIMUM USE OF FINE
ADJUSTMENTS, FEW ELECTRICAL CONNECTORS MATED ON MOON

VISUAL: INDICATORS (LEVELING & ALIGNMENT) PROVIDE HIGH CONTRAST;
STRIPES ON PACKAGE EDGES WHERE THERMAL DESIGN PERMITS
BARBELL CARRY

- ALLOWS ALL EQUIPMENT TO BE CARRIED BY ONE MAN IN ONE TRAVERSE
- SUITCASE HANDLES FOR TWO-MAN OR BACKUP CARRY MODE
- GIVES GOOD BALANCE & VIEW OF FEET
- EQUIVALENT EARTH WEIGHT ≈ 35 LB
- MAY BE SET DOWN TO REST
- CARRY BAR LATER USED AS ANTENNA MAST
ASTRONAUT PLSS CONSTRAINTS

2500 FT COMM LIMIT

UNSAFE

PLSS (TIME OF FAILURE OF SUIT CIRCULATION SYSTEM)

SAFE

TYPICAL DEPLOYMENT (ALSEP 1)

DISTANCE FROM LM, FT

0 200 400 600 800 1000 1200 1400

0 0.5 1.0 1.5 2.0 2.5 3.0

TIME FROM EGRESS, HR

ALSEP DESIGN INPUT, MAY NOT REPRESENT PRESENT PLSS

JAN 69 5178.2.14
DEPLOYMENT FOR ALSEP 1

300 FT BASED ON
LM ASCENT BLAST WITH
100 % SAFETY FACTOR

DATA 10 FT
PASSIVE SEISMIC

POWER 10 FT
SOLAR WIND SPECTROMETER

13 FT
SUPRATHERMAL ION DETECTOR

55 FT
COLD CATHODE ION GAGE

MAGNETOMETER

N
W
S
E

JAN 69 5178.2.15
LUNAR ENVIRONMENT
(SPECIFICATION LED 520 - 1D)

SURFACE TEMPERATURE: -300°F TO +250°F

SURFACE SLOPES: LESS THAN 12° "EFFECTIVE" SLOPE OVER SPACING OF LM LANDING GEAR (SELECTED SITES). SELECTABLE LOCATIONS FOR ALSEP LESS THAN 5° SLOPES

BEARING STRENGTH: COMBINATION OF SOFT (1 PSI PENETRATES 4 IN) & HARD (INFINITELY RIGID ROCK)

FRICTION COEFFICIENT: 0.4 to 1.0

OPTICAL PROPERTIES: LUNAR NORMAL ALBEDO (0.047 OVER SOLAR SPECTRUM, 0.098 OVER VISIBLE SPECTRUM) PLUS UNIQUE DIRECTIONAL REFLECTIVITY

PRESSURE: LESS THAN 10^{-12} TORR

MICROMETEORS: MSC DOCUMENT DS-21 APPLIES

RADIATION: NEGLIGIBLE EFFECT ON SYSTEM ELECTRONICS FOR ONE-YEAR OPERATION

OCT 67 5178.2.16
DATA TRANSMISSION AND RECEPTION

MAXIMUM COMPATIBILITY WITH APOLLO PROCEDURES & HARDWARE AT MSFN
NON-INTERFERENCE WITH APOLLO COMMUNICATIONS

PROBABILITY OF BIT ERROR $10^{-9}$ OR BETTER
UPLINK 100 DIFFERENT COMMANDS
DOWNLINK 1060 BITS/SEC DATA (NORMAL)
PROBABILITY OF BIT ERROR $10^{-4}$ OR BETTER

ONE YEAR CONTINUOUS OPERATION CAPABILITY FOR HANDLING 3 ALSEPs SIMULTANEOUSLY
TIMER TURN-OFF (2 YEAR) IN CASE OF COMMAND MALFUNCTION
MONITOR REAL-TIME DATA INITIATE COMMANDS

WORLD-WIDE REMOTED SITES OF MSFN

CONTROL CENTER

OCT 67 5178.2.17
ANTENNA POINTING REQUIREMENTS

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 PETURBATIONS
- GYROSCOPE & PENDULUM COUPLING

COMBINED EFFECTS: PATTERN CHANGES MONTHLY & YEARLY

ALSEP ANTENNA: 22° BEAM WIDTH DOWN 4.2 db AIMED AT MEAN CENTER OF PATTERN

[Diagram showing lunar longitude and latitude with specific dates and angular measurements.

JAN 69 5178.2.18]
# ALSEP/MSFN INTERFACE

<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>RESOLUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>APOLLO COMPATIBILITY</td>
<td>S-BAND EQUIPMENT, ESSENTIALLY SAME AS APOLLO; SCHEDULE SEPARATE MSFN SITES FOR APOLLO &amp; ALSEP</td>
</tr>
<tr>
<td>3 ALSEPS SIMULTANEOUSLY</td>
<td>UPLINK USE DUAL SITES; THREE XMTR FREQUENCIES (2276.5, 2278.5 &amp; 2275.5 MHz)</td>
</tr>
<tr>
<td>BIT ERROR RATE</td>
<td>10^{-9}: 10 KW XMTR POWER &amp; 15 db ALSEP ANTENNA</td>
</tr>
<tr>
<td></td>
<td>10^{-4}: 1 WATT MIN XMTR POWER &amp; 15 db ALSEP ANTENNA</td>
</tr>
<tr>
<td></td>
<td>MSFN S/N MARGIN: 30 - ft 85 - ft +28 db +35 db</td>
</tr>
<tr>
<td></td>
<td>NOTE: XMTR TUNING FOR MAX POWER IS NOT CRITICAL (ASSUMED 30-MIN TURN-AROUND APOLLO TO ALSEP)</td>
</tr>
<tr>
<td>2 - YEAR TIMER</td>
<td>BULOVA ACCUTRON 720 ± 30 DAYS</td>
</tr>
</tbody>
</table>

**S/N MARGIN:**

<table>
<thead>
<tr>
<th></th>
<th>30-ft</th>
<th>85-ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSFN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.06 KBPS</td>
<td>+7.2 db</td>
<td>HI</td>
</tr>
<tr>
<td>10.6 KBPS</td>
<td>LO</td>
<td>+6.5 db</td>
</tr>
</tbody>
</table>
SPECIAL COMMUNICATIONS FEATURES

UPLINK
- Although ALSEP was automated in original concept, it now depends on active use of many commands
- 100 possible commands but each ALSEP uses 65 to 75
- No commands requiring precise timing (+10 sec in PSE forced leveling)
- Command capability within 15 min highly desired for ≈15 on/off switches
- ALSEP reception & identification of commands is verified via TM
- Uplink 1000 BPS, 61 bits per command
- Command rate no more than 1/sec

DOWNLINK
- No data storage in ALSEP; hence, all data transmitted in near real time & 100% coverage is desired
- Normal mode (1.06 KBPS) has 64 10-bit words/frame ≈0.604 sec/frame
- Low bit rate has same format ≈1.208 sec/frame
- High bit rate is special format for ASE
- Except for ASE, no words can be interchanged between experiments, all experiments operate full-time & data is interlaced in format
- Approx. distribution of data: 5% sync, 10% housekeeping, 85% science

- Start-up while astronaut is on surface & begin initial interrogation
- Dust covers on particle experiments removed after LM ascent
MSFN/MCC SUPPORT REQUIREMENTS

- All received data must be recorded by MSFN (up to 3 ALSEPs)
- Each ALSEP must be monitored real-time for first 45 days (i.e., through second sunset) for critical thermal transients plus science
- After 45 days, real-time monitoring for 2 continuous hr per 24 req'd (2 hr per 8 hr desired) for remainder of year
- Additional continuous coverage required for 60 hours each terminator crossing (26 times per year per ALSEP)
- For multiple ALSEPs, use time-sharing of intermittent monitoring (no more than two simultaneously in real-time)
- High bit rate for ASE (10.6 KBPS) to be compressed to less than 2.4 KBPS for transmission from remoted sites to MCC. No other ALSEP monitored real-time during ASE operations
- Profile of ALSEP operations day/night to be determined

OCT 68  5178.2.21
STATION SELECTION FOR ALSEP

(MOON DECLINATION MAXIMUM NORTH)

PRIMARY ALSEP SUPPORT STATIONS (85-FT)

GDS

CNB

MAD

SECONDARY ALSEP SUPPORT STATIONS (30-FT)

HAW

GWM

ACN

ANTENNA COVERAGE ZONES (5° HORIZON)
STATION SELECTION FOR ALSEP

(MOON DECLINATION MAXIMUM SOUTH)

PRIMARY ALSEP SUPPORT STATIONS (85-FT)

GDS
CNB
MAD

SECONDARY ALSEP SUPPORT STATIONS (30-FT)

HAW
GWM
ACN

ANTENNA COVERAGE ZONES (5° HORIZON)

OCT 67 5178.2.23
GENERAL DESIGN CRITERIA

CREW SAFETY: NO SHARP EDGES, CONTACT WITH HOT SURFACES, EXPOSED HIGH VOLTAGE POINTS, OR HAZARDOUS PYROTECHNICS (USE ONLY ASI)

THERMAL DEGRADATION: SYSTEM MUST PERFORM WHEN SURFACES ARE FULLY DEGRADED BY DUST OR UV

FAIL SAFE: MALFUNCTIONS MUST NOT PROPAGATE SEQUENTIALLY

PARTIAL OPERATIONS: SYSTEM MUST PERFORM WHEN ONE OR MORE EXPERIMENTS ARE NOT DEPLOYED OR HAVE FAILED

MATERIALS: WITHOUT NASA APPROVAL, NO FLAMMABLE, TOXIC, OR UNSTABLE MATERIALS & NO PLASTICS EXCEPT EPOXY RESIN-BASED COMPOUNDS, TEFLON, OR MYLAR

EMI: ALSEP COMPONENTS SHALL NEITHER BE A SOURCE OF EM DISTURBANCES NOR BE SUSCEPTIBLE TO EXTERNAL SOURCES

GROUNDING: SEPARATE POWER & SIGNAL RETURNS; ONE COMMON GROUND POINT IN THE DATA SUBSYSTEM; SHIELDS CONNECTED TO CHASSIS GROUNDS AT BOTH ENDS

NOV 67 5178.2.24
SYSTEM LEVEL DESCRIPTION

COMMAND LINK

TELEMERTY LINK

POWER SUBSYSTEM

DATA SUBSYSTEM

COMMIMDS & TIMING

POWER

DATA

PASSIVE SEISMIC

LUNAR SURFACE MAGNETOMETER

SOLAR WIND SPECTROMETER

SUPRATHERMAL ION DETECTOR

OTHER ALSEPS

ACTIVE SEISMIC

HEAT FLOW

CHARGED PARTICLE

ALSEP 1

EXPERIMENT SUBSYSTEMS

APR 69 5178.3.1
SYSTEM HARDWARE LIST

(1) STRUCTURE/ THERMAL SUBSYSTEM
   SUBPACKAGE #1 STRUCTURE, SUBPACKAGE #2 STRUCTURE, THERMAL CONTROL,
   EXPERIMENT MOUNTING PROVISIONS, TELEMETRY SENSORS/DUST DETECTOR,
   ASTRONAUT TOOLS, ANTENNA MAST, FUEL CASK MOUNTING AND INSULATION.

(2) DATA SUBSYSTEM
   ANTENNA DIPLEXER FILTER
     RECEIVER COMMAND DECODER
     DIPL ExER SWITCH DATA PROCESSOR
     POWER DISTRIBUTION AND SIGNAL CONDITIONER

(3) ELECTRICAL POWER SUBSYSTEM
   RTG PCU POWER DISIPATION RESISTORS FUEL CASK FUEL TRANSFER TOOL
   DOME REMOVAL TOOL

(4) EXPERIMENT SUBSYSTEMS
   PASSIVE SEISMIC ACTIVE SEISMIC MAGNETOMETER
   SOLAR WIND SUPER THERMAL ION DETECTOR
   HEAT FLOW CHARGED-PARTICLE

(5) APOLLO LUNAR HAND TOOLS

NOV 67 5178.3.3
FIG. 1-1

ALSEP 1 SYSTEM GEOMETRY

SHOWS ONE SOLUTION TO THE GEOMETRIC CONSTRAINTS
ALSEP 1 SYSTEM DATA FLOW

SUPRATHERMAL ION DETECTOR (5 WORDS) 
CONTAINS SCIENCE PLUS 195 ENG & STATUS PARAMETERS (COMMUTATED)

CONTROL GROUP (3 WORDS) 
CONTAINS SYNC, ID & FRAME CNTR

PASSIVE SEISMIC (43 WORDS) CONTAINS SCIENCE PLUS 1 COMMUTATED TEMP

LUNAR SURFACE MAGNETOMETER (7 WORDS) CONTAINS SCIENCE PLUS 1 HK WORD WITH 8 ENG PARAMETERS (COMMUTATED) & STATUS FLAGS

SOLAR WIND SPECTROMETER (4 WORDS) CONTAINS SCIENCE PLUS 92 ENG & STATUS PARAMETERS (COMMUTATED)

64-WORD ALSEP FRAME (10 BITS/WORD) 0.604 SEC (NORMAL)

TO XMTR

90-CHANNEL ANALOG MULTIPLEXER (1 WORD) CONTAINS:
65 ALSEP ENG PARAMETERS
8 PASSIVE SEISMIC ENG PARAMETERS
2 SUPRATHERMAL ION (SCIENCE)
15 NOT USED ON ALSEP 1

COMMAND VERIFICATION (1 WORD) CONTAINS CMD AS RCVD & MAP

OCT 68 5178.3.5
STRUCTURE/ THERMAL
SUBSYSTEM CHARACTERISTICS

PHYSICAL PARAMETERS
SIZE, IN.: VARIOUS
EARTH WT, LB: 70.02 TOTAL
  SUBPACKAGE #1 SUBPACKAGE #2 EXTERNAL
   21.91  24.45°  14.6
* INC 0.66 DUST DETECTOR
POWER, W: DUST DETECTOR 0.54 ON, 0.07 OFF

OPERATIONS
DEPLOYMENT: LOCATE 300 FT FROM LM,
ORIENT ±5° WRT SHADOW,
REMOVE EXPERIMENTS & ERECT
SUNSHIELD, CONNECT MAST
APPROX TIME, NOT INC TRAVERSE,
8 MIN
POST DEPLOYMENT: TURN DUST DETECTOR ON
PRE-ASCENT

COMPONENTS

<table>
<thead>
<tr>
<th>SUBPACKAGE #1</th>
<th>SUBPACKAGE #2</th>
</tr>
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<tbody>
<tr>
<td>PRIMARY STRUCTURE</td>
<td>SUNSHIELD</td>
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<tr>
<td>CURTAINS ETC.</td>
<td>EXPER MTG PROVISIONS</td>
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<tr>
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<td>RTG CABLE STORAGE</td>
</tr>
<tr>
<td>TM INC DUST</td>
<td>SUBPALLEET</td>
</tr>
<tr>
<td></td>
<td>SPECIAL TOOLS</td>
</tr>
</tbody>
</table>

COMMUNICATIONS
COMMANDS: 2 FOR DUST CELLS ON/OFF
5 FOR HEATERS
DATA: 19 ANALOG ENGINEERING PARAMETERS
(INC 6 FOR DUST) SAMPLED ONCE EACH
PER 54 SEC ALSEP SEQUENCE

KEY FEATURES
LM WEIGHT INCLUDES 5.00 LBS FOR CASK MOUNTING PROVISIONS (NOT PART OF ALSEP BUDGET)
TO COVER NECESSARY REINFORCING & TIE-POINT FITTINGS. ORIGINALLY SPECIFIED AT 3.00 LBS.
STRUCTURAL COMPONENTS

SUBPACKAGE #1 (21.91 LB)  SUBPACKAGE #2 (24.43 LB)

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight (LB)</th>
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<tbody>
<tr>
<td>RTG CABLE STORAGE</td>
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<tr>
<td>SUNSHIELD (INC DUST DETECTOR)</td>
<td>12.05</td>
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<tr>
<td>ANTENNA AIMING MECHANISM</td>
<td>4.03</td>
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<tr>
<td>PALLET</td>
<td>12.68</td>
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<tr>
<td>CURTAINS, REFLECTORS</td>
<td>1.66</td>
</tr>
<tr>
<td>SUBPALLETER, TOOL MTG, SIDE EXPER MTG</td>
<td>6.06</td>
</tr>
<tr>
<td>PRIMARY STRUCTURE</td>
<td>8.20</td>
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<tr>
<td>TOTAL</td>
<td>24.43</td>
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OCT 68 5178.3.7
**THERMAL CONTROL**

**PHILOSOPHY:** EACH SEPARATE UNIT CONTROLLED INDEPENDENTLY EXCEPT FOR ELECTRICAL HEATER POWER REQUIREMENTS

<table>
<thead>
<tr>
<th>RTG</th>
<th>CENTRAL ELECTRONICS</th>
<th>PASSIVE SEISMIC</th>
<th>MAGNETOMETER</th>
<th>SUPRATHERMAL ION</th>
<th>SOLAR WIND</th>
<th>CHARGED-PARTICLE</th>
<th>ACTIVE SEISMIC</th>
<th>HEAT FLOW</th>
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</table>

**LEGEND**

- **R** = TOP & ALL SIDES
- **C** = COMBINED TOP & SUNSHIELD
- **S/T** = S FOR ELECTRONICS, T FOR SENSORS
- **C/A** = C FOR MORTAR PACKAGE ONLY
- **C/H** = C FOR PROBE ELECTRONICS ONLY
- **T** = TOP ONLY
- **S** = SIDES ONLY (NORTH & SOUTH FOR MAGNETOMETER, SOUTH ONLY FOR SOLAR WIND)
- **I** = INSULATED FROM LUNAR SURFACE
- **P** = COUPLED TO LOCAL LUNAR SURFACE
- **E** = EXTENDS OVER RADIATOR ON SIDE
- **B** = BIDIRECTIONAL, EAST & WEST
- **A** = ALL SIDES ON MORTAR PACKAGE
- **L** = NO COMMAND OVERRIDE
- **J** = COMMAND OVERRIDE OFF
- **K** = COMMAND OVERRIDE ON/OFF

**NOV 67 5178.3.8**
SUBPACKAGE #1 THERMAL COMPONENTS

- SUNSHIELD (PART OF STRUCTURE)
- CURTAIN RESTRAINTS (3)
- REFLECTOR
- SIDE CURTAINS
- INSULATION MASKS
- THERMAL PLATE
- THERMAL BAG
- PRIMARY STRUCTURE (REF)
EXPERIMENT MOUNTING PROVISIONS

ATTACHMENT BY 75° ROTATION
BOYD BOLT FASTENERS

SUNSHIELD

SIDE

SWS

APR 69 5178.3.10
SPECIAL TOOLS

DOME REMOVAL TOOL (PART OF ELECTRICAL POWER SUBSYSTEM)

UHT 0.53 LB EACH

MAST 1.30 LB, TOTAL (ONE HALF SHOWN)

ALL WEIGHTS ARE EARTH LB
14.6 LB FUEL CASK MOUNT & INSULATION, PART OF STRUCTURE/ THERMAL SUBSYSTEM, COVERED UNDER ELECTRICAL POWER SUBSYSTEM
STRUCTURE/THERMAL TELEMETRY

CODE AT, AX, ETC., INDICATES DATA VIA ALSEP ANALOG MULTIPLEXER (READ OUT ONCE PER 54 SEC)

TOTAL 19 PARAMETERS

AT-01 SUNSHIELD 1 (OUTSIDE)
AT-02 SUNSHIELD 2 (INSIDE)

AT-03 THROUGH AT-07
ON THERMAL PLATE

AT-11 PRI/ST W3 (ON BACK PANEL)
AT-08 PRI/ST W1
AT-09 PRI/ST W2 (ON OPPOSITE WALL)

AT-10 PRI/ST B1 (ON BOTTOM)

AT-12 INSUL INT (ON WALL)
AT-13 INSUL EXT (ON WALL)

DUST DETECTOR: 3 CELLS WITH 3 TEMPERATURE SENSORS (BEHIND CELLS)
MOUNTED ON TOP & E-W FACES OF CUBE; AX-01 THROUGH AX-06
EARTH WT, LB: 0.66
COMMANDS: DUST CELLS ON/OFF (CELL OUTPUT ONLY)

OCT 68 5178.3.12
ELECTRONICS COMPARTMENT

- THERMAL PLATE TEMP SENSORS (TM)
- DSS HEATER THERMOSTATS
- DSS & BACKUP HTR ELEMENTS

COMMANDS (2):
- DSS HTR ON/OFF

PART OF ELECTRICAL POWER SUBSYSTEM

- XMTR B
- XMTR A
- DIPLEXER FILTER
- DATA PROCESSOR
- COMMAND DECODER
- PASSIVE SEISMIC ALL ALSEPS
- ACTIVE SEISMIC (ALSEP 4)
- ANALOG MULTIPLEXER
- RCVR HTR
- PCU
- PDU

OCT 68 5178.3.13
ANTENNA AND AIMING MECHANISM

PHYSICAL PARAMETERS
MODIFIED AXIAL HELIX
23 IN. LONG x 1.5 IN. DIAM, 15° PITCH
5 IN. GROUND PLANE WITH 2 IN.
CYLINDRICAL SKIRT
EARTH WT, LB: 1.28 INC CABLE

PHYSICAL PARAMETERS
SIZE, IN: 10.8 x 6.0 x 4.7
EARTH WT, LB: 2.00
(INC IN STRUCTURE/ THERMAL)

PERFORMANCE
RIGHT HAND CIRC. POLARIZED
GAIN ON BORESIGHT, db XMTR RCV
GAIN AT ±27°, db 15.2 14.7

DEPLOYMENT OPERATIONS
SET COARSE & FINE ELEV TABLE PLUS
SET COARSE & FINE AZ VOICE BACKUP
LEVEL, ALIGN SHADOW, RECHECK LEVEL
APPROX TIME, 9 MIN

KEY FEATURES
RANGE OF ADJUSTMENT: AZIMUTH ± 90°, ELEVATION ± 50° WRT VERTICAL, LEVEL ± 6°,
SUN ± 15° WRT MAST
MAX. ERRORS: 0.99°, DUE TO MFG, MOUNTING, THERMAL DISTORTION, & BACKLASH

NOV 67 5178.3.14
# DATA SUBSYSTEM CHARACTERISTICS

## Components

![Component Diagram](https://example.com/component-diagram.png)

### PHYSICAL PARAMETERS

<table>
<thead>
<tr>
<th>Size, In.</th>
<th>Earth Wt, Lb</th>
<th>Power, W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diplexer Filter</td>
<td>6.88 x 2.5 x 2.5</td>
<td>0.90</td>
</tr>
<tr>
<td>Receiver</td>
<td>8 x 4 x 1.75</td>
<td>1.84</td>
</tr>
<tr>
<td>Diplexer Switch</td>
<td>6.25 x 3.94 x 2.8*</td>
<td>2.70</td>
</tr>
<tr>
<td>Transmitters (2)</td>
<td>4.5 x 4 x 1.3</td>
<td>1.28</td>
</tr>
<tr>
<td>Data Processor (A)</td>
<td>7.5 x 2.0 x 1.5</td>
<td>1.13</td>
</tr>
<tr>
<td>Data Processor (D)</td>
<td>6.25 x 3.94 x 2.8</td>
<td>2.70</td>
</tr>
<tr>
<td>PDU</td>
<td>7.25 x 4.0 x 2.8</td>
<td>2.37</td>
</tr>
</tbody>
</table>

* NOT INC CONNECTOR

**TOTAL** 16.57 15.91

**NOT INC ANTENNA**

## Communications

**COMMANDS:**
- 12 FOR EXPER PWR OPER/Stby/off
- 13 SPECIAL CMDs FOR: BIT RATE (3)
- DSS PROC SEL (2)
- XMT SEL (2)
- XMT ON/OFF (2)
- TIMER OUT ACCEPT/INHIBIT (2)

**DATA:**
- 24 ANALOG ENG PARAMETERS
- 2 ANALOG SIGNALS FOR PDU SWITCHES (EXPER STBY)
- SAMPLED ONCE EVERY 54-SEC
- ALSEP SEQUENCE
- ADDITIONAL WORD IN DATA FORMAT PROVIDED FOR "CMD AS RCVR" & "CMD MAP"

**DISPLAY:** ANALOG CHARTS OR TABULAR PRINT/TV PLUS EVENT LIGHTS

## Key Features

- **Modulation:**
  - UPLINK, 1 & 2 KHz BI-PHASE
  - DOWNLINK, PCM SPLIT-PHASE

- **REDUNDANCY:**
  - **RCVR** AT CIRCUIT LEVEL
  - **CMD DECODERS** ESSENTIALLY DUAL ("A" & "B") WITH INDIVIDUAL ADDRESSES
  - **DATA PROCESSORS** ESSENTIALLY DUAL ("X" & "Y") SELECTED BY CMD
  - **XMTs** COMPLETE DUAL ("A" & "B") WITH ONE IN STBY SELECTED BY CMD

- **Either processor can be used with either XMT**

- **Thermal Integrity:** If XMT or RCVR switch off, equivalent heaters automatically switch on

- **Timer:** 2-Yr TIMER also supplies delayed (programmed) commands to allow limited operational capability in case of uplink (RCVR, etc.) malfunction

- **Astronaut switches provide backup capability to turn ALSEP on in case of uplink malfunction**

## Performance

**XMT:** 1 W MIN, DIFFERENT FREQUENCIES FOR EACH ALSEP
- **STABILITY:** LONG-TERM: ±0.0025%/YEAR
- **SHORT-TERM:** 2 x 10^-10 PARTS/SEC

**RCVR:** 2119 MHz ±0.001%

**CMD DECODER:** 100 DIFFERENT CMDs, UNIQUE ADDRESSES FOR EACH ALSEP

**DATA PROCESSOR:** NORMAL BIT RATE (NBRl, 1.06 KBPS)
- LBR, 0.53 KBPS
- HBR (ACTIVE SEISMIC), 10 & 16 KBPS FORMATTED BY ASE NORMAL & LOW FRAME, 64 TEN-BIT WORDS (MSB FIRST)
- ADC, 8 BITS PARALLEL OUT TO 9V IN 1. ±0.3% ACCURACY

**PDU:** INCLUDES ANALOG SIGNAL CONDITIONERS

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**APR 69 5178.3.15**
ELECTRICAL POWER SUBSYSTEM

- RADIOISOTOPE THERMOELECTRIC GENERATOR (RTG)
- POWER MANAGEMENT REQUIREMENTS
- POWER CONDITIONING UNIT (PCU)
- POWER DISSIPATION RESISTORS (PDR)
- CIRCUIT & SYSTEM PROTECTION
- FUEL CASK & MOUNTING
- RTG/ASTRONAUT INTERFACE
RADIOISOTOPE THERMEOLECTRIC GENERATOR

KEY FEATURES
FUEL: Pu 238, 90-yr half life, generator output may decrease with time due to decreased thermoelectric perf
THERMOELECTRIC: Lead telluride, previously used at 900°-950°F hot junction, tested to 1250°F, melts at 1600°F
ATMOSPHERE: ~25 psi argon at oper temp (<15 psi at room temp); lead telluride oxidizes in air & sublimes in hard vacuum
RE-ENTRY CRITERION: INTACT; FACTOR IN CASK DESIGN

PHYSICAL PARAMETERS

<table>
<thead>
<tr>
<th>Size, in.</th>
<th>Earth wt, lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generator</td>
<td>16 diam x 18 high</td>
</tr>
<tr>
<td>Capsule</td>
<td>2.6 diam x 17 high</td>
</tr>
</tbody>
</table>

* NOT INC END PLATE

PERFORMANCE

- OUTPUT POWER: 14-24W (one year) & up to 74 W
- OUTPUT VOLTAGE: 16 VDC (nominal)
- CURRENT: 4 AMP (approxi)
- OVERALL EFFICIENCY: 4% (approxi)
- HOT JUNCTION TEMP: 1100° F MAX
- COLD JUNCTION TEMP: 600° F MAX
- FUEL CAPSULE THERMAL OUTPUT: 1400 to 1520 W
- FUEL CLAD TEMP: 1390° F MAX

* LUNAR DAY/ NIGHT PERF NEARLY SAME

FUEL CAPSULE ASSEMBLY
CARRIED TO MOON ON EXTERNAL CASK

SNAP-27

POWER DATA

PCU PDU

COMPONENTS

GENERATOR ASSEMBLY

COMMUNICATIONS

COMMANDS: NO RTG CMDs
DATA:
6 ANALOG PARAMETERS (TEMPS) each sampled once every 34-SEC ASLEEP SEQUENCE
DISPLAY: ANALOG CHARTS, METERS, PRINTER, OR TV

NOTE: AR-05 IS ACTUALLY ON FIN, NEAR COLD FRAME

SECTION A-A
(1/4 inch from bottom)

SECTION B-B
(1/8 inch from bottom)

OCT 68 5178.3.18
RTG WARM-UP CYCLE

TEMPERATURE, DEG F

Capsule
HOT FRAME
COLD FRAME
FINS

OPERATING DIFFERENTIAL (ΔT)
(OUTPUT DEPENDS ON TEMP & ΔT)

TIME TO START-UP TBD

TIME FROM FUELING, HR

LUNAR SURFACE

NOV 67 5178.3.19
POWER MANAGEMENT REQUIREMENTS

- RTG not like solar cell/fuel cell/battery systems
  - Steep curve of V vs. A
  - No source or sink (all power used when generated)
- ALSEP uses load adjustment PCU to minimize EMI
  - Monitors PCU input voltage, proportional to RTG output voltage
  - Adds variable load to demand load, \( A_d \), bringing current up to "control" value, \( A_c \), thus maintaining "control" voltage, \( V_c \)

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>REQUIREMENT</th>
<th>RESOLUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-operating</td>
<td>Short-circuit, to keep thermoelectric cool</td>
<td>PCU provides wide range (( \approx 40 ) W) of shunt regulation: circuit breakers, ripple-off, &amp; ground command power management procedures (switchable loads)</td>
</tr>
<tr>
<td>Initialization</td>
<td>Digital electronics need fast rise to a stable condition</td>
<td>PCU senses when output reaches acceptable level with resistive load ( &amp; ) then starts oscillator to supply all users ( &amp; )</td>
</tr>
<tr>
<td>Operational contingencies</td>
<td>System must preclude overloads and underloads at RTG interface</td>
<td>PCU cable has shorting plug (with ammeter) &amp; switch for turn-on after connection</td>
</tr>
</tbody>
</table>
POWER CONDITIONING UNIT

**COMPONENTS**

- 29V
- 15V
- ETC
- POWER USERS

**PERFORMANCE**

<table>
<thead>
<tr>
<th>OUTPUT VOLS</th>
<th>LOAD, AMP</th>
<th>REGULATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>+29</td>
<td>1.19</td>
<td>+1% on all</td>
</tr>
<tr>
<td>+15</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>+12</td>
<td>0.30</td>
<td>(regulator operates from +12V output)</td>
</tr>
<tr>
<td>+5</td>
<td>0.90</td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>-12</td>
<td>0.15</td>
<td></td>
</tr>
</tbody>
</table>

**PHYSICAL PARAMETERS**

- SIZE, IN.: 8.4 x 4.2 x 2.8
- EARTH WT, LB: 4.6
- POWER: DISSIPATION INSIDE PCU IS A FUNCTION OF OVERALL DISSIPATION TO MAINTAIN RTG OUTPUT VOLTAGE. AVERAGE 25% INSIDE & 75% IN PDR

**COMMUNICATIONS**

- COMMANDS: +2 basic (PCU 1 SEL & PCU 2 SEL)
- +4 others (apply or remove 2 external loads in PDR)
- DATA: +8 analog eng parameters: PCU input (RTG output) volts & amps (2), shunt regulator currents (2), PCU temps (4), +6 output voltages in PDU, sampled once per 54-sec, ALSEP sequence

**KEY FEATURES**

- PCU IS "FIXED-RATIO" CONVERTER; THUS, REGULATION OF 12V LINE REGULATES ALL LINES & MAINTAINS RTG OUTPUT FIXED
- PCU PROTECTS RTG (EXAMPLE, AGAINST OPEN CIRCUITS)
- PCU REGULATES BY LOAD ADJUSTMENT OVER 40W SWING BUT ADDITIONAL EXTERNAL LOADS (PDVal) CAN BE SWITCHED ON/OFF BY COMMAND; MAY BE Dictated BY CENTRAL STATION THERMAL BALANCE
- PARTIAL REDUNDANCY WITH COMMAND SELECTION (PCU 1 OR PCU 2) PLUS AUTOMATIC SWITCHOVER FROM 1 TO 2 VIA OUT-OF-TOLERANCE SENSOR VOLTAGE PROTECTIONS. NO SWITCHBACK, NORMALLY OPERATE WITH PCU 1
- CAPACITANCES MAINTAIN VOLTAGES DURING SWITCHEOVER

**KEY PARAMETERS**

- SIZE, IN.: 8.4 x 4.2 x 2.8
- EARTH WT, LB: 4.6
- POWER: DISSIPATION INSIDE PCU IS A FUNCTION OF OVERALL DISSIPATION TO MAINTAIN RTG OUTPUT VOLTAGE. AVERAGE 25% INSIDE & 75% IN PDR

**COMMUNICATIONS**

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- +4 others (apply or remove 2 external loads in PDR)
- DATA: +8 analog eng parameters: PCU input (RTG output) volts & amps (2), shunt regulator currents (2), PCU temps (4), +6 output voltages in PDU, sampled once per 54-sec, ALSEP sequence

**DISPLAY**: ANALOG CHART, METERS OR PRINTER/TV

**NOV 67 5178.3.21**
POWER DISSIPATION RESISTORS

- Part of power management provisions
- Mounted external to central electronics
- Together with experiment standby resistors, provide initial RTG loads during lunar start-up

Characteristics:

<table>
<thead>
<tr>
<th>ID</th>
<th>Number of Resistors</th>
<th>Rating, Ohms</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1, 2, 3)</td>
<td>3 in parallel</td>
<td>20 (Each)</td>
<td>PCU 1 shunt</td>
</tr>
<tr>
<td>(4, 5, 6)</td>
<td>3 in parallel</td>
<td>20 (Each)</td>
<td>PCU 2 shunt</td>
</tr>
<tr>
<td>(8)</td>
<td>1</td>
<td>121</td>
<td>DISSIP R1</td>
</tr>
<tr>
<td>(7)</td>
<td>1</td>
<td>64.9</td>
<td>DISSIP R2</td>
</tr>
</tbody>
</table>

8 total
CIRCUIT AND SYSTEM PROTECTION

PHILOSOPHY: PROTECT ALSEP SYSTEM AT THE EXPENSE OF INDIVIDUAL EXPERIMENTS, IF NECESSARY.  

MINOR OVERLOADS
• ACCEPTED UNTIL TOTAL EXCEEDS AVAILABLE POWER AS SENSED IN PCU SHUNT AMPS
• MARGINAL SIGNAL CAUSES AUTOMATIC RIPPLE-OFF (SEQUENTIAL) OF EXPER 4, 3 & 1 (SIDE, SW & PSE IN ALSEP 1). STOPS WHEN MARGIN IS OK
• RIPPLE-OFF SWITCHES FROM OPER TO STBY

MAJOR OVERLOADS
• CIRCUIT BREAKERS 0.50 ± 0.05 AMP IN EXPER OPER (29V) LINES SWITCH TO STBY
• CIRCUIT BREAKERS 0.70 ± 0.14 AMP IN 29V LINE OF XMTR & 0.110 to 0.225 AMP IN 12V LINES OF XMTR & RCVR
• WHEN XMTR OR RCVR GO OFF, EQUIVALENT HEATERS ARE SWITCHED ON
• FUSES 0.50 AMP IN EXPER STBY (HEATER) 29V LINES & 0.25 AMP IN DUST DETECTOR +12V & -12V LINES

RESET: TIMER AUTOMATICALLY ATTEMPTS RESET OF RCVR & EXPER 4 EVERY 12 HRS (EXPER 4 IS CONTINGENCY PROVISION FOR NG UPLINK)
OTHER EXPER & XMTR RESET BY COMMAND ONLY

DEMAND ANALYSIS: OPERATIONAL POWER MANAGEMENT INCLUDES MONITORING POWER RESERVE (PCU SHUNT AMPS) VIA TM & SWITCHING PDR ON/OFF

UNDERLOAD: IF PCU 1 CANNOT ADD ENOUGH LOAD, SWITCHOVER TO PCU 2 OCCURS

OCT 68 5178.3.23
FUEL CASK AND MOUNTING

REQUIREMENTS: LESS THAN 100 BTU/HR TO LM & LM SKIN 270°F MAX

CASK IN FLIGHT POSITION SIZE, IN.
8 DIAM x 23 HIGH
25 LB

REMOVAL POSITION (ADJUSTABLE BY ASTRONAUT)

THERMAL SHIELD 2.8 LB
RELEASE LATCH (LANYARD OPERATED)
MOUNTING & STRUCTURE 11.92 LB
LM INTERFACE FITTINGS (GRUMMAN)
ROTATION MECHANISM (LANYARD OPERATED)

SUMMARY OF EARTH WT (ADJUSTABLE BY ASTRONAUT)

<table>
<thead>
<tr>
<th>POWER SUBSYSTEM</th>
<th>STRUCTURE/ THERMAL SUBSYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CASK 25.0 LB</td>
<td>THERMAL SHIELD 2.80 LB</td>
</tr>
<tr>
<td>NOT INC</td>
<td>MOUNT &amp; STRUCTURE 11.92 LB</td>
</tr>
<tr>
<td>15.0 LB FUEL CAPSULE</td>
<td>MISC (ASTRO PROTECT) 5.28</td>
</tr>
<tr>
<td></td>
<td>TOTAL 20.0 LB</td>
</tr>
</tbody>
</table>

OPERATIONS

RELEASE LATCHES AND DOME LOCK, ROTATE CASK, UNSCREW CASK DOME (DOME REMOVAL TOOL), TRANSFER FUEL CAPSULE (FUEL TRANSFER TOOL) APPROX TIME 3 MIN, INC IN PRE-TRAVERSE TOTAL

APR 69 5178.3.24
# RTG/ASTRONAUT INTERFACE

<table>
<thead>
<tr>
<th>CONSTRAINT</th>
<th>RESOLUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>THERMAL:</td>
<td>• THERMAL BARRIER (SMALL DOOR) PROTECTION WHILE AT SEQ BAY</td>
</tr>
<tr>
<td></td>
<td>• NO SUIT CONTACT WITH SURFACES MORE THAN 250°F</td>
</tr>
<tr>
<td></td>
<td>• LANYARDS FOR CASK ROTATION &amp; DOME LOCK</td>
</tr>
<tr>
<td></td>
<td>• MINIMIZE HEAT LOAD ON SUIT COOLING EQUIP</td>
</tr>
<tr>
<td></td>
<td>• TOOL FOR DOME REMOVAL</td>
</tr>
<tr>
<td></td>
<td>• TOOL FOR FUEL TRANSFER, CASK TO GENERATOR</td>
</tr>
<tr>
<td></td>
<td>• SUBPACKAGE 2 CARRY PLACES RTG AWAY FROM SUIT</td>
</tr>
<tr>
<td>NUCLEAR:</td>
<td>• PU 238 IS $\alpha$ Emitter</td>
</tr>
<tr>
<td></td>
<td>• $\alpha$ PARTICLES ARE ENTIRELY ABSORBED IN HEAT GENERATION</td>
</tr>
<tr>
<td></td>
<td>• ONLY SECONDARY TYPES ($\gamma$ &amp; NEUTRONS) GET OUT</td>
</tr>
<tr>
<td></td>
<td>• LOW EXTERNAL FIELD, VERY LOW DOSE LEVEL</td>
</tr>
<tr>
<td>ELECTRICAL:</td>
<td>• RTG CABLE HAS SHORTING SWITCH IN CONNECTOR</td>
</tr>
<tr>
<td></td>
<td>• NO EXPOSED CHARGED CONTACTS</td>
</tr>
<tr>
<td></td>
<td>• ASTRONAUT READS AMMETER, REMOVES DUST COVERS,</td>
</tr>
<tr>
<td></td>
<td>ENGAGES CONNECTOR, &amp; ACTIVATES SWITCH</td>
</tr>
</tbody>
</table>

## OPERATIONS

PREPARE CASK FOR TRANSFER, 2 MIN; TRANSFER FUEL CAPSULE CASK TO GENERATOR, 1 MIN; DEPLOY SUBPACKAGE 2, UNREEL CABLE & MAKE CONNECTION, 2 MIN (ALL TIMES ARE APPROX)

APR 69 5178.3.25
APOLLO LUNAR HAND TOOLS

GEOLOGIC SAMPLING TOOLS

ASEPTIC SAMPLER
SPRING SCALE
HAMMER
SCOOP
CORE TUBE AND CAP
BRUSH/SCRIBER/HAND LENS
TONGS
CARRIER

SURVEYING & PHOTOGRAPHIC INSTRUMENTS

EARTH WT, 17.5 LB
GEOLGICAL TASKS WILL BE INDEPENDENT OF ALSEP DEPLOYMENT TASKS (NOT INC IN ALSEP TIME-LINE)

TENTATIVE

1 Gnomon
2 Surveying Instrument
3 Instrument Staff

APR 69 5178.3.26
PASSIVE SEISMIC CHARACTERISTICS

COMPONENTS

- POWER
- DSS & TIMING
- DATA
- COMMANDS
- CENTRAL ELECTRONICS
- IN CENTRAL STATION

THERMAL CONTROL ASS'Y

- STRUCTURE
- STOOL

INSTRUMENT ELECTRONICS & LEVELING

- SENSORS
- LP (3) & SP (1)

EXTERNAL (DEPLOYED) EQUIP

COMMUNICATIONS

- COMMANDS:
  - POWER OPER/STBY/OFF
  - 15 SPECIAL CMDs FOR:
    - UNCAGE (1)
    - AUTO & FORCED LEVEL (6)
    - CALIBRATE (2)
    - GAIN CHANGE (3)
    - AUTO & FORCED THERMAL CONTROL (1)
    - COARSE LEVELING SENSOR (1)
    - FILTER BYPASS (1)
  - BACKUP FROM TIMER TO UNCAGE & TO CALIBRATE SP

- DATA:
  - 43 DIGITAL WORDS PER ALSEP FRAME
  - 712 BPS (AVERAGE)
  - 98% SCIENCE, 2% HK
  - 1.2 SEC NORMAL REP RATE
  - 8 ANALOG ENG PARAMETERS SAMPLED ONCE PER 54-SEC ALSEP SEQUENCE

DISPLAY:
- SPECIAL SEISMIC ANALOG CHART
- 8-CHANNEL ANALOG (INC 1 TEMP)
- EVENT LIGHTS OR PRINTER/TV

OPERATIONS

DEPLOYMENT
- LOCATE 10 FT FROM CENTRAL STATION
- PLACE STOOL
- SET INSTRUMENT
- ROUGH LEVEL +5°
- ORIENT +20° WRT SHADOW (SCIENTIFIC)
- UNFOLD SHROUD
- REPORT ALIGN +5° WRT SHADOW

APPROX TIME, 3 MIN

POST DEPLOYMENT
- TURN ON (OPER) PRE-ASCENT
- UNCAGE (MAY BE PRE-ASCENT)
- FINE LEVEL
- CALIBRATE
- CHANGE GAINS
- RELEVEL AS NECESSARY
- CONTINGENCY CORRECTIVE ACTIONS

KEY FEATURES

- EARTH CALIBRATION REQUIRES REMOVAL OF 1/6 OF LUNAR MASS
- SENSORS CAGED BY PNEUMATIC RESTRAINT, RELEASED BY COMMAND (ARM/FIRE)
- SENSORS MOUNTED ON GIMBAL & CAPABLE OF CORRECTING INITIAL +5° ERROR BY LVL COMMANDS
- INDIVIDUAL HEATERS FOR CENTRAL ELECTRONICS & INSTRUMENT, "THERMOSTATICALLY" CONTROLLED

PHYSICAL PARAMETERS

- SIZE, IN:
  - INTERNAL: 7.2 x 6.5 x 2.8
  - EXTERNAL: 11.8 DIAM x 15.2 HIGH
- EARTH WT, LB: 25 TOTAL
- POWER, W: 7.5 (APPROX, MAX)

APR 69 5178.3.27
PASSIVE SEISMIC SENSORS

LONG PERIOD:
TRIAXIAL SET OF PENDULUMS WITH NATURAL FREQUENCY OF 1/15 CPS
SENSIVITY 10 $\mu$ (1 $\mu$ GOAL) WITH 80 db DYNAMIC RANGE
CAPACITANCE - TYPE DISPLACEMENT TRANSDUCERS
COIL - MAGNET DAMPING

SHORT PERIOD:
SINGLE VERTICAL SEISMMETER WITH FREE RESONANCE 1 TO 2 CPS
SENSIVITY 10 $\mu$ (1 $\mu$ GOAL) WITH 80 db DYNAMIC RANGE
COIL-MAGNET TRANSDUCER

TIDAL OUTPUT:
FEEDBACK FILTER ON LONG-PERIOD DATA
SENSIVITY: 320$\mu$ GAL VERTICAL (8$\mu$ GAL GOAL)
0.4 ARC SEC TILT (0.01 ARC SEC GOAL)

MODES OF OPERATION:
INDEPENDENT GAIN CHANGE BY COMMAND ON LP HORIZ,
LP VERTICAL, & SP (0, -10, -20, -30 db)

BASIC DATA WORD:
10-BIT WORD FOR EACH SENSOR READING
ACTIVE SEISMIC CHARACTERISTICS

**KEY FEATURES**
- **High Bit Rate (10.6 KBPS)**: Requires 85-ft MSFN antenna (on request)
- Explosives have safe/arm protection features
- Grenades launched to 500, 1000, 2000 & 5000 ft range from geophones
- Charge equivalent to 150 milligram TNT in thumper and up to 1.0 lb TNT in grenade
- Impact point of grenades determined by launch angle, initial launch velocity, & impact time
- Individual heater for mortar box, "thermostatically" controlled electronically

**PHYSICAL PARAMETERS**
- **Central Electronics**: Size, in. (THUMPER/GEOPHONES: 14.5 (folded)
  | MORTAR PACKAGE: 15.6 x 11.5 x 5.1) (irregular)
- **Earth WT, LB**: 25.00 total
- **Power, W**: 8 (approx. operating)

**OPERATIONS**
- **Deployment & Thumper**
  - Emplace mortar package
  - Place geophones at 10, 160 & 310 ft from central station
  - Activate thumper every 15 ft
  - Remove safety release assembly and actuate safe/arm switches on mortar box
  - Approximate time: 20 min

- **Post Deployment**
  - Note ground operations during deployment/thumper requiring turn-on, geophone calibrate, & turn-off
  - Later, monitor 15 min per week
  - Near year-end, turn on & calibrate geophones, arm & fire grenades
  - Other commands as necessary

**COMMUNICATIONS**
- **Data**
  - Special format (10.6 KBPS) provides 32 20-bit words (each has four 5-bit subwords)
  - Total 21 parameters
  - 75% science 25% HK (inc 5 key Alsep parameters)
  - In normal Alsep format, 4 analog ASE parameters sampled once per 34-sec Alsep sequence

- **Display**:
  - Data compressed to 2.4 KBPS line limit & displayed on analog chart

**COMMANDS**
- Power Oper/STBY/Off
- ASE HBR On/Off
- 7 Special Commands for:
  - Geophone Calibrate (1)
  - Arm Grenades (1)
  - Fire Grenades Regular (4)
  - Sequential (1)

**COMMENTS**
- Special format (10.6 KBPS) provides 32 20-bit words (each has four 5-bit subwords)
- Total 21 parameters
- 75% science 25% HK (inc 5 key Alsep parameters)
- In normal Alsep format, 4 analog ASE parameters sampled once per 34-sec Alsep sequence

**DISPLAY**:
- Data compressed to 2.4 KBPS line limit & displayed on analog chart

OCT 68 5178.3.29
ASE DETECTION SYSTEM

GEOPHONE (SENSORS)
  TYPE: ELECTROMAGNETIC
  NATURAL FREQUENCY: 7.5 CPS
  SENSITIVITY: 250 VOLT/METER/SEC
  WEIGHT: 6 OZ EACH SENSOR

AMPLIFIER
  3 CHANNELS EACH WITH PREAMP, FILTER AND LOG COMPRESSOR
  80 DB DYNAMIC RANGE LOG COMPRESSED TO 40 DB
  LOG COMPRESSOR TEMPERATURE CONTROLLED

GEOPHONE & AMPLIFIER
  SENSITIVITY: 5 m\(\mu\) PEAK DISPLACEMENT AT 10 Hz (1 m\(\mu\) GOAL)
  AT A SIGNAL TO NOISE RATIO OF 18 db
  BANDWIDTH: 3 TO 250 Hz WITH RESPECT TO VELOCITY

BASIC DATA WORD
  5-BIT WORD FOR EACH SENSOR READING AT 500 SAMPLES/SEC
  (EACH CHANNEL)

APR 69 5178.3.30
THUMPER CHARACTERISTICS

- 22 POSITION SELECTOR SWITCH (INC OFF)
- SEPARATE ARM/FIRE SWITCH
- USES APOLLO STANDARD INITIATORS (AS1s)
- IMPACT PLATE IN LOWER END TO CONTAIN AS1 DEBRIS
MAGNETOMETER CHARACTERISTICS

### Components
- **Power Commands & Timing**
- **DSS**
- **EGRU**
- **Electronics**
- **Mechanical**
- **Sensors**
- **Leveling Legs**
- **Structure/Thermal**
- **Booms**

### Communications
- **Commands:**
  - Power On/Off (No STBY)
  - 8 Special CMDs:
    - Site Survey (1)
    - Flip/Cali (2)
    - Range Change (1)
    - Percentage Offset (2)
    - Select Thermal Control Sensor (1)
    - Filter Bypass (1)
- **Data:**
  - 7 Digital Words per ALSEP Frame
  - 116 BPS (Average)
  - 86% Science, 14% HK
  - 9.6 SEC Rep Rate
  - No Analog Outputs

### Physical Parameters
- **Size:** 25 x 12 x 11 (irregular)
- **Earth WT:** 194 lb
- **Power, W:** 5.8 (Day) 10.9 (Night)

### Key Features
- Sensor Calibration on Earth requires special flux tanks to avoid sensor saturation.
- Flip/Cali cycle must be performed every 12 hr & every 3°C temp change to remove drifts (temp, etc.) & avoid permanent offset of sensor.
- Site survey mode activated only once near start of mission (between 4th & 5th flip/cali only).
- Contamination limit less than 0.25 gamma from all other ALSEP equip & LM descent stage during prelaunch & flight, less than 1 Gauss magnetic exposure.
- **Thermostatically controlled heaters in sensor heads.** Electronics must operate essentially continuously.

