Lunar Communications Relay Unit (LCRU)
Preliminary Design Review Report
NASA/MSC, Houston, Texas
June 3, 4, and 5, 1970
Volume II
LUNAR COMMUNICATIONS RELAY UNIT (LCRU)

PRELIMINARY DESIGN REVIEW REPORT

NASA/MSC HOUSTON, TEXAS

June 3, 4 and 5, 1970

VOLUME II

- Electrical Interfaces
- Electrical Design
6.0 ELECTRICAL INTERFACES
<table>
<thead>
<tr>
<th>QTY REQD PER DASH NO.</th>
<th>U M</th>
<th>CODE IDENT</th>
<th>PART OR IDENTIFYING NO.</th>
<th>SPECIFICATION</th>
<th>NOMENCLATURE OR DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>505 -504 -503 -502 -501</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CABLE ASSEMBLY</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>8670597</td>
<td></td>
<td></td>
<td>ASSEMBLY STANDARDS</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>8551439</td>
<td></td>
<td></td>
<td>SPEC. MFG. (SOLDER &amp; ASSY.)</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>2020319</td>
<td></td>
<td></td>
<td>SPECIFICATION, MANUFACTURING</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>2020674</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AR</td>
<td>SN6385</td>
<td></td>
<td></td>
<td>SOLDER</td>
</tr>
<tr>
<td></td>
<td>AR</td>
<td>2010811-2</td>
<td></td>
<td></td>
<td>TAPE, LACING</td>
</tr>
<tr>
<td></td>
<td>AR</td>
<td>2010703-16</td>
<td></td>
<td></td>
<td>TAPE, INSULATING</td>
</tr>
<tr>
<td></td>
<td>AR</td>
<td>2010744-178</td>
<td></td>
<td></td>
<td>COAX, RG-178/U</td>
</tr>
<tr>
<td></td>
<td>AR</td>
<td>8524924-1</td>
<td></td>
<td></td>
<td>CABLE, 2 CONDUCTOR (SHLD)</td>
</tr>
<tr>
<td></td>
<td>AR</td>
<td>999129-90</td>
<td></td>
<td></td>
<td>WIRE</td>
</tr>
<tr>
<td></td>
<td>AR</td>
<td>999129-92</td>
<td></td>
<td></td>
<td>WIRE</td>
</tr>
<tr>
<td></td>
<td>AR</td>
<td>999129-99</td>
<td></td>
<td></td>
<td>WIRE</td>
</tr>
<tr>
<td></td>
<td>AR</td>
<td>999129-923</td>
<td></td>
<td></td>
<td>WIRE</td>
</tr>
<tr>
<td></td>
<td>AR</td>
<td>999129-928</td>
<td></td>
<td></td>
<td>WIRE</td>
</tr>
<tr>
<td></td>
<td>P1</td>
<td>ZG 6E1717-26SD</td>
<td></td>
<td></td>
<td>CONNECTOR, PLUG</td>
</tr>
<tr>
<td></td>
<td>P2</td>
<td>ZG 6E1511-98PA</td>
<td></td>
<td></td>
<td>CONNECTOR, PLUG</td>
</tr>
<tr>
<td></td>
<td>P3</td>
<td>ZG 6E1717-26SE</td>
<td></td>
<td></td>
<td>CONNECTOR, PLUG</td>
</tr>
<tr>
<td>QTY REQ'D PER DASH NO.</td>
<td>U M</td>
<td>CODE IDENT</td>
<td>PART OR IDENTIFYING NO.</td>
<td>SPECIFICATION</td>
<td>NOMENCLATURE OR DESCRIPTION</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----</td>
<td>------------</td>
<td>--------------------------</td>
<td>---------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>X X</td>
<td></td>
<td>8670967</td>
<td>CABLE ASSEMBLY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X X</td>
<td></td>
<td>8551439</td>
<td>ASSEMBLY STANDARDS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X X</td>
<td></td>
<td>2020319</td>
<td>SPEC.MFG. (SOLDER &amp; ASSY)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X X</td>
<td></td>
<td>2020674</td>
<td>SPECIFICATION, MANUFACTURING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AR AR</td>
<td></td>
<td>SN63BS</td>
<td>SOLDER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AR AR</td>
<td></td>
<td>77872</td>
<td>CABLE, COAX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P1 1 1</td>
<td>11312</td>
<td>KCMC0-3</td>
<td>CONNECTOR, PLUG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P2 1 1</td>
<td>14402</td>
<td>LSC380-00602-03</td>
<td>CONNECTOR,</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
NOTE 1. ALL LCRU SUBASSEMBLIES ARE PACKAGED IN CLOSED CASES WITH RFI COVERS

2. ALL SIGNALS ARE CARRIED BY COAX OR SHIELDED CABLE.
TRIPLEXER REJECTION CHARACTERISTICS

ATTENUATION - db

0 10 20 30 40 50

0 200 400 600 800 1000 1200 1400 MHz

FREQUENCY - MHz

- - - TRANSMITTER TO ANT

- - - ANT TO RECEIVER

TO 2500 MHz
S-BAND DIPLEXER REJECTION CHARACTERISTICS

- **Antenna to Receiver**
- **Transmitter to Antenna**

![Graph](image-url)

- Frequency ranges:
  - TO DC
  - 1850 MHz to 2490 MHz (TO 8 GHz)
- LCRU EMI PROTECTION -

- All subassemblies are packaged in closed cases with RFI covers.

- All signals are carried by coax or shielded cable.

- High frequency EMI filters are provided on critical LCRU input lines.

- Low frequency filters are provided on DC/DC converter input/output circuits.

- All LCRU subassembly power lines include RF bypass decoupling.

- Antenna conducted filters have been incorporated in transmitter output circuit for S-band and VHF transmitters.

- Front-end rejection filtering is provided in VHF and S-band receivers.

- S-band diplexer and VHF triplexer provide additional front-end rejection for receivers and additional attenuation of antenna conducted spurious emanation from transmitters.

- LCRU LRV grounding scheme prevents ground loops and provides isolation from LRV power common to shield RFI voltages by referencing all signals to LRV supply.
2. On Sheet 21 of the ICD add the following paragraph:

"4.3.3 LRV/LCRU Electrical Interface

The electrical interface between the LRV and LCRU shall be in accordance with the following requirements:

a. Electrical interface between the LRV and LCRU shall be at the LRV auxiliary connector.

b. Source impedance at the LRV auxiliary connector shall be 0.4 ohms maximum, shunted by 500 micro-farads plus or minus 20 percent.

c. Power bus at the LRV auxiliary connector shall consist of two pairs of number 20 wire (two plus and two common).

d. LRV power system shall incorporate a single point ground at the battery common.

e. LCRU power drain shall not exceed 150 watts and not more than 16 amperes peak sawtooth current at a minimum rate of 17 kHz."

3. On Sheet 20 of the ICD revise auxiliary connector pin functions as shown below:

```
+36 VDC