### Deployment
- Locate 50 ft from central station (away from LMI)
- Set and adjust leveling legs ± 5°
- Unfold Booms
- Orient + 5° wrt shadow (scientific and thermal)
- Report align ± 5°

### Post Deployment
- Turn on OPER! pre-ascent
- Flip/Cali
- Site survey after ascent
- Change range
- Adjust offset
- Contingency corrective actions

**Approximate Time:** 8 min

**APR 69 5178.3.32**
MAGNETOMETER SENSORS

SENSOR TYPE: FLUX GATE
FULL SCALE RANGE: ± 100, ± 200, ± 400 GAMMA (SELECTED BY COMMAND); EARTH'S EQUATORIAL FIELD ≈ 35,000 GAMMA (1 GAUSS = 10^5 GAMMA)
RESOLUTION: 0.2 % FULL SCALE
ACCURACY: 0.5 % FULL SCALE
FREQUENCY RESPONSE: APPROX 1.5 CPS
MODES OF OPERATION: MANY COMBINATIONS OF RANGE & OFFSET
  NORMAL ORIENTATION: ORTHOGONAL
  SITE SURVEY: SPECIAL MODE IN WHICH SENSORS ARE GIMBALLED 90° AND ROTATED SO THAT ALL THREE POINT SEQUENTIALLY ALONG X, Y, & Z AXIS
BASIC DATA WORD: 10-BIT WORD FOR EACH SENSOR READING, INCLUDING 9-BIT VALUE PLUS POLARITY (SIGN) BIT
SOLAR WIND SPECTROMETER CHARACTERISTICS

COMPONENTS

- POWER COMMANDS & TIMING
- ELECTRONICS
- RELEASE
- SENSORS (7)
- DUST COVERS
- STRUCTURE/ THERMAL
- DATA
- LEGS

PHYSICAL PARAMETERS

- SIZE, in.: 11 X 9 X 14.75
- EARTH WT, lb: 12.25
- POWER, W: 6.5 (APPROX)

OPERATIONS

DEPLOYMENT
- LOCATE 13 FT FROM CENTRAL STATION (PREFERABLY N-S)
- EXTEND LEVELING LEGS
- LEVEL +5°
- ORIENT +5° WRT SHADOW (SCIENTIFIC & THERMAL)
- APPROX TIME, 1 MIN

POST DEPLOYMENT
- TURN ON (OPER) MAY BE PRE-ASCENT
- READ BASE LINE DATA
- AFTER ASCENT, REMOVE DUST COVERS
- HIGH GAIN MODE
- NO OTHER COMMAND FUNCTIONS

COMMANDS:
- POWER OPER/STBY/OFF
- 1 SPECIAL CMD FOR DUST COVER REMOVAL (ALSO USED TO OBTAIN HIGH GAIN MODE)

COMMUNICATIONS

- DISPLAY: PRINTER
- DATA:
  - 4 DIGITAL WORDS PER ALSEP FRAME
  - 66 BPS (AVERAGE)
  - 72% SCIENCE, 18% HK
  - 449 SEC NORMAL REP RATE
  - NO ANALOG OUTPUTS

DATA:

- NO ANALOG OUTPUTS

KEY FEATURES

- REQUIRES CLEAR HEMISPHERE OF SPACE, OBSTRUCTIONS SUCH AS CENTRAL STATION SHOULD BE LOCATED IN ZONE OF REDUCED SENSOR SENSITIVITY
- "THERMOSTATICALLY" CONTROLLED HEATER

JAN 69 5178.3.34
SWS SENSORS

MODES OF OPERATION: INTERNAL PROGRAM STEPS SENSORS THROUGH 21 LEVELS (14 POS & 7 NEG)

BASIC DATA WORD: 8-BIT WORD FOR EACH SENSOR READING WITH TWO FLAG BITS FOR ID

SENSOR TYPE: FARADAY CUPS (7)
FIELD OF VIEW: APPROX 57° EACH
RANGE: ELECTRONS 6 TO 1330 ev, POSITIVE IONS 18 TO 9980 ev
   READ OUT AS CURRENTS FROM $10^{-12}$ TO $10^{-8}$ amps (LOGARITHMIC)

DIRECTIONALITY: BY ANALYSIS OF DIFFERENT SENSORS CAN DETERMINE FLUX DIRECTION ±15°
SUPRATHERMAL ION DETECTOR CHARACTERISTICS

COMPONENTS

- POWER COMMANDS & TIMING
- ELECTRONICS (SIDE & CCIG)
- COLD CATHODE GAUGE
- SENSORS (HI & LO ENERGY)
- STRUCTURE/ THERMAL
- GROUND PLANE
- LEVELING STRUCTURE
- DUST COVER

KEY FEATURES

- HIGH & LOW ENERGY SENSORS CANNOT OPERATE IN ATMOSPHERE (CALIBRATE IN VACUUM)
- CCIG SEALED PRELAUNCH, SQUIB-ACTUATED RELEASE MECHANISM (SEAL BREAK COMMAND)
- CCIG MAGNET SHIELDED TO AVOID INTERFERENCE WITH OTHER INSTRUMENTS
- CONTAMINATION AT SIDE LOCATION MUST BE LESS THAN 0.01 GAUSS & 1 V/M (DC TO 10 Hz)
- DETECTOR ORIENTATION AWAY FROM SUB-EARTH POINT, CCIG ORIFICE AWAY FROM ALSEP, LM & EARTH
- "THERMOSTATICALLY" CONTROLLED HEATER IN DETECTOR PACKAGE

OPERATIONS

DEPLOYMENT

- LOCATE 55 FT FROM CENTRAL STATION (AWAY FROM LSM)
- SET GROUND PLANE
- REMOVE & PLACE (ORIENT) CCIG
- LEVEL SIDE +5°
- ORIENT +5° WRT SHADOW (SCIENTIFIC & THERMAL)

APPROX TIME, 4 MIN

POST DEPLOYMENT

- TURN ON (OPER) SIDE POST-ASCENT
- READ BASE LINE DATA
- REMOVE DUST COVER, BREAK CCIG SEAL, READ DATA
- CONTINGENCY CORRECTIVE ACTIONS (CHANGE SIDE MODES)

COMMUNICATIONS

COMMUNICATIONS

COMMANDS:

- POWER OPER/STBY/OFF
- 5 SPECIAL CMDS MULTIPLEXED (4 LOADS & 1 EXECUTE)
- CMDS PERFORM:
  2 ONE-TIME FUNCTIONS
  • REMOVE DUST COVER
  • BREAK SEAL
  15 REPETITIVE FUNCTIONS
  • CALIBRATE (1)
  • CHANGE MODES (9)
  • TURN EQUIP ON/OFF (5)
  • BACKUP FROM TIMER FOR DUST COVER & SEAL BREAK AND PWR TURN ON EVERY 12 HRS (FLT NO. 1)

DATA:

- 5 DIGITAL WORDS PER ALSEP FRAME
- 83 BPS (AVERAGE)
- 40% SCIENCE, 60% HK
- 155 SEC BASIC REP RATE
- 3711 SEC FULL CYCLE NORMAL
- 2 ANALOG CHANNELS OF SCIENCE DATA SAMPLED ONCE PER 54-SEC ALSEP SEQUENCE

DISPLAY: PRIMARILY PRINTER

DATA:

- PHYSICAL PARAMETERS

  SIZE, IN.: 15.3 x 13.0 x 4.5
  EARTH WT, LB: 19.6
  POWER, W: 6.0 (APPROX)

JAN 69 5178.3.36
# Side Sensors

<table>
<thead>
<tr>
<th>Sensor Type</th>
<th>Ion Detector</th>
<th>Cold Cathode Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field of View</td>
<td>30° x 6°</td>
<td>NA</td>
</tr>
<tr>
<td>Range</td>
<td>Positive Ions 10 to 3500 ev</td>
<td>Positive Ions 0.2 to 48.6 ev **</td>
</tr>
<tr>
<td>Directionality</td>
<td>Detector Axes 15° off Vertical Reference (Parallel)</td>
<td>Orifice Horizontal, Preferably South</td>
</tr>
<tr>
<td>Modes of Operation</td>
<td>Programmed Steps, Variable by Command. Also ×10 Integration for Low Flux Levels</td>
<td>Three Overlapping Ranges Automatically Selected by Internal Logic</td>
</tr>
<tr>
<td>Basic Sensor Data Word</td>
<td>2 10-Bit Words, Each Limited to 999 Decimal, Hence Max Particle Count 999,999</td>
<td>8-Bit Word for Each Sensor Reading, Multiplexed with Side HK</td>
</tr>
</tbody>
</table>

*Velocity Selector (Crossed Electric/Magnetic Fields) on Low Energy Detector

**1 to 130 AMU per Unit Charge

Ground Plane Steps Through 24 Voltage Levels (11 Pos, 11 Neg, & 2 Zeros) ± 27.6V, Max

APR 69 5178.3.37
HEAT FLOW CHARACTERISTICS

COMPONENTS

- POWER COMMANDS & TIMING
- PROBE EMPLACEMENT TOOL
- ELECTRONICS
- APOLLO LUNAR SURFACE DRILL
- PROBES (2)
- STRUCTURE/ THERMAL

OPERATIONS

DEPLOYMENT
- LOCATE ELECTRONICS 30 FT FROM CENTRAL STATION
- LEVEL ±12°
- ALIGN ±5° WRT SHADOW (THERMAL)
- DRILL HOLES (2) 3 METERS DEEP & PLACE PROBES IN BOTTOM OF HOLES USING TOOL
- HOLES 30 FT APART & 16 FT FROM ELECTRONICS
- APPROX TIME, 9 MIN, PLUS 30 MIN FOR DRILLING

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 CMDS FOR:
  - SELECT GRADIENT, HI CONDUCTIVITY, OR LO CONDUCTIVITY MODES (3)
  - SELECT MEASUREMENT SEQUENCE (6)
  - SELECT & ACTIVATE CONDUCTIVITY HTRS (1)

DATA:
- 1 DIGITAL WORD PER ASEPB FRAME (FOR 16 OUT OF EVERY 90 FRAMES)
- 3.0 BPS (APPROX)
- 60% SCIENCE, 30% HK
- 435 SEC REP RATE (FULL SEQUENCE)
- 6 ANALOG ENG PARAMETERS SAMPLED ONCE PER 54 SEC ASEPB SEQUENCE

DISPLAY: X-Y PLOTTER OR PRINT (REQUIRES DATA ANALYSIS)

APR 69 5178.3.38

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)
- ELECTRONICS 13 x 9 x 8
- PROBES 25.5 x 4.5 x 3.5 (IN PACKAGE)
- EARTH WT, LB: 9.7 LB (TOTAL)
- POWER, W: 3.9 TO 10.6

DATA:
- 1 DIGITAL WORD PER ASEPB FRAME (FOR 16 OUT OF EVERY 90 FRAMES)
- 3.0 BPS (APPROX)
- 60% SCIENCE, 30% HK
- 435 SEC REP RATE (FULL SEQUENCE)
- 6 ANALOG ENG PARAMETERS SAMPLED ONCE PER 54 SEC ASEPB SEQUENCE

DISPLAY: X-Y PLOTTER OR PRINT (REQUIRES DATA ANALYSIS)
HEAT FLOW SENSORS

DIURNAL VARIATION
WITH SUPERIMPOSED
HI-ORDER EFFECTS

ANNUAL VARIATION
(DUE TO MOON'S ORBIT)

• 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)
• THERMCOUPLER 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

APR 69 5178.3.39
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)
- APPROX 40 MIN FOR PREPARATION,
  DRILL WITHDRAWAL, & ENCASEMENT
- INSTALLATION/REMOVAL OF SHEATH
  (CASING) IN UNCONSOLIDATED MA-
  TERIAL TBD

TENTATIVE

JAN 69 5178.3.40
CHARGED-PARTICLE EXPERIMENT CHARACTERISTICS

PHYSICAL PARAMETERS
SIZE, IN: 11.3 x 8.5 x 4.5
EARTH WT, LB: 5.8
POWER, W: (APPROX) 6.1 NIGHT MAX

COMPONENTS
POWER COMMANDS & TIMING EXPERIMENT ELECTRONICS
DATA SENSORS (2 SETS OF 6) DUST COVER
LEGS STRUCTURE/HEAT

KEY FEATURES
SENSORS CANNOT OPERATE AT ATMOSPHERIC PRESSURE (CALIBRATE IN VACUUM)
THERMOSTATICALLY CONTROLLED HEATER

POWER

PHYSICAL PARAMETERS

COMMANDS:
- POWER OPER/STBY/OFF
- 8 SPECIAL CMDS FOR:
  - DUST COVER REMOVAL (1)
  - AUTO/CMD THERMAL CONTROL (2)
  - AUTO/CMD VOLTAGE PROGRAM TO SENSOR (3)
  - CHANGE SENSOR GAIN (2)
- BACKUP FROM TIMER TO REMOVE DUST COVER

DATA:
- 6 DIGITAL WORDS PER ALSEP FRAME
  - 99 BPS (APPROX)
  - 97% SCIENCE, 3% HK
  - 19.3 SEC NORMAL REP RATE
- 6 ANALOG ENG PARAMETERS
  - SAMPLED ONCE PER 54-SEC ALSEP SEQUENCE

DISPLAY: PRINTER/TV

OPERATIONS

DEPLOYMENT
- LOCATE 10 FT FROM CENTRAL STATION
- LEVEL ± 2.5
- ALIGN ± 2° WRT SHADOW (SCIENTIFIC & THERMAL)

APPROX TIME, 2 MIN

POST DEPLOYMENT
- TURN ON OPER/ PRE-ASCENT
- READ BASELINE DATA (COVER ON)
- AFTER ASCENT REMOVE DUST COVER
- CONTINGENCY CORRECTIVE ACTIONS

APR 69 5178.3.41
CHARGED-PARTICLE EXPERIMENT SENSOR

SENSOR TYPE: CHANNELTRON® ELECTRON MULTIPLIER

PHYSICAL ANALYZERS

FIELD OF VIEW: 4° x 20°

ENERGY RANGE: 40 eV TO 70 keV

FLUX LEVEL: 10^5 TO 10^{10} PARTICLES/CM^2/SEC/STERADIAN

MODES OF OPERATION: INTERNAL PROGRAM STEPS

DEFLECTION VOLTAGE THROUGH 8 LEVELS

(±35, ±350, ±3500, BACKGROUND & CAL)

BASIC DATA WORD: 19-BIT COUNTERS FOR EACH

OF 4 C-TYPE & 20-BIT COUNTERS FOR 1 C-TYPE

& HELIX

EACH READING COVERED BY 2 ALSEP WORDS

WITH FLAG (ID) IN 20TH BIT WHEN AVAILABLE

PARTICLES IN COLLIMATING SLITS

DEFLECTION PLATES

HELIX TYPE

ELECTRON MULTIPLIER

C-TYPE

PHYSICAL ANALYZER

2/CPL (ONE VERTICAL & ONE 60° OFF VERTICAL)

OCT 68 5178.3.42
SEISMIC EXPERIMENT SUMMARY

TIDAL DATA

INCREASING DISTANCE TO SOURCE OF ACTIVITY

PSE LONG PERIOD
250 TO 0.3 SEC

PSE SHORT PERIOD
5 TO 0.04 SEC

ASE
3 TO 250 Hz

FREQUENCY, CYCLES/SEC (Hz)

PERIOD, SEC

DEC 67 5178.3.43
PARTICLE EXPERIMENTS SUMMARY

LEGEND:
- Indicates measures in two directions
- Indicates measures in seven directions

LOW-ENERGY SOLAR COSMIC RAYS
MAGNETOSPHERIC TAIL
THERMALIZED SOLAR WIND
SOLAR WIND
ELECTRONS
POSITIVE IONS
SOLAR WIND
SOLAR WIND ELECTRONS
POSITIVE SOLAR IONS WIND

SOLAR WIND SPECTROMETER
SUPRATHERMAL ION DETECTOR
LECPA
PLUS VELOCITY FILTERING (CAN DETERMINE MASS)
HECPA
CHARGED-PARTICLE LUNAR ENVIRONMENT

JAN 69 5178.3.44
LEVEL AND ALIGN INDICATORS

**BUBBLE**
- Ring on face indicates required setting
- Used on: Antenna LSM SIDE CPLEE
- PSE has ball

**COMPASS**
- Used on: Antenna
- LSM
- Sun
- Tool
- CPLEE

**PAINT**
- Shadow cast by sensor head
- Used on: PSE, SWS, (side subearth) HFE & CPLEE
- LSM
- East
- N & S (plus → E on top)
- SWS

**APR 69 5178.3.45**
CABLES, REELS AND CONNECTORS

CONDUCTORS (COPPER)
WIDTH 0.025 IN.
THICKNESS 0.002 IN.
SPACING 0.050 IN. CENTER TO CENTER
EQUIV #32 AWG
RESISTANCE:

<table>
<thead>
<tr>
<th>TEMP °C</th>
<th>OHMS/1000 FT</th>
</tr>
</thead>
<tbody>
<tr>
<td>-175</td>
<td>4.4</td>
</tr>
<tr>
<td>20</td>
<td>18.8</td>
</tr>
<tr>
<td>125</td>
<td>26.5</td>
</tr>
</tbody>
</table>

MUTUAL CAPACITANCE: 5 PF/FT

INSULATION ('KAPTON'H-FILM, FEP TEFON SANDWICH)
KAPTON: 0.002 IN. THICKNESS (OUTER)
FEP TEFON: 0.002 IN. THICKNESS (INNER)
RESISTANCE: $3 \times 10^6$ MEG OHMS/FT

CABLE
WEIGHT ≈ 0.5 LB/1000 FT/CONDUCTOR
ALSEP USES OVER 4000 CONDUCTOR-FT
(SAVES 10 LB COMPARED TO ROUND CABLE)
USES MULTIPLE CONDUCTORS IN PARALLEL
FOR HEAVY CURRENTS
CONNECT EVERY OTHER LEAD FOR SHIELDING

SPECIAL CABLE FOR RTG
SPECIAL CONNECTORS FOR RTG & SIDE
(TO BE MATED ON THE MOON)

JAN 69 5178.3.46
# Astronaut Provisions

## Constraints

<table>
<thead>
<tr>
<th>Activity</th>
<th>Biomed</th>
<th>Temp</th>
<th>Puncture</th>
<th>Mobility</th>
<th>Dexterity</th>
<th>Visual</th>
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</thead>
<tbody>
<tr>
<td>Unloading from LM</td>
<td>S</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td></td>
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<tr>
<td>RTG Fuel Transfer</td>
<td></td>
<td>P</td>
<td>P</td>
<td>S</td>
<td></td>
<td></td>
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<tr>
<td>300-FT Traverse</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
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<td></td>
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<tr>
<td>Elect Connections</td>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equip Disassembly</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exper Carry</td>
<td>P</td>
<td>P</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level &amp; Align</td>
<td></td>
<td></td>
<td>P</td>
<td>P</td>
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<tr>
<td>Antenna Align</td>
<td>P</td>
<td>P</td>
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<td>Backup Switches</td>
<td></td>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
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</tr>
</tbody>
</table>

## Comments
- Thermal Shield for Cask
- Special Tools
- Barbell Carry (Suitcase Backup)
- 2(RTG & SIDE)
- Special Tool; Boyd Bolt Fastener
- Special Tool
- Bubble, Sun Compass, Paint
- Special Knobs & Dials; On Mast
- Mainly Backup; Tool Operated

---

**Legend**

- **P** = Primary Consideration
- **S** = Secondary Consideration
# WEIGHT SUMMARY

**FOR ALSEP 1**

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>SUBPACKAGE 1</th>
<th>SUBPACKAGE 2</th>
<th>EXTERNAL</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRUCTURE/ THERMAL</td>
<td>25.49</td>
<td>21.73</td>
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<td>47.22</td>
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<tr>
<td>POWER</td>
<td>5.07</td>
<td>28.62</td>
<td>60.0</td>
<td>93.69</td>
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<tr>
<td>DATA</td>
<td>33.47</td>
<td>2.06</td>
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<td>35.53</td>
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<tr>
<td>EXPER CABLES</td>
<td>2.06</td>
<td>1.68</td>
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<td>3.74</td>
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<tr>
<td>PSE</td>
<td>23.94</td>
<td>0.17</td>
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<td>24.11</td>
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<tr>
<td>LSM</td>
<td>17.55</td>
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<td>17.55</td>
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<td>SWS</td>
<td>11.68</td>
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<td>11.68</td>
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<tr>
<td>SIDE</td>
<td></td>
<td>19.41</td>
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<td>19.41</td>
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<td>SPECIAL TOOLS</td>
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<td>20.00</td>
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<td>20.00</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>119.26</strong></td>
<td><strong>93.67</strong></td>
<td><strong>60.0</strong></td>
<td><strong>272.93</strong></td>
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</tbody>
</table>

WEIGHT LEFT ON LM = 45 LB

DEC 67  5178.3.48
ALSEP 1 DAY TIME POWER

POWER, WATTS

DATA SUBSYSTEM

DECEMBER 1 5178.3.49
ALSEP 1 NIGHT POWER

WORST CASE: IF RTG OUTPUT IS LESS THAN 68.08 W, SOMETHING MUST BE SWITCHED OFF

PROPORTIONAL CONTROL OVER RANGE FROM 5.28 TO 7.58

SW SWS HTR USES OFF-PEAK POWER (MAX TOTAL 6.50)
ADDITIONAL 1 WATT FOR LSM FLIP/CAL EVERY 12 HR

POWER, WATTS

OCT 68 5178.3.50
# ALSEP 1 DATA SUMMARY

<table>
<thead>
<tr>
<th>Normal Bit Rate (1.06 KBPS)</th>
<th>SIT</th>
<th>POWER</th>
<th>DSS</th>
<th>PSE</th>
<th>LSM</th>
<th>SWS</th>
<th>SIDE</th>
<th>NOT USED</th>
<th>COMMENTS</th>
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<tbody>
<tr>
<td><strong>CMD</strong></td>
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<tr>
<td>POWER CONTROL</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3(a)</td>
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<tr>
<td>OTHER OPERATIONS</td>
<td>2</td>
<td>9</td>
<td>15</td>
<td>8</td>
<td>1</td>
<td>5</td>
<td>35</td>
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<tr>
<td><strong>NUMBER OF WORDS</strong></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>PER ALSEP FRAME</td>
<td>5(b)</td>
<td>43</td>
<td>7</td>
<td>4</td>
<td>5</td>
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<tr>
<td>PER EXPER FRAME</td>
<td>86</td>
<td>7</td>
<td>186</td>
<td>10</td>
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<tr>
<td><strong>REPEAT RATE (SEC)</strong></td>
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<td></td>
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<tr>
<td>BASIC FRAME</td>
<td>0.6</td>
<td>1.2</td>
<td>0.6</td>
<td>28.1</td>
<td>1.2</td>
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<tr>
<td>COMPLETE CYCLE</td>
<td>54</td>
<td>1.2</td>
<td>9.6</td>
<td>449</td>
<td>3710</td>
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<tr>
<td><strong>NUMBER OF PARAMETERS</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>HK, IN EXPER FORMAT</td>
<td>6(c)</td>
<td>1</td>
<td>25</td>
<td>92</td>
<td>195</td>
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<td>VARIOUS SETTINGS</td>
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<td>HK, IN ALSEP ADC</td>
<td>19</td>
<td>22</td>
<td>24</td>
<td>8(d)</td>
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<td></td>
<td></td>
<td>INC CAL SIGNALS</td>
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<tr>
<td>SCIENCE, IN ALSEP ADC</td>
<td>15</td>
<td>5</td>
<td>3</td>
<td>8</td>
<td>5</td>
<td></td>
<td></td>
<td>TOTAL 90</td>
<td></td>
</tr>
</tbody>
</table>

(a) MAY BE USED FOR TEST; (b) 5 DSS WORDS = ADC OUTPUT PLUS 6 PARAMETERS;
(c) SYNC, FRAME CNTR, BIT RT ID, ALSEP ID, CMD AS RCVD, CMD MAP;
(d) 8 PSE WORDS = 11 PARAMETERS

**DEC 67 5178.3.51**
ALSEP OPERATIONS

• PRELAUNCH PHASE: FROM START OF PRELAUNCH ACCEPTANCE TESTS TO COMPLETION OF INSTALLATION IN LAUNCH VEHICLE

• LUNAR SURFACE PHASE: CREW ACTIVITIES WHILE DEPLOYING ALSEP ON LUNAR SURFACE

• LUNAR MISSION PHASE: INITIAL START-UP ACTIVITIES AT MCC FROM FIRST COMMAND (XMTR ON) TO COMPLETION OF EXPERIMENT PREPARATION FOR NORMAL OPERATION (OVERLAPS APOLLO LUNAR MISSION)

• FORTY-FIVE DAY CONTINUOUS DATA PHASE: FROM COMPLETION OF EXPERIMENT PREPARATION FOR NORMAL OPERATION TO END OF 45TH DAY AFTER DEPLOYMENT

• ONE-YEAR ALSEP MISSION PHASE: FROM COMPLETION OF 45TH DAY AFTER DEPLOYMENT TO TERMINATION OF OPERATIONS (POSSIBLY TWO YEARS AFTER DEPLOYMENT)
PRELAUNCH PHASE

KSC ALSEP INTEGRATION

INSTALLATION IN LUNAR MODULE

RTG CASK LOADING

ALSD INSTALLATION
KSC ALSEP INTEGRATION

- CHECK OUT DATA SUBSYSTEM
- CHECK OUT AND INTEGRATE EACH EXPERIMENT
- INTEGRATED SYSTEM TEST

NETWORK TESTS CONDUCTED SEPARATELY
TESTS COMPLETED BEFORE F-60 DAYS
INSTALLATION IN LUNAR MODULE

- SLIDE IN
- LIFT AND INSERT PIP PINS
- CLOSE THERMAL DOOR

INSTALLATION FIXTURE

OCT 68 5178.4.4
ALSD INSTALLATION

- ALSD BATTERY MUST BE FRESH OR RECHARGED NEAR LAUNCH TIME
- ACCOMPLISHED BY INSTALLING CHARGED ALSD AT F-12 HR (APPROX)
  (ALSD HAS BEEN FIT-CHECKED PRIOR TO ALSEP INSTALLATION)
- ALSD HAND-CARRIED TO SEQ BAY
- OPEN SEQ BAY DOOR
- INSERT ALSD
- INSTALL PIP-PIN
- CLOSE SEQ BAY DOOR
LUNAR SURFACE PHASE

ALSEP DEPLOYMENT TASKS ASSOCIATED WITH LM

ALSEP DEPLOYMENT TASKS AT EXPERIMENT SITE

TRANSFER FUEL

PREPARE FOR TRAVERSE

REMOVE PACKAGES

DEPLOY CENTRAL STATION

DEPLOY ANTENNA

DEPLOY EXPERIMENTS

APR 69 5178.4.7
ALSEP DEPLOYMENT TIMELINE

• KEY TO MISSION PLANNING

• THIS TIMELINE IS FOR REFERENCE ONLY – THE FINAL TIMELINE WILL CONFORM TO THE FLIGHT PLAN

• ALSEP 1 TIMELINE, 2-MAN EVA

LEGEND:

--- EVENT LINE

TEAM ACTIVITY. BOTH EVA CREWMEN REQUIRED TO ACCOMPLISH A GIVEN TASK

COUPLED ACTIVITY. BOTH CREW MEMBERS ARE WORKING ON RELATED TASKS AND ARE IN VOICE COMM WITH EACH OTHER. VISUAL CONTACT BETWEEN CREWMEN IS HIGHLY DESIRABLE BUT NOT MANDATORY

UNCOUPLLED ACTIVITY. CREW MEMBERS WORKING ON UNRELATED TASKS AND PROCEEDING INDEPENDENTLY

OCT 68 5178.4.8
ACTIVITY TIMELINE

CREW PREPARATION ACTIVITIES NOT INCLUDED IN ALSEP TIMELINE:

- DESCENT TO SURFACE
- PLSS STATUS CHECKS
- EVA COMM CHECK
- OPEN SEQ BAY DOOR

ALSEP DEPLOYMENT ACTIVITIES START WITH CREW MEN ON SURFACE AND SEQ BAY DOOR OPEN
# ACTIVITY TIMELINE (CONT.)

<table>
<thead>
<tr>
<th>MIN : SEC</th>
<th>COMMANDER ACTIVITY</th>
<th>LM PILOT ACTIVITY</th>
<th>MCC &amp; REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>00:00</td>
<td>REMOVE PKG #1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(54 SEC)</td>
<td>REPORT: PKG #1 OUT</td>
<td>ACK &amp; LOG</td>
</tr>
<tr>
<td>00:54</td>
<td>RELOCATE PKG #1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(15 SEC)</td>
<td>REPORT: PKG #2 OUT</td>
<td></td>
</tr>
<tr>
<td>00:55</td>
<td>MONITOR FOR SAFETY</td>
<td>REMOVE PKG #2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(53 SEC)</td>
<td></td>
</tr>
<tr>
<td>02:02</td>
<td>REPORT: PKG #2 OUT</td>
<td>RELOCATE PKG #2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(11 SEC)</td>
<td></td>
</tr>
<tr>
<td>02:03</td>
<td>MONITOR FOR SAFETY</td>
<td>REMOVE ALHT</td>
<td>ACK &amp; LOG</td>
</tr>
<tr>
<td></td>
<td>RESTOW BOOMS</td>
<td>(42 SEC)</td>
<td>(REMOVE PACKAGES)</td>
</tr>
<tr>
<td></td>
<td>(30 SEC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CLOSE SEQ BAY DOOR</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(01 MIN)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TENTATIVE</td>
<td>OBTAIN &amp; STOW GEOLOGICAL TOOLS</td>
<td>REMOVE &amp; DEPLOY ALSEP TOOLS</td>
<td>ACK &amp; LOG</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(01 MIN 30 SEC)</td>
<td></td>
</tr>
<tr>
<td>04:26</td>
<td>REPORT: READY FOR FUEL TRANSFER</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**April 69 5178.4.10**
REMOVE PACKAGES

• REMOVE PKG #1
  RETRIEVE BOOM LANYARD, PULL
  PKG OUT & LOWER WITH BOOM.
  RELEASE PKG & PLACE IN
  TEMPORARY LOCATION

• REPEAT FOR PKG #2

• RELEASE & REMOVE ALHT
• RETRIEVE DOOR LANYARD &
  LOWER DOOR
• REMOVE & DEPLOY TOOLS
  REMOVE PULL PINS, RETRIEVE
  TOOLS AND PLACE IN NEW
  LOCATIONS, MATE MAST TO PKG #1

APR 69  5178.4.11
<table>
<thead>
<tr>
<th>MIN : SEC</th>
<th>COMMANDER ACTIVITY</th>
<th>LM PILOT ACTIVITY</th>
<th>MCC &amp; REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>04:27</td>
<td>CONTINUE STOWING GEOLOGICAL TOOLS</td>
<td>ROTATE PKG #2 UPRIGHT &amp; REMOVE SUBPALLE (40 SEC)</td>
<td>(TRANSFER FUEL)</td>
</tr>
<tr>
<td></td>
<td>MONITOR FOR SAFETY &amp; SUPPLY TOOLS</td>
<td>ROTATE FUEL CASK (43 SEC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>REMOVE CASK DOME (26 SEC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TENTATIVE</td>
<td>TRANSFER FUEL CAPSULE (01 MIN 08 SEC)</td>
<td></td>
</tr>
<tr>
<td>07:24</td>
<td>REPORT: RTG FUELED</td>
<td>ACK &amp; LOG</td>
<td></td>
</tr>
<tr>
<td>07:25</td>
<td>RETRIEVE SUBPALLE (16 SEC)</td>
<td>ASSEMBLE BARBELL CONFIGURATION (27 SEC)</td>
<td>(PREPARE FOR TRAVERSE)</td>
</tr>
<tr>
<td>07:52</td>
<td>REPORT: START OF TRAVERSE</td>
<td>ACK &amp; LOG</td>
<td></td>
</tr>
<tr>
<td>07:53</td>
<td>CARRY SUBPALLE &amp; ALHT LEAD TRAVERSE</td>
<td>CARRY BARBELL</td>
<td>(TRAVERSE)</td>
</tr>
<tr>
<td></td>
<td>PICK ROUTE</td>
<td>REST AS NECESSARY (5 MIN 52 SEC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>REST AS NECESSARY (5 MIN 52 SEC)</td>
<td>ACK &amp; LOG</td>
<td></td>
</tr>
<tr>
<td>13:45</td>
<td>REPORT: TRAVERSE COMPLETE</td>
<td>ACK &amp; LOG</td>
<td></td>
</tr>
</tbody>
</table>

OCT 68 5178.4.12
TRANSFER FUEL

• ROTATE PKG #2 & REMOVE SUBPALLETT
  USE UHT TO ROTATE PKG #2 UPRIGHT
  RELEASE BOYD BOLTS, REMOVE SUBPALLETT FROM PKG #2

• ROTATE FUEL CASK FOR FUEL TRANSFER
  RETRIEVE CASK LANYARD
  ROTATE LEVERS
  PULL SPLINE
  ROTATE CASK TO DESIRED ANGLE

• REMOVE CASK DOME USING DRT

• TRANSFER FUEL CAPSULE
  ENGAGE FTT WITH CAPSULE
  LOCK TOOL TO CAPSULE TO RELEASE
  FROM CASK
  WITHDRAW CAPSULE
  LOWER INTO RTG
  RELEASE TOOL FROM CAPSULE TO
  LOCK IN RTG
PREPARE FOR TRAVERSE

- ROTATE & RE-ORIENT PKG #2
- JOIN MAST TO PKG #2
  (ALREADY MATED TO PKG #1)
TRAVERSE

- COMMANDER
  CARRIES SUBPALLETT & ALHT
  LEADS & PICKS ROUTE
- LM PILOT
  CARRIES ALSEP BARBELL
- REST, AS NECESSARY
- COMMANDER PICKS DEPLOYMENT SITE

APR 69 5178.4.15
<table>
<thead>
<tr>
<th>MIN: SEC</th>
<th>COMMANDER ACTIVITY</th>
<th>LM PILOT ACTIVITY</th>
<th>MCC &amp; REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>13:46</td>
<td>TEMPORARILY EMPLACE SUBPALLE</td>
<td>DEPLOY MAST/PKG #1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&amp; ALHT (14 SEC)</td>
<td>(22 SEC)</td>
<td>(DEPLOY</td>
</tr>
<tr>
<td></td>
<td>ROTATE PKG #2</td>
<td></td>
<td>CENTRAL</td>
</tr>
<tr>
<td></td>
<td>(9 SEC)</td>
<td>MONITOR FOR</td>
<td>STATION)</td>
</tr>
<tr>
<td></td>
<td>DEPLOY PKG #2</td>
<td>SAFETY</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(10 MIN 3 SEC)</td>
<td>(10 MIN 3 SEC)</td>
<td></td>
</tr>
<tr>
<td>15:12</td>
<td>REPORT: AMMETER</td>
<td>REMOVE SIDE/CCIG</td>
<td>ACK &amp; LOG</td>
</tr>
<tr>
<td></td>
<td>READING</td>
<td>&amp; CONNNECT CABLE</td>
<td>PET-ZERO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(41 SEC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ACTIVATE RTG SW</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2 SEC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>REPORT: RTG SW ON</td>
<td></td>
</tr>
<tr>
<td>15:13</td>
<td>CONNECT RTG TO</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CENT STA (02 SEC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DISCONNECT &amp; STOW</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MAST (58 SEC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16:13</td>
<td>Rotate PKG #1</td>
<td>DEPLOY PSE STOOL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(14 SEC)</td>
<td>(18 SEC)</td>
<td></td>
</tr>
<tr>
<td>16:14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16:28</td>
<td></td>
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</tr>
</tbody>
</table>

**MCC & REMARKS**

**APR 69 5178.4.16**
# Activity Timeline (Cont.)

<table>
<thead>
<tr>
<th>MIN: SEC</th>
<th>Commander Activity</th>
<th>LM Pilot Activity</th>
<th>MCC &amp; Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>16:29</strong></td>
<td><strong>Release SWS</strong> (32 SEC)</td>
<td><strong>Deploy SWS</strong> (01 MIN 22 SEC)</td>
<td><strong>ACK</strong> (DEPLOY CENTRAL STATION)</td>
</tr>
<tr>
<td></td>
<td><strong>Release PSE</strong> (32 SEC)</td>
<td><strong>Report: Alignment Complete</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Remove LSM</strong> (54 SEC)</td>
<td><strong>Ack</strong> (DEPLOY (EXPER)</td>
<td></td>
</tr>
<tr>
<td>TENTATIVE</td>
<td><strong>Release Sunshield</strong> (03 MIN)</td>
<td><strong>Report: Alignment Values</strong> (01 MIN 05 SEC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Deploy Sunshield</strong> (53 SEC)</td>
<td><strong>Ack</strong> (DEPLOY (ANTENNA)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Assemble Antenna</strong> (02 MIN 06 SEC)</td>
<td><strong>Deploy LSM</strong> (02 MIN 34 SEC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Confirm: AZ/EL Setting</strong> (02 MIN 07 SEC)</td>
<td><strong>Report: Alignment Values</strong></td>
<td><strong>Ack</strong> (DEPLOY (ANTENNA)</td>
</tr>
<tr>
<td></td>
<td><strong>Actuate SW-1</strong></td>
<td><strong>Deploy SIDE/CCIR</strong> (03 MIN 42 SEC)</td>
<td><strong>Give: AZ/EL Setting</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Request: XMT ON</strong></td>
<td><strong>Obtain Metric Photographs of Deployed ALSEP</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>If ALSEP Does Not Respond</strong></td>
<td><strong>Command: XMT ON</strong></td>
<td><strong>ACK &amp; Log</strong></td>
</tr>
<tr>
<td><strong>28:00</strong></td>
<td><strong>Actuate SW-2 and SW-3</strong></td>
<td><strong>Report: TM Status</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Report: SW Positions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TBD</td>
<td><strong>Return to LM</strong></td>
<td><strong>Return to LM</strong></td>
<td></td>
</tr>
</tbody>
</table>
DEPLOY CENTRAL STATION

- DEPLOY MAST/PKG #1
  - DISCONNECT MAST FROM PKG #2
  - CARRY MAST/PKG #1 10 FT
- DEPLOY PKG #2
  - ROTATE PKG #2 UPRIGHT & ALIGN E-W
  - READ AMMETER
- CONNECT RTG TO CENTRAL STATION
  - RELEASE BOYD BOLTS & REMOVE CABLE
  - PLUG IN CABLE
  - ACTIVATE RTG SWITCH

- REMOVE SIDE AND CONNECT CABLE
  - RELEASE/REMOVE SIDE FROM SUBPALLETS
  - TEMPORARILY PLACE ON SURFACE
  - PLUG IN CABLE
  - DISCONNECT MAST FROM PKG #1 & STOW TEMPORARILY
  - ROTATE PKG #1 UPRIGHT AND ALIGN E-W
- REMOVE EXPER AND DEPLOY SUNSHIELD
  - REMOVE PSE STOOL FROM SUBPALLETS & DEPLOY
  - REMOVE & DEPLOY SWS
  - REMOVE & DEPLOY PSE SENSOR
  - REMOVE LSM & PLACE TEMPORARILY ON SURFACE
  - RELEASE SUNSHIELD & ANTENNA BOYD BOLTS
  - USE TOOL TO CONTROL UPWARD (SPRING) MOTION OF SUNSHIELD
  - REMOVE & DISCARD CURTAIN COVERS

APR 69 5178.4.18
DEPLOY ANTENNA

- ASSEMBLE ANTENNA
  - INSTALL MAST ON CENTRAL STATION
  - INSTALL AIMING MECHANISM ON MAST
  - INSTALL ANTENNA ON AIMING MECHANISM

- ORIENT ANTENNA
  - ENTER COARSE & FINE ADJUSTMENTS IN AZIMUTH
  - ENTER COARSE & FINE ADJUSTMENTS IN ELEVATION
  - LEVEL AIMING MECHANISM BASE
  - ALIGN E-W WRT SHADOW
  - RECHECK LEVEL
# DEPLOY EXPERIMENTS

<table>
<thead>
<tr>
<th>SWS</th>
<th>PSE</th>
<th>LSM</th>
<th>SIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CARRY 13 FT</td>
<td>CARRY 10 FT</td>
<td>CARRY 50 FT</td>
<td>CARRY 55 FT</td>
</tr>
<tr>
<td>EXTEND LEVELING LEGS</td>
<td>REMOVE GIRDLE</td>
<td>DEPLOY SUPPORT LEGS</td>
<td>PLACE ON SURFACE</td>
</tr>
<tr>
<td>PLACE ON SURFACE (PARTIALLY SELF-LEVELING)</td>
<td>PLACE ON STOOL</td>
<td>PLACE ON SURFACE</td>
<td>DEPLOY GROUND SCREEN</td>
</tr>
<tr>
<td>ALIGN BY SHADOWS</td>
<td>UNFOLD SHROUD</td>
<td>UNFOLD SENSOR ARMS</td>
<td>RELEASE CC IG</td>
</tr>
<tr>
<td></td>
<td>LEVEL BY BALL INDICATOR</td>
<td>REMOVE PRA COVERS</td>
<td>EMPLACE SIDE ON GROUND SCREEN</td>
</tr>
<tr>
<td></td>
<td>READ ALIGNMENT</td>
<td>LEVEL BY BUBBLE</td>
<td>EMPLACE CC IG</td>
</tr>
<tr>
<td></td>
<td>BY Gnomon SHADOWGRAPH</td>
<td>ALIGN BY SHADOW</td>
<td>LEVEL BY BUBBLE</td>
</tr>
<tr>
<td></td>
<td>READ SHADOWGRAPH ALIGNMENT</td>
<td>ALIGN BY SHADOWS</td>
<td></td>
</tr>
</tbody>
</table>

**APR 69 5178.4.20**
MSFN/MCC OPERATIONS

- OPERATIONAL CONCEPT
- SCHEDULE OF MONITORING
- MCC MONITORING & CONTROL REQMTS
- OPERATIONAL PHASES
## SINGLE-ALSEP SCHEDULING

<table>
<thead>
<tr>
<th>TIME PERIOD</th>
<th>≈ F-70 DAYS</th>
<th>0-45 DAYS</th>
<th>45-365 DAYS</th>
<th>365-720 DAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTIVITIES AT MSFN SITES</td>
<td>NETWORK COMPATIBILITY TESTS (SEVERAL HOURS)</td>
<td>RECORD CONTINUOUSLY ALL ALSEP DATA</td>
<td>IF CONDITIONS WARRANT, ALSEP CAN BE LEFT ON UP TO 2 YR, TERMINATED BY ACCUTRON TIMER</td>
<td></td>
</tr>
<tr>
<td>MCC-H ACTIVITIES</td>
<td>MONITOR &amp; CONTROL CONTINUOUSLY</td>
<td>MONITOR &amp; CONTROL 2 HR PER DAY*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*ALSO LONGER PERIODS, UP TO 60 HR, DURING LUNAR SUNRISE & SUNSET; PLUS EXTENSION WHEN CONTINGENCIES OCCUR

DEC 67 5178.4.23
CMD AND TM SUMMARY

**BUILDING 4 ALSEPS FOR EARLY APOLLO LUNAR LANDINGS**

<table>
<thead>
<tr>
<th>UPLINK (CMD)</th>
<th>DOWNLINK (TM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• ONE FREQUENCY, 2119 MHz</td>
<td>• 4 DIFFERENT S-BAND FREQUENCIES ALLOCATED</td>
</tr>
<tr>
<td>• 8 DECODER ADDRESSES (2/ALSEP)</td>
<td></td>
</tr>
<tr>
<td>• 100 ALSEP COMMANDS, 65-75 USED ON ANY SINGLE ALSEP (7-BIT CMD ALLOWS 128, BUT 28 ARE NOT VALID)</td>
<td>• DATA RATES: 1.06 KBPS NORMAL, 0.53 KBPS CONTINGENCY (ALSEP 4 HAS ADDITIONAL 10.6 KBPS HBR SELECTED BY CMD; USED ONLY PERIODICALLY TO SUPPORT ASE; ASE REQMT ONCE/WK 15-30 MIN PLUS ∼ 1 HR WHEN CREW IS ON SURFACE &amp; ∼ 1 HR SEVERAL MONTHS LATER)</td>
</tr>
<tr>
<td>• ALL COMMANDS ARE RTC’S, NO 'LOAD' CAPABILITY IS REQUIRED; (SIDE USES 5 CMDs MULTIPLEXED, 4-CALLED LOADS-TO SET REGISTER &amp; 1 TO EXECUTE)</td>
<td>• 30-FT MSFN ANTENNA ADEQUATE FOR NORM BIT RT; 85-FT REQD FOR HBR</td>
</tr>
<tr>
<td>• NO TIME-CRITICAL CMDs EXCEPT PSE FORCED LEVELING (BACKUP TO AUTO MODE) WHERE CMD IS SENT TWICE WITH TIME INTERVAL ± 10 SEC</td>
<td>• ALSEP FRAME = 64 10-BIT WORDS (0.60377 SEC @ NORM BIT RT)</td>
</tr>
<tr>
<td>• MAX 1 CMD/SEC LIMITED BY DECODER</td>
<td>• CMD VERIFICATION WORD (INCMAP) APPEARS ONLY ONCE IN TM STREAM</td>
</tr>
</tbody>
</table>

APR 69 5178 4.24
MULTIPLE-ALSEP SCHEDULING

NETWORK TEST 1
F_1=70  PET_1=0  PET_1=45
SUNRISE 71  RISE

NETWORK TEST 2
PET_2=0
85  RISE 99  SET 113  RISE 127  SET 141  RISE 155  SET

NETWORK TEST 3
PET_3=0  PET_3=45
57  RISE 141  SET
169  RISE 183  SET 197  RISE 211  SET 225  RISE 239  RISE 253  SET 267  RISE 281  RISE 365  RISE

DECISION FOR ALSEP 1
155  RISE
393  RISE

DECISION FOR ALSEP 2
477  RISE
589  RISE

DECISION FOR ALSEP 3
491
505
603
715

TMRCUTOFF FOR ALSEP 1
827
949

TMRCUTOFF FOR ALSEP 2
963

DEC 67  5178.4.25
### MCC Monitoring and Control Requirements

#### Table

<table>
<thead>
<tr>
<th>Monitoring &amp; Control</th>
<th>Initial Start-up</th>
<th>0 to 45 Days</th>
<th>45 to 365 Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>PWR/Thermal</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Other Eng Status</td>
<td>H</td>
<td>M</td>
<td>C</td>
</tr>
<tr>
<td>Science</td>
<td>P</td>
<td>P+R</td>
<td>R</td>
</tr>
<tr>
<td>CMD Function Status</td>
<td>H</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>Send Commands</td>
<td>I+C</td>
<td>E+C</td>
<td>E+C</td>
</tr>
</tbody>
</table>

#### Legend

- **H** = High Priority
- **M** = Medium Priority
- **L** = Low Priority
- **C** = Contingency-Oriented
- **P** = Principal Investigator
- **R** = Routines, Preplanned
- **I** = Initial Tune-Up
- **E** = Environmental Changes (such as solar flares)

OCT 68 5178.4.26
LUNAR MISSION PHASE

- SYSTEM START-UP
- EXPERIMENT START-UP
- ACTIVITIES PHASED TO LM ASCENT
- PRE-SPLASHDOWN CONSTRAINTS
# SYSTEM START-UP

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>CREW: REQUESTS XMTR ON</td>
<td></td>
</tr>
<tr>
<td>MCC: CMD XMTR ON</td>
<td>NOTE: START-UP DEPENDS UPON RTG WARM-UP CYCLE.</td>
</tr>
<tr>
<td>MCC: VERIFY XMTR ON</td>
<td></td>
</tr>
<tr>
<td>MCC: ADVISE CREW &quot;XMTR ON&quot;</td>
<td></td>
</tr>
</tbody>
</table>

- THIS ACTIVITY MARKS BEGINNING OF LUNAR MISSION PHASE
- THIS IS THE ONLY CREW/MCC COUPLED ACTIVITY
  (THERE IS NO CREW TUNE-UP, CALIBRATION, ETC.)
EXPERIMENT START-UP TIMELINE

<table>
<thead>
<tr>
<th>HR:MIN</th>
<th>MCC ACTIVITY</th>
<th>STATUS</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>PSE</td>
<td>MONITOR POWER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LSM</td>
<td>RESERVE STATUS &amp; ADJUST PDR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SWS</td>
<td>LOADS BEFORE EACH NEW EXPER, IF NECESSARY</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SIDE</td>
<td>EXPER CHECKS CONTINUE CONCURRENTLY</td>
</tr>
<tr>
<td></td>
<td>CMD XMTR ON</td>
<td></td>
<td>LM ASCENT</td>
</tr>
<tr>
<td></td>
<td>RECEIVE TM</td>
<td>ading</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CHECK TM STATUS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CMD LSM OPER</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CHECK LSM STATUS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CMD PSE OPER</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CHECK PSE STATUS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* CMD SWS OPER</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CHECK SWS STATUS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* CMD SIDE OPER</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CHECK SIDE STATUS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CMD DUST ON</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CHECK DUST STATUS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CMD LSM RANGE &amp; OFFSET</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CMD LSM FLIP/CAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MONITOR FLIP/CAL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* MAY REQUEST SEVERAL DAYS VACUUM SOAK  

OCT 68 5178.4.29
## START-UP TIMELINE (CONT.)

<table>
<thead>
<tr>
<th>HR: MIN</th>
<th>MCC ACTIVITY</th>
<th>STATUS</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>PSE</td>
<td>MAY BE PRE-ASCENT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LSM</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SWS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SIDE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CMD PSE UNCAGE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CHECK PSE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CMD SIDE STBY</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CMD SWS STBY</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CMD PSE LEVEL</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CMD PSE GAIN</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CMD PSE CAL</td>
<td></td>
<td>AS NECESSARY FOR POWER MANAGEMENT DURING PSE LEVELING</td>
</tr>
<tr>
<td></td>
<td>CMD SWS OPER</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CMD SIDE OPER</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CMD LSM FLIP/CAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MONITOR FLIP/CAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CMD SWS COVER GO</td>
<td></td>
<td>REPEAT AS NECESSARY; SITE SURVEY MUST OCCUR BETWEEN 4TH &amp; 5TH FLIP/CAL</td>
</tr>
<tr>
<td></td>
<td>CMD SIDE COVER GO</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CMD CC1G SEAL BREAK</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CMD LSM SITE SURVEY</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MONITOR SURVEY</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FULL OPERATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TENTATIVE SEQUENCE**

OCT 68 5178.4.30
ACTIVITIES PHASED TO LM ASCENT

• LSM FLIP/CAL REQD APPROX 1 HR BEFORE ASCENT

• PSE UNCAGE MAY BE SCHEDULED BEFORE ASCENT

• MONITOR ALL SCIENTIFIC & ENGINEERING DATA BEFORE, DURING, & AFTER ASCENT TO DETERMINE EFFECTS OF LAUNCH (DUST DETECTOR IS A KEY MEASUREMENT)

• REMOVE DUST COVERS & BREAK COLD CATHODE GAUGE SEAL SHORTLY AFTER ASCENT

OCT 68 5178.4.31
PRE-SPLASHDOWN CONSTRAINTS

IF NECESSARY DURING CRITICAL APOLLO MANEUVERS, ALSEP XMTR MAY BE TURNED OFF. OTHER APOLLO PRIORITIES MAY TAKE PRECEDENCE OVER ALSEP PRIORITIES.
45-DAY CONTINUOUS DATA PHASE

- Monitor Engineering & Science data against limits
- Establish Engineering data trends for use during later intermittent operations
- Adjust experiments for optimum scientific data collection & changing environmental conditions as requested by the Principal Investigator
- Apply corrective commands for contingencies, as necessary
ONE-YEAR ALSEP MISSION PHASE

- Monitor engineering & science data against limits & trends established during previous continuous operations.
- Adjust experiments in accordance with routines prescribed by the principal investigators.
- Apply corrective commands for contingencies, as necessary.
- At year end, turn off XMTR or continue operations as directed.

DEC 67  5178.4.34
STRUCTURE/THERMAL SUBSYSTEM

- COMPONENTS & FUNCTION
- DEPLOYMENT
- COMMANDS & DATA

APR 69 5178.5.1
MECHANICAL CRITERIA

- WITHSTAND LOADS OF LAUNCH, FLIGHT, & LUNAR LANDING
- WITHSTAND LOADS ASSOCIATED WITH DEPLOYMENT
- SUPPORT THE EQUIPMENT ON THE LUNAR SURFACE

- HOLD SECURELY IN LOCKED POSITIONS
- RELEASE & FUNCTION DURING DEPLOYMENT

SPECIAL JIGS & SHIPPING CONTAINERS PROVIDE PROTECTION FOR PRELAUNCH HANDLING, TRANSPORTATION, & STORAGE
CENTRAL STATION THERMAL CONTROL

MECHANICAL

SUNSHEILD
REFLECTORS
CURTAINS (E-W)
HEATERS
ELECTRONICS
INSULATION
THERMAL PLATE (RADIATOR)

ELECTRICAL

DSS HTR 1
055
SEL

DSS HTR 2
057
OFF

DSS HTR 3
056
2 SEL

RETURN

THERMOSTAT
(OPERATES <0° F)

29 V

DSS HTR 3
024
ON

10 W

DSS HTR 3
025
OFF

10 W

RETURN

APR 69 5178.5.3
DUST DETECTOR

- To assess dust accretion on ALSEP & infer degradation of thermal surfaces
- Uses three 2 cm x 2 cm photocells, each having:
  - Blue filter to cut off UV below 0.4 microns
  - 0.060-in. fused silica radiation protection
  - Thermistor on rear to monitor temp

Note: At ALSEP turn-on, flip-flop can be either on or off

Amplifiers (3)

Data Subsystem
FASTENERS

BOYD BOLT
USED FOR TENSION & SHEAR CONNECTIONS:
EXPER/SUNSHIELD
SUNSHIELD/PRIMARY STRUCTURE

PIP PINS
SPRING-LOADED DETENT BALLS
USED FOR SHEAR CONNECTIONS:
SUBPALLETPALLET
ALSO PALLET TOOLS SUBPALLETPALLET

APR 69 5178.5.5
MAST/AIMING MECHANISM

TOP VIEW

REMOVABLE COVER

STUD

TAPER APPROX 2°
SUNSHIELD TIE-DOWN

RELEASE THIS FASTENER LAST

FASTENER LOCATIONS

LUNAR SURFACE

DEC 67 5178.5.10
EXTENDERS

TUBULAR EXTENDERS (4)
(HUNTER SPRING)
## Subpackage 1 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>Distance from LM</td>
<td>300 + 10 FT</td>
<td>2</td>
<td>May Have Range-Finder</td>
<td>Trade off of PLSS constraints against ascent stage blast</td>
</tr>
<tr>
<td>Direction from LM</td>
<td>Not Due E or W</td>
<td>2</td>
<td>Eyeball</td>
<td>Avoid walking into Sun or Shadow</td>
</tr>
<tr>
<td>Site Selection</td>
<td>Approx Horiz</td>
<td>1</td>
<td>Eyeball</td>
<td>Avoid craters and slopes for thermal and antenna stability</td>
</tr>
<tr>
<td>Level, WRT Indicator</td>
<td>Accept Local Slope</td>
<td>1</td>
<td>Bubble</td>
<td>Interacts with alignment</td>
</tr>
<tr>
<td>Align, WRT Shadow</td>
<td>$\pm 5^\circ$ E-W</td>
<td>1</td>
<td>Partial Rose (Null Line)</td>
<td>Thermal requirement; Rose allows $180^\circ$ rotation</td>
</tr>
<tr>
<td>Special Requirements</td>
<td>Selection of site should consider that most subsystems require approximately equal elevations for clear field of view (Scientific and Thermal).</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*200 FT distance gives zero theoretical safety margin, 300 FT gives 100%.
## Aiming Mechanism 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>Distance and Direction</td>
<td>NA</td>
<td>-</td>
<td>-</td>
<td>Attached to Subpackage 1</td>
</tr>
<tr>
<td>Level, WRT Indicator</td>
<td>±0.5° of Vertical</td>
<td>1</td>
<td>Bubble</td>
<td>Interacts with alignment</td>
</tr>
<tr>
<td>Align, WRT Shadow</td>
<td>±0.5° E-W</td>
<td>1</td>
<td>Null Line</td>
<td>Precludes 180° rotation</td>
</tr>
<tr>
<td>Special Requirements</td>
<td>Note that criteria are shown for base of aiming mechanism; azimuth-elevation gimbal settings are from special tables.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**APR 69 5178.5.13**
STRUCTURE/ THERMAL ALIGNMENT MARKINGS

EAST

SHADOW POST

SHADOW REFERENCE (PAINT)

BUBBLE LEVEL

ANTENNA

AFTER LEVELING, ROTATE THIS KNOB TO BRING SHADOW OF POST UP TO PAINT

DEC 67 5178.5.14
STRUCTURE/THERMAL TELEMETRY

HK-27 AT-01 SUNSHIELD 1 DEG F
HK-42 AT-02 SUNSHIELD 2 DEG F
HK-04 AT-03 THERM PLT 1 DEG F
HK-28 AT-04 THERM PLT 2 DEG F
HK-43 AT-05 THERM PLT 3 DEG F
HK-58 AT-06 THERM PLT 4 DEG F
HK-71 AT-07 THERM PLT 5 DEG F
HK-59 AT-08 PRI/ST W1 DEG F
HK-87 AT-09 PRI/ST W2 DEG F
HK-15 AT-10 PRI/ST B1 DEG F
HK-88 AT-11 PRI/ST W3 DEG F*
HK-60 AT-12 INSUL INT DEG F
HK-72 AT-13 INSUL EXT DEG F

HK-83 AX-01 DUST CELL 1 DEG F
HK-30 AX-02 DUST CELL 2 DEG F
HK-56 AX-03 DUST CELL 3 DEG F
HK-84 AX-04 DUST 1 OUT MV/CM2
HK-26 AX-05 DUST 2 OUT MV/CM2
HK-41 AX-06 DUST 3 OUT MV/CM2

ALL PARAMETERS SAMPLED
ONCE PER 54 SEC ALSEP SEQUENCE

* NOW LOCATED ON POWER DISSIPATION RESISTOR PANEL

APR 69 5178.5.15
STRUCTURE/THERMAL COMMANDS

OCTAL CMD NUMBER

027  DUST CELLS ON
CMD 027 IS A ONE-STATE CMD THAT ACTIVATES THE SOLAR CELL
OUTPUTS (3) OF THE DUST DETECTOR

031  DUST CELLS OFF
CMD 031 IS A ONE-STATE CMD THAT DEACTIVATES THE SOLAR CELL
OUTPUTS (3) OF THE DUST DETECTOR
NOTE THAT THERE IS EQUAL PROBABILITY OF THE DUST CELLS BEING
ON OR OFF WHEN ALSEP STARTS UP INITIALLY ON THE LUNAR SURFACE

055  DSS HTR 1 SEL
CMD 055 ACTUATES RELAY K-14 IN THE PDU APPLYING +29 VDC TO THE
10-WATT HTR IN THE CENT STA AND REMOVING +29 VDC FROM THE 5-WATT HTR

056  DSS HTR 2 SEL
CMD 056 ACTUATES RELAYS K-14 AND K-15 IN THE PDU APPLYING +29 VDC
TO THE 5-WATT HTR IN THE CENT STA AND REMOVING +29 VDC FROM THE
10-WATT HTR

057  DSS HTR 2 OFF
CMD 057 ACTUATES RELAY K-15 IN THE PDU REMOVING +29 VDC FROM THE
5-WATT HTR IN THE CENT STA. IF THE 10-WATT HTR IS ON, TRANSMISSION
OF THIS CMD WILL HAVE NO EFFECT

024  DSS HTR 3 ON
CMD 024 ACTUATES RELAY K-18 IN THE PDU APPLYING +29 VDC TO THE
THERMOSTATICALLY-CONTROLLED 10-WATT HTR IN THE CENT STA

025  DSS HTR 3 OFF
CMD 025 ACTUATES RELAY K-18 IN THE PDU REMOVING +29 VDC FROM THE
THERMOSTATICALLY-CONTROLLED 10-WATT HTR IN THE CENT STA

APR 69 5178.5.16
ELECTRICAL POWER SUBSYSTEM

• RADIOISOTOPE THERMOELECTRIC GENERATOR
  • COMPONENTS
  • PERFORMANCE
  • KEY FEATURES
• FUEL TRANSFER AND RTG DEPLOYMENT
• POWER CONDITIONING UNIT
  • FUNCTIONS AND PERFORMANCE
  • POWER/Thermal INTERACTIONS
• COMMANDS AND DATA
POWER GENERATING FUNCTION

- FUEL CAPSULE
- THERMOELECTRIC COUPLE ASSEMBLY
- COMPRESSION SPRING
- FOLLOWER
- HOT FRAME
- COLD FRAME
- INSULATION
- HEAT REJECTION FINS
- BORON NITRIDE INSERT
- HOT SHOE
- HOT FRAME
- COLD CAP
- PCU

TEMP TM TO DSS

- RADIOISOTOPE ENERGY SOURCE
- RADIAITIVE HEAT TRANSFER
- HOT FRAME
- THERMAL ENERGY
- RADIATIVE HEAT TRANSFER
- COLD FRAME
- CONDUCTIVE HEAT TRANSFER
- OUTER CASE & FINS
- THERMAL RADIATION TO SPACE

NOV 68 5178.6.2
RTG PERFORMANCE

OUTPUT POWER: 56.2 W (ONE YR) AND UP TO 74 W
OUTPUT VOLTAGE: 16 VDC (NOMINAL)
CURRENT: 4 AMP (APPROX)
OVERALL EFFICIENCY: 4 % (APPROX)
HOT JUNCTION TEMP: 1100 °F* (MAX)
COLD JUNCTION TEMP: 600 °F* (MAX)
FUEL CAPSULE THERMAL OUTPUT: 1430 TO 1520 W
FUEL CLAD TEMP: 1390 °F (MAX)

*LUNAR DAY (NIGHT PERF NEARLY SAME)
RTG DAY/NIGHT EFFECTS

LEGEND:
THEORETICAL

TEST
- NIGHT, -200°F
- DAY, +175°F

(FIRST FLIGHT MODEL)

VOLTAGE, V

0 5 10 15 20 25 30 35

CURRENT, A

0 1 2 3 4 5 6 7 8

HOT JUNCTION TEMP,

JAN 68 5178.6.4
RTG SUBASSEMBLIES

- THERMOPILE
  - COUPLES, PLUS HOT SHOES, ETC.
  - SPRING LOADED TO KEEP
    THE THERMOELECTRIC
    ELEMENTS IN COMPRESSION
    LOADING

- HERMETIC SEAL
  - FORWARD (TOP) SEAL
    SECURES HOT FRAME
    TO OUTER CASE
  - AFT (BOTTOM) SEAL
    PROVIDES END COVER
    FOR OUTER CASE
  - POWER LEADS ENTER
    THROUGH AFT SEAL

- STRUCTURE AND HEAT REJECTION
  - CONTAIN AND SUPPORT OTHER
    EQUIPMENT
  - DISTRIBUTE THERMAL
    ENERGY (PRIMARILY IN
    RADIAL DIRECTION)

- WIRING
  - SERIES-PARALLEL ARRANGEMENT OF
    THERMOELECTRIC ELEMENTS
  - FIELD CANCELLATION COILS AT EACH
    END OF GENERATOR LIMIT CURRENT-
    INDUCED MAGNETIC FIELD INTENSITY
    TO 0.24 GAMMAS AT ONE METER, ALONG
    AXIAL CENTERLINE
RTG FUEL CASK

- Constructed primarily of graphite
- Contains fuel capsule during translunar flight
- Provides reentry protection in case of orbital abort
- Provides free radiation surface for capsule heat rejection
- Mounted on LM exterior
RTG FUEL TRANSFER
# RTG 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>Distance from Subpackage 1</td>
<td>$11 \pm 1$ ft</td>
<td>2</td>
<td>12 ft Cable</td>
<td>Astronaut safety and maximum view of space</td>
</tr>
<tr>
<td>Direction from Subpackage 1</td>
<td>Due E or W</td>
<td>1</td>
<td>Eyeball</td>
<td>Minimize thermal load on subpackage 1</td>
</tr>
<tr>
<td>Site Selection</td>
<td>Approx Horiz</td>
<td>1</td>
<td>Eyeball</td>
<td>Avoid craters and slopes for thermal reasons</td>
</tr>
<tr>
<td>Level</td>
<td>$\pm 5^\circ$ of vertical</td>
<td>1</td>
<td>Eyeball</td>
<td>Thermal reasons</td>
</tr>
<tr>
<td>Align</td>
<td>None</td>
<td>3</td>
<td>-</td>
<td>Favor cable exit</td>
</tr>
<tr>
<td>Special Requirements</td>
<td>RTG needs approximately hemisphere view of space for thermal reasons; no experiment will be within 10 ft due to their own requirements.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
POWER DISTRIBUTION UNIT
POWER CONDITIONING UNIT

PHYSICAL DESCRIPTION

SIZE  -  8.36 X 4.14 X 2.94 IN.

WEIGHT - 4.5 POUNDS


PARTS COUNT

- TRANSISTORS 27
- DIODES 44
- ZENER DIODES 4
- CAPACITORS 71
- RESISTORS 87
- RELAY 1
- THERMISTORS 4
- INDUCTORS 11
- TRANSFORMERS 8

PACKAGING - SEVEN CORDWOOD MODULES ARE MOUNTED ON A "MOTHER BOARD". THERMAL REQUIREMENTS ARE MET BY USING MACHINED, GOLD-PLATED, MAGNESIUM CASES FOR THE MODULES.

CONNECTOR - HUGHES - 88 PIN
PCU FEATURES

* Consists of redundant power conditioners with both automatic and commandable selection of the standby section. Over/under voltages are sensed for automatic switching from PCU#1 to PCU#2.
* Provides 6 regulated DC output voltages with nominal values of +29, +15, +12, +5, -6, and -12 volts.
* Contains filters to limit output ripple voltage to be approximately 150 millivolts peak-to-peak.
* Operates at an efficiency of about 85% with a 48 watt load.
* Has 'hold-off' circuit on PC#1 to prevent starting until RTG power is sufficient to permit PCU operation with regulation.
* To maintain the RTG temperature within safe limits, the PCU holds the RTG load at a (relatively) constant value.
* Provides TM signals for monitoring RTG current, RTG voltage, shunt regulator current and temperatures.
* Provides reserve power reference and reserve power level signals to ripple-off circuits in the PDU.

JAN 68 5178.6.11
PCU 1 DIAGRAM

- REGULATOR RESISTOR - LOCATED ON EXTERIOR OF CENTRAL STATION
- HOLD-OFF CIRCUIT ON PCU #1 ONLY. SWITCH IS ASTRONAUT SWITCH S-1
- TYPICAL (1 OF 6) RECTIFIER/FILTER CIRCUIT. FILTER IS COMMON TO BOTH PCU #1 & PCU #2.
RTG CURRENT AND VOLTAGE TM

RTG

(+)

EXCITATION

EXCITATION

(-)

32.4 K

32.4 K

10K

10K

10K (TO ASE TM)

10K (TO ALSEP TM)

10K (TO ASEP TM)

10K (TO ASE TM)

AE-04 PCU IN AMPS

AE-03 PCU IN VOLTS

K1

PCU 1

PCU 2

PCU 1

PCU 2

NOV 68 5178.6.14
PCU SELECTION FUNCTION

[Diagram showing the selection process between PCUs 1 and 2, involving relay drivers, overvoltage, and undervoltage senses.]

JAN 68 5178.6.15
PCU POWER/ THERMAL RELATIONSHIP

55 WATT REGULATOR
* APPROXIMATE

EXPER OFF
STBY
OPER
MIN
MAX

OPERATING RANGE

REGULATOR EXTERNAL DISSIPATION

PCU INTERNAL DISSIPATION

63 W IN
74 W IN

NOV 68 5178.6.16
## EPS DATA

<table>
<thead>
<tr>
<th>FROM RTG</th>
<th>FROM PCU</th>
<th>FROM PDU</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR-01 HOT FRAME 1 DEG F</td>
<td>AT-36 PCU 1 OSC DEG F</td>
<td>AE-07 PCU + 29V OUT</td>
</tr>
<tr>
<td>AR-02 HOT FRAME 2 DEG F</td>
<td>AT-37 PCU 2 OSC DEG F</td>
<td>AE-08 PCU + 15V OUT</td>
</tr>
<tr>
<td>AR-03 HOT FRAME 3 DEG F</td>
<td>AT-38 PCU 1 REG DEG F</td>
<td>AE-09 PCU + 12V OUT</td>
</tr>
<tr>
<td>AR-04 CLD FRAME 1 DEG F</td>
<td>AT-39 PCU 2 REG DEG F</td>
<td>AE-10 PCU + 5V OUT</td>
</tr>
<tr>
<td>AR-05 CLD FRAME 2 DEG F</td>
<td>AE-03 PCU IN VOLTS</td>
<td>AE-11 PCU - 12V OUT</td>
</tr>
<tr>
<td>AR-06 CLD FRAME 3 DEG F</td>
<td>AE-04 PCU IN AMPS</td>
<td>AE-12 PCU - 6V OUT</td>
</tr>
<tr>
<td></td>
<td>AE-05 PCU 1 SHUNT AMPS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AE-06 PCU 2 SHUNT AMPS</td>
<td></td>
</tr>
</tbody>
</table>

JAN 68 5178.6.17
EPS COMMANDS

OCTAL CMD NUMBERS

• 017 DISSIP R1 ON
  This CMD ACTUATES RELAY K-16, IN THE PDU, TO THE POSITION THAT APPLIES +29 VDC TO A 7-WATT POWER DISSIPATION RESISTOR, AND IS USED TO OPTIMIZE THE LOAD ON THE PCU.

• 021 DISSIP R1 OFF
  This CMD ACTUATES RELAY K-16, IN THE PDU, TO THE POSITION THAT REMOVES +29 VDC FROM THE 7-WATT POWER DISSIPATION RESISTOR.

• 022 DISSIP R2 ON
  This CMD ACTUATES RELAY K-17, IN THE PDU, TO THE POSITION THAT APPLIES +29 VDC TO A 14-WATT POWER DISSIPATION RESISTOR, AND IS USED TO OPTIMIZE THE LOAD ON THE PCU.

• 023 DISSIP R2 OFF
  This CMD ACTUATES RELAY K-17, IN THE PDU, TO THE POSITION THAT REMOVES +29 VDC FROM THE 14-WATT POWER DISSIPATION RESISTOR.

• 060 PCU 1 SEL
  This CMD ACTUATES RELAY K-01, IN THE PCU, WHICH APPLIES +16 VDC FROM THE RTG TO PCU 1 AND SIMULTANEOUSLY DEENERGIZES PCU 2. PCU 1 IS PRESET TO BE ENERGIZED AT INITIAL LUNAR ACTIVATION. NOTE THAT THERE IS AN AUTOMATIC SWITCH-OVER FEATURE TO PCU 2 IN THE EVENT THE +12 VDC BUS VARIES MORE THAN ±1 VDC. ADDING OR REMOVING ELECTRICAL LOADS (VIA GROUND COMMANDS) ON PCU 1 CAN PREVENT THE +12 VDC BUS FROM VARYING OUT OF LIMITS. IN THE EVENT AUTOMATIC SWITCH-OVER TO PCU 2 HAS OCCURRED, THIS COMMAND MUST BE FLAGGED AS HIGHLY CRITICAL. THE CAUSE OF THE SWITCH-OVER MUST BE DETERMINED BEFORE THIS COMMAND IS EXECUTED.

• 062 PCU 2 SEL
  This CMD ACTUATES RELAY K-01, IN THE PCU, WHICH APPLIES +16 VDC FROM THE RTG TO PCU 2 AND SIMULTANEOUSLY DEENERGIZES PCU 1. NOTE THAT AT THE TIME OF LUNAR ACTIVATION, PCU 2 IS DEENERGIZED, WITH NO MEANS TO DETERMINE ITS CONDITION. FURTHER NOTE THAT THERE IS NO AUTOMATIC SWITCH-OVER FROM PCU 2 TO PCU 1. THIS SITUATION, THEREFORE, MAKES THIS COMMAND HIGHLY CRITICAL. THIS COMMAND SHOULD BE EXECUTED ONLY AFTER DETERMINING THAT PCU 1 IS ON THE VERGE OF FAILING.

NOV 68 5178.6.18
COMMAND AND
TELEMETRY LINKS

COMMAND LINK

TELEMETRY LINK

TIMING & COMMANDS

EXPERIMENT SUBSYSTEMS

POWER

SCI & ENG DATA

DATA SUBSYSTEM

POWER

ENG DATA
CENTRAL STATION DEPLOYED CONFIGURATION

ANTENNA ALIGNMENT MECHANISM
EXPERIMENT MOUNTING SUPPORTS
SIDE CURTAIN
CONNECTORS TO DEPLOYED EXPERIMENTS
ASTRO HANDLE
HELICAL ANTENNA
SUNSHIELD
DUST DETECTOR
THERMAL REFLECTOR
THERMAL RADIATOR
DATA SUBSYSTEM COMPONENTS (Hidden)
ACTIVATION SWITCHES

APR 69 5178.7.2
CENTRAL STATION
DATA SUBSYSTEM COMPONENTS

- HELICAL ANTENNA
- AIMING MECHANISM
- PRIMARY STRUCTURE
- THERMAL BAG
- TRANSMITTERS
- DIPLEXER SWITCH
- COMMAND RECEIVER
- THERMAL PLATE
- POWER CONDITIONING UNIT
- DATA PROCESSOR
- COMMAND DECODER
- PASSIVE SEISMIC ELECTRONICS
- MULTIPLEXER & A/D CONV
- DIPLER FILTER
- REPEATER

SEPT 68 5178.7.3
# DATA SUBSYSTEM HARDWARE

<table>
<thead>
<tr>
<th>ITEM</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) POWER DISTRIBUTION &amp; SIGNAL CONDITIONER</td>
<td>CONTROL OF POWER SWITCHING AS COMMANDED AND CONDITIONING OF ENGINEERING STATUS DATA</td>
</tr>
<tr>
<td>(B) COMMAND DECODER</td>
<td>DECODE RECEIVED SIGNAL &amp; ISSUE COMMANDS TO THE SYSTEM</td>
</tr>
<tr>
<td>(C) DATA PROCESSOR</td>
<td>COLLECT AND FORMAT SCIENTIFIC OUTPUTS FROM THE EXPERIMENTS. COLLECT AND CONVERT ANALOG HOUSEKEEPING DATA INTO DIGITAL FORM</td>
</tr>
<tr>
<td>(D) COMMAND RECEIVER</td>
<td>ACCEPT THE EARTH-TO-MOON UPLINK SIGNAL</td>
</tr>
<tr>
<td>(E) TRANSMITTER</td>
<td>GENERATE MOON-TO-EARTH DOWNLINK SIGNAL</td>
</tr>
<tr>
<td>(F) DIPL ExER SWITCH</td>
<td>CONNECT EITHER TRANSMITTER TO THE ANTENNA</td>
</tr>
<tr>
<td>(G) DIPL ExER FILTER</td>
<td>CONNECT RECEIVER INPUT AND TRANSMITTER OUTPUT TO THE ANTENNA WITH REQUIRED RECEIVER/TRANSMITTER ISOLATION</td>
</tr>
<tr>
<td>(H) CENTRAL STATION TIMER</td>
<td>PROVIDE AUTOMATIC ACTIVATION FEATURES (AS A BACK-UP) AND SWITCH OFF TRANSMITTERS AFTER 2 YEARS</td>
</tr>
<tr>
<td>(I) ANTENNA</td>
<td>RECEIVE AND RADIATE UP-AND-DOWN LINK RF SIGNALS</td>
</tr>
<tr>
<td>(J) ANTENNA AIMING MECHANISM</td>
<td>MEANS OF ADJUSTMENT FOR DIRECTING ANTENNA TO EARTH</td>
</tr>
<tr>
<td>(K) MISCELLANEOUS- COMPRISING:--</td>
<td>MAINTAIN TEMPERATURE DURING LUNAR NIGHT. PROVIDE A BACK-UP FEATURE FOR LOCAL ALSEP ACTIVATION</td>
</tr>
<tr>
<td>i. CENTRAL STATION HEATERS</td>
<td>SUPPLY TEMPERATURE DATA OF SELECTED POINTS AROUND THE CENTRAL STATION</td>
</tr>
<tr>
<td>ii. ASTRONAUT SWITCHES</td>
<td></td>
</tr>
<tr>
<td>iii. TEMPERATURE SENSORS</td>
<td></td>
</tr>
</tbody>
</table>

NOV 67 5178.7.6
## SUMMARY OF DATA S/S COMPONENTS

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>VOLTAGE/POWER REQUIREMENTS</th>
<th>TOTAL POWER</th>
<th>SIZE, IN.</th>
<th>WEIGHT LBs</th>
<th>RELIABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>POWER DISTRIBUTION UNIT</td>
<td>+29V 375 mw</td>
<td>1753 mw</td>
<td>2.8x4.0x7.25</td>
<td>2.29</td>
<td>0.94484</td>
</tr>
<tr>
<td></td>
<td>+15V 75 mw</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>+12V 735 mw</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>± 5V 85 mw</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 6V 8 mw</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-12V 475 mw</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>COMMAND DECODER</td>
<td>+12V 325 mw</td>
<td>1330 mw</td>
<td>2.8x3.9x6.25</td>
<td>2.68</td>
<td>0.98304</td>
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<tr>
<td></td>
<td>+5V 775 mw</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 6V 230 mw</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>DATA PROCESSOR</td>
<td>+12V 50 mw</td>
<td>500 mw</td>
<td>2.8x3.9x6.25</td>
<td>2.64</td>
<td>0.95863</td>
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<tr>
<td></td>
<td>+5V 450 mw</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MULTIPLEXER</td>
<td>+15V 65 mw</td>
<td>1100 mw</td>
<td>2.62x4.23x5.92</td>
<td>1.89</td>
<td></td>
</tr>
<tr>
<td></td>
<td>± 5V 150 mw</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>± 5V 1100 mw</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-12V 120 mw</td>
<td>1435 mw</td>
<td>2.62x4.23x5.92</td>
<td>1.89</td>
<td></td>
</tr>
<tr>
<td>TRANSMITTER (EACH)</td>
<td>+29V 8000 mw</td>
<td>8900 mw</td>
<td>1.5x2.0x7.5</td>
<td>1.17</td>
<td>0.9796</td>
</tr>
<tr>
<td></td>
<td>+12V 500 mw</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RECEIVER</td>
<td>+12V 665 mw</td>
<td>695 mw</td>
<td>1.5x4.0x8.0</td>
<td>3.01</td>
<td>0.98888</td>
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<tr>
<td></td>
<td>- 6V 30 mw</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIPLEXER SWITCH</td>
<td>+12V 150 mw</td>
<td>130 mw</td>
<td>2.1x4.0x4.5</td>
<td>1.31</td>
<td>0.9997</td>
</tr>
<tr>
<td>DIPLEXER FILTER</td>
<td>-252 5x7.0</td>
<td></td>
<td></td>
<td></td>
<td>0.9999</td>
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<tr>
<td>ANTENNA</td>
<td>-5x23+ GND PL</td>
<td></td>
<td>1.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIM MECHANISM</td>
<td>-11x4.25x5.75</td>
<td></td>
<td>2.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CENT STA TIMER</td>
<td>BATTERY</td>
<td>1.3x1.32x2.63</td>
<td>.036</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HARNESS ASSY</td>
<td>(INCLUDES PCB s CONNECTORS &amp;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SWITCHES)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL POWER AND WEIGHT</td>
<td></td>
<td>14.345 w</td>
<td>2.92</td>
<td>22.55</td>
<td></td>
</tr>
</tbody>
</table>

*MEASURED POWER AT ROOM TEMPERATURE
**INCLUDES DIPLEXER FILTER

APR 69 5178.7.8
ALSEP COMMAND LINK

* ANTENNA
* DIPLEXER
* COMMAND RECEIVER
* COMMAND DECODER
# COMMAND LINK CHARACTERISTICS

<table>
<thead>
<tr>
<th>FUNCTION/PARAMETER</th>
<th>ALSEP</th>
<th>MSFN</th>
</tr>
</thead>
<tbody>
<tr>
<td>FREQUENCY</td>
<td>2119 ± 0.001% MHz</td>
<td>2119 MHz</td>
</tr>
<tr>
<td>MODULATION</td>
<td>—</td>
<td>PM, ± 3 RADIANS</td>
</tr>
<tr>
<td>MODULATING SIGNAL</td>
<td>—</td>
<td>1 KHz SINE WAVE SYNC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SIGNAL LINEARLY ADDED</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TO A 2 KHz SUBCARRIER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1000 bps</td>
</tr>
<tr>
<td>DATA RATE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IF BANDWIDTH (3 db)</td>
<td>275 ± 25 KHz</td>
<td>—</td>
</tr>
<tr>
<td>RECEIVER DYNAMIC RANGE</td>
<td>-101 TO -61 dbm</td>
<td>—</td>
</tr>
<tr>
<td>PERMISSIBLE Pe (PROBABILITY OF BIT ERROR)</td>
<td>10^-9</td>
<td></td>
</tr>
<tr>
<td>REQUIRED PREDETECTION S/N FOR 10^-9 BER</td>
<td>+ 12 db</td>
<td></td>
</tr>
<tr>
<td>S/N MARGIN FOR Pe of 10^-9 (30' ANTENNA)</td>
<td>NOMINAL +32 db</td>
<td>WORST CASE +28 db</td>
</tr>
</tbody>
</table>

**NOV 67  5178.7.10**
ANTENNA AND AIMING MECHANISM
ANTENNA DESCRIPTION

* FLAT "RIBBON-LIKE" COPPER CONDUCTOR WRAPPED AROUND FIBERGLASS-EPOXY TUBE
* 1 1/2 INCHES IN DIAMETER AND 23 INCHES LONG
* USES 5" GROUND PLANE WITH A 2" CYLINDRICAL SKIRT
* IMPEDANCE MATCHING TRANSFORMER AT ANTENNA FEED POINT MATCHES THE ANTENNA IMPEDANCE TO A 50 OHM COAXIAL LINE
* DESIGNED FOR EASY ATTACHMENT TO THE POINTING MECHANISM WITH "QUICK-CONNECT" SPRING LOADED DETENTS
* COATED WITH WHITE REFLECTING THERMAL PAINT
* WEIGHT - 1.28 POUNDS INCLUDING CONNECTOR AND CABLE
# ANTENNA CHARACTERISTICS

<table>
<thead>
<tr>
<th></th>
<th>TRANSMIT</th>
<th>RECEIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SPEC</td>
<td>MEAS</td>
</tr>
<tr>
<td><strong>GAIN</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ON BORESIGHT</strong></td>
<td>15.2 db</td>
<td>16.0 db</td>
</tr>
<tr>
<td><strong>BEAMWIDTH AT 11.0 db GAIN</strong></td>
<td></td>
<td>27°</td>
</tr>
<tr>
<td><strong>BEAMWIDTH AT 11.5 db GAIN</strong></td>
<td>27°</td>
<td>33°</td>
</tr>
<tr>
<td><strong>AXIAL RATIO</strong></td>
<td>3 db</td>
<td>1.3 db</td>
</tr>
<tr>
<td><strong>INPUT VSWR</strong></td>
<td>1.25 : 1</td>
<td>1.20 : 1</td>
</tr>
<tr>
<td><strong>SIDELOBE LEVEL</strong></td>
<td>-10 db</td>
<td>-11 db</td>
</tr>
<tr>
<td><strong>WEIGHT (ACTUAL)</strong></td>
<td>1.28 LB s (including cable)</td>
<td></td>
</tr>
</tbody>
</table>

SEPT 68 5178.7.13
ANTENNA TEST

1. ANTENNA PATTERN THRU ANT CENTERLINE AND FEED TERM (NOT SHOWN)
2. ANTENNA PATTERN THRU ANT CENTERLINE AND 90° TO TERM (SHOWN BELOW)

NOTE:
COMPLETE INTERIOR COVERED WITH ABSORBER

SOURCE ANTENNA
SIGNAL SOURCE

NOV 67 5178.7.14
ANTENNA PATTERN (DOWNLINK)

- HORIZ POLAR
- VERT POLAR

FREQUENCY 2277.5 MHz
S/N 4
POSITION OF CONNECTOR

RELATIVE POWER ONE WAY (db)

ANGLE

SEPT 68 5178.7.15
DIPLEXER

* PROVIDES TRANSMITTER/RECEIVER ISOLATION WITH A COMMON ANTENNA
* USES TUNEABLE CAVITY BANDPASS FILTERS - 5 IN TRANSMIT AND 5 IN RECEIVE PATH

**CHARACTERISTICS**

<table>
<thead>
<tr>
<th>RECEIVER PATH</th>
<th>MEAS</th>
<th>SPEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>INSERTION LOSS</td>
<td>1.30 db</td>
<td>2.5 db</td>
</tr>
<tr>
<td>VSWR</td>
<td>1.10:1</td>
<td>1.36:1</td>
</tr>
<tr>
<td>CENTER FREQUENCY:</td>
<td>2119</td>
<td>2118-2120 MHz</td>
</tr>
<tr>
<td>MAX 3 db BANDWIDTH</td>
<td>11.0 MHz</td>
<td>24 MHz</td>
</tr>
<tr>
<td>MIN 3 db BANDWIDTH</td>
<td>11.0 MHz</td>
<td>2.18 MHz</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TRANSMITTER PATH</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>INSERTION LOSS:</td>
<td>0.70 db</td>
<td>0.8 db</td>
</tr>
<tr>
<td>VSWR</td>
<td>1.10:1</td>
<td>1.36:1</td>
</tr>
<tr>
<td>CENTER FREQUENCY:</td>
<td>2275-2280 MHz</td>
<td>2275-2280 MHz</td>
</tr>
<tr>
<td>MAX 3 db BANDWIDTH</td>
<td>45 MHz</td>
<td>60 MHz</td>
</tr>
<tr>
<td>MIN 3 db BANDWIDTH</td>
<td>45 MHz</td>
<td>5.35 MHz</td>
</tr>
<tr>
<td>POWER HANDLING CAPABILITY</td>
<td>20.0 WATTS</td>
<td>1.5 WATTS</td>
</tr>
</tbody>
</table>

* MISCELLANEOUS
  
  DIMENSIONS - 2.5 x 2.5 x 6.88 INCHES
  WEIGHT - 0.9 POUNDS

NOV 67 5178.7.18
DIPLEXER FILTER

MINIMUM REJECTION REQUIREMENTS

---

NOV 67 5178.7.19
COMMAND RECEIVER

BOTTOM VIEW
COMMAND RECEIVER

* RECEIVES SIGNALS FROM THE MSFN STATIONS ON A FREQUENCY OF 2119 MHz.

* LOW SIDE LOCAL OSCILLATOR INJECTION PROVIDED BY STANDBY REDUNDANT LOCAL OSCILLATORS.

* SYNCHRONOUS TUNED IF AMPLIFIERS PROVIDE AMPLIFICATION, FILTERING AND 40db LIMITING PRIOR TO SIGNAL DEMODULATION.

* FM DISCRIMINATOR AND INTEGRATOR GIVES COMBINED 1 and 2 KHz OUTPUT.

* OUTPUT LEVEL IS 0.8 VOLTS/RADIAN FOR AN INPUT DEVIATION OF 3.0 RADIANS.

* EMPLOYS MODULAR CONSTRUCTION ON A "MILLED" MAGNESIUM BASE PLATE.

* SIZE - 8 x 4 x 1.75 INCHES
  WEIGHT - 1.84 POUNDS

* POWER - 665 MILLIWATS (NOMINAL) AT + 12 vdc
  30 MILLIWATTS (NOMINAL) AT - 6 vdc
COMMAND RECEIVER
SIMPLIFIED BLOCK DIAGRAM

PART OF POWER DISTRIBUTION
-6VDC
+12VDC
12 HR RESET

INPUT 2119 MHz
-101 to -61 dbm

LO INPUT 2059 MHz 2 MW

MIXER

IF PRE-AMPL AND FILTER
TO LEVEL SENSOR
LOCAL OSCILLATOR SYSTEM

-6VDC
+12VDC

IF AMPLIFIER

AMPLIFIER AND DISCRIMINATOR

INTEGRATOR AND OUTPUT AMPL

OUTPUT COMBINED 1 & 2 KHz SIGNAL

AE - 13 CH 21 RCVR PRE/LIM dbm

AB - 01 CH 9 RCVR 1 KHz STA

TM AMPL

TM AMPL

SEPT 68 5178.7.23
COMMAND RECEIVER TELEMETRY SUMMARY

CHANNEL 36  AE-14  RCVR LOCAL OSC  LEVEL  
* DETECTOR CIRCUIT SAMPLES OSCILLATOR  
  SIGNAL. DETECTED SIGNAL IS THEN  
  AMPLIFIED TO PROPER TM LEVEL.

CHANNEL 16  AT-21  LOCAL OSC CRYSTAL A TEMP  
* USES THERMISTOR/RESISTOR NETWORK  
  POWERED BY 12 VDC.  
* THERMISTOR IS CEMENTED (EPOXY) TO  
  CRYSTAL CAN.

CHANNEL 17  AT-22  LOCAL OSC CRYSTAL B TEMP  
* USES THERMISTOR/RESISTOR NETWORK  
  POWERED BY 12 VDC.  
* THERMISTOR IS CEMENTED (EPOXY) TO  
  CRYSTAL CAN.

CHANNEL 9  AB-01  CMD DEMOD 1KHz PRESENT  
* SIGNAL IS OBTAINED FROM  
  RECEIVER'S AUDIO OUTPUT.  
* USES 1KHz BANDPASS AMPLIFIER  
  AND DIODE DETECTOR.

CHANNEL 21  AE-13  RCVR PRE-LIMITING LEVEL  
* DIODES IN FINAL STAGE OF IF  
  PROVIDE HARD LIMITING.  
* TM SIGNAL PROVIDED BY THE  
  LIMITING DIODE CURRENT.
COMMAND RECEIVER SPECIFICATIONS

* INPUT FREQUENCY 2119 MHz ± 0.001%
* INPUT SIGNAL LEVEL -101dbm to -61dbm
* NOISE FIGURE 10db MAXIMUM
* LOCAL OSC FREQUENCY 2059 MHz ± 0.0025%/YR
* INTERMEDIATE FREQUENCY 60 MHz
* IF 3db BANDWIDTH 250 to 350KHz WITH AN INPUT SIGNAL LEVEL OF -100dbm
* IF REJECTION 60db MINIMUM AT 3.4 MHz
* AUDIO OUTPUT SIGNAL
  (a) LEVEL - 0.8 VOLT/RADIAN (UP TO ± 3.0 RADIANS)
  (b) FREQ - 100 Hz TO 5KHz
* POWER
  + 12 VDC AT 55 MILLIAMPERES (NOMINAL) - SUPPLIED THROUGH A CIRCUIT BREAKER RATED AT 150 MILLIAMPERES (NOMINAL). CIRCUIT IS AUTOMATICALLY GIVEN A RESET COMMAND EVERY 12 HOURS.
  - 6VDC AT 55 MILLIAMPERES (NOMINAL) - SYSTEM PROTECTION PROVIDED BY SERIES RESISTOR.
* CONNECTORS - RF - COAXIAL OSM 210-2
  - OTHER - HUGHES WST0014M20BNH00

SEP 68 5178.7.26
COMMAND DECODER PHYSICAL DESCRIPTION

* SIZE - 2.8 x 3.94 x 6.25 INCHES
* POWER - 1330 MILLIWATTS (NOMINAL AT ROOM AMBIENT)
* WEIGHT - 2.70 POUNDS
* PARTS COUNT - 352 FLATPACKS
   26 TRANSISTORS
   83 RESISTORS
   28 CAPACITORS
   13 DIODES
* PARTS MOUNTED ON 10 PRINTED CIRCUIT BOARDS WITH FROM 2 to 12 LAYERS
* CONNECTOR - HUGHES - 244 PIN
COMMAND DECODER SIMPLIFIED BLOCK DIAGRAM

DATA PROCESSOR

RCVR \rightarrow DEMODULATOR \rightarrow DECODER A \rightarrow DECODER B

DECODER B \rightarrow COMMAND SEQUENCER

CENTRAL STATION TIMER \rightarrow 12 HR & 1 MIN

12 HR REPETITIVE

COMMANDS TO USERS

7 COMMANDS TO EXPER
PDU - TURN ON EXPER #4
PDU
RCVR RESET

SEPT 68 51787.29
COMMAND DECODER

* CONTAINS A DEMODULATOR
  - TO GENERATE AN NRZ-C BIT STREAM FROM THE
    PHASE MODULATED COMPOSITE 1 & 2 KHz AUDIO
    INPUT.
  - WHICH DETECTS "THRESHOLD" TO START DECODER
    "SEARCH MODE".
  - TO GENERATE 1, 2 AND 4 KHz TIMING CLOCKS
    WHICH ARE SYNCHRONIZED WITH THE 1KHz SYNC
    SUBCARRIER RECEIVED FROM THE MSFN.

* ACCEPTS COMMAND SIGNALS FROM THE MSFN NETWORK AND
  PROVIDES UP TO 100 UNIQUE COMMANDS TO USERS.

* A COMMAND FROM THE MSFN CONSISTS OF A 2KHz SUBCARRIER
  PHASE MODULATED WITH A 1KHz SUBCARRIER TO PRODUCE 61
  SERIAL BITS WITH THE FOLLOWING FORMAT.

<table>
<thead>
<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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</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

1. - PREAMBLE - ALL ONES OR ALL ZEROS
2. - ADDRESS INDIVIDUAL ALSEP (A or B DECODER)
3. - COMMAND COMPLEMENT
4. - COMMAND
5. - TIMING (EXECUTION) - ALL ONES OR ALL ZEROS

SEPT 68 5178.7.30
COMMAND DECODER

ADDRESSING

* The seven address bits are used to uniquely command four separate ALSEPs deployed on the lunar surface.

* Each command decoder has an "A" section and a redundant "B" section. Either may be selected to process a command by transmitting the proper address code.

* Codes

<table>
<thead>
<tr>
<th>ALSEP</th>
<th>ADDRESS NO. (OCTAL)</th>
<th>CODE PATTERN</th>
<th>COMMAND DECODER NUMBER</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>130</td>
<td>1011000</td>
<td>1A</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>0011000</td>
<td>1B</td>
</tr>
<tr>
<td>2</td>
<td>116</td>
<td>1001110</td>
<td>2A</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>0001110</td>
<td>2B</td>
</tr>
<tr>
<td>3</td>
<td>151</td>
<td>1101001</td>
<td>3A</td>
</tr>
<tr>
<td></td>
<td>51</td>
<td>0101001</td>
<td>3B</td>
</tr>
<tr>
<td>4</td>
<td>25</td>
<td>0010101</td>
<td>4A</td>
</tr>
<tr>
<td></td>
<td>65</td>
<td>0110101</td>
<td>4B</td>
</tr>
</tbody>
</table>
COMMAND DECODER DELAYED COMMAND SEQUENCER

* PROVIDES A BACKUP FEATURE FOR LOCAL GENERATION OF COMMANDS IN CASE THE COMMAND LINK CANNOT BE ESTABLISHED

* GENERATES 7 ONE-TIME COMMANDS AFTER A DELAY OF 96 (PLUS) HOURS FROM START OF "PET" (WHERE 'PET' STARTS AT THE TIME THE ASTRONAUT MATES THE RTG WITH THE CENTRAL STATION BY INSERTING P22 INTO J22)

* COMMANDS ARE IDENTICAL TO THOSE GENERATED IN RESPONSE TO SIGNALS FROM THE MSFN AND ARE OR'ED IN THE COMMAND LINE DRIVER.

* DELAYED (ONE-TIME) COMMANDS ARE IDENTIFIED AS FOLLOWS:

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>TIME OF EXECUTION</th>
<th>COMMAND NUMBER (OCTAL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>REMOVE CPL EE DUST COVER</td>
<td>96 HRS &amp; 2 MIN</td>
<td>113</td>
</tr>
<tr>
<td>SET CCIG SEAL BREAK</td>
<td>96 HRS &amp; 2 MIN</td>
<td>105</td>
</tr>
<tr>
<td>UNCAGE PSE</td>
<td>96 HRS &amp; 2 MIN</td>
<td>073</td>
</tr>
<tr>
<td>EXECUTE CCIG SEAL BREAK</td>
<td>96 HRS &amp; 3 MIN</td>
<td>110</td>
</tr>
<tr>
<td>SWS DUST COVER REMOVAL</td>
<td>96 HRS &amp; 4 MIN</td>
<td>122</td>
</tr>
<tr>
<td>SET SIDE DUST COVER</td>
<td>96 HRS &amp; 4 MIN</td>
<td>107</td>
</tr>
<tr>
<td>EXECUTE SIDE DUST COVER REMOVAL</td>
<td>96 HRS &amp; 5 MIN</td>
<td>110</td>
</tr>
</tbody>
</table>

SEPT 68 5178.7.35
I. ACTIVATE COMMAND #113 TO BLOW CHARGED PARTICLE DUST COVER.
2. ACTIVATE COMMAND #105 TO SET CCIG SEAL BREAK
3. ACTIVATE COMMAND #973 TO UNCAKE PASSIVE SEISMIC EXP

ACTIVATE COMMAND #122 TO BLOW SOLAR WIND DUST COVER.
2. ACTIVATE COMMAND #107 TO SET SIDE BLOW DUST COVER.

ACTIVATE COMMAND #131 MAGNETOMETER FLIP CAL COMMAND

REPEAT CYCLE FOR N - 1 TO N - 721 ONE YEAR OPERATIONS
COMMAND DECODER POWER RESET

FEATURES

DETECTS INITIAL POWER TURN-ON OR MOMENTARY POWER INTERRUPTION TO -

1. SET COMMAND DECODER IN SEARCH MODE
2. SET COMMAND DECODER IN "TIMER ACCEPT" MODE
3. START DELAYED COMMAND SEQUENCER
COMMAND DECODER-OTHER LOCAL COMMANDS

THE FOLLOWING REPETITIVE COMMANDS ARE GENERATED WITHIN THE COMMAND DECODER:

1 - PSE CALIBRATE - COMMAND #065
   * OCCURS 12 HOURS AFTER $T_0$ AND EVERY 12 HOURS THEREAFTER

2 - RECEIVER CIRCUIT BREAKER RESET
   * OCCURS 12 HOURS AFTER $T_0$ AND EVERY 12 HOURS THEREAFTER

3 - MAGNETOMETER FLIP-CALIBRATE - COMMAND #131
   * FIRST OCCURRENCE IS 108 HOURS PLUS 1 MIN
     AFTER $T_0$ - REPEATS EVERY 12 HOURS THEREAFTER

4 - RESTORE POWER TO LOW PRIORITY EXPERIMENT - CMD #052
   * FIRST OCCURRENCE IS 108 HOURS AND 7 MINUTES AFTER $T_0$
     AND EVERY 12 HOURS THEREAFTER
   * ALL ABOVE COMMANDS MAY BE INHIBITED BY TRANSMITTING COMMAND #033

COMMAND #033 IS CONSIDERED CRITICAL! SHOULD THE COMMAND LINK BE LOST FOLLOWING TRANSMISSION OF CMD #033, THEN ALL LOCALLY GENERATED COMMANDS WOULD BE LOST
TIMER/COMMAND DECODER INTERFACE

POWER
RESET

TIMER OUTPUT
ACCEPT
CMD #032

TIMER OUTPUT
INHIBIT
CMD #033

12 HOUR
INPUT

680 Ω

2.7 µfd

12 HOUR
OUTPUT

AMPL

PULSE
SHAPER

12 HOUR
OUTPUT

680 Ω

2.7 µfd

1 MIN
INPUT

AMPL

PULSE
SHAPER

1 MIN
OUTPUT

SEPT 68 5178.739
COMMAND DECODER INTERFACE CIRCUIT
(ONE EACH FOR 100 COMMANDS)

Vcc
4.5 - 5.5 VDC

INTERFACE

40KΩ  21KΩ  1KΩ  15KΩ

2  3

LINE DRIVER
FAIRCHILD LPDT µL 9042

4  5  6  3

SOURCE CURRENT

SINK CURRENT

0.0022 µfd

COMMAND PULSE

20 ± 2 M SEC

4.0 ± 1.5

0.2 ± 0.2

t = 10 µ SEC (MAX)

INACTIVE STATE

ACTIVE STATE

DRIVER SPECIFICATION
SOURCE I ≤ 45 µ AMP
(INACTIVE STATE)
SINK I ≤ 750 µ AMP
(ACTIVE STATE)

SEPT 68 5178.7.41
COMMAND DECODER TELEMETRY SUMMARY

* COMMAND VERIFICATION (CV) WORD
  - LOCATED IN WORD 46 OF TELEMETRY FORMAT FOR FLIGHT SYSTEMS 1 & 2 AND IN WORD 5 FOR FLIGHT SYSTEMS 3 & 4
  - CONSISTS OF 2 ZEROS, THE RECEIVED COMMAND AND A PARITY BIT
  - EXAMPLE OF CV WORD RECEIVED AT THE MSFN

\[
\begin{array}{c|c|c|c|c|c|c|c}
\hline
0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 \\
\hline
\end{array}
\]

FILLER COMMAND PARITY BITS (OCTAL 36)

\[
\begin{array}{c|c|c|c|c|c|c|c}
\hline
0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 \\
\hline
\end{array}
\]

ONCE FOR EACH CMD TRANSMITTED

- PARITY "ONE" VERIFIES BIT BY BIT CHECK OF COMMAND WITH COMPLEMENT.
- THE SEVEN COMMAND BITS IDENTIFY THE BINARY CODE DETECTED BY THE COMMAND DECODER.
COMMAND DECODER TELEMETRY SUMMARY

CHANNEL 48 AT-31 COMMAND DECODER BASE TEMP
*SIGNAL OBTAINED FROM THERMISTOR
LOCATED NEAR CENTER OF BASE PLATE

CHANNEL 49 AT-32 COMMAND DECODER INTERNAL TEMP
*THERMISTOR LOCATED ON "PULSE SHAPER" PRINTED CIRCUIT BOARD

CHANNEL 61 AT-33 COMMAND DEMODULATOR, VCO TEMP
*THERMISTOR LOCATED ON DEMODULATOR PRINTED CIRCUIT BOARD

CIRCUITS - TEMPERATURE SENSING CIRCUITS ARE ARRANGED AS FOLLOWS:

+12VDC 3010Ω  RT-1  3010Ω
TO MULTIPLEXER
RETURN

RT-1 "FENWAL" ISO-CURVE 15K ohm THERMISTOR.
TELEMETRY READOUT VS. TEMPERATURE

Used in the following measurements:

- AT-27
- AT-28
- AT-29
- AT-30
- AT-31
- AT-32
- AT-33
- AT-03
- AT-04
- AT-05
- AT-06
- AT-07
- AT-34
- AT-35
- AT-36
- AT-37
- AT-38
- AT-39

Temperature in degrees Fahrenheit:

- 0
- 50
- 100
- 150
- 200

Dec/decimal:

- 0
- 40
- 100
- 140
- 200
- 240
- 300
- 340
- 372

Octal:

- 0
- 12
- 3010

RT 1
Thermistor

NOV 67 5178.7.44
ALSEP TELEMETRY LINK

* DIGITAL DATA PROCESSOR (DDP)
* MULTIPLEXER/CONVERTER
* TRANSMITTERS (TWO)
* DIPLEXER/SWITCH
* ANTENNA
DIGITAL DATA PROCESSOR
DIGITAL DATA PROCESSOR

PHYSICAL DESCRIPTION –

SIZE - 2.8 X 3.94 X 6.25 INCHES

WEIGHT - 3.03 POUNDS

POWER - 450 MILLIWATTS AT 5 VDC
       50 MILLIWATTS AT 12 VDC
       (NOMINAL AT ROOM AMBIENT TEMPERATURE)

PARTS COUNT - 199 FLATPACKS
       2 TRANSISTORS
       41 RESISTORS
       19 CAPACITORS
       3 DIODES

PARTS ARE MOUNTED ON 9 PRINTED CIRCUIT BOARDS WITH
FROM 3 TO 12 LAYERS

CONNECTOR - HUGHES - 244 PIN
DIGITAL DATA PROCESSOR

THE DIGITAL DATA PROCESSOR -

* IS THE FOCAL POINT FOR THE COLLECTION, FORMATTING AND CONTROL OF ALL TELEMETERED DATA

* CONTAINS COMMAND SELECTABLE "X" AND "Y" SECTIONS. EXCEPT FOR THE FRAME COUNTER AND INTERFACE CIRCUITS, THE DDP IS FULLY REDUNDANT

* HAS 3 MODES OF OPERATION DEFINED AS "NORMAL" (1060b/s), "SLOW" (530b/s) AND ACTIVE SEISMIC (10,600b/s)

* USES A CRYSTAL OSCILLATOR TO DERIVE ALL TIMING AND CONTROL SIGNALS

* COLLECTS DATA INTO A 64 WORD FRAME REPEATING EACH 604 MILLISECONDS. EACH WORD CONSISTS OF 10 BITS OR ABOUT 9.43 MILLISECONDS (NORMAL MODE)

* PROCESSES COLLECTED DATA INTO THE REQUIRED TELEMETRY FORMAT IS SERIAL FORM. EACH DATA SOURCE IS SAMPLED AT LEAST ONCE PER FRAME

DEC 67 5178.7.48
DATA PROCESSOR
SIMPLIFIED BLOCK DIAGRAM

--- Diagram Content ---

- Analog Inputs
- Digital Experimental Data
- Master Reset Cmd
- Normal Mode Cmd
- Slow Mode Cmd
- Active Seismic On Cmd
- Active Seismic Off Cmd
- Command Decoder Data (ICV Words)
- Analog Multiplexer
- Analog Data Clock
- 90th Frame
- Frame Counter
- Reset
- Digital Experimental Data
- Other Experimental Data
- Interface
- Demands to Experiments
- Control Signals to Users
- To XMT "A"
- To XMT "B"
- Timing Logic
- Digitize
- Control Timing
- Timing
- Housekeeping
- Modulator
- Split Phase
- Modulated Data
- Processor "X" Redundant Unit
- Processor "Y"
GENERATION OF BASIC CLOCKS

169.6 KHz
OSC (0.005%)

÷ 2

84.8 KHz

÷ 2

MODE
SELECT

÷ 10

÷ 8

1060 BPS
OR
530 BPS

÷ 8

42.4 KBPS

÷ 2

÷ 2

"X" SECTION

REDUNDANT "Y" SECTION

A - NORMAL MODE
B - SLOW MODE

APR 69 5178.7.50
DIGITAL DATA PROCESSOR

* CONTROL WORD GENERATOR
  - GENERATES THE 22-BIT SYNCHRONIZATION CODE
  - PROVIDES MODE, FRAME AND ALSEP ID IN THE LAST 8 BITS OF THE 30-BIT SYNCH WORD

* SPLIT PHASE MODULATOR
  - ENCODES DATA INTO A "SPLIT PHASE" SIGNAL
  - PCM "0" IS REPRESENTED BY "01" AND CAUSES A POSITIVE PHASE TRANSITION
  - PCM "1" IS REPRESENTED BY A "10" AND CAUSES NEGATIVE PHASE TRANSITION

* FRAME COUNTER
  - IS NOT REDUNDANT
  - CONTAINS A COUNTER WHICH IS ADVANCED ONE STEP PER 64 WORD FRAME
  - IS RESET BY A 90TH FRAME "END OF FRAME" SIGNAL FROM THE MULTIPLEXER/CONVERTER

DEC 67 5178.7.51
DIGITAL DATA PROCESSOR

* MULTIPROFORMAT COMMUTATOR
  - USES 2 DIVIDE-BY-8 COUNTERS WITH GATING FOR ANY ONE OF 64 CONSECUTIVE PERIODS (WORDS)
  - PRODUCES SIGNALS OF ONE WORD LENGTH AND MULTIPLES OF ONE WORD LENGTH TO SELECT AND GATE DATA INTO A MODULATOR
  - CONTAINS A "PATCH PLANE" FOR FLEXIBLE WORD ASSIGNMENTS

* DEMAND REGISTER
  - ACTS AS A BUFFER BETWEEN THE DEMAND DECODER ASSEMBLY AND THE DEMAND LINES TO ELIMINATE GATING TRANSIENTS
  - ACTS AS A MASTER SWITCH TO INHIBIT ALL DEMANDS DURING ASE MODE

* DIGITAL MULTIPLEXER
  - CONTAINS A 10-BIT SHIFT REGISTER TO ACCEPT 8 PARALLEL BITS FROM THE A/D CONVERTER OR 8 SERIAL BITS FROM THE COMMAND DECODER
  - SHIFTS OUT 10-BIT WORDS WITH "ZEROS" IN THE TWO MOST SIGNIFICANT FIGURES. BITS ARE SHIFTED HIGH ORDER FIRST
## FORMAT FLIGHT SYSTEMS 1 & 2

### Legend

<table>
<thead>
<tr>
<th># of Words Per Frame</th>
<th>Assignments</th>
</tr>
</thead>
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<tr>
<td>3</td>
<td>X CONTROL</td>
</tr>
<tr>
<td>29</td>
<td>PASSIVE SEISMIC (SHORT PERIOD)</td>
</tr>
<tr>
<td>12</td>
<td>PASSIVE SEISMIC (LONG PERIOD SEISMIC)</td>
</tr>
<tr>
<td>2</td>
<td>PASSIVE SEISMIC (LONG PERIOD TIDAL + TEMP)</td>
</tr>
<tr>
<td>7</td>
<td>0 MAGNETOMETER</td>
</tr>
<tr>
<td>4</td>
<td>S SOLAR WIND</td>
</tr>
<tr>
<td>5</td>
<td>I SUPRATHERMAL ION DETECTOR/CCGE</td>
</tr>
<tr>
<td>0</td>
<td>HF HEAT FLOW</td>
</tr>
<tr>
<td>0</td>
<td>CP CHARGED-PARTICLE</td>
</tr>
<tr>
<td>1</td>
<td>CV COMMAND VERIFICATION (ALL ZEROS IF NO COMMAND)</td>
</tr>
<tr>
<td>1</td>
<td>H HOUSEKEEPING</td>
</tr>
<tr>
<td>0</td>
<td>NA NOT ASSIGNED (ALL ZEROS TRANSMITTED)</td>
</tr>
<tr>
<td>0</td>
<td>CG COLD CATHODE GAUGE EXPERIMENT (MSC)</td>
</tr>
</tbody>
</table>

Each box contains one 10-bit word. Total represents one frame or 640 bits.

### Table

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
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<td>x</td>
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<tr>
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<tr>
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<td>7</td>
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</table>

September 68 5178.7.53
# Telemetry Format

## Flexible Word Assignments

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<th>1</th>
<th>2</th>
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<td>62</td>
<td>63</td>
<td>64</td>
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</tr>
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</table>

Words marked with X are assigned by drawing during fabrication of the digital data processor's multi-format commutator.
### FORMAT FLIGHT SYSTEM #3

<table>
<thead>
<tr>
<th>&quot;# OF WORDS PER FRAME&quot;</th>
<th>&quot;LEGEND&quot;</th>
<th>&quot;ASSIGNMENTS&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>x</td>
<td>CONTROL</td>
</tr>
<tr>
<td>30</td>
<td>X</td>
<td>PASSIVE SEISMIC (SHORT PERIOD)</td>
</tr>
<tr>
<td>12</td>
<td>-</td>
<td>PASSIVE SEISMIC (LONG PERIOD SEISMIC)</td>
</tr>
<tr>
<td>2</td>
<td>•</td>
<td>PASSIVE SEISMIC (LONG PERIOD TIDAL + TEMP)</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>MAGNETOMETER</td>
</tr>
<tr>
<td>0</td>
<td>S</td>
<td>SOLAR WIND</td>
</tr>
<tr>
<td>0</td>
<td>I</td>
<td>SUPRATHERMAL ION DETECTOR/CCGE</td>
</tr>
<tr>
<td>1</td>
<td>HF</td>
<td>HEAT FLOW</td>
</tr>
<tr>
<td>6</td>
<td>CP</td>
<td>CHARGED PARTICLE</td>
</tr>
<tr>
<td>1</td>
<td>CV</td>
<td>COMMAND VERIFICATION (ALL ZEROS IF NO COMMAND)</td>
</tr>
<tr>
<td>1</td>
<td>H</td>
<td>HOUSEKEEPING</td>
</tr>
<tr>
<td>3</td>
<td>NA</td>
<td>NOT ASSIGNED (ALL ZEROS TRANSMITTED)</td>
</tr>
<tr>
<td>5</td>
<td>CG</td>
<td>COLD CATHODE GAUGE EXPERIMENT (MSC)</td>
</tr>
</tbody>
</table>

EACH BOX CONTAINS ONE 10 BIT WORD. TOTAL REPRESENTS ONE FRAME OR 640 BITS.

SEPT 68 5178.755
FORMAT FLIGHT SYSTEM #4

<table>
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<th># OF WORDS PER FRAME</th>
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<th>ASSIGNMENTS</th>
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</tr>
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<td>X</td>
<td>PASSIVE SEISMIC (SHORT PERIOD)</td>
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<td>PASSIVE SEISMIC (LONG PERIOD SEISMIC)</td>
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<td>•</td>
<td>PASSIVE SEISMIC (LONG PERIOD TIDAL + TEMP )</td>
</tr>
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<td>0</td>
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<tr>
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<td>S</td>
<td>SOLAR WIND</td>
</tr>
<tr>
<td>5</td>
<td>I</td>
<td>SUPRATHERMAL ION DETECTOR/CCGE</td>
</tr>
<tr>
<td>0</td>
<td>HF</td>
<td>HEAT FLOW</td>
</tr>
<tr>
<td>6</td>
<td>CP</td>
<td>CHARGED PARTICLE</td>
</tr>
<tr>
<td>1</td>
<td>CV</td>
<td>COMMAND VERIFICATION (ALL ZEROS IF NO COMMAND)</td>
</tr>
<tr>
<td>1</td>
<td>H</td>
<td>HOUSEKEEPING</td>
</tr>
<tr>
<td>4</td>
<td>NA</td>
<td>NOT ASSIGNED (ALL ZEROS TRANSMITTED)</td>
</tr>
<tr>
<td>0</td>
<td>CG</td>
<td>COLD CATHODE GAUGE EXPERIMENT (MSC)</td>
</tr>
</tbody>
</table>

EACH BOX CONTAINS ONE 10 BIT WORD. TOTAL REPRESENTS ONE FRAME OR 640 BITS.

SEPT 68  5178.7.56
ALSEP DATA FORMAT

54.34 SEC = 1 CYCLE
(90 FRAMES)

1 2 3 4 5 6 7 8 9

78 79 80 81 82 83 84 85 86 87 88 89 90

32/53 SEC = 1 FRAME
(64 WORDS)

1 2 3 4 5 6 7 8 9

51 52 53 54 55 56 57 58 59 60 61 62 63 64

1/106 SEC = 1 WORD
(10 BITS)

1 2 3 4 5 6 7 8 9 10

1/1060 SEC = 1 BIT

NORMAL BIT RATE SHOWN
SLOW RATE = 0.5 x 1060
= 530 BPS
(FOR CONTINGENCY)
HIGH BIT RATE = 10,600 BPS
FORMATTED BY ASE

DEC 67 5178.7.57
CONTROL WORDS AND CMD VERIFICATION

DA-01 ALSEP FRAME SYNC
BARKER CODE
COMPLEMENT OF BARKER CODE

DA-02 ALSEP FRAME CNTR
(1, 2...89, 0)

WORD 46 ON ALSEP 1
FILLER BITS (ZEROS)

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

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

MODE BIT, DEFINED AS FOLLOWS:

<table>
<thead>
<tr>
<th>FRAME</th>
<th>MODE BIT</th>
<th>MEANING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>NORMAL BIT RATE</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>LOW BIT RATE</td>
</tr>
<tr>
<td>3</td>
<td>X MSB</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>X</td>
<td>DATA PROC</td>
</tr>
<tr>
<td>5</td>
<td>X</td>
<td>1D NO.</td>
</tr>
<tr>
<td>6</td>
<td>NONE</td>
<td>NONE</td>
</tr>
<tr>
<td>•</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>•</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>•</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>89</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>0</td>
<td>NONE</td>
<td>NONE</td>
</tr>
</tbody>
</table>

DA-03 ALSEP BIT RT ID
DATA PROC
DA-04 ALSEP ID
1D NO.
ALSEP 1 DATA COMMUTATION

Cycle and sequence can be shortened by command.

X 24 ground plane steps = 3709 sec; full side cycle.

NOTE: Times are for normal bit rate.

SEPT 68  5178.759
DATA PROCESSOR TIMING/CONTROL SIGNALS

90TH FRAME MARK

N X 118 μSEC

N X 90 X \( \frac{32}{53} \) SEC

FRAME MARK

N X \( \frac{32}{53} \) SEC

EVEN FRAME MARK

N X 118 μSEC

N X 118 μSEC

N X 118 μSEC

N X 118 μSEC

N X 236 μSEC

N X 236 μSEC

N X 236 μSEC

N X 118 μSEC

1060 ± 0.01% b/s

DATA DEMAND

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

DATA GATE

N X 118 μSEC

9.4 X N MILLISECONDS

FIRST WORD TIME

PER TELEMETRY FORMAT

FIRST WORD TIME

LAST WORD TIME

ODD FRAME

ODD FRAME

All other times are accurate only to the significant figure shown.
TIMING/CONTROL SIGNAL INTERFACE

DATA PROCESSOR
LINE DRIVER
+ 4.5 - 5.5 VDC

INTERCONNECTING CABLE

USER

LOGICAL "ZERO" + 0.2 ± 0.2 VOLTS
USER SHALL LIMIT "SINK" CURRENT TO 0.75 ma OR LESS

LOGICAL "ONE" + 4.0 ± 1.5 VOLTS
USER SHALL LIMIT "SOURCE" CURRENT TO 0.045 ma OR LESS

R, C₁ & C₂ CONTROL RISE AND FALL TIME

SEPT 68 5178.7.61
EXPERIMENT/DATA PROCESSOR INTERFACE

DIGITAL DATA

LOGICAL "ZERO"
+ 0.2 ± 0.2 VOLTS
THE SOURCE LINE DRIVER MUST
BE CAPABLE OF "SINKING" UP TO 0.215 ma

LOGICAL "ONE"
+ 4.0 ± 1.5 VOLTS
THE SOURCE LINE DRIVER MUST BE
CAPABLE OF "SOURCING" UP TO 0.012 ma

R, C1, & C2
CONTROL RISE AND FALL TIME
## DIGITAL DATA PROCESSOR

### TELEMETRY SUMMARY

<table>
<thead>
<tr>
<th>CHANNEL</th>
<th>CALIBRATION</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHANNEL 2</td>
<td>AE-01 0.25 VDC</td>
<td>0.25 VDC CALIBRATION OF ADC. A ZENER DIODE AND RESISTIVE DIVIDER IS USED TO PROVIDE AN ACCURATE REFERENCE VOLTAGE FOR TM CHANNEL CALIBRATION.</td>
</tr>
<tr>
<td>CHANNEL 3</td>
<td>AE-02 4.75 VDC</td>
<td>4.75 VDC CALIBRATION OF ADC. THIS VOLTAGE IS OBTAINED FROM THE SAME NETWORK AS THE 0.25 VDC AND PROVIDES A SECOND CALIBRATION POINT.</td>
</tr>
<tr>
<td>CHANNEL 46</td>
<td>AT-29 DIGITAL DP, BASE TEMPERATURE</td>
<td>USES A THERMISTOR LOCATED ON THE BASE PLATE.</td>
</tr>
<tr>
<td>CHANNEL 47</td>
<td>AT-30 DIGITAL DP, INTERNAL TEMPERATURE</td>
<td>USES A THERMISTOR LOCATED ON ONE OF THE PRINTED CIRCUIT BOARDS.</td>
</tr>
</tbody>
</table>
ANALOG MULTIPLEXER CONVERTER
# ANALOG MULTIPLEXER/CONVERTER

## PHYSICAL DESCRIPTION

<table>
<thead>
<tr>
<th>SIZE</th>
<th>2.62 x 4.23 x 5.92 inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>WEIGHT</td>
<td>2.2 pounds</td>
</tr>
</tbody>
</table>

**POWER**

Requires a total of 1435 milliwatts (nominal at room ambient) at the following voltage levels:
- 65 milliwatts at +15 Vdc
- 150 milliwatts at +12 Vdc
- 1100 milliwatts at +5 Vdc
- 120 milliwatts at -12 Vdc

**PARTS COUNT**

<table>
<thead>
<tr>
<th>Category</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated Circuits</td>
<td>76</td>
</tr>
<tr>
<td>Field Effect Transistors</td>
<td>156</td>
</tr>
<tr>
<td>Transistors</td>
<td>185</td>
</tr>
<tr>
<td>Diodes</td>
<td>307</td>
</tr>
<tr>
<td>Zener Diodes</td>
<td>9</td>
</tr>
<tr>
<td>Capacitors</td>
<td>158</td>
</tr>
<tr>
<td>Resistors</td>
<td>102</td>
</tr>
<tr>
<td>Crystals</td>
<td>2</td>
</tr>
</tbody>
</table>

**PACKAGING**

All parts are mounted on 15 two layer PCBs

**CONNECTOR**

Hughes - 244 pin
ANALOG MULTIPLEXER/CONVERTER

THE COMPONENT -

- CONSISTS OF A 90 CHANNEL ANALOG MULTIPLEXER, A SEQUENCER, BUFFER AMPLIFIERS AND TWO EIGHT-BIT A/D CONVERTERS WITH BUFFERED OUTPUTS

- USES REDUNDANT GATES, DRIVERS AND A/D CONVERTERS FOR RELIABLE OPERATION

- MONITORS UP TO 90 DATA SOURCES ON A SEQUENTIAL SAMPLE BASIS. REQUIRES ABOUT 54 SECONDS FOR ONE COMPLETE SEQUENCE OF SAMPLES

- CONVERTS EACH INPUT INTO AN 8-BIT BINARY WORD

- PROVIDES THE 8-BIT BINARY WORD IN PARALLEL TO THE DIGITAL MULTIPLEXER OF THE DDP
SIMPLIFIED BLOCK DIAGRAM
MULTIPLEXER GATE ARRANGEMENT DIAGRAM

FIRST TIER

SECOND TIER

THIRD TIER

FROM ADC NO. 2

TO ADC NO. 1

FROM ADC NO. 1

TO ADC NO. 2

LEGEND

FET GATE

FET GATE DRIVER

90 HIGH LEVEL ANALOG INPUTS

FROM 15:1 COUNTER MATRIX "C" RATE PULSES

FROM 6:1 COUNTER MATRIX "R" RATE PULSES

SEPT 68 5178.7.68
MULTIPLEXER TIMING DIAGRAM

C1
C2
C3
C4
C15
5 OF 15 'C' RATE
PULSES

R1
2 OF 6 'R' RATE
PULSES

MUX OUTPUT

CHANNEL #1
CHANNEL #2
CHANNEL #3
CHANNEL #4

MUX ADVANCE
PULSES

ADC
ENCODER
COMMAND

DATA AVAILABLE

DATA FORMAT AND
CHANNEL SEQUENCE

R1
R2
R3
R4
R5
R6

SEPT 68 5178.7.69
A/D CONVERTER FUNCTIONAL BLOCK DIAGRAM

ANALOG INPUT FROM BUFFER AMPLIFIER

RAMP GENERATOR

COMPARATOR

OFFSET ADJ

ADC ENCODE, ACCUMULATOR (BINARY COUNTER)

SYNC LOGIC

OSC SYNC INPUT

2 MHz OSC

GATE

ACCUMULATOR RESET

CONTROL

A/D ENCODE

SYNC

CONTROL GATE

CONTROL

8 PARALLEL OUTPUT

SEPT 68 5178.7.70
INPUT REQUIREMENTS

ANALOG INPUTS

<table>
<thead>
<tr>
<th>Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 TO +5 volts</td>
<td>(ON state)</td>
</tr>
<tr>
<td>≥ 1 megohm</td>
<td>(OFF state)</td>
</tr>
<tr>
<td>≥ 50 megohms</td>
<td></td>
</tr>
</tbody>
</table>

SOURCE Z  ≤ 10 k ohms

*PROPER OPERATION WITH AN OVERVOLTAGE OF
  +8 to -6.5 volts for channels 21, 36, 45, & 80
  +8 to -9 volts for channels 6, 7, 26, 52, 67, & 70
  +8 to -5 volts for all other channels

IS NOT DAMAGED BY AN OVERVOLTAGE OF ± 12 VOLTS ON ANY CHANNEL.

ADVANCE PULSE

REQUIRED FOR ADVANCING MULTIPLEXER THROUGH ITS 90 CHANNELS.
SUPPLIED BY DDP

ADC START (ENCODE) PULSE

DRIVES SYNC LOGIC TO START A/D CONVERSION. SUPPLIED BY DDP

*PROPER OPERATION IS NOT GUARANTEED BEYOND
PLUS AND MINUS OPERATIONAL LIMITS
ANALOG MULTIPLEXER/CONVERTER OUTPUTS

BINARY OUTPUT -
00000000 FOR A NEGATIVE INPUT
00000001 FOR ZERO INPUT
11111110 FOR +5 VOLTS INPUT
11111111 FOR GREATER THAN +5 VOLTS INPUT

LOGICAL "0" IS +4.0 ± 1.5 VOLTS
LOGICAL "1" IS +0.2 ± 0.2 VOLTS

TEMPERATURE TELEMETRY
CHANNEL 33 AT-27 BASE TEMP
(SIGNAL OBTAINED BY A THERMISTOR/RESISTOR NETWORK POWERED BY +12 VDC
THERMISTOR LOCATED ON BASE PLATE)

CHANNEL 34 AT-28 INTERNAL TEMP
(SAME AS ABOVE EXCEPT THERMISTOR MOUNTED ON PCB)

SEPT 68 5178.772
ANALOG MULTIPLEXER CHANNEL ASSIGNMENTS

APPEARS IN WORD 33 ON ALSEP 1
TRANSMITTER

PHYSICAL DESCRIPTION

• SIZE 1.5 x 2 x 7.5 inches
• WEIGHT 1.17 pounds (each)
• POWER 8 watts at 29 VDC
  0.5 watts at 12 VDC
• EMPLOYS MODULAR CONSTRUCTION WITH 11 SEPARATE CIRCUIT MODULES
• MODULES ARE MOUNTED ON A MILLED MAGNESIUM BASE PLATE WITH INTER-MODULE WIRING THROUGH MILLED PASSAGEWAYS

SEPT 68 5178.7.75
TRANSMITTER

* PROVIDES A MINIMUM OF 1 WATT INTO A 50 OHM LOAD WITH A MAXIMUM VSWR OF 1.3:1

* PROPER CRYSTAL IS INSTALLED DURING MANUFACTURE FOR OPERATION ON EITHER 2276.5 MHz (CHANNEL #1), 2278.5 MHz (CHANNEL #2) OR 2275.5 MHz (CHANNEL #3). 2279.5 MHz (CHANNEL #4) IS ASSIGNED BUT NOT IMPLEMENTED

* FREQUENCY STABILITY IS 0.0025%/YEAR

* TWO IDENTICAL COMPONENTS, TRANS A AND TRANS B, ARE PROVIDED WITH ONE IN STANDBY

* EITHER A OR B MAY BE SELECTED BY COMMAND FROM THE MSFN

* IF ONE IS SWITCHED "OFF" DUE TO AN OVERCURRENT CONDITION, THE OTHER IS AUTOMATICALLY SWITCHED "ON"

* IF COMMANDED "OFF" A RESISTOR (HEATER) IS AUTOMATICALLY SWITCHED ON FOR CENT STA THERMAL STABILITY

SEPT 68 5178.7.76
TRANSMITTER, BLOCK DIAGRAM

- **BINARY INPUT MODULATION**
  - 29 V
  - +10 V

- **OUTPUT**
  - ± 1.25 RAD

**Power Supplies and Components**

- **CH 8/12 AE-17/18 TRANS PWR DOUBLER DC CURRENT**
  - +12 V

- **CH 19/32 AT-24/26 TRANS HEAT SINK TEMP**

- **VARACTOR STRIPLINE FILTER**
  - +30.5 dBm

- **AGC FILTER, DETECTOR, AMPLIFIER**
  - -18 V

- **BIAS SUPPLY**

- **CH 18/31 AT-23/25 TRANS CRYSTAL TEMP**

**Note:**

Power distribution unit supplies +12 VDC and +29 VDC.

**Technical Specifications**

- **Power Output:** 1 Watt
- **Frequency:** 2276.5 MHz
- **Temperature:** ± 1.25 RAD

**Date:** Sept 68 5178.7.77
# TRANSMITTER

## TELEMETRY SUMMARY

<table>
<thead>
<tr>
<th>TRANSMITTER A</th>
<th>TELEMETRY DATA</th>
<th>TRANSMITTER B</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHANNEL</td>
<td>SYMBOL</td>
<td>CHANNEL</td>
</tr>
<tr>
<td>18</td>
<td>AT-23</td>
<td>TRANSMITTER CRYSTAL TEMP USES A 15 K OHM THERMISTOR AND 2 RESISTORS TO DEVELOP SIGNAL. PARTS ARE LOCATED IN OSC-BUFFER-MODULATOR MODULE</td>
</tr>
<tr>
<td>19</td>
<td>AT-24</td>
<td>TRANSMITTER HEAT SINK TEMP USES A 15 K OHM THERMISTOR AND 2 RESISTORS TO DEVELOP SIGNAL. LOCATED IN POWER DOUBLER</td>
</tr>
<tr>
<td>51</td>
<td>AE-51</td>
<td>TRANS AGC VOLTAGE AGC VOLTAGE IS AMPLIFIED TO GIVE TM SIGNAL OF PROPER LEVEL</td>
</tr>
<tr>
<td>81</td>
<td>AE-17</td>
<td>TRANS PWR DOUBLER DC CURRENT SIGNAL OBTAINED FROM SMALL RESISTOR IN POWER RETURN</td>
</tr>
</tbody>
</table>

APR 69 5178.7.78
POWER CONDITIONING UNIT
POWER DISTRIBUTION UNIT

PHYSICAL DESCRIPTION OF THE PDU

* SIZE 2.8 x 4 x 7.25 inches
* WEIGHT 2.29 pounds
* POWER 375 milliwatts at +29 VDC
  75 milliwatts at +15 VDC
  735 milliwatts at +12 VDC
  85 milliwatts at +5 VDC
  8 milliwatts at -6 VDC
  475 milliwatts at -12 VDC
* PARTS COUNT - 17 FLATPACKS 238 RESISTORS
  37 TRANSISTORS 44 CAPACITORS
  11 AMPLIFIERS 7 FUSES
  98 DIODES 2 THERMISTORS
  27 RELAYS
* PACKAGING - ALL PARTS ARE MOUNTED ON 5 PCBs
* CONNECTOR - HUGHES - 244 PIN
POWER DISTRIBUTION UNIT

THE PDU -

• PROVIDES FOR THE DISTRIBUTION AND CONTROL OF POWER TO EXPERIMENTS AND CENT STA COMPONENTS
• CONTAINS CIRCUITRY TO PROTECT THE SYSTEM AGAINST OVERLOADS OCCURRING FROM COMPONENT FAILURES
• PROVIDES SIGNAL CONDITIONING FOR CENT STA AND POWER SUBSYSTEM TELEMETRY SIGNALS
• WILL, BY SEQUENTIAL TURN-OFF OF 3 EXPERIMENTS, ADJUST THE TOTAL POWER DEMAND TO A VALUE WITHIN THE AVAILABLE POWER LIMIT
• UPON SENSING A POWER OVERLOAD CONDITION, WAITS ABOUT 135 MILLISECONDS BEFORE SWITCHING AN EXPERIMENT TO STANDBY
• PROVIDES MOUNTING SPACE FOR THE "DUST DETECTOR" ELECTRONICS

DEC 67  5178.7.81
SIMPLIFIED BLOCK DIAGRAM PDU

- FROM PCU: POWER
- FROM CMD DECODER: COMMANDS
- RES POWER SIGNAL
- REFERENCE SIGNAL
- SENSORS: SENSOR SIGNAL
- FROM SENSORS

LOAD AND HEATER POWER CONTROL

DATA PROCESSOR POWER CONTROL

RECEIVER POWER CONTROL

TRANSMITTER POWER CONTROL

TM SIGNAL PROCESSING

TO PDRs AND CENT STA HEATERS

TO DATA PROCESSOR

TO COMMAND RECEIVER

TO TRANSMITTERS

TO MULTIPLEXER

TO EXPERIMENTS
EXPERIMENT POWER CONTROL (1 OF 4)

*NOTE: RIPPLE-OFF SEQ USED ON 1, 3 & 4 ONLY  SEPT 68 5178.7.83
EXPERIMENT RIPPLE-OFF SEQUENCE

- **SENSE REF (RTG VOLTAGE)**
- **RESERVE PWR**

**Comparator** → **Delay 135±15MS** → **Amplifier** → **Counter Running** → **1 KHz Clock**

- **TO EXP #4**
- **TO EXP #3**
- **TO EXP #1**

- **STBY SEL CMD**

- **SENSE START**
- **OVERLOAD COUNTER**

- **0 0 9 17 25**

- **Delay 135±15MS**

- **IF OVERLOAD CONDITION EXISTS FOR 135±15MS, THEN FROM COUNT 1 TO COUNT 9 A "STBY SEL" CMD IS ISSUED TO EXP #4.**
- **AFTER 9MS, IF OVERLOAD STILL EXISTS, A "STBY SEL" CMD IS ISSUED TO EXP #3 FROM COUNT 9 TO COUNT 17.**
- **IF OVERLOAD STILL EXISTS, A "STBY SEL" CMD IS ISSUED TO EXP #1 FROM COUNT 17 TO COUNT 25.**
- **WHEN OVERLOAD IS CLEARED THE COUNTER IS RESET AND FURTHER EXPERIMENT SWITCHING IS INHIBITED.**

**SEPT 68 5178.7.84**
FROM EXP PWR CONTROL

+29 VDC WHEN EXP NO 1 IS IN STBY
+29 VDC WHEN EXP NO 2 IS IN STBY
+29 VDC WHEN EXP NO 3 IS IN STBY
+29 VDC WHEN EXP NO 4 IS IN STBY
+29 VDC WHEN HTR NO 2 IS ON

80.6K 40.2K 20K 2K 2K

20K 38.3K

AB-04 CH-12 EXP 1/2 STBY STA
AB-05 CH-14 EXP 3,4 STBY STA & HTR #2 ON/OFF

SEPT 68 5178.7.85
DATA PROCESSOR & CMD RCVR PWR CONTROL CKTS

DATA PROCESSOR

- +12 VDC TO DIGITAL DP
- "X" PROC SEL CMD
- +15VDC
- -12VDC
- +5VDC
- ASTRO SW 2

CMD

"Y" PROC SEL CMD

COMMAND RECEIVER

- +12 VDC
- +29 VDC

12 HR
RESET CMD

NOTES:
1. CB1 IS LATCHING TYPE RELAY
2. CB6 IS "HOLDING" TYPE RELAY
NOMINAL COIL VOLTAGE IS 18 VDC

SEPT 68 5178.7.87
SWITCHING FOR POWER DUMP RESISTORS

- Each resistor is 340 ohms
- Resistors are located on the exterior of central station

CMD ON (017) +29VDC
CMD OFF (021)

CMD ON (022) +29VDC
CMD OFF (023)

APR 69 5178.7.88
SWITCHING FOR CENTRAL STA HEATERS

- CMD ON (024)
  - DRIVER
  - RELAY
  - THERMOSTAT
  - CMD OFF (025)
    - DRIVER
    - RELAY
    - THERMOSTAT

- EACH RESISTOR IS 340 ohms
  - RESISTORS ARE MOUNTED ON THERMAL PLATE
TELEMETRY SIGNAL CONDITIONING

CHANNEL 62  AT-34  POWER DISTRIBUTION, BASE TEMP
CHANNEL 63  AT-35  POWER DISTRIBUTION, INTERNAL TEMP

THE ABOVE SIGNALS ARE OBTAINED FROM THERMISTORS AND RESISTOR DIVIDERS POWERED BY +12VDC. FOR AT-34, THE THERMISTOR IS LOCATED ON THE BASE PLATE AND FOR AT-35 THE THERMISTOR IS LOCATED ON PCB.

CHANNEL 06  AR-01  RTG HOT FRAME #1 TEMP
CHANNEL 37  AR-02  RTG HOT FRAME #2 TEMP
CHANNEL 52  AR-03  RTG HOT FRAME #3 TEMP
CHANNEL 07  AR-04  RTG COLD FRAME #1 TEMP
CHANNEL 67  AR-05  RTG COLD FRAME #2 TEMP
CHANNEL 82  AR-06  RTG COLD FRAME #3 TEMP

THE ABOVE TELEMETRY SIGNALS ARE OBTAINED FROM PLATINUM WIRE SENSORS LOCATED IN THE RTG. THESE SENSORS ARE CONNECTED INTO A BRIDGE CIRCUIT LOCATED IN THE PDU. THE BRIDGE OUTPUT IS AMPLIFIED BY A LINEAR DEVICE TO GIVE AN ACCURATE TM VOLTAGE.
PDU TELEMETRY CIRCUITS

PLATINUM WIRE SENSOR IN RTG

+12 VDC

AMPI

10K Ω

+ SIG

COMMON RTN

TM SIG

TM CKT FOR RTG HOT & COLD FRAME

15K THERMISTOR

+12 VDC

3010

+ SIG

COMMON RTN

TM SIG

TM CKT "INTERNAL" TEMPERATURES

2000 OHM Ni WIRE SENSOR

+12 VDC

5900 Ω

+ SIG

COMMON RTN

TM SIG

TM CKT FOR STRUCTURE TEMPERATURES

1 FENWAL ISO-CURVE THERMISTOR - 15K OHMS

2 TYLAN FG-108 NICKEL WIRE SENSOR - 2000 OHMS

SEPT 68 5178.7.91
TELEMETRY SIGNAL CONDITIONING

THE PDU PROVIDES THE +12 VOLT SUPPLY AND ONE 3010 OHM SERIES RESISTOR FOR EACH OF THE FOLLOWING TM MEASUREMENTS:

- CHANNEL 04 AT-03 THERMAL PLATE 1
- CHANNEL 28 AT-04 THERMAL PLATE 2
- CHANNEL 43 AT-05 THERMAL PLATE 3
- CHANNEL 58 AT-06 THERMAL PLATE 4
- CHANNEL 71 AT-07 THERMAL PLATE 5
- CHANNEL 48 AT-31 COMMAND DECODER BASE TEMP
- CHANNEL 49 AT-32 COMMAND DECODER INTERNAL TEMP
- CHANNEL 61 AT-33 COMMAND DEMODULATOR, VCO TEMP
- CHANNEL 46 AT-29 DIGITAL DP, BASE TEMP
- CHANNEL 47 AT-30 DIGITAL DP, INTERNAL TEMP
TELEMETRY SIGNAL CONDITIONING

THE PDU PROVIDES +12 VOLTS AND ONE 5900 OHM RESISTOR, IN SERIES WITH THE EXTERNALLY LOCATED 2000 OHM NICKEL WIRE SENSOR, FOR EACH OF THE FOLLOWING TM MEASUREMENTS:

- CHANNEL 27 AT-01 SUNSHIELD TEMP 1
- CHANNEL 42 AT-02 SUNSHIELD TEMP 2
- CHANNEL 59 AT-08 LEFT SIDE STRUCTURE TEMP W1
- CHANNEL 87 AT-09 RIGHT SIDE STRUCTURE TEMP W2
- CHANNEL 15 AT-10 BOTTOM STRUCTURE TEMP B1
- CHANNEL 88 AT-11 BACK STRUCTURE TEMP W3
- CHANNEL 60 AT-12 INSULATION INNER TEMP
- CHANNEL 72 AT-13 INSULATION OUTER TEMP

SEPT 68 5178.7.93
MISCELLANEOUS ITEMS

- CENTRAL STATION TIMER
- ASTRONAUT BACK-UP SWITCHES
- WIRE HARNESS
CENTRAL STATION TIMER

• THE CST IS AN ACCUTRON MECHANISM OBTAINED FROM THE BULOVA WATCH CO.
• A TUNING FORK IS USED TO ACCURATELY CONTROL SWITCH CLOSURE TIME
• SIZE: 1.32 x 1.32 x 2.63 INCHES
• WEIGHT: 0.265 POUNDS
• POWER IS PROVIDED BY A SEPARATE BATTERY
• TWO MODES OF OPERATION ARE PROVIDED-
  - "STOP MODE" - POWER IS APPLIED AND FORK IS OSCILLATING AT LOW LEVEL - ROTARY MOTION IS NOT PRODUCED. MAXIMUM CURRENT IS 7 MICROAMPERES. THIS MODE IS USED FROM FINAL TEST UNTIL DEPLOYMENT ON THE LUNAR SURFACE
  - "START MODE" - ADDITIONAL POWER IS APPLIED FOR INCREASED AMPLITUDE OF FORK OSCILLATION. ROTARY MOTION IS PRODUCED TO DRIVE THE SWITCH MECHANISM. MAXIMUM CURRENT IS 12 MICROAMPERES

SEPT 68 5178.7.95
CENTRAL STA TIMER MECHANISM

OUTSIDE CENTRAL STATION

E65
E66
* REMOVABLE JUMPER

TB1

FORC

ACCUTRON MOVEMENT

CONVERT TO ROTARY MOTION & DRIVE SWITCH MECHANISM

1 MIN SW ACTION PRODUCED BY SINGLE SEGMENT COMMUTATOR

WIRE BRUSH

METAL

INSULATION

WIRE BRUSH

EQUIV SW CLOSED FOR 500 ±200 MS

12 HR SWITCH IS PRODUCED SNAP ACTION MECHANISM

SPST

720 ±30 DAY SWITCH

* JUMPER IS REMOVED AND 360 Hz SIGNAL APPLIED TO START FORK.

SEPT 68 5178.7.97
CENT STA TIMER BATTERY

- CONSISTS OF A P.R. MALLORY ZINC-MERCUric-OxIDe, TYPE RMCC1W CELL, IN A SPECIAL PACKAGE FOR ALSEP. BASIC CELL IS CALLED "PACER"
- INITIAL TERMINAL VOLTAGE IS 1.5 VOLTS MAXIMUM
- MINIMUM CELL CAPACITY IS 750 MILLIAMPERE HOURS
- CELL CAPACITY IS DERATED TO 375 MILLIAMPERE HOURS FOR ALSEP
- CELL CAPACITY IS GUARANTEED AFTER STORAGE (OPEN CIRCUIT) FOR UP TO 2 YEARS
- OPERATING TEMPERATURE IS -27 to +162°F
**ASTRONAUT SWITCHES**

- Switches interface with UHT
- All switches rot CW
- Visual indicators show switch pos

### Table: Switches

<table>
<thead>
<tr>
<th>Switch Number</th>
<th>QTY/TYPE/ROT</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1/SPST/180°</td>
<td>Disables the hold-off circuit. Must be operated by the astronaut</td>
</tr>
</tbody>
</table>
| 2             | 1/SPST/180° Momentary | (A) turn XNR B on  
(B) turn Data Processor Y on  
(C) reset RCVR               |
| 3             | 4/SPST/270° Momentary | Mechanically ganged & operated sequentially to activate exper  
oper sel power switches (in 1, 2, 4, 3 order) at ≈0.1 sec intervals |

**ALSEP 4 includes the ASE; has 2 additional switch**

**Backup**

- (A) Activate ASE Oper SEL Power Switch  
  (not inc on SW #3)  
- (B) Switch data processor to ASE HBR on

**Operational**

- (A) Activate ASE STBY SEL Power Switch  
- (B) Switch data processor to ASE HBR off  
  (return to norm bit RT)  
- (C) Activate switch to interrupt ASE  
  29 V oper PWR line; safety feature  
  redundant with (A)

---

*Nov 68 5178.7.99*
WIRE HARNESS

• ALL COMPONENTS ARE INTERCONNECTED WITH A PRE-FORMED WIRE HARNESS WHICH PROVIDES THE PROPER MATING PLUGS

• WITHIN THE THERMALLY CONTROLLED AREA, AWG# 24 SINGLE CONDUCTOR, STRANDED, COPPER WIRE IS USED

• TWO PRINTED CIRCUIT TERMINAL BOARDS ARE USED TO PERMIT TRANSITION FROM COPPER TO MANGANIN FOR WIRES WHICH MUST GO OUTSIDE THE THERMALLY CONTROLLED AREA

• TO REDUCE THERMAL CONDUCTION, MANGANIN WIRE, WHICH HAS A THERMAL CONDUCTIVITY ABOUT 1/17 THAT OF COPPER, IS USED BETWEEN THE PC TERMINAL BOARDS AND EXTERNAL INTERFACES (CONNECTORS). BECAUSE OF THE HIGH CURRENT, + AND - WIRES TO THE RTG CONNECTOR ARE COPPER

• CONNECTORS USED ARE MADE BY HUGHES, SCHJELDAHL, DEUSTCH AND MICRODOT

JAN 69  5178.7.100
HARNESS TO EXTERNAL CONNECTORS

COPPER WIRES IN HARNESS

TERMINAL BOARD NO. 1

COPPER WIRES IN HARNESS

TERMINAL BOARD NO. 2

EXTERNAL CONNECTORS ON STRUCTURE

MANGANIN WIRES

CONTROLLED ENVIRONMENT

THERMAL BAG

EXPOSED TO LUNAR ENVIRONMENT

DEC 67 5178.7.101
PASSIVE SEISMIC EXPERIMENT

- COMPONENTS & FUNCTION
- DEPLOYMENT
- COMMANDS & DATA

CENTRAL STATION ELECTRONICS
MANGANIN RIBBON CABLES - THERMAL BARRIER
PAIR OF RIBBON CABLES
SENSOR ASSY WITHIN THERMAL CONTROL ASSY
LEVELING STOOL
CABLE REEL
PSE FUNCTIONAL BLOCK DIAGRAM

DATA PROCESSOR

- ENG (ANALOG) DATA (8 LINES)
- DATA SCIENCE (DIGITAL) DATA
- DIGITAL DATA, SYNC AND CONTROL PULSES

LEVELING COMMANDS

LEVELING

- LONG PERIOD (LP) HORIZONTAL (X AXIS) SEISMIC ACTIVITY MON
- LONG PERIOD (LP) HORIZONTAL (Y AXIS) SEISMIC ACTIVITY MON
- LONG PERIOD (LP) VERTICAL (Z AXIS) SEISMIC ACTIVITY MON

UNCAGING COMMANDS

UNCAGING

- SHORT PERIOD (SP) VERTICAL (Z AXIS) SEISMIC ACTIVITY MON

HEATER CONTROL COMMANDS

HEATER CONTROL

- SHORT PERIOD (SP) VERTICAL (Z AXIS) SEISMIC ACTIVITY MON

POWER

- TEMPERATURE DATA

PDU

- +29 VDC STBY
- +29 VDC OPER

TEMPERATURE MONITORING

OUTPUT DATA HANDLING

- LP X SEISMIC
- LP Y SEISMIC
- LP Z SEISMIC

COMMAND DECODER

- LEVELING COMMANDS
- CALIBRATION AND GAIN CHANGE COMMANDS
- UNCAGING COMMANDS
- HEATER CONTROL COMMANDS

TEMPERATURE DATA

SEPT 68 5178.8.3
LONG PERIOD (LP) SEISMIC FUNCTION
SHORT PERIOD (SP) SEISMIC FUNCTION

PSE/SP CALIB PWR

SP CALIB LOGIC

CALIB STEP ATTEN

SP CALIB SIGNAL SWITCH

CALIB COIL

SEISMIC SENSOR

PRE-AMP

STEP ATTEN

POST-AMP

LO-PASS FILTER

SEISMIC OUTPUT SIGNAL TO PSE OUTPUT DATA HANDLING FUNCTION

PSE/SP GAIN CH (0, -10, -20, -30 DB)

SP ATTEN LOGIC

+2.5 VDC

DEC 67 5178.8.5
DATA HANDLING FUNCTION

DATA CHANNEL SELECTOR

FRAME POSITION COUNTER

10 BIT A/D CONVERTER

TRANSFER GATES

SHIFT REGISTER

PROGRAM CONTROL AND BUFFER AMPLIFIERS

EVEN FRAME MARK PULSES

DATA GATE PULSES

DEMAND PULSES

SHIFT PULSES

PSE DIGITAL (SCIENTIFIC)

OUTPUT DATA

PSE SCIENTIFIC DATA

LP X SEISMIC

LP Y SEISMIC

LP Z SEISMIC

LP X TIDAL

LP Y TIDAL

LP Z TIDAL

SP SEISMIC

LEVELING DIRECTION

LEVELING SPEED

LEVELING MODE

COARSE SENSOR

X & Y GAIN

LP CALIBRATE

SP CALIBRATE

Z GAIN

SP GAIN

THERMAL CONTROL

UNCAGED

DATA HANDLING FUNCTION

DSS

DSS

SEPT 68 5178.8.6
UNCAGING AND LEVELING FUNCTION
## PSE Timing

Timing pulses provided by DSS for synchronization and data control

<table>
<thead>
<tr>
<th>Pulse</th>
<th>Subfunction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Even Frame Mark</td>
<td>Program control, frame position counter, data channel selector</td>
</tr>
<tr>
<td>Data Demand</td>
<td>Allows data shift out to DSS</td>
</tr>
<tr>
<td>Data Gate</td>
<td>Indicates individual words within a data demand pulse of multiple word length</td>
</tr>
<tr>
<td>Shift Pulse</td>
<td>Timing for data shift-out</td>
</tr>
</tbody>
</table>

**Note:** Timing does not affect the PSE power profile.
PSE POWER PROFILE

SENSOR HTR 0.2 TO 2.50 W PROP
SENSOR HTR 0.75 W
CENTRAL STATION HTR 3.75 W CONTINUOUS

12.3 W MAX OPER TRANSIENT LUNAR NIGHT (DURATION 43 MSEC)
7.0 W MAX OPER LUNAR NIGHT STEADY STATE
FUNCTIONAL POWER ON HEATER OFF MOTOR OFF
MIN OPER 5.1 LUNAR DAY STEADY STATE
ONE AXIS ONLY
MOTOR ONE AXIS
7.4

STBY OPER LVL OPER

037 EXP 1 STBY SEL 030 EXP 1 OPER SEL
030 LVL MTRX ON/OFF (OPER ONE AXIS ONLY)
070 LVL MTRX ON/OFF

APR 69 5178.8.10
PSE TIE-DOWN

RELEASE 4 FASTENERS

INSERT UHT

LIFT EXPERIMENT

SOCKET
FOR
UHT
# PSE 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>Distance from Subpackage 1</td>
<td>9 ±1 FT</td>
<td>1</td>
<td>10 FT Cable</td>
<td>15 FT Separation Requirement from RTG for Thermal Reasons</td>
</tr>
<tr>
<td>Direction from Subpackage 1</td>
<td>Due E or W*</td>
<td>1</td>
<td>Eyeball</td>
<td>Out of Field of View of Central Station Radiator</td>
</tr>
<tr>
<td>Site Selection</td>
<td>'Quiet' Location</td>
<td>1</td>
<td>Eyeball</td>
<td>Free from Loose Rubble</td>
</tr>
<tr>
<td>Level, WRT Indicator</td>
<td>±5° of Horizontal</td>
<td>1</td>
<td>Ball Level</td>
<td>Interacts with Alignment; Instrument Fine-Levels Internally</td>
</tr>
<tr>
<td>Rough Align</td>
<td>±20° of E-W</td>
<td>2</td>
<td>Arrow**</td>
<td>Before Opening Shroud</td>
</tr>
<tr>
<td>Readout of Alignment WRT Shadow</td>
<td>±5° of E-W</td>
<td>1</td>
<td>Full Rose</td>
<td>After Opening Shroud</td>
</tr>
<tr>
<td>Experiment Interrelation</td>
<td>*No less than 10 FT from other subsystems to minimize pickup of stray vibrations.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special Requirements</td>
<td>**Arrow nominally points East although Scientific output depends only on knowing final alignment. Final reading is accomplished with assistance of Azimuth Gnomon mounted on top of Thermal Shroud.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

APR 69 5178.8.12
# PSE Alignment Markings

<table>
<thead>
<tr>
<th>PHASE</th>
<th>CONFIGURATION</th>
<th>TASK</th>
<th>MARKING</th>
</tr>
</thead>
<tbody>
<tr>
<td>INITIAL</td>
<td>CYLINDRICAL SENSOR ASSY INSIDE THERMAL CASE, ENCLOSED IN THERMAL SHROUD WITH GIRDLE OVER SHROUD</td>
<td>ROUGH ALIGN VIA MARKING ON TOP OF GIRDLE (ARROW EAST)</td>
<td>ALTERNATE LOCATIONS (DEPENDING ON SENSOR ORIENTATION INSIDE)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>STOOL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GIRDLE RETAINING PIN</td>
</tr>
<tr>
<td>FINAL</td>
<td>SHROUD OPENED &amp; ASSY LEVELLED</td>
<td>READOUT VIA SHADOWS WRT COMPASS MARKINGS ON TOP</td>
<td></td>
</tr>
</tbody>
</table>

APR 69 5178.8.13
PSE OPERATE MODES

CAGED: PROTECTS EQUIPMENT
PRECEDES OTHER MODES
CANNOT BE RECAGED AFTER UNCAGE

NORM (UNCAGED): DIGITAL SCIENCE DATA (INCLUDING ONE TEMP
MEAS FOR DATA INTERPRETATION)
ANALOG ENG DATA

LEVEL: REQUIRED FOR VALID DATA
MAY BE REPEATED
TWO METHODS • AUTO-SERVO LEVELED
• FORCED-COMMANDED STEPS FROM OBSERVED
  DATA
NOTE: Z-AXIS "LEVELING" IS ADJUSTMENT OF LACOSTE SPRING

CALIB: THREE DISTINCT FUNCTIONS
• CALIB SP
• CALIB LP X & Y (HORIZ)
• CALIB LPZ
**PSE Command Philosophy**

- Commands are interrelated
- Leveling mode is an example
- All these CMDs are bi-state CMDs

<table>
<thead>
<tr>
<th>OCTAL CMD</th>
<th>CMD</th>
<th>LEVELING MODE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>AUTO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>COARSE</td>
</tr>
<tr>
<td>103</td>
<td>LVL MDE A/F</td>
<td>A</td>
</tr>
<tr>
<td>101</td>
<td>FILT IN/OUT</td>
<td>OUT</td>
</tr>
<tr>
<td>102</td>
<td>LVL SNSR IN/OUT</td>
<td>IN</td>
</tr>
<tr>
<td>074</td>
<td>LVL DIR POS/NEG</td>
<td>--</td>
</tr>
<tr>
<td>075</td>
<td>LVL SPEED HI/LO</td>
<td>--</td>
</tr>
<tr>
<td>070</td>
<td>LVL MTRX ON/OFF</td>
<td>X</td>
</tr>
<tr>
<td>071</td>
<td>LVL MTRY ON/OFF</td>
<td>Y</td>
</tr>
<tr>
<td>072</td>
<td>LVL MTRZ ON/OFF</td>
<td>OR Z</td>
</tr>
</tbody>
</table>

*Order optional but must be set with 070, 071, & 072, off

Send last but only one on at a time. X, Y to precede Z

*In forced mode the level motor runs to mech stop unless cmd off

*Individual motors must be cmd off after leveling as each continues to draw power

Apr 69 5178.8.15
<table>
<thead>
<tr>
<th>OCTAL CMD NUMBER</th>
<th>CMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>063</td>
<td>PSE/XY GAIN CH</td>
</tr>
<tr>
<td></td>
<td>Switches different Attenuation into LPX &amp; LPY ckt. to control Gain. Repeated CMD successively steps Attenuation through values of 0 dB, -10 dB, -20 dB, -30 dB. CMD controls Cal current of LPX &amp; LPY. Attenuation reset to 0 dB upon PSE activation.</td>
</tr>
<tr>
<td>064</td>
<td>PSE/XY GAIN CH</td>
</tr>
<tr>
<td></td>
<td>Affects LPX ckt similar to 063 above.</td>
</tr>
<tr>
<td>065</td>
<td>PSE/SP GAIN CH</td>
</tr>
<tr>
<td></td>
<td>Applies current thru SP ckt. Attenuation selected by CMD 0671 to SP ckt. SP Cal is also performed auto every 12 hr. under timer control (unless inhibited by CMD 0311). By CMD 0311, reset to off upon PSE activation.</td>
</tr>
<tr>
<td>066</td>
<td>PSE/SP GAIN CH</td>
</tr>
<tr>
<td></td>
<td>Applies current thru LP ckt. Attenuation selected by CMD 063 &amp; 064 to the LP damping ckt. (3 axes). CMD is bi-state on/off &amp; is set to off upon PSE activation.</td>
</tr>
<tr>
<td>067</td>
<td>PSE/SP GAIN CH</td>
</tr>
<tr>
<td></td>
<td>Affects SP ckt. similar to 063 above.</td>
</tr>
<tr>
<td>070</td>
<td>LVL MKTR ON/OFF</td>
</tr>
<tr>
<td></td>
<td>Applies power to X-axis drive motor. CMD is bi-state on/off &amp; is set to off upon PSE activation. Motor consumes power until CMD off. Note: only one drive motor to be on at one time.</td>
</tr>
<tr>
<td>071</td>
<td>LVL MKTR ON/OFF</td>
</tr>
<tr>
<td></td>
<td>Affects Y-axis similar to 070 above.</td>
</tr>
<tr>
<td>072</td>
<td>LVL MKTR ON/OFF</td>
</tr>
<tr>
<td></td>
<td>Affects Z-axis similar to 070 above. But adjusts Lacroix spring. Note: do not send while experiment is caged - will destroy sensor.</td>
</tr>
<tr>
<td>073</td>
<td>UNCACT ARM FHM</td>
</tr>
<tr>
<td></td>
<td>Irreversible function necessary to obtain PSE scientific data. First CMD arms, second CMD fires actuator uncaging all spring mass systems. Subsequent CMDs will arm and then attempt fire using PWR without affecting cage condition. Arm &amp; fire also accomplished by 12 hr timer pulses 5 by 12 hr. &amp; 2 min. pulse from delayed arm seq. Therefore arm is accomplished by CMD 073 or 12 hr timer pulse or 12 hr. + 2 min. pulse and fire when in the arm state is accomplished by the next CMD 073 or 12 hr timer pulse or 12 hr. + 2 min. pulse.</td>
</tr>
<tr>
<td>074</td>
<td>LVL DIR POS/NEG</td>
</tr>
<tr>
<td></td>
<td>Reverses direction of level motors LPX, LPY, LPZ in the forced level mode. CMD is bi-state POS/NEG &amp; is set to POS upon PSE activation.</td>
</tr>
<tr>
<td>075</td>
<td>LVL SPEED HI/LO</td>
</tr>
<tr>
<td></td>
<td>Controls speed of level motors LPX, LPY, LPZ in the forced level mode. CMD is bi-state HI/LO &amp; is set to HI upon PSE activation.</td>
</tr>
<tr>
<td>076</td>
<td>PSE TC FL CH</td>
</tr>
<tr>
<td></td>
<td>Controls sensor heaters by selecting off, forced-on, or auto mode. 4-state CMD is set to auto-on upon PSE activation. Successive CMD steps thru modes in this sequence: AUTO-OFF &gt; 29 VDC connected from heater. FORCED-ON &gt; 29 VDC connected to heater, auto thermostat control bypassed. FORCED-OFF &gt; 29 VDC connected from heater. AUTO-ON &gt; 29 VDC connected to heater, auto thermostat control enabled. Note: CMD does not control heater in PSE central station electronics. CMD does not control sensor heaters when PSE is in exp 1 standby sel. CMD 0371.</td>
</tr>
<tr>
<td>077</td>
<td>PSE FILT IN/OUT</td>
</tr>
<tr>
<td></td>
<td>Removes feedback loop filters from LPX, LPY, LPZ. CMD is bi-state in/out &amp; is set to out upon PSE activation. For proper PSE operation, CMD out for leveling and in or out for calib &amp; for normal operation. Note: do not transmit this CMD when any level motor is on in manual mode. CMD has no effect. Do not send CMD when in auto mode.</td>
</tr>
<tr>
<td>078</td>
<td>LVL SNSR IN/OUT</td>
</tr>
<tr>
<td></td>
<td>Allows coarse level sensors to control LPX &amp; LPY drive motors in the auto level mode. CMD is bi-state in/out &amp; is set to out upon PSE activation.</td>
</tr>
<tr>
<td>079</td>
<td>PSE LVL MDL AF</td>
</tr>
<tr>
<td></td>
<td>Selects leveling mode of LPX, LPY, LPZ. CMD is bi-state autoforced &amp; is set to auto upon PSE activation. Note: do not transmit this CMD when any level motor is on.</td>
</tr>
</tbody>
</table>

APR 69 5178.8.16
# PSE Measurements

<table>
<thead>
<tr>
<th>Measurement Name</th>
<th>Symbol</th>
<th>Alsep Word No's</th>
<th>Alsep Frames</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSE/X Data</td>
<td>DL-01</td>
<td>9, 25, 41, 57</td>
<td>EVERY</td>
</tr>
<tr>
<td>PSE/Y Data</td>
<td>DL-02</td>
<td>11, 27, 43, 59</td>
<td>EVERY</td>
</tr>
<tr>
<td>PSE/Z Data</td>
<td>DL-03</td>
<td>13, 29, 45, 61</td>
<td>EVERY</td>
</tr>
<tr>
<td>PSE Tidal X Data</td>
<td>DL-04</td>
<td>35</td>
<td>EVEN</td>
</tr>
<tr>
<td>PSE Tidal Y Data</td>
<td>DL-05</td>
<td>37</td>
<td>EVEN</td>
</tr>
<tr>
<td>PSE Tidal Z Data</td>
<td>DL-06</td>
<td>35</td>
<td>ODD</td>
</tr>
<tr>
<td>PSE Inst Deg F</td>
<td>DL-07</td>
<td>37</td>
<td>ODD</td>
</tr>
<tr>
<td>PSE/SP Data</td>
<td>DL-08</td>
<td>EVERY EVEN EXCEPT 2°, 46, AND 56</td>
<td>EVERY</td>
</tr>
</tbody>
</table>

* IN ALSEP'S 1 AND 2

<table>
<thead>
<tr>
<th>Measurement Name</th>
<th>Symbol</th>
<th>Alsep Word No's</th>
<th>Alsep Frames</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSE/XY Gain dB</td>
<td>AL-01</td>
<td>33</td>
<td>23</td>
</tr>
<tr>
<td>PSE/Z Gain dB</td>
<td>AL-02</td>
<td>33</td>
<td>38</td>
</tr>
<tr>
<td>LVL Dir/V Sta</td>
<td>AL-03</td>
<td>33</td>
<td>53</td>
</tr>
<tr>
<td>PSE/SP Gain Db</td>
<td>AL-04</td>
<td>33</td>
<td>68</td>
</tr>
<tr>
<td>LVL Mode Snsr Sta</td>
<td>AL-05</td>
<td>33</td>
<td>24</td>
</tr>
<tr>
<td>PSE T Ctrl Sta</td>
<td>AL-06</td>
<td>33</td>
<td>39</td>
</tr>
<tr>
<td>PSE/LP/SP Cal Sta</td>
<td>AL-07</td>
<td>33</td>
<td>54</td>
</tr>
<tr>
<td>PSE Uncage Status</td>
<td>AL-08</td>
<td>33</td>
<td>69</td>
</tr>
</tbody>
</table>
ACTIVE SEISMIC EXPERIMENT SUBSYSTEM

XMTR ANTENNA AND RANGE LINE (DEPLOYED)

RECEIVING ANTENNA

XMTR ANTENNA AND RANGE LINE (DEPLOYED)

GRENADe ASSEMBLY (4)

14.5 IN. FOLDED
44.5 IN. DEPLOYED

INITIATOR SELECTOR SWITCH

ARM/FIRE SWITCH

TO CENTRAL STATION

GRENADe LAUNCH ASSEMBLY

GEOPHONE DETECTORS (3)

4.80 IN. HEIGHT (INC SPIKE)
1.66 IN. DIAM

GEOPHONE FLAG

MORTAR BOX ASSEMBLY
15.6 X 9.5 X 4.0 IN
(STOWED)

RF CABLE

GRENADe LAUNCH ASSEMBLY

CENTRAL ELECTRONICS
6.77 X 6.18 X 2.75 IN.

APR 69 5178.9.1
ASE GENERAL FEATURES

**PURPOSE:**
- Monitor natural lunar seismic activity
- Generate & monitor artificial seismic energy
- Range from 3 to 250 Hz

**GENERATE (SOURCES):**
- Explosive devices
- Thumper
- Mortar
- A.S.T.'s
- Grenades

**MONITOR (DETECTORS):**
- Geophones (3) with log compression amplifiers

**By varying the magnitude & location of sources with respect to detectors:**
- Obtain penetration of waves to ≈ 500 ft
- Thus investigate velocity through several layers of subsurface material

**Range, Ft:**
- 500
- 1000
- 3000
- 5000

**Charge proportional to range**

**Actuated near marked positions on geophone cable**

**Shot time and range is fundamental for analysis of geophone data**

<table>
<thead>
<tr>
<th>Shot Time</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thumper</td>
<td>Pressure sw signal</td>
</tr>
<tr>
<td>Grenades</td>
<td>Xmr. off signal</td>
</tr>
</tbody>
</table>

JAN 68 5178.9.2
ASE THUMPER FEATURES

• INITIATOR (ASI) MOUNTING PLATE & BASE PLATE }
  INSIDE LOWER END

• ARM/FIRE & ASI SELECTOR SWITCHES }
  ON UPPER END

• FLAT, 4-CONDUCTOR CABLE TO CENTRAL ELECTRONICS }
  ON UPPER SPLIT REEL
  ON LOWER INTEGRAL REEL }
  UNWOUND DURING DEPLOYMENT

• 3 GEOPHONES WITH CABLES }

• GEOPHONE FLAG

• PRESSURE SWITCH ON ASI MOUNTING PLATE DETECTS TIME OF SEISMIC EXPLOSION

• GEOPHONE FLAG DEPLOYED ON LUNAR SURFACE AT 150 FT TO AID IN GEOPHONE

• CABLE ALIGNMENT

• GEOPHONES AND CABLES STOWED ON THUMPER UNTIL DEPLOYED

APR 69 5178.9.5
ASE GEOPHONE FUNCTION

DSS

GEOPHONE TEMP

GEO 1

TO ASE Timing & Data Function

AS-04 Geophone Deg C

DS-01 Geophone 1 Data

DS-02 Geophone 2 Data

GEO 2

GEO 3

DS-03 Geophone 3 Data

JAN 68 5178.9.6
ASE GEOPHONE FEATURES

- Electromagnetic transducers (velocity sensor) (output to separate log compression amplifiers)
- Implanted in surface by spike
- Temperature sensor in one geophone
- 7.5 CPS natural frequency
- Spring constant designed for lunar gravity

![Diagram of frequency response]

- Mean of 10 to 100 Hz response characteristic
- 12 dB/Octave
- 2.0 Hz
- 7.5 Hz
- Filter pre-emphasis
- Combined geophone and amplifier filter response (before log compression)

-35 dB above 450 Hz
-40 dB above 500 Hz

APR 69 5178.9.7
ASE MORTAR PACKAGE COMPONENTS

- GRENADE LAUNCH ASSEMBLY (GLA)
  - LAUNCH TUBE ASSEMBLY
    - TEMP. SENSORS (2)
    - TWO - AXIS INCLINOMETER
    - MICRO SWITCHES (3) (FOR SEQ. FIRE)
  - GRENADES (4)
    - TRANSMITTERS
    - THERMAL BATTERY
    - DETONATOR
    - HNS EXPLOSIVE
    - SAFE SLIDE

- MORTAR PACKAGE
  - ELECTRONICS
    - ARM/FIRE
    - THERMAL CONTROL
    - TEMP SENSOR
    - HEATER
  - RECEIVING ANTENNA (FOLDS LIKE CARPENTER'S SCALE)
  - SAFETY SWITCHES (2)
  - THERMAL INSULATION
  - SUPPORT FRAME & LEGS

- SAFETY RELEASE ASSEMBLY

- LAUNCH TUBES: 3-IN. SQUARE, TWO 6-IN. LONG, TWO 4-IN. LONG (APPROX)
- EACH LAUNCH TUBE PROVIDES FOR RANGE LINE BREAKWIRES (2)
- INCLINOMETER PROVIDES DATA ON DEVIATION OF PACKAGE FROM VERTICAL (PITCH & ROLL)

APR 69 5178.9.9
ASE GRENADE CHARACTERISTICS

DESCRIPTION

• CASING SIZE:
  - 2.7 IN. SQUARE
  - 4 TO 6 IN. LONG APPROX

• CASING CONTAINS:
  - SOLID FUEL ROCKET MOTOR
  - SAFE SLIDE
  - HIGH EXPLOSIVE CHARGE
  - IGNITION & DETONATION DEVICES
  - THERMAL BATTERY
  - 30 MHz XMTR CONNECTED TO TRAILING WIRE ANTENNA (FUNCTIONS AS RANGE LINE)

• GRENADES DIFFER ONLY IN AMOUNT OF PROPELLANT & HIGH EXPLOSIVE

OPERATION

• GRENADE ARM CMD APPLIES PULSE TO ROCKET MOTOR ARMING CIRCUIT CHARGING CONDENSER IN MORTAR BOX AND CHARGES MATCH CONDENSER IN GRENADE

• GRENADE FIRE CMD DISCHARGES CONDENSER THROUGH ASI IGNITING ROCKET MOTOR

• WHEN GRENADE LEAVES TUBE:
  - SPRING EJECTED SAFE SLIDE ENABLES DETONATOR
  - SLIDE Ejection ACTIVATES MICROSWITCH IN GRENADE
  - MICROSWITCH DISCHARGES CONDENSER ACROSS MATCH ACTIVATING THERMAL BATTERY

• BATTERY PROVIDES INTERNAL POWER FOR:
  - 30 MHz XMTR
  - CHARGING DETONATOR CONDENSER

• EVENT MARK FOR:
  - BREAKWIRE (10-IN. & 25-FT + 10-IN. TRAVEL)

• AT IMPACT, AN OMNIDIRECTIONAL IMPACT SWITCH DISCHARGES CONDENSER THROUGH DETONATOR SETTING OFF HIGH EXPLOSIVE

• EXPLOSION DESTROYS BATTERY AND TRANSMITTER TERMINATING RF TRANSMISSION

• EVENT MARK FOR XMTR OFF

APR 69 5178.9.10
ASE GRENADE RANGING

CONCEPT
• BALLISTIC TRAJECTORY OF GRENADE IS CALCULATED FROM ITS INITIAL DIRECTION & TIME OF FLIGHT:
  • DIRECTION (45° ANGLE OF MORTAR CORRECTED BY INCLINOMETER ROLL & PITCH)
  • TIME-OF-FLIGHT FROM LAUNCH (FIRST RANGE LINE SIGNAL TO IMPACT (XMTR OFF)
• CONFIDENCE IS ENHANCED BY KNOWING INITIAL LAUNCH VELOCITY (BASED ON TIME BETWEEN RANGE LINE EVENTS FOR 10-IN. & 25-FT + 10-IN. TRAVEU)

MECHANIZATION
• RANGE LINE: A THIN STRANDED CABLE WOUND AROUND THE OUTSIDE OF LAUNCH TUBE & CONNECTED AT ONE END TO GRENADE (30 MHZ TRANSMITTING ANTENNA)
• BREAKWIRES (2): EACH A SINGLE LOOP OF FINE COPPER WIRE ARRANGED TO BE SEVERED WHEN RANGE LINE REACHES 10-IN. & 25-FT + 10-IN. POINTS
• INCLINOMETER: MEASURES DEVIATIONS AROUND TWO AXES
  • PITCH: INCREASE OR DECREASE IN THE 45° LAUNCH ANGLE
  • ROLL: ROTATION AROUND A HORIZONTAL AXIS PERPENDICULAR TO THE PITCH AXIS

IMPLICATIONS
• INCLINOMETER DATA IS AVAILABLE IN CASE MORTAR PACKAGE SHIFTS DURING EACH FIRING
• PACKAGE STABILITY ENHANCED BY "BLOWOUT" REAR CLOSURE & THRUST TERMINATION BEFORE GRENADE LEAVES TUBE
• SEQUENTIAL FIRING ORDER (2, 4, 3, 1), ALSO USED FOR STANDARD FIRING, OPTIMIZES PACKAGE STABILITY
• NOTE THAT ARM CMD MUST BE SENT 4 TIMES (SEQUENTIAL & STANDARD CONDENSERS ARE CHARGED & DISCHARGED SIMULTANEOUSLY); ALSO, SEQUENTIAL FIRE ACTUATES ONE GRENADE EACH TIME SENT

SEPT 68 5178.9.11
ASE CENTRAL ELECTRONICS FEATURES

TIMING & DATA

- TEMP SENSING
  Internal temperature monitored in basic Alsep data as well as ASE data stream

- LOG COMPRESSION AMPLIFIERS
  Low-noise, provide wide dynamic range
  Pre-emphasis to increase low freq geophone response

- GEOPHONE CALIBRATION
  - DRIVER (PULSE STRETCHER) CONVERTS COMMAND INTO 1-SEC EXCITATION PULSE APPLIED VIA AMPLIFIERS
  - ELECTRICALLY DRIVES GEOPHONES FOR MEASUREMENT OF RESONANT FREQUENCY, GENERATOR CONSTANT, & DAMPING COEFFICIENT
  - COMPARE TO PREFLIGHT DATA (RELATIVE CALIBRATION)
  - PULSE VOLTAGE SAMPLED IN ASE DATA

- ANALOG MULTIPLEXER & ADC
  - ASE COMPRESSED SEISMIC DATA CONVERTED TO 5-BIT DIGITAL
  - ASE ENG &ALSEP HK (5 KEY PARAMETERS) CONVERTED TO 8-BIT DIGITAL, & BOTH READ OUT AS 4 BITS IN EACH OF TWO ASE WORDS
  - ADC CAL CIRCUIT GIVES 2-POINT CHECK

- TIMING & CONTROL
  - 4, 5, & 32 SEQUENCE COUNTER OPERATES ON 10.6 KHz SQUARE WAVE FROM DSS
  - PROVIDES FOR 5-BIT SUBWORDS, 4 PER ASE WORD (20 BITS) & 32 WORDS PER FRAME (640 BITS)
  - DATA RATE, 10.6 KBPS (ALMOST ENTIRELY ASE DATA) GIVE:
    - RELATIVELY HIGH-FREQUENCY SEISMIC DATA
    - ACCURATE ENCODING & TRANSMISSION OF REAL-TIME EVENTS

POWER CONTROL

- ASE HAS NO DC/DC CONVERSION; ALL VOLTAGES SUPPLIED THROUGH DSS

- CURRENT LIMITERS

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<tr>
<th>LINE, VOLTS</th>
<th>LIMIT, AMPS</th>
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<tr>
<td>+15</td>
<td>0.15</td>
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<tr>
<td>+5</td>
<td>0.50</td>
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<td>-12</td>
<td>0.15</td>
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- POWER RESET BY SWITCHING +29 V EXPER POWER OPER/STBY/OPER

APR 69 5178.9.12
ASE TIMING AND DATA FUNCTIONS

TO MORTAR PACKAGE

ARM & FIRE CMDs (6)

GEO CAL GO

CALIBRATION DRIVER

AS-G1 ASE INT PKG DEG C

2 SENSORS; NEW NUMBER TBD

ASEP HK PARAMETERS (5)

START PULSE

ANALOG MULTIPLEXER & 8-BIT ADC

DS-10 ASE ADC 1.25 VOLTS

HOLDING PULSES

AML GATE PULSE

SHIFT REGISTER & MULTIPLEXER LOGIC

DS-12 ASE MODE ID

DS-17 ASE FRAME SYNC

FROM MORTAR PACKAGE

DS-08 ASE CAL SIG VOLTS

OUTPUT MODE SEL

LOG COMPRESSION AMPLIFIERS

GEO 1 OUTPUT

GEO 2 OUTPUT

GEO 3 OUTPUT

GLA TEMP

GND MON

PITCH DEG

ROLL DEG

FROM ASE GEOPHONE FUNCTION

FROM ASE MORTAR PACKAGE

GRENAD ARM EVENTS

RANGE LINE EVENTS

RCVR

30 MHz

RTE LOGIC

FIRE EVENTS

ARM SIGNAL

FROM THUMPER

DIGITAL MULTIPLEXER & SHIFT REGISTER

SYNC & ID

SEPT 68 5178.9.13
ASE POWER CONTROL FUNCTIONS

ASTRO SWITCH (NOT IN ASE)

+29 V OPER
+29 V STBY

+15 V
+5 V
-12 V

OPER POWER ON SIGNAL

TO TIMING & DATA FUNCTION

RELAY DRIVER
RELAY POWER

POWER RELAY SWITCH

TO OTHER ASE FUNCTIONS

RESET
RESET SIGNAL
+15 V
+5 V
-12 V

CURRENT LIMITER
POWER INTERRUPT SIGNAL

SEPT 68 5178.9.14
ASE THERMAL CONTROL

MECHANICAL (MORTAR PACKAGE)

• 0.5-IN. MULTILAYER ALUMINIZED MYLAR ON SIDES & BOTTOM
• THIN ALUMINIZED MYLAR SUNSHIELD OVER TOP
• GRENADES LAUNCHED THROUGH SUNSHIELD
• ROCKET BLAST DISSIPATES MYLAR INSULATION REDUCING RECOIL EFFECT ON BOX STABILITY

ELECTRICAL

• MORTAR PACKAGE
  • ELECTRONIC SENSOR/CONTROL CIRCUIT OPERATES SERIES/PARALLEL HEATER ARRAY TO MAINTAIN TEMP ABOVE -60° C
  • PROPORTIONAL CONTROL, DISSIPATION IS A FUNCTION OF TEMPERATURE
  • CIRCUIT ACTIVATED ONLY IN STBY (NOTE: ASE IS IN STBY MOST OF THE TIME)
  • CENTRAL ELECTRONICS IS CONTROLLED BY CENTRAL STATION ENVIRONMENT
  • THUMPER HAS NO HEATER

SEPT 68 5178.9.15
ASE POWER PROFILE

OPERATIONAL

MAXIMUM 7.15
MINIMUM 3.99

DEPENS ON MODE OF OPERATION

MAXIMUM OCCURS INITIALLY AT TURN-ON
DURING GEOPHONE AMPLIFIER OVEN WARM UP

STBY HEATER

MAXIMUM 2.75
MINIMUM 0.20

PROPORTIONAL CONTROL

POWER, WATTS

SEPTEMBER 68 5178.9.16
ASE SAFETY FEATURES

**THUMPER**
- Rotary arming switch, spring loaded to safe position, actuated ~4 sec to charge condenser (then push to fire)
- ASI selector switch has 22 positions (inc off) and shorts all ASI's except the selected one

**CENTRAL ELECTRONICS**
- Central station astronaut switch (two-position) opens and closes +29 V oper power line between PDU & ASE
- In series with CMD-activated relay of PDU
- In open position, precludes accidental application of oper power to ASE
- Supported within launch tubes, locked in place by safety rod assy for flight & deployment (removed by astronaut)
- Arming & firing circuits of all 4 rocket motors shorted by 2 safety switches on mortar box (activated by astronaut)

**GRENADES**
- Safe slide between detonating cartridge & high explosive in each grenade, spring-ejected at launch
- Thermal battery inactive (& shorted) until plate ejection trips a microswitch
- Thermal battery match is activated by a condenser which is charged via grenade arm cmd
- Thermal battery operates through (a) 15-sec time delay & (b) impact switch to supply power to the grenade detonator. If impact comes before 15 sec or after ~10 min, there is no battery power for detonator

SEPT 68 5178.9.17
ASE DEPLOYMENT SEQUENCE

1. VERIFY THAT CENTRAL STATION ASTRONAUT SWITCH IS IN OPEN POSITION

2. REMOVE THUMPER & PLACE IN TEMPORARY LOCATION

3. REMOVE MORTAR BOX & PLACE 10 FT FROM CENTRAL STATION IN OPPOSITE DIRECTION TO THAT SELECTED FOR GEOPHONES

4. ALIGN TO FIRE AWAY FROM GEOPHONES & ERECT ASE RECEIVING ANTENNA (INC FLAG)

5. ERECT CENTRAL STATION SUNSHIELD & ANTENNA

6. PLACE CENTRAL STATION ASTRONAUT SWITCH IN CLOSED POSITION

7. AFTER ALSEP COMMUNICATIONS HAVE BEEN ESTABLISHED & SWITCHED TO ASE HBR, UNFOLD THUMPER & WALK OUT IN SELECTED DIRECTION PLACING GEOPHONES AT 10, 160, & 310 FT FROM CENTRAL STATION & IN LINE +3° USING FLAG ON MORTAR BOX (PLUS FLAG PLACED AT 160-FT GEPHONE LOCATION) AS REFERENCE

8. RETURN ALONG GEOPHONE CABLE ACTUATING THUMPER AT 15-FT INTERVALS AS INDICATED BY CABLE MARKINGS

9. PLACE CENTRAL STATION ASTRONAUT SWITCH IN OPEN POSITION

10. REMOVE GRENADE RETAINING ROD ASSY FROM MORTAR BOX

11. ACTUATE MORTAR BOX SAFETY SWITCHES (2) REMOVING SHORTS FROM GRENADE ARM/FIRE CIRCUITS

12. PLACE CENTRAL STATION ASTRONAUT SWITCH IN CLOSED POSITION

SEPT 68 5178.9.18
ASE EMPLACEMENT DIAGRAM

GEOPHONES ALIGNED ± 3°,
MINIMUM 200 FT FROM LM
MAXIMUM 300 FT FROM LM

RTG/CENTRAL STATION
ALIGNED E-W

FLAG

200-FT RADIUS

300-FT RADIUS

ARBITRARY DIRECTION FROM LM TO CENTRAL STATION

GRENADERS FIRE OPPOSITE TO GEOPHONES ± 3°

CENTRAL STATION

MORTAR PACKAGE

GEOPHONES ALIGNED WRT LM

3 FT

GEPHONE 1

12 FT

RTG TO LM

11 FT

FLAG ON ANTENNA

SEPT 68 5178.9.19
# ASE Emplacement Criteria

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
<th>Priority</th>
<th>Indicator</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td><strong>Site Selection</strong></td>
<td>Level (Uprange &amp; Downrange)</td>
<td>1</td>
<td>Eyeball</td>
<td>Selection must consider both grenade impact &amp; geophone areas</td>
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<tr>
<td><strong>Distance from Subpackage 1</strong></td>
<td>10 ± 1 FT (11 FT Cable)</td>
<td>2</td>
<td>Paced Off</td>
<td>At least 10 FT from RTG</td>
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<tr>
<td><strong>Direction from Subpackage 1</strong></td>
<td>130 ± 8° from LM °</td>
<td>2</td>
<td>Eyeball</td>
<td>122° for 300 FT PLSS constraint, 138° for 200 FT LM separation</td>
</tr>
<tr>
<td><strong>Level</strong></td>
<td>± 10° of Horizontal</td>
<td>1</td>
<td>Eyeball</td>
<td>Internal level sensors</td>
</tr>
<tr>
<td><strong>Align</strong></td>
<td>± 3° from assumed geophones deployment line</td>
<td>1</td>
<td>Eyeball</td>
<td>Fires away from LM &amp; geophones</td>
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<tr>
<td><strong>Distance from Subpackage 1</strong></td>
<td>12 ± 2 FT to 1ST</td>
<td>1</td>
<td>314 FT Cable</td>
<td>Geophones set laterally from cable on 3-FT pigtails</td>
</tr>
<tr>
<td><strong>Direction from Subpackage 1</strong></td>
<td>50 ± 8° from LM °</td>
<td>2</td>
<td>Eyeball</td>
<td>Opposite mortar package</td>
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<tr>
<td><strong>Level Geophone</strong></td>
<td>± 7° of Horizontal</td>
<td>2</td>
<td>Eyeball</td>
<td>Geophone response requirement</td>
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<tr>
<td><strong>Align Cable</strong></td>
<td>± 3° from straight</td>
<td>1</td>
<td>Flags **</td>
<td>Variation of 2nd geophone from line between 1st &amp; 3rd</td>
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<tr>
<td><strong>Special Requirements</strong></td>
<td>*30° from N-S line of Subpackage 1 to avoid field of view of central station radiator.</td>
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<td></td>
<td><strong>2 Flags:</strong> Mortar Box and 2nd Geophone (used for Alignment)</td>
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<td></td>
<td>Antenna mounted on Mortar Box (Omni-directional.)</td>
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<tr>
<td><strong>Experiment Interrelation</strong></td>
<td><strong>Geophones at least 10 FT from RTG and Subpackage 1</strong></td>
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</table>

SEPT 68 5178.9.20

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*Note: The table and information provided are based on the content of the document and are not meant to represent real-world data or instructions.*
ASE MODES OF OPERATION

THUMPER MODE: APPROX 7 MIN (PLUS SET UP) WHILE ASTRONAUT IS ON SURFACE. USES SMALL SEISMIC SOURCES RELATIVELY CLOSE TO GEOPHONES.

LISTENING (PASSIVE) MODE: 15 MINUTES, ONCE PER WEEK (AVERAGE). DETECTS TECTONIC DISTURBANCES OR METEOROID IMPACTS TO EVALUATE SYSTEM STATUS, PARTICULARLY LUNAR SURFACE NOISE LEVEL (WHICH MAY BE A FUNCTION OF AMBIENT TEMPERATURE), AND ASSIST IN SELECTING OPTIMUM TIME FOR MORTAR MODE.

MORTAR OR GRENADE MODE: APPROX 1 HR NEAR END OF ALSEP MISSION. USES RELATIVELY LARGE SEISMIC SOURCES AT RANGES UP TO 5000 FT.

NOTE: ALL MODES REQUIRE 85-FT MSFN ANTENNA BUT, WITH THE EXCEPTION OF THE THUMPER MODE, CAN BE SCHEDULED FOR MOST CONVENIENT GROUND OPERATIONS.
ASE COMMANDS

OCTAL COMMAND NUMBERS

003 ASE HBR ON

THIS CMD DISCONNECTS THE ALSEP DATA PROCESSOR FROM THE MODULATOR & CONNECTS THE MODULATOR TO THE ASE PROCESSOR WHICH SUPPLIES HBR DATA (10.6 KBPS).

THIS CMD TAKES EFFECT AT THE SCHEDULED END OF THE 64-WORD ALSEP FRAME DURING WHICH THE CMD IS RECEIVED.

THE DOWNLINK DATA IS MEANINGLESS IF THIS CMD IS EXECUTED WITH NO ASE ON BOARD OR IF ASE IS NOT OPERATING.

005 ASE HBR OFF

THIS CMD DISCONNECTS THE ASE PROCESSOR FROM THE MODULATOR & CONNECTS TO THE ALSEP DATA PROCESSOR WHICH SUPPLIES NBR (1.06 KBPS) OR LBR (0.53 KBPS) DEPENDING ON THE LATEST PREVIOUS BIT RATE CMD.

THIS CMD TAKES EFFECT AT THE SCHEDULED END OF THE 64-WORD ALSEP FRAME DURING WHICH THE CMD IS RECEIVED (ALSEP PROCESSOR OPERATES CONTINUOUSLY).

CENTRAL STATION ACTIVATION OR POWER RESET INITIALIZES ASE HBR OFF.

156 GEO CAL GO

THIS CMD INITIATES A 1-SEC CALIBRATION PULSE WHICH ELECTRICALLY EXCITES THE GEOPHONES. THE PULSE VOLTAGE ALSO APPEARS IN THE ASE DATA.

162 ASE SEQ FIRE

EACH TRANSMISSION OF THIS CMD FIRES A SINGLE ROCKET MOTOR (IF ARMED) IN THE 2, 4, 3, 1 FIRING ORDER. A GRENADES ARM CMD MUST PRECEDE EACH FIRE CMD. THE SEQUENCE IS CONTROLLED BY MICROSWITCHES IN THE LAUNCH TUBES; HENCE, PREVIOUS GRENADE MUST LAUNCH BEFORE NEXT MOTOR WILL FIRE.

163 GRENADE 1 FIRE

THIS CMD FIRES THE ROCKET MOTOR OF GRENADE 1, IF ARMED. THIS CMD (LIKE 164, 165 & 166) FOR A SPECIFIC GRENADE PROVIDES AN ALTERNATIVE TO CMD 162 FOR FIRING THE GRENADES.

164 GRENADE 2 FIRE

THIS CMD FIRES THE ROCKET MOTOR OF GRENADE 2, IF ARMED, SEE CMD 163.

165 GRENADE 3 FIRE

THIS CMD FIRES THE ROCKET MOTOR OF GRENADE 3, IF ARMED, SEE CMD 163.

166 GRENADE 4 FIRE

THIS CMD FIRES THE ROCKET MOTOR OF GRENADE 4, IF ARMED, SEE CMD 163.

170 GRENADES ARM

THIS CMD ARMS THE FIRING CIRCUIT APPLICABLE TO ANY OF THE 4 ROCKET MOTORS BY CHARGING A PAIR OF CONDENSERS, ONE FOR SEQUENTIAL FIRING & THE OTHER FOR SPECIFIC GRENADE FIRING. SUBSEQUENT ACTIVATION OF A FIRING CMD DISCHARGES BOTH CONDENSERS, ONE THROUGH A ROCKET MOTOR IGNITION AS & THE OTHER THROUGH A GROUNDING CIRCUIT. IF NO FIRING CMD IS TRANSMITTED, THE CONDENSERS WILL REMAIN CHARGED INDEFINITELY; HOWEVER, THEY MAY BE RESET TO SAFE (DISCHARGED) BY SWITCHING THE ASE OFF (STBY) FOR A FEW SECONDS.

THIS CMD ALSO CHARGES THE THERMAL BATTERY MATCH CIRCUITS OF ALL 4 GRENADES (UNUSED CIRCUITS DISCHARGED BY FIRE CMD)

JAN 68 5178.9.22
ASE DATA FORMAT

1 ASE FRAME = 32 ASE WORDS = 0.060377 SEC

1 ASE WORD = 4 SUBWORDS = 2/1060 SEC

TYPICAL FOR 13 ENGINEERING PARAMETERS (ASE WORDS 3 THROUGH 28)

1 BIT = 1/10,600 SEC

JAN 68 5178.9.23
ASE REAL TIME EVENT DATA

- THUMPER FIRE: INITIATED BY PRESSURE SWITCH ON ASI MOUNTING PLATE
- GRENADE LAUNCH: FIRST BREAKWIRE INDICATES 10-IN. TRAVEL
- VELOCITY: SECOND BREAKWIRE INDICATES 25-FT + 10-IN. TRAVEL
- IMPACT: XMTR OFF
- MARK EVENT (ASE WORD 29): NON-ZERO PATTERN (00100) INDICATES THAT AN RTE HAS OCCURRED DURING THE PRECEDING 32-WORD FRAME
- WORD COUNT (ASE WORD 30): INDICATES DURING WHICH WORD OF PRECEDING FRAME THE RTE OCCURRED (5 WORD COUNT BITS = 32 DECIMAL POSSIBILITIES)
- EVENT BIT COUNT (ASE WORD 31): INDICATES DURING WHICH BIT IN THAT WORD THE RTE OCCURRED (ONE OF 20 BITS, GIVES NEAREST 0.1 M SEC)

JAN 68 5178.9.24
ASE MODE ID

SPECIAL BIT PATTERNS FOR EACH OF THE FOLLOWING:

- THUMPER ARM: PICKOFF ON ARM/FIRE SWITCH ACTIVATES ID REGISTER WHICH MAINTAINS THIS PATTERN UNTIL 4 SEC AFTER THUMPER FIRES; REGISTER THEN CLEARS TO ZERO

- GRENADE ARM/FIRE: GRENADE ARM CMD ACTIVATES ID REGISTER WHICH MAINTAINS THIS PATTERN UNTIL CHANGED BY RECEIPT OF GRENADE FIRE CMD
  GRENADE FIRE PATTERN IS MAINTAINED UNTIL CHANGED BY RECEIPT OF NEXT ARM CMD
  PATTERN MAY BE RESET TO ZERO (REGISTER CLEARED) BY SWITCHING ASE OFF (STBY) & ON (OPER)

- GEOPHONE CAL: GEO CAL GO CMD ACTIVATES ID REGISTER FOR THE 1-SEC DURATION OF THE CALIBRATION PULSE; REGISTER THEN CLEARS TO ZERO

JAN 68 5178.9.25
## ASE DATA OUTPUT

4 ASE TEMPS READ OUT IN THE INDICATED ANALOG CHANNELS OF ALSEP

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<th>WORD 33 (ALSEP 4)</th>
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<td>DS-17</td>
<td>ASE FRAME SYNC</td>
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<td>DS-03</td>
<td>GEOPHONE 3 DATA</td>
<td>ALL</td>
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<td>DS-01</td>
<td>GEOPHONE 1 DATA</td>
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<tr>
<td>AR-04</td>
<td>CLD FRAME 1 DEG F</td>
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<td>AE-05</td>
<td>PCU 1 SHUNT AMPS</td>
<td>5</td>
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<td>DS-05</td>
<td>ASE GND MON VOLTS</td>
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<td>DS-06</td>
<td>ASE ROLL DEG</td>
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<td>DS-07</td>
<td>ASE PITCH DEG</td>
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<td>DS-11</td>
<td>ASE ADC 3.75 VOLTS</td>
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<td>ASE ADC 1.25 VOLTS</td>
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<td>HOT FRAME 1 DEG F</td>
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<td>DS-18</td>
<td>ASE MARK EVENT</td>
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<td>AS-04</td>
<td>GEOPHONE DEG C</td>
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**NOTE:**

ALSEP ANALOG CHANNELS SAMPLED ONCE PER 54 SEC ALSEP SEQUENCE

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<td>GEOPHONE DEG C</td>
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* SWITCHED BY ASE OPER POWER-ON SIGNAL
** TWO SENSORS, NEW SYMBOL TBD

** APR 69 5178.9.26**
# ASE DATA ENCODING

## ASE WORD 1

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- **SUBWORD**
- **DS-17 INFO**

## ASE WORD 30, SUBWORD 1

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<td>11110</td>
</tr>
<tr>
<td>3</td>
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<td>4</td>
<td>01011</td>
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<td>11011</td>
</tr>
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<td>15</td>
<td>11001</td>
</tr>
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<td>6</td>
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<td>7</td>
<td>10110</td>
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<td>8</td>
<td>10111</td>
<td>18</td>
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</tr>
<tr>
<td>9</td>
<td>10011</td>
<td>19</td>
<td>00011</td>
</tr>
</tbody>
</table>

*SEPT 68 5/178.9.27*
LUNAR SURFACE MAGNETOMETER
EXPERIMENT SUBSYSTEM

- COMPONENTS & FUNCTION
- COMMANDS & DATA
- DEPLOYMENT

SURFACE • EAST

DEPLOYED

51 IN.

40 IN.

19.4 LB W/O CABLE

FOLDED

APR 69 5178.10.1
**LSM FEATURES & PERFORMANCE**

<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>CORRESPONDING FEATURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEASURE MAGNETIC FIELD VECTOR</td>
<td>3 MAGNETIC SENSORS ALIGNED ALONG ORTHOGONAL AXES (X, Y, &amp; Z)</td>
</tr>
<tr>
<td>CAPABILITY FOR MEASURING BOTH DC &amp; SLOW VARIATIONS OF FIELD</td>
<td>DIGITAL FILTERING OF SENSOR OUTPUT</td>
</tr>
<tr>
<td>ACCOMMODATE UNCERTAINTY IN FIELD MAGNITUDE</td>
<td>RANGE SELECTION &amp; PERCENTAGE OFFSET BY CMD</td>
</tr>
<tr>
<td>OBTAIN HIGH OVERALL ACCURACY</td>
<td>HIGH-GAIN SENSOR OUTPUT 10-BIT ADC &amp; SCIENCE TIMING POLARITY SIGN</td>
</tr>
<tr>
<td>MINIMIZE AMBIGUITY</td>
<td>MEASURE LOCAL FIELD GRADIENT (SITE SURVEY MODE) USE LOW INSTRUMENT BIAS SENSORS FLIP 180° BY CMD OR TIMER</td>
</tr>
</tbody>
</table>

- PROVIDES BASIC DATA ON MAGNITUDE & TEMPORAL VARIATIONS OF THE LUNAR SURFACE EQUATORIAL MAGNETIC FIELD VECTOR
- DATA TAKEN IN SOLAR & ANTI-SOLAR DIRECTION PROVIDES INFORMATION ON HOW INTERPLANETARY MAGNETIC FIELD DIFFUSES THROUGH MOON (ELECTROMAGNETIC PROPERTIES OF DEEP INTERIOR)
- AID IN RECONSTRUCTING GEOLOGICAL EVOLUTION OF MOON
- DETERMINE FEATURES OF MAGNETIC TAIL OF THE EARTH

---

<table>
<thead>
<tr>
<th>RANGE</th>
<th>PERCENTAGE OFFSET</th>
</tr>
</thead>
<tbody>
<tr>
<td>± 100 Y, ± 200 Y, ± 400 Y</td>
<td>SELECTED BY CMD</td>
</tr>
</tbody>
</table>

7 VALUES SELECTED BY CMD FOR EACH RANGE: 0, +25%, +50%, +75%, -75%, -50%, -25% OF NOMINAL FULL SCALE WITH AN ACCURACY OF 0.3% FULL SCALE

- FREQ. RESPONSE RESOLUTION: ≈ 1.5 CPS
- CROSS-COUPLED LESS THAN ±1 LSB
- MONOTONICALLY MONOTONIC OVER FULL RANGE; SATURATED OUTPUT VERIFIED TO 1000 Y & AT EARTH'S FIELD (≈ 35,000 Y)
- DC OFFSETS LESS THAN +1 FULL SCALE OVER OPER TEMP RANGE
- PERIODICITY SIMULTANEOUSLY ALL 3 SENSORS SAMPLED WITHIN 588 µ SEC
- TIME JITTER LESS THAN 100 µ SEC

CALIBRATION (BY CMD OR TIMER) USES SAME CIRCUIT AS ZERO OFFSET & 14 STEPS IN SEQUENCE, 0, -15%, -30%, -45%, 0, +25%, +50%, +75%, & REPEAT

---

SEPT 68 5178.10.2
LSM MODES OF OPERATION

• SCIENTIFIC MODE: NORMAL OPERATING MODE OF MAGNETIC FIELD SENSING

• SITE SURVEY MODE: PERFORMED ONCE (BY CMD) DURING EARLY OPERATIONS. ALL THREE SENSORS ALIGNED, IN SEQUENCE, TO THE X, Y, & Z AXES. PURPOSE OF SITE SURVEY IS TO IDENTIFY & LOCATE ANY MAGNETIC INFLUENCES PERMANENTLY INHERENT IN THE DEPLOYMENT SITE. THUS, THEIR EFFECTS (LOCAL FIELD GRADIENT) CAN BE CONSIDERED IN THE INTERPRETATION OF NORMAL SCIENTIFIC DATA

• CALIBRATION MODE: PERFORMED BY CMD OR AUTOMATICALLY (AT 12-HR INTERVALS) VIA ALSELP TIMER. PURPOSE OF CALIBRATION IS TO DETERMINE ABSOLUTE ACCURACY OF THE MAGNETIC SENSORS & CORRECT ANY DRIFT FROM THEIR LABORATORY CALIBRATION (DUE POSSIBLY TO RESIDUAL MAGNETIC PERMS ON THE SENSORS)

JAN 68 5178.10.3
LSM ELECTRO-MECHANICAL

• ANGLE DEFINITIONS:
  FLIP MOTION ROTATES SENSORS
  +180° IN THESE PLANES (FIRST +90°
  OF ROTATION SHOWN) & -180° RETURNS
  SENSOR TO ORIGINAL SETTING.
  AFTER GIMBAL MOTION, FLIP
  MOTION IS IN DIFFERENT PLANE

GIMBAL MOTION ROTATES
SENSORS +90° IN THESE
DIRECTIONS (ONCE FOR
EACH SENSOR)

<table>
<thead>
<tr>
<th>SENSOR</th>
<th>PRE-GIMBAL</th>
<th>POST-GIMBAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>X 1</td>
<td>+X→+ Y←- X</td>
<td>+X→+ Z←- X</td>
</tr>
<tr>
<td>Y 2</td>
<td>+Y→+ X←- Y</td>
<td>+Y→+ Z←- Y</td>
</tr>
<tr>
<td>Z 3</td>
<td>+Z→+ X←- Z</td>
<td>+Z→+ Y←- Z</td>
</tr>
</tbody>
</table>

SEPT 68 5178.10.5
LSM EGFU AND SENSOR ARM

SENSOR ARM (Z-AXIS)

LOWER HINGE/SUPPORT

FIBERGLAS COVER HOUSES GIMBAL-FLIP MECHANISM & LEVEL SENSORS

ELECTRONICS MOUNTED ON ALUMINUM BASE PLATE

MIDDLE HINGE (FOR STOWING)

GIMBAL BEARING SENSOR HEAD

THERMAL BLANKET SUPPORT SLEEVE

THERMAL CONTROL SURFACE

ELECTRONICS/GIMBAL-FLIP UNIT (EGFU)
LSM ORIENTATION MECHANISM

FREE-MOUNTED IDLER PULLEYS (4)

IDLER SHAFT INSIDE LOWER HINGE

SLACK TAKE-UP SPRING

PRIMARY TOGGLE ARM

DRIVER, PRIMARY ARM

GEAR TRAIN & CLUTCH

AC MOTOR

ONE-WAY CLUTCH

DETENT SYSTEM

90° STOP CAM

ALLOWS SITE SURVEY AFTER EXACTLY 4 FLIP/CALS

FLIP CABLES (CAPTIVE-ENDED TOP & BOTTOM)

TORSION SPRING (PRODUCES GIMBAL MOTION)

LOWER HALF OF BEARING FASTENED TO TUBE

90° STOP CABLE

90° GIMBAL CABLE (WHEN PULLED, ROTATES HEAD 90°)

TOGGLE SPRING

SECONDARY TOGGLE ARM

OUTPUT SHAFT WITH DRIVE PULLEY (2:1 STEP UP RATIO)

GIMBAL RELEASE ACTUATOR

FOllOWER ASSEMBLY FOR POSITIVE ENGAGEMENT OF 90° STOP:

OVERRIDE FEATURE (LEAF SPRING)

SPLIT HOUSING (FOR METALLIC DISCONTINUITY)

SENSOR SHAFT HEATER

SENSOR (90° POSITION)

SENSOR (0° POSITION)

90° STOP PAWL (TORSION SPRING LOADING NORMALLY HOLDS STOP OPEN)

SEPT 68  5178.10.7
LSM MOTORS, STOPS, AND PISTONS

MOTORS: FLIPPING OF SENSORS IS POWERED BY INDIVIDUAL 400 ~, 2 φ AC MOTORS (PHASE REVERSAL CAUSES MOTOR MOTION REVERSAL)

FLIP MOTION STOPS: THREE STOPS IN EACH SENSOR'S SUPPORT YOKE
- FIXED STOPS AT 0° & 180° (FLIP & SURVEY) FOR ACCURATE CONTROL
- RETRACTABLE STOP AT 90° (SURVEY ONLY) OF SENSOR POSITION

RETRACTABLE STOP:
- CONTROLLED BY CAM & FOLLOWER ASSEMBLY
- SPRING LOADED IN RETRACTED POSITION (OPEN)
- POWER FOR STOP INSERTION (CLOSED) FROM FLIP MOTOR VIA CAM/FOLLOWER
- USED ONCE (DURING SITE SURVEY) & THEN PERMANENTLY RETRACTED

GIMBAL MOTION: ROTATION OF SENSOR SUPPORT YOKE ABOUT SUPPORT ARM AXIS
- CONTROLLED BY GEAR TRAIN FROM FLIP MOTOR
- POWERED BY PRESET TORSION SPRING IN SENSOR ARM
- PERFORMED ONCE (SENSOR YOKE ROTATES 90°) DURING SITE SURVEY
- FLIP MOTION, 0° TO 180° & BACK, CAN BE PERFORMED IN EITHER SETTING (PRE-GIMBAL OR POST-GIMBAL)
LSM FLUX MEASUREMENT

- Flux gate magnetic sensors, in conjunction with sensor electronics, provide analog signal outputs proportional to the intensity of incident magnetic field components parallel to the sensors.

- Conversion sensitivity: 20\mu\text{V} \text{per} \gamma \text{ at } 10 \text{ Hz}

- Sensor electronics:
  - Provides fundamental power (with negligible second harmonic) to excite the fluxgate sensors
  - Accepts sensor output signals, selecting & amplifying only the second harmonic component
  - Demodulates this to provide analog outputs (frequency response: DC to 50 Hz)
  - Provides feedback current to the sensors from the analog outputs
  - Generates fundamental & second harmonic reference square waves (5.9625 & 11.925 kHz) derived from 1.06 kHz ALSEP clock pulses
LSM SENSOR ELECTRONICS

TIMING & PROGRAM CONTROL

23.850 Hz

INPUT FLIP-FLOP

DELAY

OUTPUT FLIP-FLOP

BANDPASS FILTER

SENSOR DRIVE MODULE

TO OTHER SENSORS

FLIP-FLOP MODULE

SENSOR COMMON ELECTRONICS

PRELIAIS FILTER

DEMOD & INTEGRAL

BUFFER AMP (BROAD-BAND)

INPUT AMP (BANDPASS & NOTCH FILTER)

SENSOR CHANNEL ELECTRONICS

SENSE COIL

FEEDBACK COIL

CAL & OFFSET STEP GENERATOR

ADC

FILTER (BROAD-BAND)

INPUT FIELD

CHANNEL FEEDBACK

DM-26 LSM Y-AXIS SCI

DM-25 LSM X-AXIS SCI

DM-27 LSM Z-AXIS SCI

JAN 68 5178.10.10
LSM CAL, TIMING, AND SEQUENCING

• RANGE COMMAND
• RANGE MEMORY & SWITCH DRIVERS
  • OFFSET COMMANDS
  • OFFSET MEMORY & TRANSFER LOGIC
  • TIMING & PROGRAM CONTROL
    • FLIP/CAL COMMANDS
    • FLIP/CAL SEQUENCE
      • CAL & OFFSET GENERATOR
        • SITE SURVEY COMMAND
        • SITE SURVEY SEQUENCE
          • POWER CONVERTER
          • POWER PROFILE

JAN 68 5178.10.11
LSM RANGE COMMAND AND FUNCTION

OCTAL CMD NUMBER

123  LSM RANGE STEPS

This is a 3-state cmd that determines the full-scale range of the three sensors (X, Y & Z). LSM activation presets the range to +400\( \gamma \). Repeated transmission of this cmd steps the range through sequential values (+400\( \gamma \), +100\( \gamma \), +200\( \gamma \), +400\( \gamma \), etc.) The selected range is common to all 3 sensors.

FUNCTION

RANGE MEMORY & SWITCH DRIVERS

- Memory register, advanced by cmd 123, provides for selection of appropriate switch drivers

- Switch drivers activate switches in cal & offset generator to control sensor range (by modifying gain in feedback)

- Register setting also appears in lsm data
LSM OFFSET COMMAND & MEMORY

OCTAL CMD NUMBER

124  LSM FLD O/S CH

This is a 7-state cmd controlling field offset percentage independently for each of the three sensors (X, Y & Z). LSM activation presets the offset to 0%. Repeated transmission of this cmd advances the offset through sequential values (+25%, +50%, +75%, -75%, -50%, -25%, 0%, etc.) Percentages are referenced to the current full-scale range as selected by cmd 123 (Example: With range set at +100 Y by cmd 123, offset at +25%, for a particular sensor, the resulting range for that sensor would be from -75 Y to +125 Y).

125  LSM O/S ADD CH

This is a 4-state cmd used to address the three sensors (X, Y & Z) for offsetting. LSM activation presets the address to neutral (no sensor is addressed). Repeated transmission of this cmd advances the address sequentially through X, Y, Z, neutral, etc. (Example: With address set by cmd 125 to Y sensor, the next transmission of cmd 124 advances the Y-sensor offset one step without affecting the X & Z sensors.

- Offset memory & transfer logic stores, in response to cmds 124 & 125, one of the 7 offset (bias) levels for each of the 3 sensor channels (X, Y & Z).

- Stored in binary form in a flip-flop memory whose output states drive the appropriate offset switches in the cal & offset generator.

- Memory setting also appears in LSM data.

- Transfer logic receives sensor position data (flip & gimbal) & derives appropriate switch inputs (offset level & polarity). Example: During flip/cal, when sensor rotates 180°, offset polarity is reversed. Similarly, during X site survey when Y & Z sensors flip 90° (parallel to X axis) they are given the X-axis offset.
LSM TIMING AND PROGRAM CONTROL

- Generates all timing & synchronization signals necessary to synchronize the data processing & sequencing.

- Contains internal (count-down) clock which generates timing signals for flip/call & site survey sequences (~10-sec intervals).

Note: LSM timing & filtering matched to ALSEP normal bit rate (1.06 KBPS) & will not produce valid data at slow rate (0.53 KBPS).
LSM FLIP/CAL

OCTAL CMD NUMBER

127 FLIP/CAL INHIB

This is a 2-state cmd (IN/OUT) used to inhibit the FLIP/CAL sequence of the LSM. LSM activation presets the logic so that FLIP/CAL is inhibited. Repeated transmission of this cmd steps the system back & forth between inhibit in & out. Since the inhibited state also prevents FLIP/CAL via the ALSEP timer (every 12 hrs), this cmd must be considered critical (possibility of ALSEP losing uplink capability)

131 FLIP/CAL GO

This is a 1-state cmd to initiate a FLIP/CAL sequence, unless inhibited as a result of cmd 127. ALSEP timer also initiates FLIP/CAL sequence every 12 hrs (unless FLIP/CAL is inhibited or timer is inhibited). Upon completion of FLIP/CAL, LSM returns to normal (scientific) mode & sequencer shuts off. Note: There must be exactly 4 FLIP/CAL sequences before site survey.

FLIP SEQUENCE GENERATOR

1. Triggers calibration portion of cal & offset generator to apply series of cal steps (RASTER) simultaneously to all 3 sensors (~160 sec)
2. Applies power to X motor causing X sensor flip (~10 sec)
3. After 10 sec power to X motor is switched off & Y motor on
4. Repeat steps 2 & 3 for Y motor, switching to Z upon completion
5. Repeat step 2 for Z motor
6. Cal raster initiated and applied simultaneously to all 3 sensors (~160 sec)
7. Signal (CAL COMPLETE) turns off power to FLIP sequence generator

Notes: A. Offset memory & transfer logic reverses polarity of each offset when activated by change in flip position detectors (offset also appears in LSM data)
B. Special flip motions initiated on demand from site survey sequence generator

SEPT 68 5178.10.15
LSM CAL AND OFFSET FUNCTION

- **Range Selection**: Changes sensor feedback gain
- **% Offset (Bias)**: Inserted in feedback loop of sensor electronics
- **Calibration (Rasters)**: Sensor electronics
- **Feedback Circuit Provides**:
  - Accurate summation of offset, calibration, & feedback (demod + integ) voltages at all combinations of signals
  - Linear drive of fluxgate sensor feedback winding over wide dynamic range

- **Offset Generator**: Switch drivers (one set for each sensor channel) controlled by offset memory & transfer logic; activate ladder networks (17 states)
- **Calibration Sequence Generator**:
  - Generates two identical sequences (before & after flip)
  - Each sequence has 14 steps of ~10 sec step (~10-sec clock pulses from timing & program control)
  - Each step activates switch driver for switches in calibration (ladder) network of cal & offset step generator
  - Upon completion of second sequence (after flip) clock input is inhibited & signal (cal complete) is sent to flip sequence generator

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**Diagram Notes**

- One channel of offset step generator shown (identical for X, Y & Z)
- Same ladder network used for calibration

**Sept 68 5178.10.16**
LSM SITE SURVEY (GENERAL)

OCTAL CMD NUMBER

133 SITE SURVEY XYZ

This is a 1-state cmd transmitted three times, in succession, to activate the site survey sequence generator. The first transmission initiates the survey in the x-axis direction. Upon completion of the x-axis sequence, the LSM returns to the scientific (normal) mode of operation. The second and third transmissions of this cmd initiate surveys in the y-axis & z-axis directions, respectively, & after each survey the LSM returns to the scientific (normal) mode of operation. The complete site survey sequence is performed only once. It must be preceded by exactly 4 flip/cal sequences.

- To accomplish site survey, all three sensors are aligned parallel to the x-axis direction, y-axis direction, & z-axis direction (3 subsequences)
- Uses combinations of partial (90°) flip motion & gimbal motion
- Controlled by site survey sequence generator which uses timing pulses from timing & program control
- Operates through flip sequence generator to activate flip motors (motors also actuate gimbal motion)
- 90° flip is programmed through cams & cam followers
- Position detectors (through offset memory & transfer logic) apply appropriate offsets to each sensor
- Position detectors also have outputs in LSM data
- Detent system permanently disengages cam toggling mechanism so that 90° flip can not occur after completion of site survey
- Controls site survey (3 subsequences) in response to 3 successive ground cmd's
- Consists of a binary counter which steps one step at the completion of each operation
- Counter outputs are gated; coincidence signals activate the following:
  - Flip motor power switching (3 motors, each fwd & reverse)
  - Calibration sequence initiation
  - Sequence inhibit

OCT 68 5178.10.17
 LSM X-AXIS SURVEY

A. SENSORS INITIALLY IN SCIENTIFIC ORIENTATION (OUTWARD ALONG AXES) AS SHOWN AT LEFT
B. TRANSMIT FIRST SITE SURVEY CMD
C. FLIPICAL CYCLE CALIBRATES ALL SENSORS, THEN FLIPS IN SEQUENCE (+180°)
D. X-AXIS SENSOR IN X-Y PLANE (X-Y-X)
E. Y-AXIS SENSOR IN X-Y PLANE (Y-X-Y)
F. Z-AXIS SENSOR IN Z-X PLANE (Z-X-Z)
G. ALL SENSORS ARE CALIBRATED AGAIN IN THE NEW POSITION

INITIAL POSITION & FIRST ROTATIONS

H. X-AXIS SENSOR FLIPS -180° (-X-Y-X)
I. Y-AXIS SENSOR FLIPS -90°, ENGAGING STOP (-Y-X)
J. Z-AXIS SENSOR FLIPS -90°, ENGAGING STOP (-Z-X)
K. SENSORS ARE ALL ORIENTED IN X-DIRECTION (FOR X-AXIS SITE SURVEY) AS SHOWN AT RIGHT

FLIPICAL SEQUENCE

FINAL ROTATIONS & END POSITIONS

L. AFTER COLLECTING X-AXIS SURVEY DATA FOR ≈150 SEC, X-AXIS SENSOR FLIPS -180° (X-Y-X)
M. Y-AXIS SENSOR FLIPS +90°, RELEASING STOP (X-Y)
N. Z-AXIS SENSOR FLIPS +90°, RELEASING STOP (X-Z)
O. SENSORS ARE NOW IN SCIENTIFIC ORIENTATION (REVERSED) AS SHOWN AT LEFT AND WILL REMAIN THERE UNTIL NEXT GROUND CMD IS TRANSMITTED

NEXT ROTATIONS & SURVEY POSITION

THIS COMPLETES SUBSEQUENCE 1 OF SITE SURVEY

SEPT 68  5178.10.18
LSM Y-AXIS SURVEY

INITIAL POSITION & FIRST ROTATIONS

A. Sensors initially in scientific orientation (inward along axes) as shown at left
B. Transmit second site survey cmd
C. FLIPICAL CYCLE CALIBRATES ALL SENSORS, THEN FLIPS IN SEQUENCE (+180°)
D. X-AXIS SENSOR IN X-Y PLANE (-X-Y-X)
E. Y-AXIS SENSOR (-Y-X/Z-Y) INC 90° GIMBAL ROTATION
F. Z-AXIS SENSOR (-Z-X/IY-Z) INC 90° GIMBAL ROTATION
G. ALL SENSORS ARE CALIBRATED AGAIN IN THE NEW POSITION

FLIPICAL SEQUENCE

H. X-AXIS SENSOR FLIPS +180° (X-Y--X) & SETS 90° STOP
I. Y-AXIS SENSOR FLIPS +180° (Y-Z--Y)
J. Z-AXIS SENSOR FLIPS +180° (Z-Y--Z) & SETS 90° STOP
K. X-AXIS SENSOR FLIPS -90°, ENGAGING STOP (-X-Y)
L. Y-AXIS SENSOR FLIPS -180° (-Y-Z--Y)
M. Z-AXIS SENSOR FLIPS -90°, ENGAGING STOP (-Z-Y)
N. SENSORS ARE ALL ORIENTED IN Y-DIRECTION (FOR Y-AXIS SITE SURVEY) AS SHOWN AT RIGHT
O. AFTER COLLECTING Y-AXIS SITE SURVEY DATA FOR ~150 SEC, X-AXIS SENSOR FLIPS +90°, RELEASING STOP (Y--X)
P. Y-AXIS SENSOR FLIPS +180° (Y-Z--Y)
Q. Z-AXIS SENSOR FLIPS +90°, PERMANENTLY RELEASING STOP (Y--Z)
R. SENSORS ARE NOW IN SCIENTIFIC ORIENTATION (REVERSED) AS SHOWN AT LEFT & WILL REMAIN THERE UNTIL NEXT GROUND CMD IS TRANSMITTED

THIS COMPLETES SUBSEQUENCE 2 OF SITE SURVEY

JAN 68 5178.10.19


**LSM Z-AXIS SURVEY**

**FLIP/CAL SEQUENCE**

- A. Sensors initially in scientific orientation inward along axes as shown at left.
- B. Transmit third site survey cmd.
- C. Flip/cal cycle calibrates all sensors, then flips in sequence (±180°).
- D. X-axis sensor (-X-Y-Z) inc 90° gimbal rotation.
- G. All sensors are calibrated again in the new position.

**INITIAL POSITION & FIRST ROTATIONS**

- A. Sensors initially in scientific orientation inward along axes as shown at left.
- B. Transmit third site survey cmd.
- C. Flip/cal cycle calibrates all sensors, then flips in sequence (±180°).
- D. X-axis sensor (-X-Y-Z) inc 90° gimbal rotation.
- G. All sensors are calibrated again in the new position.

**NEXT ROTATIONS & SURVEY POSITION**

- H. X-axis sensor flips +180° (X-Z-Z) & sets 90° stop.
- K. X-axis sensor flips -90° engaging stop (-X-Z).
- N. Sensors are all oriented in Z-direction (for Z-axis site survey) as shown at right.

**FINAL ROTATIONS & END POSITIONS**

- P. Y-axis sensor flips -90°, permanently releasing stop (Z--Y).
- R. Flip/cal cycle calibrates all sensors, then flips in sequence (±180°).
- S. X-axis sensor in X-Z plane (-X-Z-X).

**FLIP/CAL CYCLE**

- V. Final calibration of all sensors in new position.
- • Sensors are in scientific orientation as shown at left.
- • Will not perform any more 90° flips or gimbal rotations (flip/cal by cmd or timer).
- • All power to site survey sequencer is cut off (completion of subsequence 3 & site survey).

SEPT 68 5178.10.20
LSM FAIL-SAFE PROVISIONS

- IF FLIP MECHANISM OR INDICATOR MALFUNCTIONS, 10-SEC TIMER TURNS OFF MOTOR AND ADVANCES SEQUENCE TO NEXT STEP (PARTIAL FAILURE, AT WORST)

- DETENT SYSTEM DISENGAGES 90° STOP CAM AND GIMBAL RELEASE AT END OF SITE SURVEY (NOT USED THEREAFTER)
LSM POWER CONVERTER

- Converts ALSEP +29V input to 8 regulated outputs (±5V, ±7V, ±10V, ±15V)

- Provide switching to remove power from various portions of LSM electronics when they are on inactive standby

- A power filter module is included in the sensor common electronics for certain precision requirements
LSM POWER PROFILE

HEATERS ON 10.85W
HEATERS OFF 5.8W
HEATERS ON 12.25W
MOTORS ON 9.8W
HEATERS OFF 7.2W
HEATERS ON 11.95W
MOTORS ON 9.8W

SCIENTIFIC MODE
SITE SURVEY MODE
FLIP/CAL MODE

APR 69 5178.10.23
LSM ENGINEERING ELECTRONICS

- TEMPERATURE CONTROL CMD & FUNCTION
- MOTOR DRIVERS
- FLIP & GIMBAL POSITION DETECTORS
- LEVEL SENSOR
- ENG SEQUENCER
LSM TEMPERATURE CONTROL

**SENSORS**
- Sensors housed in fiberglass structural jacket
- Wrapped with insulation except upper horizontal surface
- Upper surface is heat radiator
- 3 temp sensors (X, Y, & Z) for TM, X or Y selected by CMD for heater control
- Individual 2-watt heaters

**EGFU**
- 2-section package (top & bottom with aluminum base plate in module)
- Electro-mechanical on top & electronics on bottom mounted on plate conductive thermal transfer
- Plate coupled to PFA thermal radiators on 2 sides of EGFU (NASI)
- Top of EGFU has fiberglass cover
- Aluminized Kapton insulation over all surfaces except radiators
- 2 temp sensors in TM
- 2 3-watt heaters

Operating range: -38°C to +48°C
No standby (survival) power connection

**Detail CMD number**
3M  LSM T CTL XYO

This is a 3-state command (X, Y, Off) which is used to select one of two temp sensors for heater control or to deactivate the heater power. All 4 heaters are controlled in parallel by either of two temp sensors (one in the sensor X assembly & one in the sensor Y assembly). LSM activation presets to the X state. Repeated transmission of this CMD advances the state sequentially through Y, Off, X, etc. In the off state, all power to all 4 heaters is removed.

**Diagram**

- LSM power converter
- 5v regulated supply
- 5v switched power off
- Reset
- 100KHz clock
- Select logic
- Located in sensor assemblies & EGFU
- Isolated switch
- Heaters

To LSM analog multiplexer
To LSM sequencer

**SEPT 68 5178.10.25**
LSM FLIP POSITION DETECTORS

NOTE: • 3 FLIP POSITION DETECTORS (0°, 90°, 180°) SHOWN FOR ONE LSM SENSOR (EXAMPLE: X, IN TABLE)
• SIMILAR FOR LSM SENSORS Y & Z (TOTAL 9 DETECTORS)

<table>
<thead>
<tr>
<th>POSITION</th>
<th>MSB</th>
<th>LSB</th>
</tr>
</thead>
<tbody>
<tr>
<td>X = 0°</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>X = 90°</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>X = 180°</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>NEITHER</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

SEPT 68  5178.10.27
LSM GIMBAL POSITION INDICATORS

LSM POWER CONVERTER

+5V (SWITCHED)

+5V (CONTINUOUS)

X-AXIS SENSOR GIMBAL SWITCH

Y-AXIS SENSOR GIMBAL SWITCH

Z-AXIS SENSOR GIMBAL SWITCH

MICROSWITCH TRIPPED BY CAM ON Z ASSEMBLY AT COMPLETION OF SITE SURVEY

SITE SURVEY DISABLE SWITCH

BI-LEVEL STATUS DATA

DM-12 GMBL POSN X DEG

DM-13 GMBL POSN Y DEG

DM-14 GMBL POSN Z DEG

LSM ENG SEQUENCER

POWER CUT-OFF FOR SITE SURVEY

LSM POWER CONVERTER

SEPT 68 5178.10.28
LSM LEVEL SENSOR

- 100 kHz SQUARE WAVE (5V P-P) EXCITATION
- LSM POWER CONVERTER
  - +15V (SWITCHED)
  - -6V (SWITCHED)
  - -7V REF (CONTINUOUS)
- LSM TIMING
  - RETURN
  - (TO ANALOG GROUND)
- CAPACITIVE PICKUP
- ELECTRONIC LEVEL (GRAVITY) DETECTOR
  - MOUNTED ON TOP OF BASE PLATE IN EGFU
  - RANGE: ± 15° FROM HORIZONTAL

AXIS 1
AXIS 2

LEVEL SENSOR ELECTRONICS 1
LEVEL SENSOR ELECTRONICS 2

DM-06 LSM LVL 1 DEG
DM-07 LSM LVL 2 DEG

ANALOG OUTPUTS (0 TO 1.250V FULL SCALE)
LSM ANALOG MULTIPLEXER

SEPT 68 5178.10.29
LSM ENG SEQUENCER

LSM FLIP & GIMBAL POSITION DETECTORS
LSM TEMP & HTR CONTROL
RANGE & OFFSET SWITCHES (SENSOR COMMON ELECTRONICS)
LSM FLIP SEQUENCE GENERATOR
LSM OFFSET MEMORY & TRANSFER LOGIC
LSM DIGITAL FILTER

ENG DATA MULTIPLEXER
FORMATTER
DM-30 LSM FRAME CNTR
LSM DATA OUTPUT BUFFER

ALSEP FRAME MARK
LSM TIMING
10.925 KHz

ENG DATA GATE DRIVER SIGNALS
SEQUENCE SIGNALS
LSM ADC

JAN 68 5178.10.30
LSM DATA HANDLING

**SCIENTIFIC**
- Outputs of 3 sensor electronics channels (prefiltered) are sampled, by sample & hold circuit, within 125 µsec of each other at the digital filter sampling rate.
- Multiplexed sequentially into the 10-bit ADC.
- Converted into 10-bit binary (polarity & 9-bit magnitude) & stored in digital filter memory.
- Digital filter (computer):
  - Reduces to acceptable level aliasing error introduced by sampling rate.
  - Uses state variables (filtered output of each channel at a real-time instant) to perform filter computations.
  - Stored in core memory when not in use.
- 3 channels (X, Y, & Z) time share the arithmetic unit, data bus, & data control unit.
- State variables are shifted to the output data buffer.

**ENGINEERING**
- 8 analog engineering data parameters.
- 27 bi-level status signals.
- Analog is multiplexed to use same ADC as scientific data.
- 10-bit output (no polarity) truncated to 7 bits (0.5% resolution).
- Bypasses digital filter & is integrated in output data buffer (16 10-bit words):
  - Two 8-word sequences of 7-bit analog output.
  - 16 2-bit status signals (inc 5 filler bits).
  - One bit (LSM frame cntr) to flag start of 16-word sequence.
- Inserted into data stream as every 7th LSM word.

- Contents of output data buffer readout sequentially to the ALSEP DSS upon receipt of data demand pulse.

- Note that ALSEP readout of LSM scientific data is staggered (in time) but each set of 3 (X, Y, & Z) samples is obtained simultaneously & successive samples are at equal time intervals.

JAN 68 5178.10.31
LSM FILTER BYPASS COMMAND

OCTAL CMD NUMBER

132   LSM FILT IN/OUT

This is a 2-state cmd (IN/OUT). LSM activation presets the digital filter in. Transmission of this cmd causes a major portion of the filter to be bypassed. Repeated transmission of this cmd causes the filter to be in, out, in, etc.
LSM DATA FORMAT

1 LSM SEQUENCE = 16 LSM FRAMES = 9.6604 SEC

NOTE: LSM FRAME STARTS WITH 1 AT TURN-ON REGARDLESS OF ALSEP FRAME ID

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>NAME</th>
<th>WORD (EVERY FRAME)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM-25</td>
<td>LSM X-AXIS SCI</td>
<td>17, 49</td>
</tr>
<tr>
<td>DM-26</td>
<td>LSM Y-AXIS SCI</td>
<td>19, 51</td>
</tr>
<tr>
<td>DM-27</td>
<td>LSM Z-AXIS SCI</td>
<td>21, 53</td>
</tr>
</tbody>
</table>

1 LSM FRAME

ALSEP WORD NUMBERS

TYPICAL 17, 19, 21, 49, 51, 53

1 LSM ENG WORD
(ALSEP WORD 5 IN EVERY FRAME)

7-BIT ENG MEASUREMENT
(REPEATS EVERY 8 FRAMES)

DM-30 LSM FRAME CNTR
(1 IN FIRST FRAME, ZERO IN NEXT 15)

1 LSM SCIENTIFIC WORD
(SAME WORDS IN EVERY ALSEP FRAME)

9-BIT MAGNITUDE

1-BIT POLARITY
(0 = PLUS, 1 = MINUS)

JAN 68 5178.10.33
# LSM ENGINEERING DATA

## ANALOG MEASUREMENTS

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>NAME</th>
<th>LSM FRAME NUMBER</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM-01</td>
<td>LSM SNSR X DEG C</td>
<td>1, 9</td>
<td>7-BIT DATA IN ALSEP WORD 5</td>
</tr>
<tr>
<td>DM-02</td>
<td>LSM SNSR Y DEG C</td>
<td>2, 10</td>
<td></td>
</tr>
<tr>
<td>DM-03</td>
<td>LSM SNSR Z DEG C</td>
<td>3, 11</td>
<td>LSM HAS NO ANALOG DATA</td>
</tr>
<tr>
<td>DM-04</td>
<td>LSM BASE DEG C</td>
<td>4, 12</td>
<td>INPUT TO ALSEP ADC (WORD 33)</td>
</tr>
<tr>
<td>DM-05</td>
<td>LSM INT DEG C</td>
<td>5, 13</td>
<td></td>
</tr>
<tr>
<td>DM-06</td>
<td>LSM_LVL 1 DEG</td>
<td>6, 14</td>
<td></td>
</tr>
<tr>
<td>DM-07</td>
<td>LSM_LVL 2 DEG</td>
<td>7, 15</td>
<td></td>
</tr>
<tr>
<td>DM-08</td>
<td>LSM 5V SUPPLY</td>
<td>8, 16</td>
<td></td>
</tr>
</tbody>
</table>

## ENGINEERING STATUS SIGNALS

<table>
<thead>
<tr>
<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>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>20</td>
<td>21</td>
<td>20</td>
<td>21</td>
<td>20</td>
<td>21</td>
<td>20</td>
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<td>20</td>
<td>21</td>
<td>20</td>
<td>21</td>
<td>20</td>
<td>21</td>
<td>20</td>
</tr>
</tbody>
</table>

- DM-09 FLIP POSN X DEG
- DM-10 FLIP POSN Y DEG
- DM-11 GMBL POS Y DEG
- DM-12 GMBL POS X DEG
- DM-13 LSM T_CTL
- DM-14 LSM_HTR ON/OFF
- DM-15 LSM_CTL
- DM-16 LSM_RANGE
- DM-17 LSM_O/S FLD X PCT
- DM-18 LSM_O/S FLD Y PCT
- DM-19 LSM_O/S AXIS ADD
- DM-20 LSM_MODE SCI/CAL
- DM-21 LSM_O/S FLD Z PCT
- DM-22 LSM_O/S FLD Z PCT
- DM-23 LSM_FILTER IN/OUT
- DM-24 LSM_FILLER 08 BITS (ONES)
- DM-25 LSM_FILLER 16 BITS (ZEROS)

**SEPT 68 5178.10.34**
LSM DEPLOYMENT

STOWED CONFIGURATION

• FOLDED BOOMS & LEGS SECURED BY 2-PIECE HORSECOLLAR, ATTACHED TO FORWARD MOUNTING BRACKET BY BOYD BOLTS
• AFT END (EGFU) SEATED ON 2 TITANIUM PINS PROJECTING UP FROM PYLON
• EGFU LOCKED BY SLIDE PLATE (LANYARD ACTUATED) ENGAGING LOCKING SURFACES OF PINS

REMOVAL

• USE UHT TO RELEASE FORWARD BOYD BOLTS
• PULL HANDLE ON TOP OF HORSECOLLAR TO DISENGAGE BRACES AND DISCARD UPPER HALF OF HORSECOLLAR AND BRACES
• PULL HANDLE ON TOP OF EGFU TO RELEASE SLIDE PLATE FROM PINS AND LIFT LSM STRAIGHT UP TO REMOVE FROM SUNSHIELD
• GRASP HANDLE LOOPED BETWEEN BOOM HINGES, REMOVE LOWER HALF OF HORSECOLLAR AND LOWER LSM TO SURFACE

FINAL PLACEMENT

• CARRY 50 FT TOEMPLACEMENT SITE
• DEPLOY LUNAR SUPPORT LEGS
• LOWER TO SURFACE (STRIPED LEG EAST)
• UNFOLD BOOMS (DISCARD HANDLE)
• REMOVE PRA COVERS
• ADJUST LEVEL (BUBBLE ON TOP OF EGFU) USING UHT TO ROTATE SCREW IN EACH LEG AT JOINT TO EGFU
• ALIGN E-W USING SHADOWGRAPH (MOUNTED ON TOP OF EGFU)
• MAKE FINAL SHADOWGRAPH READOUT
# LSM 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>DISTANCE FROM SUBPACKAGE 1</td>
<td>50 ± 5 FT</td>
<td>2</td>
<td>55 FT CABLE</td>
<td>IN QUADRANT OPPOSITE RTG TO MINIMIZE MAGNETIC EFFECTS</td>
</tr>
<tr>
<td>DIRECTION FROM SUBPACKAGE 1</td>
<td>OPPOSITE LM ±20°</td>
<td>2</td>
<td>EYEBALL</td>
<td>MINIMIZE MAGNETIC CONTAMINATION</td>
</tr>
<tr>
<td>SITE SELECTION</td>
<td>AVOID RUBBLE</td>
<td>3</td>
<td>EYEBALL</td>
<td>FOR MAXIMUM STABILITY</td>
</tr>
<tr>
<td>LEVEL, WRT INDICATOR</td>
<td>± 5° OF HORIZ (ACCEPTABLE) ±3° OF HORIZ (GOAL)</td>
<td>1</td>
<td>BUBBLE LEVEL ON EGFU</td>
<td>TM OF INTERNAL LEVEL SENSOR</td>
</tr>
<tr>
<td>ALIGN, WRT SHADOW</td>
<td>±3° OF E-W</td>
<td>1</td>
<td>SHADOW-GRAPH</td>
<td>COLOR-CODED LEG POINTS E*</td>
</tr>
<tr>
<td>READOUT OF ALIGNMENT, WRT SHADOW</td>
<td>±1° OF E-W</td>
<td>1</td>
<td>SHADOW-GRAPH</td>
<td>NEEDED FOR SCIENTIFIC DATA INTERPRETATION; THERMAL LESS CRITICAL**</td>
</tr>
<tr>
<td>EXPERIMENT INTERRELATION</td>
<td>MUST BE AT LEAST 80 FT FROM SIDE AND PREFERABLY 100 FT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPECIAL REQUIREMENTS</td>
<td>*COULD BE ROTATED 180° AND MEET THERMAL CRITERIA; HOWEVER, SHADOWGRAPH IS NOT REVERSIBLE **RADIATORS ON ELECTRONICS REQUIRE E-W ALIGNMENT±3°.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

APR 69  5178.10.36
LSM LEVELING AND ALIGNMENT

- Bubble level on top of EGFU
- Shadowgraph (Sun compass) on top of EGFU
- Z-axis leg
- Z-axis boom
- Leg markings indicating East
  Alternate orange & white bands
  Each 0.4 in. long (total 2.8 in.)

SEP 68 5178.10.37
SOLAR WIND SPECTROMETER

- SENSOR ASSEMBLY
- MOUNTING PLATE
- PUSHBUTTON FOR RELEASING LEG EXTENSION
- CARRYING HANDLE SOCKET
- COMPONENTS & FUNCTION
- DEPLOYMENT
- COMMANDS & DATA
- ELECTRONICS ASSEMBLY
- RADIATORS (3)
- SUN SHADE (HELD DOWN WHEN LEGS ARE RETRACTED)
SWS SIZE AND WEIGHT

EARTH WT, LB = 12.25

Dimensions:
- 9 IN
- 14 IN
- 17 IN
- 11 IN

OCT 68 5178.11.2
SWS MEASUREMENT CAPABILITY

ENERGY RANGE:
- ELECTRONS - 6 to 1330 ELECTRON VOLTS
- POSITIVE IONS - 18 to 9780 ELECTRON VOLTS

TWO RANGES

FLUX DENSITY RANGE:
- $10^6$ to $10^{10}$ PARTICLES PER CM$^2$ PER SEC

ENERGY RESOLUTION:
- ELECTRONS - FACTOR OF 2
- POSITIVE IONS - FACTOR OF $\sqrt{2}$

FLUX RESOLUTION:
- 3.7% OF TRUE FLUX VALUE

DIRECTION:
- INCIDENCE ANGLES ± 15° FOR COLLIMATED FLUX

OCT 68 5178.11.3
MODULATING FARADAY CUP

• MODULATOR CIRCUIT APPLIES 2 kHz SQUARE WAVE TO SENSOR
• 2 kHz SUPERIMPOSED ON DC (PEAK-TO-PEAK)
  1/6 OF DC LEVEL FOR POSITIVE DC
  1/3 OF DC LEVEL FOR NEGATIVE DC
• DC LEVEL STEPS (STAIRCASE FASHION) THROUGH CONTINUOUS, SUCCESSIVE VALUES
  14 TIMES WITH $\sqrt{2}$ SPACING FOR POSITIVE DC
  7 TIMES WITH $x^2$ SPACING FOR NEGATIVE DC

ADVANTAGE

STRAY PARTICLE FLUXES, SUCH AS PHOTOELECTRONS PRODUCED INSIDE THE SENSOR, ARE NOT CHANGED BY THE MODULATION POTENTIAL; THEREFORE, THEY ARE NOT INCLUDED WITHIN THE MEASUREMENTS.
SWS DUST COVERS

- HEATER WIRES BURN RETAINING CORD TO RELEASE COVERS
- INITIATED BY GROUND COMMAND
- REQUIRED BURN TIME, 1.5 SEC
- POWER APPLIED 4 ± 2 SEC
SWS ELECTRONIC MODULES

MODULE 100
PREAMPS
SIGNAL CHAIN

MODULE 200
PROGRAMMER
OSCILLATOR
STEP GENERATOR
2 KHz DRIVE

MODULE 300
LOW & HIGH VOLTAGE
POWER SUPPLIES
VOLTAGE CONTROLLED
AMPLIFIER

DEC 67 5178.11.7
# SWS Verification Features

<table>
<thead>
<tr>
<th>Calibration Type</th>
<th>Number of Words</th>
<th>Distribution</th>
<th>Repetition Rate *</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 kHz Current Pulses ± 2% to Preamps</td>
<td>32</td>
<td>4 Values (inc 0) into each chain &amp; 7 combined</td>
<td>112.3 sec</td>
</tr>
<tr>
<td>Cal Voltages ± 2% to Output Commutator</td>
<td>8</td>
<td>5 Values plus 3 repeats</td>
<td>56.1 sec</td>
</tr>
<tr>
<td>Readout of AC &amp; DC High Voltages</td>
<td>42</td>
<td>14 each for + DC 7 each for - DC</td>
<td>449.2 sec</td>
</tr>
</tbody>
</table>

* at normal Alsep data rate, complete SWS cycle (449.2 sec) consists of 16 sequences (28.065 sec)
### SWS THERMAL CONTROL

**Mechanical**
- Gold-plated fiberglass housing covered with silk/mylar (aluminized)
- Coated with white paint
- Radiator (one side only)

**Electrical**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Location</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermistor (1) sensor</td>
<td>Sensor Assy</td>
<td>WINSCO model 2712-4-00-2</td>
</tr>
<tr>
<td>Thermistors (3) sensor</td>
<td>MOD 100, 200, 300</td>
<td>YELLOW SPRINGS YSI 44063</td>
</tr>
<tr>
<td>Thermistor (1) control</td>
<td>MOD 300</td>
<td>YELLOW SPRINGS YSI 44063</td>
</tr>
<tr>
<td>Operational heaters (series)</td>
<td>MOD 200</td>
<td>43-Ohm dissipated 1.2 W</td>
</tr>
<tr>
<td>Survival (STBY) heaters (3 in parallel)</td>
<td>MOD 300</td>
<td>75-Ohm dissipated 2.1 W</td>
</tr>
<tr>
<td></td>
<td>ONE IN EACH MODULE</td>
<td>680-Ohm (2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>600-Ohm (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.0 W total (max)</td>
</tr>
</tbody>
</table>

**Notes:**
- No manual (command) thermal control
- No thermostat for survival heater
- Operational heater limited to avoid > 6.5 W total power

OCT 68 5178.11.9
## SWS Timing Functions

<table>
<thead>
<tr>
<th>Internal</th>
<th>External</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic 1024 kHz Clock</strong>&lt;br&gt;Supplies 256, 2.0, &amp; 0.5 kHz to various users&lt;br&gt;• Conversion counter operates at 256 kHz&lt;br&gt;• DC/DC converter operates at 2.67 kHz (free running)&lt;br&gt;• HV modulator operates at 2.0 kHz</td>
<td><strong>Shift pulses &amp; demand pulse from data subsystem are used to shift data from register</strong>&lt;br&gt;These pulses are also used to program commutators &amp; step generator</td>
</tr>
</tbody>
</table>

One sequence of SWS operation consists of 14 positive steps (each time sampling total + 7 individual sensors), 16 cal words, 7 negative steps (8 words each) & 2 sequence/cycle counter words (total 186) in 28.065 sec.
SWS POWER PROFILE

- STBY POWER: 4.0 WATTS (MAX)
- OPER POWER SHOWN EXCEPT FOR DUST COVER REMOVAL (10 WATTS FOR 4±2 SEC)
- TURN-ON TRANSIENT
  \( \approx 10.5 \text{ WATTS FOR less than } 60 \text{ MSEC} \)
SWS TIE-DOWN AND RELEASE

FOUR FASTENERS RELEASED BY UHT INSERT UHT IN SOCKET AND LIFT LEG ASSEMBLIES ATTACHED TO MOUNTING PLATE IN TIE-DOWN POSITION COMPRESSES HEXAGONAL SEPARATORS IN EACH CORNER:

1. RESTRAINING PIVOTING MOTION
2. LOCKING SUNSHADE IN STOWED POSITION

RELEASE OF TIE-DOWN FASTENERS & LEGS ALLOWS 1/4 IN. VERTICAL SEPARATION CABLE REEL IS STOWED UNDER SWS

OCT 68 5178.11.12
# SWS 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>Distance from Subpackage 1</td>
<td>13 ± 1 ft (15 ft cable)</td>
<td>1</td>
<td>Paced Off</td>
<td>See experiment interrelation</td>
</tr>
<tr>
<td>Direction from Subpackage 1</td>
<td>± 30° from Due N or S*</td>
<td>2</td>
<td>Eyeball</td>
<td>± 10° area of reduced sensitivity (Others at 60°)</td>
</tr>
<tr>
<td>Site Selection</td>
<td>Approx Horiz</td>
<td>3</td>
<td>Eyeball</td>
<td>Avoid thermal disturbances</td>
</tr>
<tr>
<td>Level</td>
<td>± 5° of Horiz</td>
<td>2</td>
<td>Eyeball &amp; Gravity</td>
<td>Pendulum effect on one lateral axis. Internal sun sensor.</td>
</tr>
<tr>
<td>Align, WRT Shadow</td>
<td>± 5° of E-W</td>
<td>2</td>
<td>Paint** and UHT shadow</td>
<td>Louvered side away from RTG (thermal and science requirement)</td>
</tr>
<tr>
<td>Experiment Interrelation</td>
<td>* No other subsystem should subtend an angle greater than 0.03 steradian at the solar wind location and should be in an area of reduced sensitivity.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special Requirements</td>
<td>** Arrow nominally points east although scientific output depends only on knowing final alignment (could be east or west). Final alignment by setting orange faces (N-S) on sensor assembly equally in shade, and UHT shadow parallel to sensor edge.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SWS ALIGNMENT MARKING

ARROW DESIGNATING EAST

ORANGE PATTERN 2 SIDES (N & S)

ALIGNMENT IS OBTAINED BY ROTATING SWS UNTIL ORANGE SURFACES HAVE EQUAL SHADOWS AND UHT SHADOW IS PARALLEL TO SENSOR EDGE
**SWS ALIGNMENT MECHANISM**

**SLIT**
0.01 IN. X 0.9 IN.

**TO SUN**

**SUN REFERENCE SENSOR**
(HOFFMAN HR 1077)

- SUN REFERENCE SENSOR GIVES A SHARP VOLTAGE PEAK FOR ≈ 1 HR WHEN SUN PASSES 30° OFF VERTICAL (VERIFY SWS ALIGNMENT)

- OUTPUT WHEN SUN IS OFF-AXIS IS REDUCED BUT SUFFICIENT TO VERIFY DUST COVER RELEASE
SWS COMMANDS

OCTAL CMD NUMBER

122 SWS CVR GO

CMD 122 CAUSES THE ONE TIME FUNCTION OF REMOVING THE SWS DUST COVERS. THIS CMD IS AN IRREVERSIBLE FUNCTION AND IS NECESSARY TO OBTAIN SWS SCIENTIFIC DATA.

122-122-122 HV GAIN CHANGE

TRANSMISSION OF CMD 122 THREE TIMES WITHIN 10 SEC SWITCHES THE VOLTAGE CONTROL AMPLIFIER FROM THE INITIAL (TURN-ON) LOW GAIN MODE TO THE HIGH GAIN MODE. BOTH GAIN SETTINGS WILL BE USED FOR SCIENTIFIC DATA COLLECTION. LOW GAIN MINIMIZES POSSIBILITY OF ARCING.
SWS DATA FORMAT

NOTES:
• 4 SWS WORDS PER ALSEP FRAME (7, 23, 39, & 55)
• SWS SEQUENCE CAN START ANYWHERE & MAY BE ANY FOR 1 SEQUENCE
• CURRENT CAL IN SWS WORDS 120-127
  SEQ 0, 4, 8, 12 = 0
  SEQ 1, 5, 9, 13 = 6 PA
  SEQ 2, 6, 10, 14 = 58 PA
  SEQ 3, 7, 11, 15 = 6 NA
• POS ION & ELECTRON DATA SAMPLED AS FOLLOWS
  0 "SUM"
  1 CUP 1
  2 CUP 2
  3 CUP 3
  ... CUP 3
  7 CUP 7

OCT 68 5178.11.17
SUPRATHERMAL ION DETECTOR EXPERIMENT (SIDE)

• COMPONENTS & FUNCTIONS
• DEPLOYMENT
• COMMANDS & DATA
ION DETECTOR INSTRUMENT

DETECTORS:
- HIGH ENERGY
- LOW ENERGY

SUBEARTH POINT

ELECTRONICS
- HELIX
- CHANNELTRON®
- ELECTRON MULTIPLIER

CURVED-PLATE ANALYZER

COLLIMATOR

VELOCITY FILTER

SEPT 68 5178.12.2
# SIDE GENERAL FEATURES

**MEASURE IONIC ENVIRONMENT OF MOON**

<table>
<thead>
<tr>
<th>DETECT POSITIVE IONS</th>
<th>DETERMINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• RESULTING FROM UV IONIZATION OF THE LUNAR ATMOSPHERE</td>
<td>• DENSITY OF LUNAR ATMOSPHERE (INC CHANGES WITH TIME)</td>
</tr>
<tr>
<td>• FREE STREAMING &amp; THERMALIZED SOLAR WIND</td>
<td>• LOSS RATE OF CONTAMINANTS LEFT BY ASTRONAUT &amp; LM</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HIGH ENERGY CURVED PLATE ANALYZER (HECPA)</th>
<th>LOW ENERGY CURVED PLATE ANALYZER (LECPA)</th>
<th>COLD CATHODE ION GAUGE (CCIG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• NO VELOCITY FILTER</td>
<td>• PRECEDED BY VELOCITY FILTER (CROSSED ELECTRIC &amp; MAGNETIC FIELDS)</td>
<td>• MEASURES DENSITY OF NEUTRAL ATOMS (THIS, WITH TEMP OF GAUGE, ALLOWS CALCULATION OF LUNAR ATMOSPHERE PRESSURE)</td>
</tr>
<tr>
<td>• DETERMINES FLUX (PARTICLES/SEC) WITHIN STEPPED RANGES OF ENERGY PER UNIT CHARGE</td>
<td>• DETERMINES FLUX (PARTICLES/SEC) WITHIN STEPPED RANGES OF VELOCITY &amp; ENERGY PER UNIT CHARGE</td>
<td></td>
</tr>
<tr>
<td>• PLACED ON GROUND PLANE (WIRE MESH SCREEN) WITH VOLTAGE APPLIED BETWEEN INSTRUMENT &amp; SCREEN TO ASSESS LUNAR SURFACE ELECTRICAL FIELD EFFECTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• SIDE ELECTRONICS INPUT CIRCUITS PROVIDE ISOLATION FROM ALSEP (POWER &amp; SIGNAL)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

JAN 68 5178.12.4
SIDE PERFORMANCE

**HECPA**
- **Energy Range:** 10 ev to 3500 ev per unit charge
- **Angle of Coverage:** 30° X 6°
- **Alignment:**
  - ±5° to lunar equator
  - 15° off vertical & pointed away from sub-earth point
- **Measurement Technique:** Curved plate analyzer followed by Channeltron® electron multiplier
  - Curved plate analyzer uses electrostatic field (balanced potential on plates) to perform energy resolution
  - Plate voltages: 20 steps between 2.5 & 875 volts
  - Electron multiplier detects ions passed by curved plate analyzer & supplies current pulse (>10^-13 coulombs) to preamp
  - Electron multiplier operates with -3500 volt excitation

**CCIG**
- **Range:** 10^-6 to 10^-12 torr
- **Operating Voltage:** +4500 V
- **Magnetic Field:** 1020 gauss
- **Power Dissipation:** 5 milliwatts
- **Gage Body Constructed of 304 Stainless Steel
- **Three Overlapping Measurement Ranges (Switched by Internal Logic) Handle Current Measurements Between 1 x 10^-13 & 1 x 10^-6 amps
- **Placed on Surface Outside Ground Plane**

**LECPA**
- **Range:**
  - Masses up to 130 amu
  - Energies 0.2 ev to 48.6 ev per unit charge
  - Velocities 4 x 10^6 cm/sec to 9.35 x 10^6 cm/sec
- **Angle of Coverage:** 30° X 6°
- **Alignment:**
  - ±5° to equator
  - 15° off vertical & pointed away from sub-earth point
- **Measurement Technique:** Velocity filter, followed by curved plate analyzer, followed by Channeltron® electron multiplier
  - Velocity filter: Wein type (crossed electric & magnetic fields
-  - 500 gauss alnico, double-C construction magnet (62.5 grams)
-  - Parallel electrical plates with balanced potential having 120 steps between 0.12 & 28 volts
-  - Curved plate analyzer has 6 steps between 0.1 & 24.3 volts
-  - Electron multiplier same as HECPA

**GROUND PLANE**
- **Wire Mesh Screen ≈2 ft diam**
- **24 Voltage Steps (11 Positive, 11 Negative, & 2 Zeros) Between -27.6 & +27.6 Volts**

Jan 68 5178.12.5
SIDE COMMAND FUNCTION

- ALSEP SUPPLIES 5 CMDs:

<table>
<thead>
<tr>
<th>OCTAL</th>
<th>NAME</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>104</td>
<td>SIDE LOAD 1</td>
<td>TRANSMITTED FIRST. AFTER PROPER LOADING</td>
</tr>
<tr>
<td>105</td>
<td>SIDE LOAD 2</td>
<td>OF SIDE CMD INPUT REGISTER IS VERIFIED</td>
</tr>
<tr>
<td>106</td>
<td>SIDE LOAD 3</td>
<td>VIA TM, THEN EXECUTE IS TRANSMITTED.</td>
</tr>
<tr>
<td>107</td>
<td>SIDE LOAD 4</td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>SIDE EXECUTE</td>
<td></td>
</tr>
</tbody>
</table>

- IF LOAD CMDs ARE NOT PROPERLY RECEIVED, INPUT REGISTER CAN BE CLEARED BY TRANSMITTING ALL LOADS (1, 2, 3 & 4) & THEN EXECUTE

- SIDE ENCODES 15 DIFFERENT CMD COMBINATIONS (INC REGISTER RESET)

- TWO OF THE 15 ARE ALSO USED (VIA ONE-TIME REGISTER) TO PERFORM THE ONE-TIME FUNCTIONS OF CC IG SEAL BREAK & SIDE DUST COVER REMOVAL (THE FIRST TIME THEY ARE TRANSMITTED)

- CMDs ARE STROBED FROM INPUT REGISTER (BUFFER) TO MODE REGISTER WHEN EXECUTED (SIMULTANEOUSLY DECODED & APPLIED)

- TM OF MODE REGISTER INDICATES WHAT THE LAST CMD WAS; THEREFORE, HELPS VERIFY WHAT MODE THE SIDE IS IN
### Side Command Encoding

<table>
<thead>
<tr>
<th>ALSEP OCTAL CMD SEQUENCE</th>
<th>SYMBOL</th>
<th>FUNCTION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>104 105 106 107 110</td>
<td>C1-01</td>
<td>CCIG SEAL BREAK</td>
<td>ONE-TIME CMDs</td>
</tr>
<tr>
<td>C1-02</td>
<td></td>
<td>SIDE DUST COVER GO</td>
<td></td>
</tr>
<tr>
<td>X X X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>C1-06</td>
<td>GROUND PL STEP PROG ON/OFF</td>
<td>THESE CMDs</td>
</tr>
<tr>
<td>X</td>
<td>C1-07</td>
<td>RST SIDE FRAME CNTR AT 10</td>
<td>MODIFY DATA</td>
</tr>
<tr>
<td>X</td>
<td>C1-08</td>
<td>RST SIDE FRAME CNTR AT 39</td>
<td>OUTPUT MODE</td>
</tr>
<tr>
<td>X X X</td>
<td>C1-09</td>
<td>RST V/FILT CNTR AT 9</td>
<td>BY CHANGING</td>
</tr>
<tr>
<td>X X X</td>
<td>C1-10</td>
<td>RST SIDE FRAME CNTR AT 79</td>
<td>LENGTH OF</td>
</tr>
<tr>
<td>X X X</td>
<td>C1-11</td>
<td>RST CNTRs AT 79 &amp; 9</td>
<td>SIDE SEQUENCE</td>
</tr>
<tr>
<td>X X X X X X</td>
<td>C1-12</td>
<td>X10 ACCUM INTERVAL ON/OFF</td>
<td>OR CYCLE</td>
</tr>
<tr>
<td>X X X</td>
<td>C1-13</td>
<td>MASTER RST (NORMAL MODE SEL)</td>
<td>CMDs</td>
</tr>
<tr>
<td>X X X</td>
<td>C1-14</td>
<td>V/FILT VOLTAGE ON/OFF</td>
<td>AFFECTING</td>
</tr>
<tr>
<td>X X X</td>
<td>C1-15</td>
<td>LECPA HIGH VOLTAGE ON/OFF</td>
<td>STEPPER</td>
</tr>
<tr>
<td>X X X</td>
<td>C1-16</td>
<td>HECPA HIGH VOLTAGE ON/OFF</td>
<td>VOLTAGES</td>
</tr>
<tr>
<td>X X X</td>
<td>C1-17</td>
<td>FORCE CONTINUOUS CAL</td>
<td>DATA CHANGE</td>
</tr>
<tr>
<td>X X X</td>
<td>C1-18</td>
<td>CCIG HIGH VOLTAGE ON/OFF</td>
<td>(SHORT SEQUENCE)</td>
</tr>
<tr>
<td>X X X X X X</td>
<td>C1-19</td>
<td>CHANNELTRON HV ON/OFF</td>
<td>POWER</td>
</tr>
<tr>
<td>X X X X X X</td>
<td>C1-20</td>
<td>RST CMD INPUT REGISTER</td>
<td>SWITCHING</td>
</tr>
<tr>
<td>X</td>
<td>NA</td>
<td>NOT USED</td>
<td>INTERNAL TO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CMD LOGIC</td>
<td></td>
</tr>
</tbody>
</table>

JAN 68 5178.12.8
SIDE COMMAND LOGIC DIAGRAM

SIDE ISOLATION AMPLIFIERS

SIDE LOAD 1
SIDE LOAD 2
SIDE LOAD 3
SIDE LOAD 4
SIDE EXECUTE

SIDE PROGRAMMER

CMD INPUT REGISTER
ONE-TIME REGISTER
MODE REGISTER
CMD DECODER

EXECUTE GATE

RESET REGISTER
RESET REGISTER
EXECUTE CMD

EXECUTE TIMING

14 CMDs

CCIG SEAL BREAK
CCIG SEAL RELEASE
SIDE DUST COVER GO
SIDE DUST COVER RELEASE
ONE-TIME CMD/REGISTER STATUS
CMD INPUT REGISTER STATUS
MODE REGISTER STATUS

SIDE DATA HANDLING

DF-29 SIDE O/T CMD LOAD
DI-64 SIDE CMD REG LOAD
DI-65 SIDE MODE REG STA

JAN 68 5178.12.9
SIDE PROGRAMMER FUNCTION

- Provides timing & control signals to
  - HECPA
  - Velocity Filter
  - LECPA
  - Calibration Pulser
  - Ground Plane
  - CCIG
- Basic time reference is generated in Side Frame counter
  - Normally counts 128 ALSEP even frame marks (256 ALSEP frames)
  - Initiates HECPA, Velocity Filter, & LECPA steps (etc.) at proper time in Side Frame, depending on Side Frame count
  - Counter operation may be modified via Ground CMD to count less than 128 (0-79, 0-39, 0-10, 120-127)
  - Ground Plane steps once at each Side Frame counter reset unless inhibited via Ground CMD (24 Ground Plane steps)

APR 69 5178.12.10
SIDE ION DETECTION

- Positive ions passing through velocity filter & LECPA (or through HECPA) are detected by electron multipliers which supply a current pulse, for each ion that entered, to detector amplifiers (discriminators)
- Discriminators separate pulses from background noise & amplify pulse signals (also limit output to ≈one pulse per microsecond)
- Pulses are applied to count accumulators (in data handling) & to logarithmic count rate meters (4V = 40,000 CNTS/SEC; 1V = 50 CNTS/SEC)
- When side frame counter reads 120 to 127 (every 2.5 min, approx, at normal rate) cal signal pulses are gated through the detector amplifiers at the following frequencies:

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Hz</td>
<td>Background</td>
</tr>
<tr>
<td>136.72 Hz</td>
<td>(BACKGROUND)</td>
</tr>
<tr>
<td>17,500 Hz</td>
<td>IN SEQUENCE</td>
</tr>
<tr>
<td>560,000 Hz</td>
<td></td>
</tr>
</tbody>
</table>

- During calibration, the stepping voltages of HECPA & LECPA are programmed to zero & the velocity filter to the maximum positive. This prevents ion counts during calibration
- Side dust cover released by solenoid-operated catch via ground CMD
SIDE SENSOR ELECTRONICS

SIDE CMD LOGIC:
- C1-02 SIDE DUST COVER GO (ONE-TIME)
- C1-16 HECPA HIGH VOLTAGE ON/OFF
- VELOCITY FILTER STEPPER SIGNALS
- C1-14 VELOCITY FILTER P/S ON/OFF
- LECPA STEPPER SIGNALS
- C1-15 LECPA HIGH VOLTAGE ON/OFF
- C1-19 CHANNELTRON HV ON/OFF
- C1-06 GROUND PLANE STEP PROG ON/OFF
- STEPPER SIGNALS

SIDE PROGRAMMER:
- C1-06 GND PL STEP ID
- C1-11 GND PLANE VOLTS
- C1-20 SIDE 3.5 KV SUPPLY
- CAL STEPPER SIGNALS
- CODED STATUS ID

STEP VOLTAGES TO SIDE DATA HANDLING:
- DUST COVER REMOVAL
- STEP VOLTAGES
- HECPA
- STEP VOLTAGES
- LECPA VELOCITY FILTER

SCIENTIFIC INPUTS:
- CHANNELTRON
- PREAMP

SIDE DATA HANDLING:
- D1-34 SIDE A CVR/S STA
- D1-12 SIDE CVR CELL IND
- D1-06 SIDE/MHE SCI CNTS
- D1-02 SIDE/MHE SCI CNTS

JAN 68 5178.12.13
CCIG FUNCTION

- Charged particles entering the sensor are deflected into elongated spiral paths by the combination of magnetic & electrostatic fields.
- These particles collide with neutral atoms producing a large number of ions & a current flow (depending on the number of atoms) between cathode & anode.
- Electrometer amplifier amplifies the current for input to data handling.
- Automatic range selection (also read out via TM).
- The no-ion count output of the electrometer provides automatic zero correction.
- Upon demand from side frame counter, a sequence of precisely controlled currents are gated through the electrometer input circuits for calibration.
- CCIG seal is removed by an explosive piston actuator (pin-puller) which releases spring-loaded cover.

JAN 68 5178.12.14
CCIG DIAGRAM

NOTE: ALL CCIG SUPPORTING ELECTRONICS ARE IN SIDE PACKAGE

SIDE CMD LOGIC

SEAL BREAK POWER SUPPLY

POWER MECHANISM

TEMP SIGNALS

SENSOR RFI FILTER

INPUT FILTER

MODE SELECTOR

ELECTROMETER AMPLIFIER

SIDE DATA HANDLING

DI-07 CCIG 4.5 KV SUPPLY

DI-04 CCIG DEG

DI-67 CCGE/D RANGE

DI-08 CCGE/A RANGE

DI-08 CCGE SCI DATA

DI-66 SIDE/D CVR/S STA

DI-24 SIDE/A CVR/S STA

JAN 68 5178.12.15
SIDE THERMAL CONTROL

MECHANICAL

- Operating range for electronics: -20°C to +80°C
- Electronics package has outer gold cover, outer case has inner gold surface (two gold surfaces facing each other)
- Outside surface of outer case painted white
- Bottom of case has thin insulation blanket between legs
- Top of package has second surface mirror radiator
  - Dust cover protects mirror & apertures from dust until after LM ascent (also protects astronaut from mirror reflections)
  - Conductive grid over mirror provides equipotential surface around apertures

ELECTRICAL

LOW VOLTAGE POWER SUPPLY

DSS
+29V OPER
+29V RETURN

DUST COVER CMD INPUT
RETURN

DSS
+29V STBY
STBY RETURN

OPERATIONAL HTR 4.0 W

SURVIVAL HTR 1.8 W

THERMISTOR
(CONTROL RANGE 0 ± 8°C)

NOTE:
NO HTR IN CCIG

APR 69 5178.12.17
SIDE POWER SUPPLY

VOLTAGE PRE-REGULATOR & SURGE LIMITER

LOW & HIGH VOLTAGE POWER SUPPLY

+29V OPER

DSS

+29V RETURN

SURGE LIMITER HOLDS TURN-ON TRANSIENT TO LESS THAN 450 MILLIAMPS

+5V (DIGITAL)
>+60V
>+30V
>+5V (ANALOG)
>SIDE GROUND
>-5V
>-30V
>+5V (REF ALSEP GROUND)
>12 VAC (FLOATING GROUND)

SPECIAL PURPOSE POWER SUPPLIES:

- STEPPERS
  - HECPA 1.25V TO 438V
  - LECPA 0.05V TO 12.15V
  - VELOCITY FILTER 0.06V TO 14V

- CHANNELTRON ELECTRON MULTIPLIER -3500V

- COLD CATHODE ION GAUGE +4500V

JAN 68 5178.12.18
SIDE POWER PROFILE

SURGE LIMITER HOLDS TURN ON TRANSIENT <13.3W, <45 MILLISEC

INTERMITTENT (ON/OFF) HEATER 0 ± 8 °C

CONSTANT (SURVIVAL) HEATER

SEPT 68 5 178.12.19
SIDE TIE-DOWN AND RELEASE

- SIDE ON SUBPALLETE OF SUBPACK 2
- ASTRONAUT RELEASES 5 FASTENERS
  - 1 EXPER TIE-DOWN RELEASED BY ROTATING GROUND SCREEN TUBE
  - 4 EXPER TIE-DOWNS RELEASED BY USING UHT
- CONNECTOR RELEASED BY USING UHT
- EXPERIMENT LIFTED USING UHT IN HANDLING SOCKET
- CONNECTOR LIFTED BY LANYARD
- ASTRONAUT DEPLOYS LEGS BY PULLING LANYARD
- PLACES EXPER ON LUNAR SURFACE
- PLUGS CONNECTOR INTO CENTRAL STATION
- REMOVES SCREEN FROM TUBE & DEPLOYS SCREEN
- LIFTS EXPER
- REMOVES CC IG
- STANDS EXPER ON SCREEN
- DEPLOYS CC IG (OFF SCREEN)

CABLE LANYARD ATTACHED TO CABLE RELEASE PIN
(LEG RELEASE PIN PULLED BY LANYARD ON OTHER SIDE)

CONNECTOR TO BE MATED BY ASTRONAUT

SEPT 68 5178.12.20
# Side 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>Distance from Subpackage 1</td>
<td>55 ±5 ft</td>
<td>2</td>
<td>60 ft cable</td>
<td>To minimize interference at LSM location</td>
</tr>
<tr>
<td>Direction from Subpackage 1</td>
<td>110° ±10° from LSM (i.e., ≠70° from LM)</td>
<td>2</td>
<td>Eyeball</td>
<td>To obtain 80 ft separation from LSM &amp; preferably 100 ft</td>
</tr>
<tr>
<td>Site Selection</td>
<td>Smooth</td>
<td>1</td>
<td>Eyeball</td>
<td>Suitable for screen</td>
</tr>
<tr>
<td>Level, WRT Indicator</td>
<td>5° of horiz</td>
<td>1</td>
<td>Bubble</td>
<td>Interacts with alignment</td>
</tr>
<tr>
<td>Align, WRT Shadow</td>
<td>10° of E-W</td>
<td>2</td>
<td>Arrow*</td>
<td>Thermal &amp;Scientific requirement</td>
</tr>
<tr>
<td>Position</td>
<td>Off screen, opposite LM, 5 ft from detector</td>
<td>1</td>
<td>5 ft cable</td>
<td>To satisfy alignment requirements</td>
</tr>
<tr>
<td>Align orifice</td>
<td>20° of N or S</td>
<td>2</td>
<td>Paint</td>
<td>Away from (±90°) all subsystems, LM, sun &amp; earth</td>
</tr>
<tr>
<td>Experiment Interrelation</td>
<td>Heavy magnet in ion gage is shielded, IT and magnetic field of detector must be separated from LSM (direction criteria not pertinent on other experiment combinations)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special Requirements</td>
<td>*Arrow must point toward subearth point (E or W); hence, experiment is not bidirectional. Final alignment is by shadows on long sides of detector.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SEPT 68 5178.12.21
SIDE ALIGNMENT MARKINGS

- ARROW POINTS EAST OR WEST: (±5°) BUT TOWARD THE SUBEARTH POINT
- DETECTORS POINT AWAY FROM SUBEARTH POINT

DETECTORS

APR 69  5178. 12.22
SIDE COMMANDS

OTAL CMD NUMBERS

110 & 112 (CCIG) SEAL BREAK

THIS CMD IC-112 CAUSES THE ONE TIME FUNCTION OF CCIG SEAL BREAK. IT SIMULTANEOUSLY RESETS THE SIDE FRAME COUNTER AT THE DESCRIBED LATER. THIS CMD IS AN IRREVERSIBLE FUNCTION AND IS NECESSARY TO OBTAIN CCIG SCIENTIFIC DATA. THIS CMD IS ALSO GENERATED BY THE DELAYED CMD SEQUENCER [SAME TIME].

113 & 1131 SIDE DUST COVER ON

THIS CMD IC-113 CAUSES THE ONE TIME FUNCTION OF REMOVING THE SIDE DUST COVER. IT SIMULTANEOUSLY RESETS THE 3 DUST COVER DESCRIPTED LATER. THIS CMD IS AN IRREVERSIBLE FUNCTION AND IS NECESSARY TO OBTAIN SIDE SCIENTIFIC DATA. THIS CMD IS ALSO GENERATED BY THE DELAYED CMD SEQUENCER [SAME TIME].

NOTE: THE SIDE DUST COVER CAN BE REMOVED BY SENDING ANY CMD CONTAINING A 10T FOLLOWED BY 113. SIMILARLY, SEAL BREAK 110 & 112.

114 & 115 (GROUND PLANE) STOP/OFF

THIS CMD IC-114 TO-115 ARE A 2-STATE CMD ORIGINALLY THAT CONTROLS THE OPERATION OF THE GROUND PLANE STOP PROGRAMMER. SIDE ACTIVATION PREVENTS THE PROGRAMMER TO ON. THE GROUND PLANE VOLTAGE IS THEN STEPPED THROUGH TWENTY-FOUR LEVELS (A LEVELS SEQUENCE). TRANSMISSION OF THIS CMD WILL CAUSE THE STOP PROGRAMMER TO STOP AND HOLD A FIXED VOLTAGE. RE-TRANSMISSION WILL START THE PROGRAMMER AND DOES NOT RESET VOLTAGE LEVELS TO ZERO BUT CONTINUES TO STEEP FROM THE PREVIOUS LEVEL.

116 & 1161 RESET SIDE FRAME COUNTER AT 10

THIS CMD IC-1161 IS A MODE CMD. INITIATION OF A MODE CMD CHANGES THE OPERATIONAL DATA FORMAT CHARACTERISTICS. UPON RECEIPT OF THE CMD, THE EXPERIMENT BURST TO SIDE FRAME 10 BEFORE RESETTING AGAIN TO ZERO. THE VELLOCITY FILTER, HIGH AND LOW ENERGY CURVE PLATE ANALYZER STEPS THROUGH THE VALUES OBTAINED FOR THESE SIDE FRAMES IN THE NORMAL MOD OF OPERATION. THE GROUND PLANE VOLTAGE STEPS THROUGH THE NORMAL 24 STEPS, ONE STEP PER 11-FRAME SEQUENCE.

117, 118, & 119 (XII ACCUMULATION INTERVAL)


THE XII ACCUMULATION MODE CAN BE USED WITH ANY OF THE CONTROLLER RESET DATA MODES.

110, 112 & 117 (CCIG) VELOCITY FILTER CMD

THIS CMD IC-112 IS A MODE CMD. UPON RECEIPT OF THE CMD, THE EXPERIMENT OPERATES IN A SIMILAR FASHION TO THE RESET AT 10 MODE EXCEPT THAT IT RESETS AT SIDE FRAME 10.

1116 & 1117 VELOCITY FILTER CMD


1114, 1115 & 1116 REPEET SIDE FRAME COUNTER AT 10

THESE CMD IC-1114, 1115 & 1116 ARE A MODE CMD. UPON RECEIPT OF THE CMD, THE EXPERIMENT OPERATES IN A SIMILAR FASHION TO THE RESET AT 10 MODE EXCEPT THAT IT RESETS AT SIDE FRAMES 10.

11161, 11151 & 11161 VELOCITY FILTER CMD

THESE CMD IC-11161, 11151 & 11161 ARE A 2-STATE CMD. THE EXPERIMENT OPERATES IN A SIMILAR FASHION TO THE RESET AT 10 MODE EXCEPT THAT IT RESETS AT SIDE FRAME 10.

11171 & 11181 MASTER RESET

THIS CMD IC-11171 & 11181 ARE A MODE CMD. UPON RECEIPT OF THE CMD, THE EXPERIMENT WILL RETURN TO THE NORMAL OPERATIONAL MODE AS FOLLOWS:

- REMOVE ALL SHORT SEQUENCES
- RESET SIDE FRAME COUNTER (INC. CCIG, LECPA & VELOCITY FILTER COUNTERS)
- NOTE: THIS DOES NOT DISTURB ANY ONGOING CMDs IN OR STEPPERS INC. GROUND PLANE OR XII ACCUMULATION INTERVAL.

1119, 1127 & 1126 VELOCITY FILTER STOP/OFF

THESE CMD IC-1119, 1127 & 1126 ARE A 2-STATE CMD. REPEATED TRANSMISSION TURNS OFF & ON THE POWER SUPPLY FOR VELOCITY FILTER STEPS.

1129, 1137 & 1136 (LECPA) HIGH VOLTAGE STOP/OFF

THESE CMD IC-1129, 1137 & 1136 ARE A 2-STATE CMD. REPEATED TRANSMISSION TURNS OFF & ON THE POWER SUPPLY FOR LECPA STEPS.

1134, 1135, 1137 & 1138 (HIGH VOLTAGE STOP/OFF)

THESE CMD IC-1134, 1135, 1137 & 1138 ARE A 2-STATE CMD. REPEATED TRANSMISSION TURNS OFF & ON THE POWER SUPPLY FOR CCIG SCIENCE DATA OUTPUT.

1139, 1147 & 1138 (CHANNEL 1) HIGH VOLTAGE STOP/OFF

THESE CMD IC-1139, 1147 & 1138 ARE A 2-STATE CMD. REPEATED TRANSMISSION TURNS OFF & ON THE POWER SUPPLY FOR THE CHANNEL 1 VOLTAGE STOP/OFF FOR THE CHANNEL 1 VOLTAGE STOP/OFF FOR THE CHANNEL 1 VOLTAGE STOP/OFF FOR THE CHANNEL 1 VOLTAGE STOP/OFF.

1144, 1145 & 1146 (LECPA INPUT REGISTER)

THESE CMD IC-1144, 1145 & 1146 ARE A 2-STATE CMD. REPEATED TRANSMISSION TURNS OFF & ON THE POWER SUPPLY FOR THE LECPA INPUT REGISTER.

1147, 1148 & 1149 (CCIG CURRENT LIMITER)

THESE CMD IC-1147, 1148 & 1149 ARE A 2-STATE CMD. REPEATED TRANSMISSION TURNS OFF & ON THE POWER SUPPLY FOR THE CCIG CURRENT LIMITER.

SEPT 68 5178.12.23
### Side Data Format

**1 Side Cycle** = 24 Side Sequences = 3711 sec (Normal)

- Side Sequences differ only in ground plane volts.
- Full Side Cycle:
  - For X10 Accum = 10.3 HR (ALSEP NBR)
  - For X10 Accum = 20.6 HR (ALSEP LBR)

**1 Side Sequence** = 128 Side Frames = 154.5 sec (Normal)

- Each frame repeats 10 times for X10 Accum.
- Side Frame = 10 side words = 2 ALSEP frames ≈ 1.2 sec.
- Even ALSEP frame:
  - 15 31 47 56 63
- Odd ALSEP frame:
  - 15 31 47 56 63

- LECPA stepper change point
- HECPA stepper change point
- HECPA SCI data
- LECPA SCI data
- Parity, even frame ID, side frame counter
- HECPA stepper volts
- Analog sub-com (32 parameters & CCG SCI data)
- Parity, odd frame ID, digital sub-com
- LECPA stepper volts
- Velocity filter

---

**APR 69 5178.12.24**
SIDE DATA MODES

VOLTAGE LEVELS
NOT TO SCALE

VELOCITY FILTER
20 STEPS
(≈LOGARITHMIC)

VELOCITY FILTER
RESET AT 9 MODE (AFFECTS LECPA BUT NOT HECPA)

SIDE FRAME COUNTER READING

0 20 40 60 80 100 120 127

SIDE FRAME COUNTER READING

SEPT 68 5178.12.25
**SIDE DATA WORD STRUCTURE**

- **SIDE FRAME NUMBER**: 
  - EVEN FRAME ID (00)
  - PARITY: 1, IF ODD ONES; 0, IF EVEN ONES
  - IN PREVIOUS 50 BITS

- **ANALOG SUB-COM**: 
  - FILLER BITS

- **HECPA STEPPER VOLTS**: 
  - FILLER BITS

- **HECPA SCI DATA**: 
  - MOST SIGNIFICANT (MHE)
  - TRUNCATED TO 999 MAX

- **LECPA STEPPER VOLTS**: 
  - FILLER BITS

- **LECPA SCI DATA**: 
  - MOST SIGNIFICANT (MLE)
  - TRUNCATED TO 999 MAX

- **DIGITAL SUB-COM**: 
  - ENCODED STATUS DATA
  - ODD FRAME ID (11)
  - PARITY: SEE SIDE WORD 1

- **VELOCITY FILTER**: 
  - FILLER BITS

- **WORD FILLER BITS**: 
  - NUMBER

- **WORD STEPPER VOLTS**: 
  - NUMBER FILLER BITS

- **HECPA SCI DATA**: 
  - LEAST SIGNIFICANT (LHE)
  - TRUNCATED TO 999 MAX

- **LECPA SCI DATA**: 
  - LEAST SIGNIFICANT (LLE)
  - TRUNCATED TO 999 MAX

**JAN 68 5178.12.26**
## SIDE ANALOG COMMUTATION

<table>
<thead>
<tr>
<th></th>
<th>+5V SUPPLY</th>
<th>CCIG SCI</th>
<th>CCIG TEMP</th>
<th>CCIG SCI</th>
<th>SIDE 2 TEMP</th>
<th>CCIG SCI</th>
<th>SIDE 3 TEMP</th>
<th>CCIG SCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>+4.5 KV</td>
<td>CCIG SCI</td>
<td>RANGE ID</td>
<td>SIDE 4 TEMP</td>
<td>SIDE 5 TEMP</td>
<td>GND PLANE</td>
<td>SIDE CVR</td>
<td>GND PLANE</td>
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</tr>
<tr>
<td>+60 VOLTS</td>
<td>+30 VOLTS</td>
<td>SIDE/D +5V</td>
<td>GND VOLTS</td>
<td>-5 VOLTS</td>
<td>-30 VOLTS</td>
<td>SIDE 6 TEMP</td>
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<tr>
<td>RANGE ID</td>
<td>ADC +30MV</td>
<td>ADC + REF</td>
<td>ADC +1.0V</td>
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<td>GND PLANE</td>
<td>ADC - REF</td>
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<tr>
<td>+5V SUPPLY</td>
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<td>CCIG TEMP</td>
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<td>GND PLANE</td>
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<td>-30 VOLTS</td>
<td>SIDE 6 TEMP</td>
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<td>ADC - REF</td>
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<tr>
<td>+5V SUPPLY</td>
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<td>CVR/SEAL</td>
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<td>SIDE 5 TEMP</td>
<td>GND PLANE</td>
<td>SIDE CVR</td>
<td>GND PLANE</td>
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<tr>
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<td>-5 VOLTS</td>
<td>-30 VOLTS</td>
<td>SIDE 6 TEMP</td>
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<tr>
<td>RANGE ID</td>
<td>ADC +30MV</td>
<td>ADC + REF</td>
<td>ADC +1.0V</td>
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<td>ADC - REF</td>
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<td>O/T CMD</td>
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<tr>
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<td>ADC -30MV</td>
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**Jan 68 5178.12.27**
**SIDE DIGITAL COMMUTATION**

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<td>CVR/SEAL</td>
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<td>CMD REG</td>
<td>RANGE ID</td>
<td>CMD REG</td>
<td>RANGE ID</td>
<td>CVR/SEAL</td>
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<tr>
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<td>CAL RT3 ID</td>
<td>CAL RT4 ID</td>
<td>CAL RT1 ID</td>
<td>CAL RT3 ID</td>
<td>CAL RT4 ID</td>
<td>CAL RT1 ID</td>
<td>CAL RT3 ID</td>
<td>CAL RT4 ID</td>
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</table>

**RST AT 39**

**RST AT 79**

*SEPT 68 5178.12.28*
SIDE DATA SUMMARY

DI-01 SIDE FRAME CNTR
DI-02 SIDE/A +5V SUPPLY
DI-03 CCGE SCI DATA
DI-04 SIDE CC G DEG C
DI-05 SIDE 2 DEG C
DI-06 SIDE 3 DEG C
DI-07 CCGE 4.5KV SUPPLY
DI-08 CCGE/A RANGE 1D
DI-09 SIDE 4 DEG C
DI-10 SIDE 5 DEG C
DI-11 GND PLANE VOLS
DI-12 SIDE CVR CELL IND
DI-13 SIDE +60V SUPPLY
DI-14 SIDE +30V SUPPLY
DI-15 SIDE/D +5V SUPPLY
DI-16 SIDE GND VOLS

DI-17 SIDE -5V SUPPLY
DI-18 SIDE -30V SUPPLY
DI-19 SIDE 6 DEG C
DI-20 SIDE 3.5 KV SUPPLY
DI-21 SIDE ADC +1.0V
DI-22 SIDE ADC +30 MV
DI-23 SIDE ADC POS REF
DI-24 SIDE/A CVR/S STA
DI-25 SIDE ADC NEG REF
DI-26 SIDE ADC -1.0V
DI-27 SIDE ADC -12V
DI-28 SIDE ADC +12V
DI-29 SIDE PRE/REG PCT
DI-30 SIDE ADC -30MV
DF-29 SIDE O/T CMD LOAD

DI-40 through
DI-60

HECPA STEP VOLS
SIDE/MHE SCI CNTS
SIDE/LHE SCI CNTS
GND PL STEP ID
SIDE CMD REG LOAD
SIDE MDF REG STA
SIDE/D CVR/S STA
CCGE/D RANGE ID
SIDE CAL RT 1 ID
SIDE CAL RT 2 ID
SIDE CAL RT 3 ID
SIDE CAL RT 4 ID

DI-72 through
DI-99

SIDE VIFILT VOLS
SIDE/MHE SCI CNTS
SIDE/LHE SCI CNTS
SIDE MDF REG STA
SIDE/D CVR/S STA
CCGE/D RANGE ID
SIDE CAL RT 1 ID
SIDE CAL RT 2 ID
SIDE CAL RT 3 ID
SIDE CAL RT 4 ID

DI-73 through
DI-99

LECPA STEP VOLS
SIDE/MHE SCI CNTS
SIDE/LHE SCI CNTS
SIDE MDF REG STA
SIDE/D CVR/S STA
CCGE/D RANGE ID
SIDE CAL RT 1 ID
SIDE CAL RT 2 ID
SIDE CAL RT 3 ID
SIDE CAL RT 4 ID

DF-04 through
DF-07

SIDE/LeE SCI CNTS
SIDE PARITY BIT
SIDE FRAME ID

A1-01 SIDE/LE CNT RT
A1-02 SIDE/HE CNT RT

APR 69 5178.12.29
HEAT FLOW EXPERIMENT

- COMPONENTS & FUNCTIONS
- DEPLOYMENT
- COMMANDS & DATA

PROBE PACKAGE
CABLE TRAY
ELECTRONICS PACKAGE
PROBE CARRYING PACKAGE (CONTAINS 2 PROBES & EMPLACEMENT TOOL)
SUNSHIELD
THERMAL MASK
REFLECTOR
CABLE BRACKET REMOVED DURING DEPLOYMENT

<table>
<thead>
<tr>
<th></th>
<th>LENGTH</th>
<th>WIDTH</th>
<th>HEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELECTRONICS PACKAGE</td>
<td>10</td>
<td>8</td>
<td>7.5</td>
</tr>
<tr>
<td>PROBE PACKAGE</td>
<td>25.5</td>
<td>3.5</td>
<td>5</td>
</tr>
</tbody>
</table>

APR 69 5178.13.1
# HFE Size and Weight

<table>
<thead>
<tr>
<th>Component</th>
<th>Size, in.</th>
<th>Earth Wt, lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunshield</td>
<td>10 x 6 x 4</td>
<td>.37</td>
</tr>
<tr>
<td>Thermal Plate</td>
<td>10 x 8 x 0.08</td>
<td>.40</td>
</tr>
<tr>
<td>Electronics</td>
<td>9 x 7 x 2.07</td>
<td>3.30</td>
</tr>
<tr>
<td>Probe Package</td>
<td>25.5 x 4.5 x 3.5</td>
<td></td>
</tr>
<tr>
<td>Probes (2), each</td>
<td>1 Dia x 43 Long</td>
<td>3.67</td>
</tr>
<tr>
<td>Emplacement Tool (Fully Extended)</td>
<td>88 Long</td>
<td></td>
</tr>
<tr>
<td>Thermal Bag</td>
<td>9.5 x 7.5 x 2.57</td>
<td>.30</td>
</tr>
<tr>
<td>Insulating Ring</td>
<td>10 x 8 x 0.4</td>
<td>.57</td>
</tr>
<tr>
<td>Outer Case</td>
<td>10 x 8 x 3.5</td>
<td>.46</td>
</tr>
<tr>
<td>Legs (4)</td>
<td>0.75 x 0.75</td>
<td>.16</td>
</tr>
<tr>
<td>Cable Reel Support, Etc.</td>
<td></td>
<td>.23</td>
</tr>
<tr>
<td>Cable Reel</td>
<td>2.57 Dia x 2.6 Long</td>
<td>.16</td>
</tr>
<tr>
<td>Screws, Washers, Etc.</td>
<td></td>
<td>.08</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>9.70</strong></td>
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</tbody>
</table>
HFE PROBE DETAILS

- LUNAR SURFACE
- RING SENSOR (4/PROBE)
- GRADIENT SENSOR (INSIDE)
- HEATER COILS (OUTSIDE)
- PROBE STOP
- TO ELECTRONICS
- RADIATION SHIELD
- THERMOCOUPLES (4) 25.6, 45.3, & 65.0 IN. ABOVE PROBE
- FLEXIBLE SPRING
- PROBE

APR 69 5178.13.3
# HFE Modes of Operation

<table>
<thead>
<tr>
<th>Measurement Sequences</th>
<th>Mode</th>
<th>Mode 2</th>
<th>Mode 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Full (All Meas)</td>
<td>SAME AS GRADIENT</td>
<td>DIFFERENTIAL &amp; AMBIENT TEMP FOR ONE BRIDGE (DEPENDING ON SELECTED HEATER)</td>
<td>RING (OR &quot;REMOTE&quot;)</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</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(HI Excitation)</td>
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</tr>
<tr>
<td>Differential Temp</td>
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<tr>
<td>(LO Excitation)</td>
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<td></td>
<td></td>
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<tr>
<td>Ambient Temp</td>
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<tr>
<td>Ref Junction</td>
<td></td>
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</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>GRADIENT</td>
<td>GRADIENT</td>
<td>RING SOURCE</td>
</tr>
<tr>
<td>Heaters</td>
<td>NONE</td>
<td>RING SOURCE</td>
<td>HEAT PULSE</td>
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*THESE MODES USED PRIMARILY FOR TESTS*
## HFE COMMAND SUMMARY

<table>
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<tr>
<th>CMD</th>
<th>NUMBERS</th>
<th>COMMAND</th>
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<tbody>
<tr>
<td>HFE</td>
<td>OCTAL</td>
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</tr>
<tr>
<td>C1</td>
<td>135</td>
<td>HFE MODE/G SEL</td>
</tr>
<tr>
<td>C2</td>
<td>136</td>
<td>HFE MODE/LK SEL</td>
</tr>
<tr>
<td>C3</td>
<td>140</td>
<td>HFE MODE/HK SEL</td>
</tr>
<tr>
<td>C4</td>
<td>141</td>
<td>HFE SEQ/FUL SEL</td>
</tr>
<tr>
<td>C5</td>
<td>142</td>
<td>HFE SEQ/P1 SEL</td>
</tr>
<tr>
<td>C6</td>
<td>143</td>
<td>HFE SEQ/P2 SEL</td>
</tr>
<tr>
<td>C7</td>
<td>144</td>
<td>HFE LOAD 1</td>
</tr>
<tr>
<td>C8</td>
<td>145</td>
<td>HFE LOAD 2</td>
</tr>
<tr>
<td>C9</td>
<td>146</td>
<td>HFE LOAD 3 (ENCODED)</td>
</tr>
<tr>
<td>C10</td>
<td>152</td>
<td>HFE HTR STEPS</td>
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*INITIALIZED TO THESE CONDITIONS AT POWER TURN-ON*

INPUT BUFFER HOLDS COMMANDS FOR EXECUTION AT 90-FRAME MARK
**HFE DIGITAL DATA FORMAT**

<table>
<thead>
<tr>
<th>ALSEP FRAME 90,8</th>
<th>MEASUREMENT (SEQUENCE) REGISTER</th>
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<tbody>
<tr>
<td>1,9</td>
<td>R₂ R₁ 0 P₄ P₃ P₂ P₁ 2₁² 2₁¹ 2₁⁰ 2₉ 2₈ 2₇ 2₆ 2₅ 2⁴ 2³ 2² 2¹ 2⁰</td>
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<table>
<thead>
<tr>
<th>MODE REGISTER</th>
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<td>2,10</td>
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<tr>
<td>R₂ R₁ M₁ M₂ M₃ 0 0 2₁² 2₁¹ 2₁⁰ 2₉ 2₈ 2₇ 2₆ 2₅ 2⁴ 2³ 2² 2¹ 2⁰</td>
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<table>
<thead>
<tr>
<th>HFE SCIENCE DATA (TYPICAL)</th>
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<tr>
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<tr>
<td>R₂ R₁ H₄ H₃ H₂ H₁ 0 2₁² 2₁¹ 2₁⁰ 2₉ 2₈ 2₇ 2₆ 2₅ 2⁴ 2³ 2² 2¹ 2⁰</td>
</tr>
</tbody>
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<p>| CONDUCTIVITY |
| HEATER |</p>
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<tr>
<td>6,14</td>
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<tr>
<td>R₂ R₁ 0 0 0 0 0 0 2₁² 2₁¹ 2₁⁰ 2₉ 2₈ 2₇ 2₆ 2₅ 2⁴ 2³ 2² 2¹ 2⁰</td>
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<table>
<thead>
<tr>
<th>SUBSEQUENCE REGISTER (WORD 11)</th>
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<td>7,15</td>
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<tr>
<td>R₂ R₁ 0 0 0 0 0 0 2₁² 2₁¹ 2₁⁰ 2₉ 2₈ 2₇ 2₆ 2₅ 2⁴ 2³ 2² 2¹ 2⁰</td>
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DEC 68 5178.13.7
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>
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<tbody>
<tr>
<td>135</td>
<td>MODE/G</td>
<td>MODE 1</td>
<td>NORMAL GRADIENT</td>
<td>100</td>
</tr>
<tr>
<td>136</td>
<td>MODE/LK</td>
<td>MODE 2</td>
<td>LOW CONDUCTIVITY</td>
<td>010</td>
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<tr>
<td>140</td>
<td>MODE/HK</td>
<td>MODE 3</td>
<td>HIGH CONDUCTIVITY</td>
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</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 Gradient Measurement Options

<table>
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<th>CMDs &amp; Order (OCTAL)</th>
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<table>
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<th>Measurement</th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>

**Note:** Gradient mode shown

- HFE SEQ/P1: 180 frames, rep rate 16 out of 90 frames
- HFE SEQ/P2: 360 frames, rep rate 90 frames

DEC 68 5178.13.9
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 (5) AND CLEAR (C) POSITIONS OF THE FLIP-FLOPS CORRESPOND TO ONE AND ZERO IN THE TM.
HFE MSP DIAGRAM

00 DTH
01 DTL
10 T
11 TC

0 = PROBE 1
1 = PROBE 2

0 = UPPER SECTION
1 = LOWER SECTION

ADVANCE PULSES
90 + 8 FRAMES
90-FRAME MARK

BYPASS P2
NORMAL BYPASS
BYPASS P4P3

NOTE
SET, S = 1
CLEAR, C = 0

APR 69 5178.13.11
HFE SUBSEQUENCE PROGRAMMER

The Subsequence Programmer is a 4-state counter having dual functions:

- Control gating of data, within a subset, to the output register:
  (where the type of subset is controlled by the MSP)

- Supply subsequence register status data for TM (R-bits)

The state of $R_2 R_1$ 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 $P_1$ from zero to one.

From ALSEP frame 16 to 89 there is no HFE data and register changes are inhibited.

<table>
<thead>
<tr>
<th>$R_2$</th>
<th>$R_1$</th>
<th>ALSEP</th>
<th>FRAME NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>0</td>
<td>90, 1</td>
<td>8, 9</td>
</tr>
<tr>
<td>01</td>
<td>0</td>
<td>2, 3</td>
<td>10, 11</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>4, 5</td>
<td>12, 13</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
<td>6, 7</td>
<td>14, 15</td>
</tr>
</tbody>
</table>

$R_2 R_1$ read out as first two bits in even numbered ALSEP frame.

Dec 68 5178.13.12
HFE TIMING FUNCTIONS

- MODE/G - GRADIENT (HEAT FLOW FROM CENTER TO SURFACE)

- MODF/LK - LOW CONDUCTIVITY
  MODE/HK - HIGH CONDUCTIVITY
  (DIFFERENT HEAT PULSES & SENSOR COMBINATIONS COORDINATED BY INTERNAL LOGIC)

- SEQUENCE REGISTER (P_1 P_2 P_3 P_4)

- TEMP GRADIENT
  - HI SENSITIVITY
    - (0000) GDT11H
    - (0010) GDT12H
  - LOW SENSITIVITY
    - (0000) TO (0111)

- TEMPERATURE AMBIENT TEMP
  - (1000) TO (1011)

- 4 HFE WORDS
  - SUBSEQUENCE REGISTER (R_2 R_1)

- 8 ALSEP WORDS
  - ALSEP FRAME 1-8 (1 WORD/FRAME)

- THERMOCOUPLES & REF JUNCTIONS
  - (1100) TO (1111)

- REP RATE:
  - 720 ALSEP FRAMES
  - ~ 434.7 SEC
  - ~ 7.25 min

NOTE: 4 HFE WORDS HAVE DIFFERENT DEFINITIONS FOR 0100 THROUGH 1111

DEC 68 5178.13.13
## 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>DIFERENTIAL</td>
<td>1/UPPER</td>
<td>HIGH VOLTAGE</td>
<td>(00) + BRIDGE EXCITATION</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1/LOWER</td>
<td></td>
<td>(01) + BRIDGE OUTPUT</td>
</tr>
<tr>
<td>DH-02</td>
<td>GDT 12H</td>
<td>0001</td>
<td>DIFFERENTIAL</td>
<td>2/UPPER</td>
<td>LOW VOLTAGE</td>
<td>(10) - BRIDGE EXCITATION</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2/LOWER</td>
<td></td>
<td>(11) - BRIDGE OUTPUT</td>
</tr>
<tr>
<td>DH-03</td>
<td>GDT 21H</td>
<td>0010</td>
<td></td>
<td>1/UPPER</td>
<td>HIGH VOLTAGE</td>
<td>(00) + BRIDGE CURRENT</td>
</tr>
<tr>
<td>DH-04</td>
<td>GDT 22H</td>
<td>0011</td>
<td>BRIDGE (GRADIENT SENSORS)</td>
<td>1/UPPER</td>
<td>LOW VOLTAGE</td>
<td>(10) - BRIDGE CURRENT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1/LOWER</td>
<td></td>
<td>(11) - BRIDGE OUTPUT</td>
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<tr>
<td>DH-09</td>
<td>GDT 11L</td>
<td>0100</td>
<td>(RESISTANCE)</td>
<td>2/UPPER</td>
<td>HIGH VOLTAGE</td>
<td>(00) + BRIDGE EXCITATION</td>
</tr>
<tr>
<td>DH-10</td>
<td>GDT 12L</td>
<td>0101</td>
<td></td>
<td>2/LOWER</td>
<td></td>
<td>(01) + BRIDGE CURRENT</td>
</tr>
<tr>
<td>DH-11</td>
<td>GDT 21L</td>
<td>0110</td>
<td></td>
<td>2/UPPER</td>
<td>VOLTAGE</td>
<td>(10) - BRIDGE EXCITATION</td>
</tr>
<tr>
<td>DH-12</td>
<td>GDT 22L</td>
<td>0111</td>
<td></td>
<td>2/LOWER</td>
<td></td>
<td>(11) - BRIDGE OUTPUT</td>
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<tr>
<td>DH-13</td>
<td>GT 11</td>
<td>1000</td>
<td>REF JUNCTION BR</td>
<td>1/UPPER</td>
<td>HV</td>
<td>SAME AS DH-01 TO DH-04</td>
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<tr>
<td>DH-14</td>
<td>GT 12</td>
<td>1001</td>
<td></td>
<td>1/LOWER</td>
<td>HV</td>
<td>SAME AS DH-01 TO DH-04</td>
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<tr>
<td>DH-15</td>
<td>GT 21</td>
<td>1010</td>
<td></td>
<td></td>
<td></td>
<td>SAME AS DH-13</td>
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<tr>
<td>DH-16</td>
<td>GT 22</td>
<td>1011</td>
<td></td>
<td></td>
<td></td>
<td>SAME AS DH-01 TO DH-04</td>
</tr>
<tr>
<td>DH-17</td>
<td>THERMOCOUPLES IN CABLE OF PROBE 1</td>
<td>1101</td>
<td>THERMOCOUPLES IN CABLE OF PROBE 1</td>
<td>1/UPPER</td>
<td>SAME AS DH-13</td>
<td></td>
</tr>
<tr>
<td>DH-18</td>
<td>WRT REF T1</td>
<td></td>
<td>WRT REF T1</td>
<td>1/LOWER</td>
<td></td>
<td>SAME AS DH-01 TO DH-04</td>
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<tr>
<td>DH-19</td>
<td>THERMOCOUPLES IN CABLE OF PROBE 2</td>
<td>1110</td>
<td>SAME AS DH-13</td>
<td>2/UPPER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DH-20</td>
<td>WRT REF T2</td>
<td></td>
<td>WRT REF T2</td>
<td>2/LOWER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DH-21</td>
<td>THERMOCOUPLES IN CABLE OF PROBE 2</td>
<td>1111</td>
<td>THERMOCOUPLES IN CABLE OF PROBE 2</td>
<td>2/UPPER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DH-22</td>
<td>WRT REF T2</td>
<td></td>
<td>WRT REF T2</td>
<td>2/LOWER</td>
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</tr>
</tbody>
</table>

DEC 68 5178.13.14
HFE HEATER SEQUENCE PROGRAMMER

152 CMD C10 HFE HTR STEPS

H4 ADV H3 ADV H2 ADV H1

- 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

\[
H_4 \begin{cases} 
0 = \text{PROBE 1} \\
1 = \text{PROBE 2} 
\end{cases}
\]

\[
H_3 \begin{cases} 
0 = \text{LOWER HEATER} \\
1 = \text{UPPER HEATER} 
\end{cases} \quad \text{(IN PROBE SECTION)}
\]

\[
H_2 \begin{cases} 
0 = \text{UPPER SECTION} \\
1 = \text{LOWER SECTION} 
\end{cases} \quad \text{(IN PROBE)}
\]

\[
H_1 \begin{cases} 
0 = \text{HEATER OFF} \\
1 = \text{HEATER ON} 
\end{cases}
\]

<table>
<thead>
<tr>
<th>(H_3) (H_2)</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>

EXAMPLE: WHEN H-BITS = 1011, HEATER H24 IS ON (WHERE H24 INDICATES FOURTH HEATER IN PROBE 2)

NOTE: THIS CODE APPLIES TO HEATER CONTROL IN BOTH MODE/LK AND MODE/HK
### HFE Measurements in Mode/HK

<table>
<thead>
<tr>
<th>Symbol</th>
<th>ABBR</th>
<th>Probe</th>
<th>Bridge</th>
<th>$H_1 \ H_2 \ H_3 \ H_4$</th>
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<tbody>
<tr>
<td>DH-50</td>
<td>RDT 11</td>
<td>1</td>
<td>1</td>
<td>0000</td>
</tr>
<tr>
<td>DH-51</td>
<td>RT 11</td>
<td>1</td>
<td>1</td>
<td>0000</td>
</tr>
<tr>
<td>DH-52</td>
<td>RDT 11</td>
<td>1</td>
<td>1</td>
<td>0001</td>
</tr>
<tr>
<td>DH-53</td>
<td>RT 11</td>
<td>1</td>
<td>1</td>
<td>0001</td>
</tr>
<tr>
<td>DH-60</td>
<td>RDT 12</td>
<td>1</td>
<td>2</td>
<td>0010</td>
</tr>
<tr>
<td>DH-61</td>
<td>RT 12</td>
<td>1</td>
<td>2</td>
<td>0010</td>
</tr>
<tr>
<td>DH-62</td>
<td>RDT 12</td>
<td>1</td>
<td>2</td>
<td>0011</td>
</tr>
<tr>
<td>DH-63</td>
<td>RT 12</td>
<td>1</td>
<td>2</td>
<td>0011</td>
</tr>
<tr>
<td>DH-56</td>
<td>RDT 11</td>
<td>1</td>
<td>1</td>
<td>0100</td>
</tr>
<tr>
<td>DH-57</td>
<td>RT 11</td>
<td>1</td>
<td>1</td>
<td>0100</td>
</tr>
<tr>
<td>DH-58</td>
<td>RDT 11</td>
<td>1</td>
<td>1</td>
<td>0101</td>
</tr>
<tr>
<td>DH-59</td>
<td>RT 11</td>
<td>1</td>
<td>1</td>
<td>0101</td>
</tr>
<tr>
<td>DH-66</td>
<td>RDT 12</td>
<td>1</td>
<td>2</td>
<td>0110</td>
</tr>
<tr>
<td>DH-67</td>
<td>RT 12</td>
<td>1</td>
<td>2</td>
<td>0110</td>
</tr>
<tr>
<td>DH-68</td>
<td>RDT 12</td>
<td>1</td>
<td>2</td>
<td>0111</td>
</tr>
<tr>
<td>DH-69</td>
<td>RT 12</td>
<td>1</td>
<td>2</td>
<td>0111</td>
</tr>
<tr>
<td>DH-70</td>
<td>RDT 21</td>
<td>2</td>
<td>1</td>
<td>1000</td>
</tr>
<tr>
<td>DH-71</td>
<td>RT 21</td>
<td>2</td>
<td>1</td>
<td>1000</td>
</tr>
<tr>
<td>DH-72</td>
<td>RDT 21</td>
<td>2</td>
<td>1</td>
<td>1001</td>
</tr>
<tr>
<td>DH-73</td>
<td>RT 21</td>
<td>2</td>
<td>1</td>
<td>1001</td>
</tr>
<tr>
<td>DH-80</td>
<td>RDT 22</td>
<td>2</td>
<td>2</td>
<td>1010</td>
</tr>
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<td>DH-81</td>
<td>RT 22</td>
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<td>1010</td>
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<td>1011</td>
</tr>
<tr>
<td>DH-83</td>
<td>RT 22</td>
<td>2</td>
<td>2</td>
<td>1011</td>
</tr>
<tr>
<td>DH-76</td>
<td>RDT 21</td>
<td>2</td>
<td>1</td>
<td>1100</td>
</tr>
<tr>
<td>DH-77</td>
<td>RT 21</td>
<td>2</td>
<td>1</td>
<td>1100</td>
</tr>
<tr>
<td>DH-78</td>
<td>RDT 21</td>
<td>2</td>
<td>1</td>
<td>1101</td>
</tr>
<tr>
<td>DH-79</td>
<td>RT 21</td>
<td>2</td>
<td>1</td>
<td>1101</td>
</tr>
<tr>
<td>DH-86</td>
<td>RDT 22</td>
<td>2</td>
<td>2</td>
<td>1110</td>
</tr>
<tr>
<td>DH-87</td>
<td>RT 22</td>
<td>2</td>
<td>2</td>
<td>1110</td>
</tr>
<tr>
<td>DH-88</td>
<td>RDT 22</td>
<td>2</td>
<td>2</td>
<td>1111</td>
</tr>
<tr>
<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.

#### Notes

- P-Bits, other than P1, are meaningless in Mode/HK.
- Measurement content:
  
<table>
<thead>
<tr>
<th>$P_2 \ P_1$</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.
HFE COMMAND DETAILS

139 OCTAL CMD 140 SEL

This CMD IC13 IS A 1-STATE CMD. IT PLACES THE HFE IN THE GRADIENT
OR NORMAL, MODE OF OPERATION IN WHICH MEASUREMENTS ARE OBTAINED
FROM THE GRADIENT SENSORS AND CALIBRATED THERMOCOUPLES UNDER
THE CONTROL OF THE MSP. CMD 138 ALSO TURNS OFF THE PROBE HEATER CURRENT
SUPPLY. DIFFERENTIAL MEASUREMENT SEQUENCES IN MODE/G MAY BE SELECTED
BY TRANSMITTING SUBSEQUENT CMDs. AT POWER-UP OR, THE HFE
INITIALIZES IN MODE/G. IF THE HFE IS IN NODE/G, TRANSMISSION OF CMD
138 HAS NO EFFECT.

NOTE THAT THE HFE INPUT BUFFER HOLDS CMDs FOR EXECUTION AT THE
PREVIOUS-STATE MARK. THEREFORE, SEQUENTIAL CMDs MUST BE EXECUTED AT
LEAST 56 SEC APART.

140 HFE MODE/HK SEL

This CMD IC13 IS A 1-STATE CMD. IT PLACES THE HFE IN THE LOW
CONDUCTIVITY, OR HFE SOURCE, MODE OF OPERATION IN WHICH
MEASUREMENTS ARE OBTAINED FROM THE HFE SOURCE SENSORS
UNDER THE CONTROL OF THE HFE SEQUENCE PROGRAMMER. NOTE THAT
CMD 140-148 MUST ALSO BE TRANSMITTED BEFORE VALID DATA WILL BE
OBTAINED IN MODE/HK. EITHER CMD MAY BE TRANSMITTED FIRST.
CMD 141 ALSO TURNS ON THE HFE HEATER CURRENT SUPPLY IN THE
HIGH, OR HFE SOURCE, MODE ALLOWING HEATERS TO BE ACTIVATED BY CMD 121.
IF THE HFE IS IN NODE/HK, TRANSMISSION OF CMD 138 HAS NO EFFECT.

141 HFE MODE/HK SEL

This MDC IC13 IS A 1-STATE CMD. IT PLACES THE HFE IN THE HIGH
CONDUCTIVITY, OR HFE SOURCE, MODE OF OPERAATION IN WHICH
MEASUREMENTS ARE OBTAINED FROM THE HFE SOURCE SENSORS
UNDER THE CONTROL OF THE HFE SEQUENCE PROGRAMMER. NOTE THAT
CMD 140-148 MUST ALSO BE TRANSMITTED BEFORE VALID DATA WILL BE
OBTAINED IN MODE/HK. EITHER CMD MAY BE TRANSMITTED FIRST.
CMD 141 ALSO TURNS ON THE HFE HEATER CURRENT SUPPLY IN THE
HIGH, OR HFE SOURCE, MODE ALLOWING HEATERS TO BE ACTIVATED BY CMD 121.
IF THE HFE IS IN NODE/HK, TRANSMISSION OF CMD 138 HAS NO EFFECT.

142 HFE SEQ/PZ SEL

This CMD IC14 IS A 1-STATE CMD. IT CANCELS THE EFFECT OF CMD 141
THROUGH 148 CAUSING THE MSP TO PERFORM ITS FULL 16-STATE CYCLE OF
OPERATION IN MODES OR MODE/HK. IF TRANSMITTED DURING MODE/HK
OPERATION, THIS CMD WILL CAUSE INVALID OPERATION UNTIL CMD 140
IS EXECUTED. AT POWER-UP OR, THE HFE INITIALIZES IN SEQ/PZ.
IF THE HFE IS IN MODES OR MODE/HK IN SEQ/PZ, TRANSMISSION OF
CMD 141 HAS NO EFFECT.

143 HFE SEQ/PZ SEL

This CMD IC14 IS A 1-STATE CMD AND ALTERNATES WITH CMD 144
TO SELECT ONLY ONE PROBE FOR MEASUREMENT. IN NODE/G THIS CMD IS
MEANINGLESS. IN MODES OR MODE/HK IT CAUSES THE MSP TO LOCK
FLIP-FLOP P4 IN THE CLEAR STATE AND BYPASS P3. THIS MDS ACTS AS AN 8-STATE COUNTER IF CMD 141 WAS PREVIOUSLY EXECUTED, OR AS
A 2-STATE COUNTER IF CMD 144, 146, OR CMD 146 WAS PREVIOUSLY EXECUTED.
SEQ/PZ IS CLEAR BY SUBSEQUENT EXECUTION OF CMD 141.

144 HFE LOAD 1

This CMD IC14 IS A 1-STATE CMD AND IS USED ALONG OR IN COMBINATION
WITH CMD 145 OR 146 TO POSITION AND LOCK TWO FLIP-FLOPS P4, P3
IN THE MSP. CMD 146 PLACES P4,P3 IN THE CLEAR POSITION. CMD 145
BYPASSES THOSE STEPS. THE MDS THEN ACTS AS A 4-STATE COUNTER IF
CMD 146 WAS PREVIOUSLY EXECUTED AND AS A 2-STATE COUNTER IF
CMD 145 OR 146 WAS PREVIOUSLY EXECUTED. THIS APPLIES TO MODE/G
AND MODE/HK. CMD 144 MUST BE EXECUTED TO OBTAIN VALID DATA. CMD 145 OR 146 MAY BE USED IN MODES OR MODE/HK,
FOLLOWING CMD 144, TO LOCK P3, P4 IN THE 0 OR 1 STATE RESPECTIVELY.
THE EFFECT OF CMD 145 IS CLEARED BY SUBSEQUENT EXECUTION OF CMD 141.
NOTE: WHEN IN MODES OR MODE/HK OR MODE/HK, THE HFE MAY NOT BE USED.
THE EFFECT OF CMD 145 IS CLEARED BY SUBSEQUENT EXECUTION OF CMD 141.

145 HFE LOAD 2

This CMD IC14 IS A 1-STATE CMD AND IS USED ALONG OR IN COMBINATION
WITH EITHER CMD 144 OR 146 TO POSITION AND LOCK TWO FLIP-FLOPS P4, P3
IN THE MSP. CMD 145 PLACES P4, P3 IN THE CLEAR POSITION AND LOCK TWO FLIP-FLOPS P4, P3 IN THE SET STATE. THEREFORE, CMD 145
PLACES P4, P3 IN THE SET STATE. CMD 145 PROBES A DIFFERENTIAL TEMPERATURE DATA ONLY, WHILE CMD 146
YIELDS A DIFFERENTIAL TEMPERATURE DATA ONLY. EXECUTION OF THIS CMD
IN MODE/HK CAUSES INVALID DATA UNTIL CMD 140 IS EXECUTED. THE
EFFECT OF CMD 145 IS CLEARED BY SUBSEQUENT EXECUTION OF CMD 141.

146 HFE LOAD 3

This CMD IC14 IS A 1-STATE CMD OPERATING ESSENTIALLY THE SAME AS
CMD 145 EXCEPT THAT IT POSITIONS A PROBE CURRENT SUPPLY IN THE SET STATE. WHEN PRECEDED BY CMD 145 IT YIELDS A CURRENT SUPPLY IN THE SET STATE. WHEN
CMD 145 IS EXECUTED, THE EFFECT OF CMD 145 IS CLEARED BY SUBSEQUENT EXECUTION OF CMD 141.

152 HFE HTR SEL

This CMD IC14 IS A 1-STATE CMD WHICH ADVANCES THE HEATER
EXCITATION PROGRAMMER. CMD 144 SELECTS THE RACK SPACE TO BE EXECUTED.
IN MODES OR MODE/HK THE HFE ACTS AS A 4-STATE COUNTER AND ADVANCES THE HEATER EXCITATION PROGRAMMER. CMD 146
ADVANCES THE HEATER EXCITATION PROGRAMMER. CMD 146 ADVANCES THE HEATER EXCITATION PROGRAMMER.
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/LK ON/OFF |
| AH-07 | HFE HTR/HK ON/OFF |

EACH SAMPLED ONCE EVERY 54 SEC ALSEP SEQUENCE
HFE THERMAL CONTROL

NOTE: ADDITIONAL THERMOSTAT TURNS A PORTION OF INSTRUMENT ELECTRONICS ON/OFF BETWEEN MEASUREMENTS IF TEMP IS LOW/HIGH

APR 69 5178.13.20
HFE POWER PROFILE

- Elect Spec
  - Watts
    - Night Max: 10.0
    - Day Max: 6.0
    - Day Average: 3.9
    - Mode/G
    - Mode/LK
    - Mode/HK

- Thermal Control
  - Heater Range

- Conductivity
  - Heaters turned on & off by ground cmd

- April 69 5178.13.21
# HFE 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>Distance from Subpackage 1</td>
<td>29 + 1 ft (30 ft cable)</td>
<td>2</td>
<td>Paced Off</td>
<td>To obtain probe separation from RTG*</td>
</tr>
<tr>
<td>Direction from Subpackage 1</td>
<td>Away from RTG</td>
<td>2</td>
<td>Eyeball</td>
<td>Greater than 80° from RTG</td>
</tr>
<tr>
<td>Level</td>
<td>±12° of vertical</td>
<td>1</td>
<td>Eyeball</td>
<td>Interacts with alignment</td>
</tr>
<tr>
<td>Align wrt shadow</td>
<td>±5° of E-W</td>
<td>1</td>
<td>Arrow** and shadows</td>
<td>Thermal req for sun shield shadows to align with plate edges.</td>
</tr>
<tr>
<td>Distance from Electronics</td>
<td>17 + 1 ft (20 ft cable to hole)</td>
<td>1</td>
<td>Paced Off (cable marked for depth)</td>
<td>To obtain 30 ft separation between probes (requirement)</td>
</tr>
<tr>
<td>Direction from Electronics</td>
<td>At least 140° apart</td>
<td>1</td>
<td>Paint Lines***</td>
<td>Probe and RTG separation* avoid shadows from all subsystems.</td>
</tr>
<tr>
<td>Vertical alignment</td>
<td>Within ±15°</td>
<td>2</td>
<td>Eyeball</td>
<td>Objective for drilling</td>
</tr>
</tbody>
</table>

**Experiment Interrelation**
- Separation distance from RTG: 40 ft minimum, avoid major disturbances (trampling, etc.) and shadows in 17 ft circle around probe.

**Special Requirements**
- Arrow nominally points east-west
- Paint lines give 120° directions centered on N-S axis but allow estimation of other directions.
HFE ALIGNMENT MARKINGS

TAPE CABLE TO
CENTRAL STATION
(PROBABLY NW OF HFE)

DEPTH
INDICATION
ON PROBE
EMPLACEMENT
TOOL

SOCKET FOR UHT

TO PROBE

TO PROBE

140°
APOLLO LUNAR SURFACE DRILL
APOLLO LUNAR SURFACE DRILL

THERMAL SHROUD

BATTERY, POWER HEAD, THERMAL GUARD & THERMAL SHROUD ASSY

DRILL STRING, BIT & CAPS

HANDLE & SWITCH ASSY

ALSD ASSY

ALSEP STOWAGE MODE

LUNAR SURFACE TRANSPORT MODE

LUNAR SURFACE OPERATIONAL MODE

WRENCH

TREADLE ASSY

RACK ASSY

CASINGS

JAN 69 5178.13.26
CHANNELTRON® ELECTRON MULTIPLIERS

C - TYPE

INSIDE COATING FOR SECONDARY ELECTRON EMISSION

100 mm

1 mm INSIDE

X 10^8 TO PREAMP

UP TO 10^6/SEC PROTONS, ELECTRONS, X-RAYS & UV (THEREFORE, SORT BEFORE ENTRANCE)

10^9

10^8

10^7

10^6

10^5

10^4

2.0

2.4

2.8

3.2

3.6

APPLIED KILOVOLTS

UNIFORM OUTPUT

NOV 67 5178.14.3
CPL EE THERMAL CONTROL
CPLEE TIMING SEQUENCE

ALSEP

FRAME NO

0 4 8 12 16 20 24 28 32

CPLEE

PHYS/AN

A B A B A B A B A B A B A B

READOUT OF A DURING B MEAS, ETC.

+3500

-350

+35

BKG

-3500

-35

CAL

• CPLEE MAY START ANYWHERE

• DATA ~ CNTS/SEC

19.3 SEC (NORMAL)

NOV 68 5178.14.6
CPL EE POWER PROFILE

STARTUP TRANSIENT
280 MW FOR 36 M SEC.

WAITs

LUNAR MORNING

LUNAR NOON

LUNAR NIGHT

LUNAR NIGHT SURVIVAL

APR 69 5178.14.7
## CPLEE PERFORMANCE CHECKS

<table>
<thead>
<tr>
<th>Technique</th>
<th>CNT/SEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta Source in Dust Cover</td>
<td>0 TO 2000 (Depending on Initial Operation)</td>
</tr>
<tr>
<td>For Complete Test during Operation</td>
<td></td>
</tr>
<tr>
<td>Test Oscillator Input to All Preamps Once During Each Operating Cycle</td>
<td>≈350,000 Hz (Fills 19th Bit of Register)</td>
</tr>
</tbody>
</table>
CPLEE TIE-DOWN

ASTRONAUT:
- RELASES FASTENERS
- INSERTS UHT
- LIFTS EXPERIMENT
- REMOVES UHT SOCKET PIN
- ROTATES EXPERIMENT

EXPERIMENT INVERTED

CABLE REEL

MOUNTING FITTINGS

SUNSHIELD

UHT SOCKET

180° ROTATION

APR 69 5178.14.10
## CPLEE 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>Distance from Subpackage 1</td>
<td>10 ± 1 ft (11 ft cable)</td>
<td>1</td>
<td>Paced Off</td>
<td>Critical separation is from RTG and Subpackage 1</td>
</tr>
<tr>
<td>Direction from Subpackage 1</td>
<td>At least 60° from RTG and 30° from N-S line of Subpackage 1</td>
<td>1</td>
<td>Eyeball</td>
<td>At least 14 ft from RTG and preferably 20 ft, avoid field of view of Central Station Radiator</td>
</tr>
<tr>
<td>Site Selection</td>
<td>Approx Horiz</td>
<td>2</td>
<td>Eyeball</td>
<td>75° (half-angle) vertical cone must be clear except for ALSEP antenna.</td>
</tr>
<tr>
<td>Level, WRTIndicator</td>
<td>±2.5° of Horiz</td>
<td>1</td>
<td>Bubble</td>
<td>Interacts with alignment</td>
</tr>
<tr>
<td>Align, WRT Shadow</td>
<td>±2° of E-W</td>
<td>2</td>
<td>Arrow**</td>
<td>Thermal requirement</td>
</tr>
<tr>
<td>Readout of alignment</td>
<td>±1° of E-W</td>
<td>1</td>
<td>Tool &amp; Rose</td>
<td>Scientific requirement**</td>
</tr>
<tr>
<td>Experiment Interrelation</td>
<td>*Contaminating radioactive field at CPLEE caused by other subsystems must be less than 0.1 count/sec in all channels.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special Requirements</td>
<td>**Experiment is bidirectional for scientific output but arrow points E and partial compass rose (using shadow of handling tool) covers only the range for Sun in East.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**EXP 68 5178.14.11**
CPLEE DIGITAL DATA FORMAT

ALSEP EVEN FRAME

ALSEP WORD

ANALYZER A OR B

19-BIT CHAN 1

VOLTAGE LEVEL MSB

DEFLECTION VOLTAGE POLARITY

19-BIT CHAN 2

MSB

LSB

VOLTAGE LEVEL LSB

19-BIT CHAN 3

ALSEP ODD FRAME

19-BIT CHAN 4

VOLTAGE LEVEL LSB

20-BIT CHAN 5

20-BIT HELIX

DC-01 THROUGH DC-34

CPE DET SCI DATA

DC-85 THROUGH DC-96

CPE CAL SIG

DC-97

CPE PHYS/AN ID

DC-98

CPE POLARITY ID

DC-99

CPE DEF_LVL ID

NOV 67 5178.14.13
CPLEE ANALOG DATA

SAMPLED ONCE PER 54-SEC
ALSEP SEQUENCE (ALSEP WORD 33)

AC - 01  CPE  DEF P/S VOLTS
AC - 02  CPE  CHAN/1 VOLTS
AC - 03  CPE  CHAN/2 VOLTS
AC - 04  CPE  CONV VOLTS
AC - 05  CPE  PHYS/AN DEG C
AC - 06  CPE  DEF P/S DEG C

NOTE: AC - 05 IS TEMPERATURE OF PHYSICAL ANALYZER A

NOV 67  5178.14.14
CPLEE COMMANDS

OCTAL COMMAND NUMBERS

111 CPE OPR HTR ON
This command bypasses the thermostat in the CPLEE and turns the operational heater on. To restore automatic thermal control, the experiment power must be commanded to STBY and back to OPER. This command has no control over survival (STBY) heaters.

112 CPE OPR HTR OFF
This command bypasses the thermostat in the CPLEE and turns the operational heater off, and is also used to turn off the operational heater after it has been turned on by command 111. See command 111 for restoration of automatic thermal control. This command has no control over survival heaters. (Operational heater on/off via 111 & 112 can be recycled indefinitely.)

113 CPE CVR GO
This command actuates the guillotine device for removing the CPLEE dust cover.

114 CPE DEF SEQ ON
This command starts the automatic sequence of voltages to the CPLEE deflection plates whenever it has been stopped (by command 117). Initial turn-on of the experiment is in the automatic sequence mode.

115 CPE DEF STEP
This command advances the voltage on the CPLEE deflection plates one step each time it is used, in the standard sequence, when the sequence has been stopped. If automatic sequence is on, this command has no effect.

117 CPE DEF SEQ OFF
This command interrupts the automatic sequence of voltages to the CPLEE deflection plates. The voltage then remains constant until advanced by command 115. It is restored to automatic sequence by command 114 or by cycling CPLEE to STBY and back to OPER.

120 CPE CHAN/HI SEL
This command increases the voltage across the Channeltron® electron multipliers in both physical analyzers (A & B) to the higher value, ≈ 3200 volts, if it is at the lower setting, ≈ 2800 volts (Δ ≈ 400 volts). If this command is sent twice, without command 121 between, the second command has no effect.

121 CPE CHAN/LO SEL
This command decreases the voltage across the Channeltron® electron multipliers in both physical analyzers (A & B) to the lower value, ≈ 2800 volts, if it is at the higher setting, ≈ 3200 volts (Δ ≈ 400 volts). If this command is sent twice, without command 120 between, the second command has no effect.

SEPT 68 5178.14.15
COLD CATHODE GAUGE EXPERIMENT (CCGE)

HEIGHT, IN. = 13.4
WIDTH, IN. = 4.6
DEPTH, IN. = 12.0
EARTH WEIGHT, LB = 12.5
CCGE GENERAL FEATURES

PURPOSE IS TO DETERMINE

• DENSITY OF LUNAR ATMOSPHERE, WHERE TIME-DEPENDENT CHANGES MAY BE
  • RANDOM
  • FUNCTION OF LUNAR CYCLE
  • FUNCTION OF SOLAR ACTIVITY

• LOSS RATE OF CONTAMINANTS LEFT BY ASTRONAUTS & LM

MEASUREMENT TECHNIQUE

• GAUGE PRODUCES AN ELECTRICAL CURRENT PROPORTIONAL TO THE NEUTRAL PARTICLE DENSITY AT ITS POSITION

• CURRENT IS AMPLIFIED & CONVERTED INTO A 10-BIT WORD FOR TRANSMISSION IN THE ALSEP FORMAT

COMBINED WITH MEASURED TEMP OF GAUGE, ALLOWS CALCULATION OF LUNAR ATMOSPHERE PRESSURE
CCGE PERFORMANCE

- RANGE: $10^{-6}$ TO $10^{-12}$ TORR
- ACCURACY: $\pm 30\%$ ABOVE $10^{-10}$ TORR, $\pm 50\%$ BELOW $10^{-10}$ TORR
- OPERATING VOLTAGE: $+4500$V
- MAGNETIC FIELD: 1020 GAUSS
- GAUGE BODY CONSTRUCTED OF 304 STAINLESS STEEL
- SEVEN OVERLAPPING MEASUREMENT RANGES (SWITCHED BY CMD OR BY INTERNAL LOGIC) HANDLE CURRENTS BETWEEN $10^{-6}$ AMPS (RANGE 1) AND $10^{-12}$ AMPS (RANGE 7)
CCGE SEAL BREAK

- INITIATED BY FIRST TRANSMISSION OF CMD 107
  (MAY BE NECESSARY TO TRANSMIT CMD 105 PRIOR TO 107 FOR ACTUATION OF SEAL BREAK)

- EXPLOSIVE-ACTUATED PISTON RELEASES SPRING WHICH RETAINED ORIFICE COVER

- RELEASE OF SPRING CAUSES COVER TO FLIP OFF
CCGE RANGE CHANGE

• 7 OVERLAPPING RANGES FROM $10^{-12}$ TO $10^{-6}$ AMPS
• SELECTED EITHER AUTOMATICALLY OR BY COMMAND
• AUTOMATIC
  • UP-DOWN COMPARATOR OF RANGE POSITION ANALYZER SENSES ELECTROMETER OUTPUT VOLTAGE
  • WHEN VOLTAGE PASSES UPPER OR LOWER TRIP POINT VALVES, COMPARATOR SUPPLIES UPRANGE OR DOWNRANGE SIGNAL TO RANGE SELECTOR NETWORK
• RANGE SELECTOR NETWORK (COUNTING REGISTER) TRACKS THE RANGES, SUPPLIES SIGNALS TO ACTUATE THE RANGE RELAY DRIVERS, & SUPPLIES ANALOG & DIGITAL TM OF RANGE ID
• BY COMMAND
  • TRANSMIT CMD 104 OR 107 TO SELECT UPRANGE OR DOWNRANGE DIRECTION FOR FORCED RANGE CHANGE
  • TRANSMIT CMD 106 TO EXECUTE FORCED RANGE STEP IN THE PRESET DIRECTION. THIS OVERRIDES RANGE POSITION ANALYZER & SUPPLIES SIGNAL TO RANGE SELECTOR NETWORK.
• NEW RANGE WILL BE RETAINED UNTIL:
  • STEPPED BY TRANSMISSION OF CMD 106
  • REVERSED (CMD 104 OR 107) & STEPPED (CMD 106)
  • RESET TO AUTOMATIC MODE (CMD 110)
CCGE SELF CALIBRATION

- PROVIDES CHECK OF ELECTROMETER CURRENT-TO-VOLTAGE CONVERSION & CORRECTS (COMPENSATES) FOR ELECTROMETER ZERO DRIFT

- CURRENT CALIBRATION
  - TRANSMISSION OF CMD 104 ENABLES CURRENT CALIBRATOR
  - CALIBRATION OCCURS AT NEXT CYCLE OF ZERO COMPENSATION
  - GAUGE OUTPUT TO ELECTROMETER IS REPLACED BY PRECISION CURRENT SOURCE
  - ELECTROMETER STEPS THROUGH 7 RANGES
  - AFTER 7 CALIBRATION STEPS, CURRENT SOURCE IS REPLACED BY GAUGE OUTPUT (NORMAL OPERATION)

- ZERO MODE CALIBRATOR
  - ACTUATED BY INTERNAL TIMING EVERY 30.9 MIN
  - GAUGE OUTPUT TO ELECTROMETER IS DISCONNECTED & OFFSET COMPENSATION NETWORK ADJUSTED (AUTOMATICALLY) TO CORRECT FOR SIGNAL DRIFT
  - CCGE THEN RETURNS TO NORMAL OPERATION, UNLESS CURRENT CALIBRATION HAS BEEN ENABLED (CMD 104)
CCGE THERMAL CONTROL

- STRUCTURAL HOUSING COVERED WITH THERMAL COATING

- SUNSHIELD (WITH REFLECTOR) SHADES THERMAL PLATE FROM DIRECT SUNLIGHT & ALLOWS RADIATIVE COUPLING TO DEEP SPACE

- REFLECTOR REDUCES HEAT INPUT FROM LUNAR SURFACE TO THERMAL PLATE

- ELECTRICAL HEATER PROVIDES 4.5W INPUT TO ELECTRONICS
  - INTERMITTENTLY IN OPER PWR MODE (CONTROL "ON" BELOW ≈ 20°F)

- NORMAL OPERATION (LUNAR DAY/NIGHT) FOR ELECTRONICS ANTICIPATED +85°C TO -20°C
CCGE POWER PROFILE

- SEAL BREAK BY CAPACITANCE DISCHARGE

INTERMITTENT (ON/OFF) HEATER, "ON" BELOW ≈ 20°F

POWER, WATTS

6.5 NIGHT MAX

4.5 NIGHT MAX

2.0 DAY MAX OPER MODE

STBY MODE

APR 69 5178.15.9
## CCGE 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>Distance from Subpackage 1</td>
<td>55 ± 5 FT (60-FT Cable)</td>
<td>2</td>
<td>Paced Off</td>
<td>Interchangeable with side</td>
</tr>
<tr>
<td>Direction from Subpackage 1</td>
<td>S (MAY BE N)</td>
<td>2</td>
<td>Eyeball</td>
<td>To satisfy orifice requirement</td>
</tr>
<tr>
<td>Site Selection</td>
<td>≈ Smooth</td>
<td>2</td>
<td>Eyeball</td>
<td>No legs on CCGE</td>
</tr>
<tr>
<td>Level, WRT Indicator</td>
<td>5° of HORIZ</td>
<td>1</td>
<td>Bubble</td>
<td>Interacts with alignment</td>
</tr>
<tr>
<td>Align, WRT Shadow</td>
<td>5° of E-W</td>
<td>1</td>
<td>Arrow &amp; &quot;E&quot;</td>
<td>Shadow of UHT covers &quot;E&quot;</td>
</tr>
<tr>
<td>Align Orifice</td>
<td>Away from (+90°) LM &amp; Cent Sta</td>
<td>2</td>
<td>Eyeball</td>
<td>Exact alignment set by shadow requirement</td>
</tr>
<tr>
<td>Special Requirements</td>
<td>Planned deployment is South of Cent Sta but would be reversed if LM is South of Cent Sta</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Jan 69 5178.15.10
CCGE COMMANDS

OCTAL CMD NUMBER

104  CCGE CAL ENABLE
TH I S  CMD (CG-O1) IS A 1-STATE CMD WHICH CAUSES THE ELECTROMETER CALIBRATION CYCLE TO OCCUR AT THE NEXT ZERO MODE CALIBRATION (EVERY 30.9 MIN). IF CMD 104 IS TRANSMITTED MORE THAN ONCE BEFORE THE TIME OF CALIBRATION ARRIVES, THE EFFECT IS THE SAME AS ONE CMD. AN ELECTROMETER CALIBRATION CYCLE CONSISTS OF STEPPING THROUGH THE 7 RANGES OF MEASUREMENT WHILE APPLYING PRECISION CURRENTS TO THE ELECTROMETER.

105  CCGE UPRANGE CH
TH I S  CMD (CG-02) IS A 1-STATE CMD WHICH SELECTS THE UPRANGE DIRECTION FOR FORCED RANGE CHANGES. REPEATED TRANSMISSION OF THIS CMD HAS NO EFFECT. SUBSEQUENT TRANSMISSION OF CMD 106 CAUSES THE RANGE CHANGE AND LOCKS OUT THE AUTOMATIC RANGE CHANGE. IT MAY BE NECESSARY TO TRANSMIT CMD 105, FOLLOWED BY CMD 107, TO EXECUTE THE CCGE SEAL BREAK

106  CCGE RNG STEP/F
TH I S  CMD (CG-03) IS A MULTI-STATE CMD WHICH FORCES THE ELECTROMETER SENSITIVITY RANGE TO CHANGE ONE STEP (IN THE DIRECTION PRE-SELECTED BY CMD 105 OR 107) EACH TIME CMD 106 IS TRANSMITTED. CMD 106 ALSO LOCKS OUT AUTOMATIC RANGE CHANGES UNTIL RELEASED BY CMD 110. REPEATED TRANSMISSION OF CMD 106 ADVANCES THE RANGE UNTIL THE MAXIMUM OR MINIMUM VALUE IS OBTAINED; FURTHER TRANSMISSION HAS NO EFFECT.

107  CCGE DNRANGE CH
TH I S  CMD (CG-04) IS A 1-STATE CMD, SIMILAR TO CMD 105, EXCEPT THAT IT SELECTS THE DOWN RANGE DIRECTION FOR FORCED RANGE CHANGES. IT ALSO BREAKS THE CCGE SEAL AT THE TIME OF FIRST TRANSMISSION UNLESS THE TOGGLE IS IN THE ADVERSE SETTING. IF SO, CMD 105 FOLLOWED BY CMD 107 WILL EXECUTE CCGE SEAL BREAK

110  CCGE RNG MODE/A
TH I S  CMD (CG-05) IS A 1-STATE CMD WHICH, FOLLOWING TRANSMISSION OF CMD 106, RELEASES THE RANGE CHANGE LOCKOUT AND ENABLES AUTOMATIC RANGE CHANGES, REPEATED TRANSMISSION OF THIS CMD HAS NO EFFECT. AT TURN-ON, THE CCGE INITIALIZES IN THE AUTOMATIC MODE OF (RANGE CHANGE) OPERATION.

APR 69 5178.15.11
CCGE DATA FORMAT

<table>
<thead>
<tr>
<th>CCGE WORD</th>
<th>ALSEP WORD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>DG-05</td>
</tr>
<tr>
<td></td>
<td>CCGE/D RANGE A/F (0 = FORCED, 1 = AUTO)</td>
</tr>
<tr>
<td></td>
<td>DG-04</td>
</tr>
<tr>
<td></td>
<td>CCGE HK ID (0-3, see CCGE WORD 5)</td>
</tr>
<tr>
<td>2</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>DG-06</td>
</tr>
<tr>
<td></td>
<td>CCGE/D RANGE ID (0-6)</td>
</tr>
<tr>
<td>3</td>
<td>47</td>
</tr>
<tr>
<td>DG-07</td>
<td>CCGE/D GAUGE OUT FLAG</td>
</tr>
<tr>
<td>4</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>DG-08</td>
</tr>
<tr>
<td></td>
<td>CCGE GAUGE DEG C FLAG</td>
</tr>
<tr>
<td>5</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>DG-10 TO DG-13 (COMMUTATED) FLAG</td>
</tr>
</tbody>
</table>

DG-01 CCGE MUX STA (0-3)
DG-02 CCGE AUTO ZERO (0 = OPER, 1 = ZEROING)
DG-03 CCGE CAL STA (0 = OPER, 1 = CAL)
DG-04 MEASUREMENT (WORD 5)
0 DG-10 CCGE 4.5KV SUPPLY
1 DG-11 CCGE +15V SUPPLY
2 DG-12 CCGE -15V SUPPLY
3 DG-13 CCGE -10V SUPPLY

APR 69 5178.15.12
CCGE DATA SUMMARY

DG-01  CCGE MUX STA  DG-08  CCGE GAUGE DEG C
DG-02  CCGE AUTO ZERO  DG-09  CCGE PKG DEG C
DG-03  CCGE CAL STA  DG-10  CCGE 4.5KV SUPPLY
DG-04  CCGE HK ID  DG-11  CCGE +15V SUPPLY
DG-05  CCGE RANGE A/F  DG-12  CCGE -15V SUPPLY
DG-06  CCGE/D RANGE ID  DG-13  CCGE -10V SUPPLY
DG-07  CCGE/D GAUGE OUT

AG-01  CCGE/A GAUGE OUT
AG-02  CCGE/A RANGE ID

JAN 69  5178.15.13
MSFN/MCC OPERATIONS

- GENERAL REQUIREMENTS
- CMD & TM PROCESSING
- SOFTWARE & DISPLAYS
- SPECIAL REQUIREMENTS
- POWER/ THERMAL MANAGEMENT
- COMMAND FUNCTION STATUS BOARD
- DETAILED MCC MONITORING ACTIVITIES
COMMAND CONSOLE PLAN

TENTATIVE

• ALL COMMANDS FOR ALL ALSEPS FROM 1 CONSOLE

• USE UNIVERSAL COMMAND SYSTEM PANEL
  - ADDRESS: ANY ONE OF 8 ALSEP DECODERS
  - COMMAND: ANY ONE OF 100 DESIGNATIONS (PREFERABLY OCTAL 003 TO 174)
  - EXECUTE

NOTES: (1) STANDARD VERIFICATION CHECKS WILL BE INCORPORATED;
         AT LEAST, GROUND REJECT

(2) NO AUTOMATIC RETRANSMIT PROCEDURE
# TM PROCESSING AT MSFN SITES

<table>
<thead>
<tr>
<th>ALSEP</th>
<th>MINIMUM REQUIREMENT</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,3</td>
<td>THROUGHPUT 2 DATA STREAMS MAX TO MCC, NO DECOMM REQ'D UNLESS THERE IS A DECISION TO MONITOR CMD VERIFICATION</td>
<td>TECHNIQUE FOR SENDING 2 STREAMS 1.06 KBPS EACH (NORMAL) ON ONE 2.4 KBPS LINE TBD. NOTE ALSEP FRAME = 0.60377 SEC</td>
</tr>
<tr>
<td>4</td>
<td>SAME AS ABOVE FOR MAJORITY OF TIME ADDITIONAL DECOMM REQMT' FOR ASE 10.6 KBPS DATA RATE TO REDUCE IT TO &lt; 2.4 KBPS &amp; SEND TO MCC. DURING ASE OPERATIONS NO OTHER ALSEP DATA STREAM IS SENT TO MCC</td>
<td>85-FT SITE REQ'D FOR 10.6 KBPS DATA. EXCEPT FOR ≈ 1 HR WHILE CREW IS ON LUNAR SURFACE, OTHER ASE OPERATIONS CAN BE SCHEDULED FOR CONVENIENCE</td>
</tr>
</tbody>
</table>

RECORDING REQ'D FOR MAX OF 3 ALSEPS SIMULTANEOUSLY PLUS RCVD STATION TIME. PLAYBACK REQMT'S TBD.
SOFTWARE

• ONE CDP COMMAND PROGRAM WILL SUPPORT ALL ALSEPS
• DECOM PROGRAMS VARY BETWEEN ALSEPS
• CAL CURVES VARY BETWEEN ALSEPS
• IN ADDITION TO VERY COMPLICATED SUBCOMMUTATION & SUPER COMMUTATION, MANY ALSEP PARAMETERS REQUIRE MORE COMPUTATION THAN ENG UNIT CONVERSION & LIMIT SENSING
### DISPLAYS
**FOR ALSEP 1**

**NOTE:**
RETENTION OF HISTORICAL DATA MUST BE MINIMIZED

<table>
<thead>
<tr>
<th>SUBSYSTEM</th>
<th>HIS PRINTER</th>
<th>METERS</th>
<th>ANALOG CHARTS</th>
<th>EVENT LIGHTS/CRT</th>
<th>HIS PRINTER</th>
<th>ANALOG CHARTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CENTRAL STATION</td>
<td>L</td>
<td>H</td>
<td>B</td>
<td>D</td>
<td>L+D</td>
<td>B</td>
</tr>
<tr>
<td>PASSIVE SEISMIC</td>
<td>L</td>
<td>B+S</td>
<td>D</td>
<td>L+D</td>
<td>B+S</td>
<td>B</td>
</tr>
<tr>
<td>MAGNETOMETER</td>
<td>L</td>
<td>B</td>
<td>D</td>
<td>L+D</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>SOLAR WIND</td>
<td>A</td>
<td></td>
<td></td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUPRATHERMAL ION</td>
<td>L</td>
<td>B</td>
<td>D</td>
<td>L+D</td>
<td>B</td>
<td></td>
</tr>
</tbody>
</table>

**LEGEND**

- **L** = LIMIT-SENSED PARAMETERS
- **H** = HIGH-PRIORITY ANALOGS
- **D** = DISCRETE
- **B** = 8-CHANNEL BRUSH RECORDER (SCIENCE DATA > 1 SAMPLE/SEC)
- **S** = SPECIAL SINGLE CHANNEL DRUM RECORDERS WITH VARIABLE BAND-PASS FILTERS
- **A** = ALL SWS DATA IN MATRIX FORMAT (1 MATRIX = 28 SEC)

APR 69 5178.16.5
MULTIPLE-ALSEP DISPLAY PHILOSOPHY

<table>
<thead>
<tr>
<th>DISPLAY</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>H/S PRINTER</td>
<td>SAME SUBSYSTEM ON DIFFERENT ALSEPS WILL USE SAME DISPLAY BUT DIFFERENT FORMATS</td>
</tr>
<tr>
<td>METERS &amp; EVENT LIGHTS</td>
<td>EACH ALSEP WILL HAVE ITS OWN METERS &amp; LIGHTS; HENCE THESE DISPLAYS WILL GIVE VALID DATA WHENEVER THEIR BIT STREAM IS BEING PROCESSED</td>
</tr>
<tr>
<td>ANALOG RECORDERS</td>
<td>SWITCHABLE IN REAL TIME BETWEEN DIFFERENT BIT STREAMS</td>
</tr>
</tbody>
</table>

CAPABILITY FOR PROCESSING 2 BIT STREAMS SIMULTANEOUSLY PROVIDES FOR PANEL LIGHT INDICATING OUT-OF-LIMITS WHENEVER IT IS DETECTED (EITHER ALSEP); ALSO INDICATES (1) WHICH ALSEP & (2) WHICH SUBSYSTEM
POWER/THERMAL MANAGEMENT

REQUIREMENT

- RTG supplies constant power (no more, no less) at a particular voltage. Overload & underload on RTG will cause serious changes in RTG voltage
- PCU adds or removes shunt loads (up to 40 W) to maintain constant system load on RTG
- PDR loads can be commanded on/off to assist PCU
- If system overload occurs (when PCU cannot unload enough), experiments are rippled off automatically to reach satisfactory load (turn-on by command only)
- If system underload (or overload) exceeds PCU capability, 12V line will go up (or down). At 13V or 11V, PCU 1 switches automatically to PCU 2 (PCU 2 has no switchback logic & will operate outside 11-13V range)

MCC ACTIVITIES

- Monitor TM data for reserve power (PCU shunt) & adjust loads by command to avoid ripple-off, switch-over, or system failure
- Maintain, as a flight control tool, a power/thermal forecast for several hours in advance & particularly before major command or timer events

NOTE:
1. Reserve power TM only every 54 sec
2. Exper power profiles are variable & asynchronous
3. No TM of individual exper power
4. PCU shunt load variations cause non-linear (but predictable) internal dissipation in PCU. This can cause serious thermal disturbance of central station

JAN 69 5178.16.7
COMMAND FUNCTION STATUS BOARD

REQUIREMENT

- ALSEP 1 WILL USE 65 OF THE 100 AVAILABLE CMDs (REMAINDER MAY BE CONSIDERED INVALID)

- SIDE USES 5 CMDs MULTIPLEXED TO PERFORM 2 ONE-TIME & 15 REPETITIVE FUNCTIONS RESULTING IN 890 "CONFIGURATIONS"

- PSE & LSM USE SINGLE CMDs REPETITIVELY FOR MULTI-STATE FUNCTIONS

- CMDs INTERACT; EXAMPLE, ONE CMD ADDRESSES X, Y OR Z-AXIS WHILE THE NEXT CMD ACTIVATES THE ADDRESSED UNIT (PSE & LSM)

- LSM HAS 7-STATE FUNCTIONS; CMD MUST BE SENT 7 TIMES TO RETURN TO INITIAL STATE

- RESULT FOR LSM IS 20,000 "CONFIGURATIONS"

- INTERNAL TIMER PROVIDES SCHEDULED FUNCTIONS (BACKUP TO EXISTING CMDs) & INTERNAL PROTECTION CAUSES UNSCHEDULED SWITCHING

APR 69 5178.16.8
DETAILED MONITORING ACTIVITIES

• ALSEP START-UP ACTIVITIES
  • EXPERIMENT TURN-ON
  • TYPICAL EXPER CHECKOUT
    (EXAMPLE, PSE)

• TYPICAL ALSEP 1 MCC OPERATIONS
  • FUNCTIONAL CHECKS
  • CRITICAL PARAMETERS
EXPERIMENT TURN-ON

ALSEP 1

- CHECK S/N RATIO AT MSFN
- SYNC & DECOM AT MCC
- CMD BACK-UP DATA MODES AS REQUIRED
- CMD EXPERIMENT 2 OPER (LSM)
- VERIFY RECEIPT & EXECUTION OF CMD
- CONFIRM POWER LOAD & RESERVE POWER STATUS
- CMD EXPERIMENT 1 OPER (PSE)
- VERIFY CMD EXECUTION & POWER STATUS AS ABOVE
- CONTINUE FOR EXPERIMENTS 3 & 4 (SWS & SIDE)
- CMD DUST DETECTOR ON
- VERIFY PRESENCE OF DUST DETECTOR DATA
- CONFIRM POWER STATUS

JAN 69 5178.16.10
TYPICAL EXPERIMENT CHECKOUT

(EXAMPLE, PSE)

- CHECK SCIENTIFIC & ENGINEERING DATA OF THE PSE
- UNCAGE PSE (MAY OCCUR PRIOR TO LM ASCENT)
- LEVEL THE PSE
- CALIBRATE THE PSE
- CHECK TEMPERATURE OF THE PSE
- COLLECT BASELINE PSE DATA
TYPICAL ALSEP 1 MCC OPERATIONS
POST 45 DAYS

1. Bring bit stream in building, decom, process, & bring up displays; meanwhile, verify that CMD panel is hot
2. Check CMD function status for changes since end of previous monitoring period
3. Compare power/thermal status to forecast
4. Observe central station parameters for out-of-limits conditions or other anomalies; if any exist, log status, determine causes, & CMD as appropriate
5. Examine PSE for satisfactory data (1.2 sec); send corrective CMDs, if necessary
6. Examine LSM data (9.66 sec) for proper operation & settings; CMD as required
7. Determine whether SWS is functioning properly by observing full data cycle (7.6 min); no functional CMDs to SWS except power oper/stby/off
8. Examine SIDE data (full cycle ≈1 hr) for proper operation & measurement ranges; adjust by CMD, if necessary

NOTES

• Indicated times are for one cycle of data at normal bit rate

• Maintain log of all CMDs sent & status changes

• Indicated tasks do not have to be serial

JAN 69 5178.16.12
TRANSMITTER CHECK

- CHECK XMTR A CRYSTAL & HEAT SINK TEMPERATURES
- CHECK RF OUTPUT POWER LEVELS
- SWITCH TO BACKUP XMTR, IF REQUIRED
- CHECK XMTR B TEMPERATURES & POWER LEVELS AS ABOVE
DIAGNOSTIC CHECKS

- Check level of received power at MSFN station
- Check prelimiting signal level of ALSEP RCVR
- Determine center frequency of ALSEP RCVR bandpass
- Determine RF level of ALSEP RCVR local oscillator
- Check for presence of 1 kHz subcarrier
- Check output voltages of dust detector
TEMPERATURE CHECKS AND THERMAL CONTROL

- CHECK CENTRAL STATION TEMPERATURES
- CHECK RTG TEMPERATURES
- CHECK DUST DETECTOR TEMPERATURES
- CMD CENTRAL STATION HEATER ON/OFF, AS REQUIRED
POWER SUPPLY STATUS CHECK

- Verify that PCU 1 is operating
- Check PCU 1 temperatures
- Check PCU 1 operating voltages
- Check power reserve status
- Cmd power dissipation resistors on/off as required
- Switch to PCU 2 only if failure is imminent
- Check ADC calibration
# CRITICAL CENTRAL STATION PARAMETERS

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>CONTINGENCY</th>
<th>CORRECTIVE ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>POWER</strong></td>
<td>1. RTG HOT &amp; COLD FRAME TEMPS ABNORMALLY HI OR LO</td>
<td>1. MAY BE UNDER LOAD OR OVERLOAD BUT PROBABLY INCIPENT FAILURE &amp; NO CORRECTIVE ACTION; COLLECT MAX DATA IN TIME REMAINING</td>
</tr>
<tr>
<td></td>
<td>2. PCU SHUNT CURRENT HI OR LO</td>
<td>2. UNDERLOAD OR OVERLOAD. ADJUST PDR &amp; SWITCH EXPER OPER/STBY TO LOCATE CAUSE</td>
</tr>
<tr>
<td></td>
<td>3. ABNORMAL PCU TEMPS OR VOLTAGES</td>
<td>3. ADJUST LOADS &amp; PREPARE TO SWITCH PCU 2 IF SITUATION DETERIORATES</td>
</tr>
<tr>
<td><strong>DATA</strong></td>
<td>1. LOSS OF CARRIER, MODULATION OR SYNC</td>
<td>1. SWITCH TO ALTERNATE XMTR OR DATA PROCESSOR</td>
</tr>
<tr>
<td></td>
<td>2. WEAK OR NOISY SIGNAL</td>
<td>2. SWITCH TO LOW BIT RT &amp; TROUBLE SHOOT (LSM DATA INVALID IN LBR)</td>
</tr>
<tr>
<td></td>
<td>3. LOSS OF 6 OR 15 ANALOG CHANNELS</td>
<td>3. MULTIPLEXER MALF; SWITCH TO ALTERNATE DATA PROCESSOR</td>
</tr>
<tr>
<td></td>
<td>4. SUBCOMM DATA NOT OK</td>
<td>4. SWITCH DATA PROCESSORS</td>
</tr>
<tr>
<td></td>
<td>5. NON-ZERO IN CMD VERIF WORD WHEN NO CMD WAS SENT</td>
<td>5. INCIPIENT DECODER LOCKOUT; SWITCH TO ALTERNATE DATA PROCESSOR BEFORE SENDING ANY OTHER CMDS</td>
</tr>
<tr>
<td></td>
<td>6. ABNORMAL TEMPS IN COMPONENTS (OR ENTIRE CENTRAL STATION)</td>
<td>6. SWITCH TO REDUNDANT EQUIP (MAN HTR ON/OFF)</td>
</tr>
</tbody>
</table>

DEC 67 5178.16.17
# CRITICAL PASSIVE SEISMIC PARAMETERS

<table>
<thead>
<tr>
<th>CONTINGENCY</th>
<th>CORRECTIVE ACTION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. INSTRUMENT OFF-LEVEL (INDICATED BY TIDAL DATA)</td>
<td>1. CMD LVL, AS NECESSARY</td>
<td>1. SINCE LEVEL SHOULD CHANGE SLOWLY (IF AT ALL) ANY CMD LVL SHOULD BE CLEARED WITH PI</td>
</tr>
<tr>
<td>2. SEISMIC DATA OFF SCALE OR INSIGNIFICANT</td>
<td>2. ADJUST AMPLIFIER GAINS</td>
<td>2. SEE NOTE</td>
</tr>
<tr>
<td>3. ERRATIC TIDAL DATA</td>
<td>3. CMD PSE FILT OUT</td>
<td>3. WITH FILT OUT, TIDAL DATA SHOULD BE SAME AS SEISMIC</td>
</tr>
<tr>
<td>4. ABNORMAL TEMPS</td>
<td>4. CMD PSE HTR A/M &amp; REGULATE TEMPS MANUALLY (PSE CAN OVERHEAT QUICKLY, THIS ACTION IS URGENT)</td>
<td>4. AUTO/MAN CMD HAS 4 STATES &amp; HTR CAN BE SWITCHED FULL ON OR FULL OFF; CAN ALSO SWITCH ALL PWR OFF IF TEMPS ARE RISING RAPIDLY</td>
</tr>
<tr>
<td>5. POSSIBLE OUT-OF-CALIBRATION</td>
<td>5. CMD CALIBRATIONS (TIMER ON SHORT PERIOD)</td>
<td>5. CALIB INTERVALS TBD</td>
</tr>
</tbody>
</table>

**NOTE:** AVOID SENDING ANY COMMANDS DURING SIGNIFICANT SEISMIC ACTIVITY

APR 69  5178.16.18
## CRITICAL MAGNETOMETER PARAMETERS

<table>
<thead>
<tr>
<th>CONTINGENCY</th>
<th>CORRECTIVE ACTION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. SCIENCE DATA NEAR FULL-SCALE, NEAR ZERO, OR</td>
<td>1. ADJUST GAINS &amp; OFFSETS AS NECESSARY</td>
<td>1. POSSIBLE DUE TO CHANGES IN LUNAR ENVIRONMENT (NOTIFY PI PROMPTLY)</td>
</tr>
<tr>
<td>OFF-CENTER</td>
<td>2. CMD ALSEP TIMER INHIBIT &amp; FLIP/CAL BY LSM CMD</td>
<td>2. DURING INTERMITTENT MONITORING FLIP/CAL BY TIMER (EVERY 12 HR) CAN</td>
</tr>
<tr>
<td>2. ERRATIC OR TOO FREQUENT FLIP/CAL</td>
<td>3. CMD LSM FILT IN/OUT</td>
<td>BE DETECTED FROM SENSOR POSITION TM</td>
</tr>
<tr>
<td>3. SCIENCE DATA NOT OK</td>
<td>4. CMD LSM T CTL XY (SEE NOTE)</td>
<td>3. BYPASS (REMOVAL) OF FILTER RESULTS IN ROUGH, BUT USABLE, DATA</td>
</tr>
<tr>
<td>4. NON-UNIFORM OR UNEXPECTED SENSOR TEMPS</td>
<td>5. NO CORRECTIVE ACTION, TURN EXPER OFF IF IT ENDANGERS</td>
<td>4. SWITCHES THERMAL CONTROL BETWEEN SENSOR HEADS (EITHER CAN BE SELECTED)</td>
</tr>
<tr>
<td>5. OTHER ABNORMAL TEMPS</td>
<td>LSM ALSEP</td>
<td>5. NO THERMAL CONTROL OVERRIDE &amp; NO STBY HTR (IF LSM IS NOT OPERATING, IT HAS NO POWER)</td>
</tr>
</tbody>
</table>

**NOTE:** FOR BEST OPERATION, FLIP/CAL MUST BE PERFORMED WHenever SENSOR TEMP CHANGES 3°C
## CRITICAL SIDE PARAMETERS

<table>
<thead>
<tr>
<th>CONTINGENCY</th>
<th>CORRECTIVE ACTION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Significant change in distribution of science data</td>
<td>1. Adjust sampling mode (internal programs step through a range; various mode CMDs delete portions of this range)</td>
<td>1. Possibly due to change in lunar environment (notify PI promptly); non-normal modes may shorten time for complete data cycle</td>
</tr>
<tr>
<td>2. Major decrease in measured flux</td>
<td>2. CMD x10 integration</td>
<td>2. Makes full cycle ( \approx 10 ) hr</td>
</tr>
<tr>
<td>3. Out-of-calibration</td>
<td>3. CMD calibration</td>
<td>3. Normal mode INC CAL every 2.5 min but other modes may not</td>
</tr>
<tr>
<td>4. Abnormal temps</td>
<td>4. CMD exper STBY or off if rising rapidly</td>
<td>4. No thermal control override</td>
</tr>
</tbody>
</table>

**Other CMDs allow portions of the experiment to be turned on/off independently but there is no corrective action for most out-of-limits conditions or hang-ups.**

CCIG portion of side has temp measurement in contact with lunar surface (the only one on ALSEP)

**DEC 67 5178.16.20**
### ALSEP ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>ampere</td>
</tr>
<tr>
<td>AB</td>
<td>Analog Bistatic (Discrete) Measurement (Code)</td>
</tr>
<tr>
<td>AC</td>
<td>Alternating Current</td>
</tr>
<tr>
<td>ACCEL</td>
<td>Acceleration</td>
</tr>
<tr>
<td>ACCEPT</td>
<td>Accept</td>
</tr>
<tr>
<td>ACK</td>
<td>Acknowledge</td>
</tr>
<tr>
<td>ACN</td>
<td>Ascension Island (MSFN)</td>
</tr>
<tr>
<td>A/D</td>
<td>Analog to Digital</td>
</tr>
<tr>
<td>ADC</td>
<td>Analog-to-Digital Converter</td>
</tr>
<tr>
<td>ADD</td>
<td>Address</td>
</tr>
<tr>
<td>ADJ</td>
<td>Adjustment</td>
</tr>
<tr>
<td>ADV</td>
<td>Advance</td>
</tr>
<tr>
<td>AE</td>
<td>Analog Electrical Parameter (Code)</td>
</tr>
<tr>
<td>AEC</td>
<td>Atomic Energy Commission</td>
</tr>
<tr>
<td>A/F</td>
<td>Automatic/Forced</td>
</tr>
<tr>
<td>AGC</td>
<td>Automatic Gain Control</td>
</tr>
<tr>
<td>AIM</td>
<td>Aiming</td>
</tr>
<tr>
<td>ALGE</td>
<td>Apollo Lunar Geological Equipment</td>
</tr>
<tr>
<td>ALHT</td>
<td>Apollo Lunar Hand Tools</td>
</tr>
<tr>
<td>ALSD</td>
<td>Apollo Lunar Surface Drill</td>
</tr>
<tr>
<td>ALSEP</td>
<td>Apollo Lunar Surface Experiments Package</td>
</tr>
<tr>
<td>ALT</td>
<td>Alternate</td>
</tr>
<tr>
<td>AMPL</td>
<td>Amplifier</td>
</tr>
<tr>
<td>AMP</td>
<td>Amperes-pl is AMPs</td>
</tr>
<tr>
<td>AMU</td>
<td>Atomic Mass Unit</td>
</tr>
<tr>
<td>ANT</td>
<td>Antenna</td>
</tr>
<tr>
<td>APPROX</td>
<td>Approximate, Approximately</td>
</tr>
<tr>
<td>A/PW</td>
<td>Analog to Pulse Width</td>
</tr>
<tr>
<td>AR</td>
<td>Analog Temp. of RTG (Code)</td>
</tr>
<tr>
<td>ARC</td>
<td>Ames Research Center</td>
</tr>
<tr>
<td>ASE</td>
<td>Active Seismic Experiment</td>
</tr>
<tr>
<td>ASI</td>
<td>Apollo Standard Initiators</td>
</tr>
<tr>
<td>ASSY</td>
<td>Assembly</td>
</tr>
<tr>
<td>ASTRO</td>
<td>Astronaut</td>
</tr>
<tr>
<td>AT</td>
<td>Analog Temperature Parameter (Code)</td>
</tr>
<tr>
<td>ATTN</td>
<td>Attenuator</td>
</tr>
<tr>
<td>AUTO</td>
<td>Automatic</td>
</tr>
<tr>
<td>AWG</td>
<td>American Wire Gage</td>
</tr>
<tr>
<td>AZ</td>
<td>Azimuth</td>
</tr>
<tr>
<td>B1</td>
<td>Bottom Location of Structure</td>
</tr>
<tr>
<td>BATT</td>
<td>Battery</td>
</tr>
<tr>
<td>BER</td>
<td>Bit Error Rate</td>
</tr>
<tr>
<td>BIOMED</td>
<td>Biomedical</td>
</tr>
<tr>
<td>BKG</td>
<td>Background</td>
</tr>
<tr>
<td>BPS</td>
<td>Bits per Second</td>
</tr>
<tr>
<td>BTU</td>
<td>British Thermal Unit</td>
</tr>
<tr>
<td>C</td>
<td>Centigrade</td>
</tr>
<tr>
<td>CAL</td>
<td>Calibrate, Calibration</td>
</tr>
<tr>
<td>CAP</td>
<td>Capacitor</td>
</tr>
<tr>
<td>CCGE</td>
<td>Cold Cathode Gauge Experiment</td>
</tr>
<tr>
<td>CCGE/A</td>
<td>Analog and Digital ID Read Out</td>
</tr>
<tr>
<td>CCGE/D</td>
<td>from CCGE</td>
</tr>
<tr>
<td>CCIG</td>
<td>Cold Cathode Ion Gauge (Instrument Portion of CCGE)</td>
</tr>
<tr>
<td>CDP</td>
<td>Command Data Processor</td>
</tr>
<tr>
<td>C/E</td>
<td>Central Electronics (of ASE)</td>
</tr>
<tr>
<td>CENT STA</td>
<td>Central Station</td>
</tr>
<tr>
<td>CFET</td>
<td>Contractor-Furnished Equipment</td>
</tr>
<tr>
<td>CG</td>
<td>Center of Gravity</td>
</tr>
<tr>
<td>CH</td>
<td>Change, Channel (Data)</td>
</tr>
<tr>
<td>CHAN</td>
<td>Channeltron; used in CPE as:</td>
</tr>
<tr>
<td></td>
<td>CHAN/1 Channeltron P/S #1</td>
</tr>
<tr>
<td></td>
<td>CHAN/2 Channeltron P/S #2</td>
</tr>
<tr>
<td></td>
<td>CHAN/HI Channeltron Voltage Increase ON</td>
</tr>
<tr>
<td></td>
<td>CHAN/LO Channeltron Voltage Increase OFF</td>
</tr>
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</table>

JAN 69 5178.A.1
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIRC</td>
<td>Circular</td>
</tr>
<tr>
<td>CKT</td>
<td>Circuit-CKTS (Pl)</td>
</tr>
<tr>
<td>CKT BKR</td>
<td>Circuit Breaker</td>
</tr>
<tr>
<td>CLD</td>
<td>Cold</td>
</tr>
<tr>
<td>CMzyx</td>
<td>Continuous Motor (Connections on LSM)</td>
</tr>
<tr>
<td>CM</td>
<td>Command (CMDs, Commands)</td>
</tr>
<tr>
<td>CMD</td>
<td>Commanded</td>
</tr>
<tr>
<td>CNB</td>
<td>Canberra, Australia (MSFN)</td>
</tr>
<tr>
<td>CNT(s)</td>
<td>Count(s)</td>
</tr>
<tr>
<td>CNTR</td>
<td>Counter</td>
</tr>
<tr>
<td>CO</td>
<td>Continuous (Motor Circuit on LSM)</td>
</tr>
<tr>
<td>COAX</td>
<td>Coaxial Cable</td>
</tr>
<tr>
<td>CON</td>
<td>Connector</td>
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<tr>
<td>COMM</td>
<td>Communications</td>
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<td>Configuration</td>
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<tr>
<td>CONN</td>
<td>Connection</td>
</tr>
<tr>
<td>CONT</td>
<td>Controlled-Control</td>
</tr>
<tr>
<td>CONV</td>
<td>Converter</td>
</tr>
<tr>
<td>CPE</td>
<td>See CPLEE</td>
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<tr>
<td>CPLEE</td>
<td>Charged-Particle Lunar Environment Experiment (Also CPE)</td>
</tr>
<tr>
<td>CPS</td>
<td>Cycles per Second</td>
</tr>
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<td>CRT</td>
<td>Cathode Ray Tube</td>
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<tr>
<td>CST</td>
<td>Central Station Timer</td>
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<tr>
<td>CTL</td>
<td>Control</td>
</tr>
<tr>
<td>CUR</td>
<td>Current</td>
</tr>
<tr>
<td>CV</td>
<td>Command Verification</td>
</tr>
<tr>
<td>CVR</td>
<td>Cover</td>
</tr>
<tr>
<td>CRV/S</td>
<td>Cover and Seal (used on SIDE)</td>
</tr>
<tr>
<td>CW</td>
<td>Clockwise</td>
</tr>
<tr>
<td>db</td>
<td>Decibels</td>
</tr>
<tr>
<td>dbm</td>
<td>Decibels, with reference to one milliwatt</td>
</tr>
<tr>
<td>DC</td>
<td>Direct Current</td>
</tr>
<tr>
<td>DDP</td>
<td>Digital Data Processor</td>
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<tr>
<td>DECOM</td>
<td>Decommutate, Decommutation</td>
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<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>DEF</td>
<td>Deflection</td>
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<tr>
<td>DEG</td>
<td>Degrees</td>
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<tr>
<td>DEMOD</td>
<td>Demodulator</td>
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<tr>
<td>DET</td>
<td>Detect, Detection, Detector</td>
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<tr>
<td>DIAM</td>
<td>Diameter</td>
</tr>
<tr>
<td>DIR</td>
<td>Direction</td>
</tr>
<tr>
<td>DIR/V</td>
<td>Direction and Speed (used on PSE)</td>
</tr>
<tr>
<td>DISSIP</td>
<td>Dissipation</td>
</tr>
<tr>
<td>DIST</td>
<td>Distribution</td>
</tr>
<tr>
<td>DSS</td>
<td>Data Subsystem; components include:</td>
</tr>
<tr>
<td>DSS/A</td>
<td>Analog Data Processor</td>
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<tr>
<td>DSS/D</td>
<td>Digital Data Processor</td>
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<tr>
<td>DSS/PROC</td>
<td>Complete Data Processor (Redundant)</td>
</tr>
<tr>
<td>E</td>
<td>East</td>
</tr>
<tr>
<td>ea</td>
<td>Each</td>
</tr>
<tr>
<td>EGFU</td>
<td>Electronics/Gimbal Flip Unit (LSM)</td>
</tr>
<tr>
<td>EL</td>
<td>Elevation</td>
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<tr>
<td>ELECT</td>
<td>Electrical</td>
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<tr>
<td>ELEV</td>
<td>Elevation</td>
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<tr>
<td>EM</td>
<td>Electromagnetic</td>
</tr>
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<td>EMI</td>
<td>Electromagnetic Interference</td>
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<td>ENG</td>
<td>Engineering</td>
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<tr>
<td>EOS</td>
<td>Electro-Optical Systems (Xerox)</td>
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<td>EPS</td>
<td>Electrical Power Subsystem</td>
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<td>EQUIP</td>
<td>Equipment</td>
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<tr>
<td>EQUIV</td>
<td>Equivalent</td>
</tr>
<tr>
<td>ev</td>
<td>Electron Volts</td>
</tr>
<tr>
<td>EVA</td>
<td>Extravehicular Activities (or Astronaut)</td>
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<tr>
<td>EXP</td>
<td>Experiment</td>
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<tr>
<td>EXPER</td>
<td>Experiment</td>
</tr>
<tr>
<td>EXT</td>
<td>External</td>
</tr>
<tr>
<td>F</td>
<td>Fahrenheit, Flight</td>
</tr>
<tr>
<td>FEP</td>
<td>Fluorinated Ethylene Propylene</td>
</tr>
<tr>
<td>FET</td>
<td>Field Effect Transistor</td>
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<tr>
<td>FILT</td>
<td>Filter</td>
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<tr>
<td>------</td>
<td>--------</td>
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<tr>
<td>FLD</td>
<td>Field</td>
</tr>
<tr>
<td>FLIP/CAL</td>
<td>Flip/Calibrate (LSM)</td>
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<tr>
<td>FREQ</td>
<td>Frequency</td>
</tr>
<tr>
<td>FT</td>
<td>Foot</td>
</tr>
<tr>
<td>FTT</td>
<td>Fuel Transfer Tool</td>
</tr>
<tr>
<td>FWD</td>
<td>Forward</td>
</tr>
<tr>
<td>g</td>
<td>Gravity</td>
</tr>
<tr>
<td>GAL</td>
<td>Gravity (used as μgal on PSE)</td>
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<tr>
<td>GDS</td>
<td>Goldstone, California (MSFN)</td>
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<tr>
<td>GDT</td>
<td>Gradient Sensor Delta Temperatures (HFE)</td>
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<table>
<thead>
<tr>
<th>PROBE</th>
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<tr>
<td>BRIDGE</td>
<td>UPPER</td>
<td>LOWER</td>
</tr>
<tr>
<td>HIGH SENSITIVITY</td>
<td>GDT1H</td>
<td>GDT1H</td>
</tr>
<tr>
<td>LOW SENSITIVITY</td>
<td>GDT1L</td>
<td>GDT1L</td>
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<table>
<thead>
<tr>
<th>GEN</th>
<th>Generator</th>
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<tr>
<td>GEO</td>
<td>Geophone</td>
</tr>
<tr>
<td>GFE</td>
<td>Government-Furnished Equipment</td>
</tr>
<tr>
<td>GHz</td>
<td>GigaHertz</td>
</tr>
<tr>
<td>GLA</td>
<td>Grenade Launch Assemble (a component of ASE)</td>
</tr>
<tr>
<td>GMBL</td>
<td>Gimbal</td>
</tr>
<tr>
<td>GMT</td>
<td>Greenwich Mean Time</td>
</tr>
<tr>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>GSFC</td>
<td>Goddard Space Flight Center</td>
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<tr>
<td>GT</td>
<td>Gradient Sensor Ambient Temperatures (HFE)</td>
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<table>
<thead>
<tr>
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<tr>
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<td>LOWER</td>
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<tr>
<td>CODE</td>
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<td>GT12</td>
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<table>
<thead>
<tr>
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<th>Guam (MSFN)</th>
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<tbody>
<tr>
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<td>Kauai Island, Hawaii (MSFN)</td>
</tr>
<tr>
<td>HBR</td>
<td>High Bit Rate</td>
</tr>
<tr>
<td>HECPA</td>
<td>High Energy Curved Plate Analyzer (a component of SIDE)</td>
</tr>
<tr>
<td>HFE</td>
<td>Heat Flow Experiment</td>
</tr>
<tr>
<td>HI</td>
<td>High</td>
</tr>
<tr>
<td>HK</td>
<td>Housekeeping, High Conductivity (HFE)</td>
</tr>
<tr>
<td>HORIZ</td>
<td>Horizontal</td>
</tr>
<tr>
<td>HR</td>
<td>Hour</td>
</tr>
<tr>
<td>H/S</td>
<td>High Speed</td>
</tr>
<tr>
<td>HTR</td>
<td>Heater; on HFE there are two cases: HTR/HK High Conductivity Heater, HTR/LK Low Conductivity Heater</td>
</tr>
<tr>
<td>HV</td>
<td>High Voltage</td>
</tr>
<tr>
<td>Hz</td>
<td>Hertz</td>
</tr>
<tr>
<td>ID</td>
<td>Identification</td>
</tr>
<tr>
<td>IF</td>
<td>Intermediate Frequency</td>
</tr>
<tr>
<td>IN</td>
<td>Input</td>
</tr>
<tr>
<td>IN.</td>
<td>Inch</td>
</tr>
<tr>
<td>INC</td>
<td>Including, Included, Increase</td>
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<tr>
<td>INHIB</td>
<td>Inhibit</td>
</tr>
<tr>
<td>INST</td>
<td>Instrument</td>
</tr>
<tr>
<td>INSUL</td>
<td>Insulation</td>
</tr>
<tr>
<td>INT</td>
<td>Internal</td>
</tr>
<tr>
<td>INTEG</td>
<td>Integrator</td>
</tr>
<tr>
<td>ISO</td>
<td>Prefix meaning &quot;single&quot;</td>
</tr>
<tr>
<td>JPL</td>
<td>Jet Propulsion Laboratory</td>
</tr>
<tr>
<td>K</td>
<td>Kelvin, Kilo</td>
</tr>
<tr>
<td>KBPS</td>
<td>Kilobits per Second</td>
</tr>
<tr>
<td>kev</td>
<td>Kilo-Electron Volts</td>
</tr>
<tr>
<td>KHz</td>
<td>KiloHertz</td>
</tr>
<tr>
<td>KSC</td>
<td>Kennedy Space Center</td>
</tr>
<tr>
<td>KV</td>
<td>Kilovolt</td>
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<tr>
<td>KW</td>
<td>Kilowatt</td>
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JAN 69 5178.A.3
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tbody>
<tr>
<td>LB</td>
<td>Pound (LBs, plural)</td>
</tr>
<tr>
<td>LBR</td>
<td>Low Bit Rate</td>
</tr>
<tr>
<td>LECPA</td>
<td>Low Energy Curved Plate Analyzer (a component of SIDE)</td>
</tr>
<tr>
<td>LGE</td>
<td>Lunar Geological Equipment</td>
</tr>
<tr>
<td>LK</td>
<td>Low Conductivity (HFE)</td>
</tr>
<tr>
<td>LM</td>
<td>Lunar Module</td>
</tr>
<tr>
<td>LO</td>
<td>Low</td>
</tr>
<tr>
<td>LOG</td>
<td>Logarithmic</td>
</tr>
<tr>
<td>LP</td>
<td>Launch Phase, Long Period (PSE)</td>
</tr>
<tr>
<td>LPDTfJ.L</td>
<td>Low-Power Diode Transistor</td>
</tr>
<tr>
<td>LSB</td>
<td>Least Significant Bit</td>
</tr>
<tr>
<td>LSM</td>
<td>Lunar Surface Magnetometer</td>
</tr>
<tr>
<td>LV</td>
<td>Low Voltage</td>
</tr>
<tr>
<td>LVL</td>
<td>Level</td>
</tr>
<tr>
<td>M</td>
<td>Meter</td>
</tr>
<tr>
<td>MA</td>
<td>Milliampere</td>
</tr>
<tr>
<td>MAD</td>
<td>Madrid (MSFN)</td>
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<tr>
<td>MAP</td>
<td>Message Acceptance Pulse</td>
</tr>
<tr>
<td>MAX</td>
<td>Maximum</td>
</tr>
<tr>
<td>MCC</td>
<td>Mission Control Center</td>
</tr>
<tr>
<td>MDE</td>
<td>Mode</td>
</tr>
<tr>
<td>MEAS</td>
<td>Measurement</td>
</tr>
<tr>
<td>MECH</td>
<td>Mechanical, Mechanism</td>
</tr>
<tr>
<td>MEG</td>
<td>Million (as in Megohm)</td>
</tr>
<tr>
<td>MFG</td>
<td>Manufacturing</td>
</tr>
<tr>
<td>MHz</td>
<td>MegaHertz</td>
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<tr>
<td>MIN</td>
<td>Minimum, Minute</td>
</tr>
<tr>
<td>MISC</td>
<td>Miscellaneous</td>
</tr>
<tr>
<td>MODE</td>
<td>Operating Modes are defined as follows:</td>
</tr>
<tr>
<td></td>
<td>for HFE</td>
</tr>
<tr>
<td></td>
<td>MODE/G Gradient Mode</td>
</tr>
<tr>
<td></td>
<td>MODE/HK High Conductivity Mode</td>
</tr>
<tr>
<td></td>
<td>MODE/LK Low Conductivity Mode</td>
</tr>
<tr>
<td>MON</td>
<td>Monitor(ing)</td>
</tr>
<tr>
<td>MS</td>
<td>Millisecond (also MSEC)</td>
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<tr>
<td>MSB</td>
<td>Most Significant Bit</td>
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<tr>
<td>MSC</td>
<td>Manned Spacecraft Center</td>
</tr>
<tr>
<td>MSEC</td>
<td>Millisecond</td>
</tr>
<tr>
<td>MSP</td>
<td>Measurement Sequence Programmer</td>
</tr>
<tr>
<td>MSFN</td>
<td>Manned Space Flight Network</td>
</tr>
<tr>
<td>MTG</td>
<td>Mounting</td>
</tr>
<tr>
<td>MTR</td>
<td>Motor; on PSE, the three motors are MTRX, MTRY, and MTRZ</td>
</tr>
<tr>
<td>MUX</td>
<td>Multiplexer</td>
</tr>
<tr>
<td>MV</td>
<td>Millivolt</td>
</tr>
<tr>
<td>mw</td>
<td>Milliwatt</td>
</tr>
<tr>
<td>MW/CM2</td>
<td>Milliwatts per Square Centimeter</td>
</tr>
<tr>
<td>μm</td>
<td>Millimicron</td>
</tr>
<tr>
<td>N</td>
<td>North, Number</td>
</tr>
<tr>
<td>NA</td>
<td>Nano Amperes, Not Applicable</td>
</tr>
<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
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<tr>
<td>NBR</td>
<td>Normal Bit Rate</td>
</tr>
<tr>
<td>NEG</td>
<td>Negative</td>
</tr>
<tr>
<td>NG</td>
<td>No Good</td>
</tr>
<tr>
<td>Ni</td>
<td>Nickel</td>
</tr>
<tr>
<td>NO.</td>
<td>Number</td>
</tr>
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<td>NORM</td>
<td>Normal</td>
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<tr>
<td>NRC</td>
<td>National Research Corporation</td>
</tr>
<tr>
<td>NRZ</td>
<td>Non-Return to Zero</td>
</tr>
<tr>
<td>OPER</td>
<td>Operate, Operation, Operating, Operator, Operational</td>
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<tr>
<td>OR'ED</td>
<td>Processed through an &quot;OR&quot; gate</td>
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<tr>
<td>O/S</td>
<td>Offset</td>
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<tr>
<td>OSC</td>
<td>Oscillator</td>
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<tr>
<td>O/T</td>
<td>One-Time</td>
</tr>
<tr>
<td>OUT</td>
<td>Output</td>
</tr>
<tr>
<td>PARAM</td>
<td>Parameter</td>
</tr>
<tr>
<td>PCB</td>
<td>Printed Circuit Board</td>
</tr>
<tr>
<td>PCM</td>
<td>Pulse Code Modulation</td>
</tr>
<tr>
<td>PCT</td>
<td>Percent</td>
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</table>

JAN 69 5178.A.4
PCU  Power Conditioning Unit
PDR  Power Dissipation Resistor
PDU  Power Distribution Unit
Pe   Probability of Bit Error
PERF Performance
PET  Package Elapsed Time (from RTG Plug-In)
PF   Picofarad
PHYS/AN Physical Analyzer (a component of the CPLEE)
PKG  Package
PL   Plane
PLSS Portable Life Support System
PM   Phase Modulation
POS  Positive
POSN Position
PRA  Parabolic Reflector Array (of LSM)
PREAMP Preamplifier
PRELIM Preliminary
PRE/LIM Pre-Limiting
PRE/REG Pre-Regulator (a component of the SIDE Power Supply)
PRI/ST Primary Structure
PROP Proportional
PROC Processor
PROG Programmer
P/S  Power Supply
PSE  Passive Seismic Experiment; also:
PSE/LP Long Period Sensors
PSE/SP Short Period Sensor
PSE/LP/SP Long and Short Period Sensors
Long Period Sensors are further defined as PSE/X, PSE/Y, and PSE/Z while PSE/XY denotes the two horizontal long period sensors
PSI  Pounds per Square Inch
PSIA Pounds per Square Inch Absolute
Pu 238 Plutonium Isotope
PWR  Power
QTY  Quantity
R  Resistor (used as R1 and R2)
RAD  Radians
RAD/SEC^2 Radians per Second per Second
RCVD Received
RCVR Receiver
RDT  Ring Sensor Delta Temperature (HFE)

<table>
<thead>
<tr>
<th>Probe</th>
<th>1</th>
<th>2</th>
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<tbody>
<tr>
<td>Bridge</td>
<td>UPPER LO</td>
<td>LOWER UPPER LOWER</td>
</tr>
<tr>
<td>Code</td>
<td>RDT11 RDT12 RDT21 RDT22</td>
<td></td>
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</tbody>
</table>

RE  Reference (Motor Circuit on LSM)
REF  Reference
REG  Regulator, Register
REP  Repetition
REQD Required
REQMT Requirement (REQMTs, pl)
RES  Reserve
RMX, Y, Z Reference Motor (connections on LSM: e.g., RMX)
RNG  Range
ROT  Rotation, Rotate
RST  Reset
RT  Rate (as in BIT RT, CNT RT, etc.)
RDT  Ring Sensor Ambient Temperatures (HFE)
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>RTC</td>
<td>Real Time Command</td>
</tr>
<tr>
<td>RTE</td>
<td>Real Time Event</td>
</tr>
<tr>
<td>RTG</td>
<td>Radioisotope Thermoelectric Generator</td>
</tr>
<tr>
<td>RTN</td>
<td>Return</td>
</tr>
<tr>
<td>S/C</td>
<td>Spacecraft</td>
</tr>
<tr>
<td>SCAS</td>
<td>Southwest Center for Advanced Studies</td>
</tr>
<tr>
<td>SCI</td>
<td>Scientific, Science</td>
</tr>
<tr>
<td>SEC</td>
<td>Second</td>
</tr>
<tr>
<td>SEL</td>
<td>Select, Selector, Selection</td>
</tr>
<tr>
<td>SEQ</td>
<td>Sequence, Sequential; used on HFE as: SEQ/FUL Full Sequence, SEQ/P1 Probe 1 Sequence, SEQ/P2 Probe 2 Sequence</td>
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<tr>
<td>SEQ/S</td>
<td>Sequential; used on ASE as: SEQ/S</td>
</tr>
<tr>
<td>SIG</td>
<td>Signal</td>
</tr>
<tr>
<td>SLA</td>
<td>Spacecraft/LM Adapter</td>
</tr>
<tr>
<td>SMEK</td>
<td>Summary Message Enable Keyboard</td>
</tr>
<tr>
<td>S/N</td>
<td>Signal to Noise</td>
</tr>
<tr>
<td>SNAP</td>
<td>Systems for Nuclear Auxiliary Power-Type 27 Sensor</td>
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<tr>
<td>SNSR</td>
<td>Space Ordnance Systems, Inc.</td>
</tr>
<tr>
<td>SOS</td>
<td>Split Phase, Short Period (PSE) Specification</td>
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<td>SP</td>
<td>Single Pole, Single Throw</td>
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<td>SPEC</td>
<td>Specimen Return Container</td>
</tr>
<tr>
<td>SPST</td>
<td>Structure/Thermal Status, Station (Cent Sta)</td>
</tr>
<tr>
<td>SRC</td>
<td>Standby Switch</td>
</tr>
<tr>
<td>STBY</td>
<td>Solar Wind Spectrometer</td>
</tr>
<tr>
<td>SW</td>
<td>Synchronization (abbreviated &quot;SY&quot; on APOLLO)</td>
</tr>
<tr>
<td>SWS</td>
<td>Temperature (also used as &quot;Thermal&quot; on ALSEP)</td>
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<tr>
<td>SYNC</td>
<td>Zero Reference Time of Timer</td>
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<tr>
<td>T</td>
<td>Telemetry for Apollo Passive Lunar Experiments</td>
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<tr>
<td>TBD</td>
<td>To Be Determined</td>
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<tr>
<td>TC</td>
<td>Thermocouple; on HFE, four cable ambient temperatures are read on each Probe: TC1A, TC1B, TC1C, TC1D (Probe 1) TC2A, TC2B, TC2C, TC2D (Probe 2) Temperature (TEMPs, p1)</td>
</tr>
<tr>
<td>TEMP</td>
<td>Terminal</td>
</tr>
<tr>
<td>TERM</td>
<td>Telemetry</td>
</tr>
<tr>
<td>TM</td>
<td>Timer</td>
</tr>
<tr>
<td>TMR</td>
<td>Trinitrotoluene</td>
</tr>
<tr>
<td>TNT</td>
<td>Unit of Pressure (one Millimeter of Mercury)</td>
</tr>
<tr>
<td>TORR</td>
<td>Transmitter</td>
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<tr>
<td>TRANS</td>
<td>JAN 69 5178.A.6</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
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</tr>
<tr>
<td>TRW</td>
<td>TRW, Inc. (Manufacturer)</td>
</tr>
<tr>
<td>TV</td>
<td>Television</td>
</tr>
<tr>
<td>UHT</td>
<td>Universal Handling Tool</td>
</tr>
<tr>
<td>USGS</td>
<td>United States Geological Survey</td>
</tr>
<tr>
<td>UV</td>
<td>Ultraviolet</td>
</tr>
<tr>
<td>V</td>
<td>Volt, Velocity (used to indicate &quot;Speed&quot; on PSE in &quot;LVL DIR/V&quot;)</td>
</tr>
<tr>
<td>Vcc</td>
<td>Transistor Supply Voltage</td>
</tr>
<tr>
<td>VCO</td>
<td>Voltage Controlled Oscillator</td>
</tr>
<tr>
<td>VDC</td>
<td>Volts Direct Current</td>
</tr>
<tr>
<td>VERT</td>
<td>Vertical</td>
</tr>
<tr>
<td>V/FILT</td>
<td>Velocity Filter</td>
</tr>
<tr>
<td>V/M</td>
<td>Volts per Meter</td>
</tr>
<tr>
<td>VSWR</td>
<td>Voltage Standing Wave Ratio</td>
</tr>
<tr>
<td>W</td>
<td>Watt, West</td>
</tr>
<tr>
<td>W1, W2, W3</td>
<td>Wall Locations of Structure Temperatures</td>
</tr>
<tr>
<td>WD</td>
<td>Word (WDs, pl)</td>
</tr>
<tr>
<td>WRT</td>
<td>With Respect To</td>
</tr>
<tr>
<td>WT</td>
<td>Weight</td>
</tr>
<tr>
<td>XMTR</td>
<td>Transmitter</td>
</tr>
<tr>
<td>XYZ</td>
<td>Axes of LSM, where XYO indicates</td>
</tr>
<tr>
<td>XYO</td>
<td>X, or Y, or neither</td>
</tr>
<tr>
<td>YR</td>
<td>Year</td>
</tr>
<tr>
<td>γ</td>
<td>Gamma (unit of Magnetic Flux)</td>
</tr>
<tr>
<td>μGAL</td>
<td>Microgal</td>
</tr>
<tr>
<td>μSEC</td>
<td>Microsecond</td>
</tr>
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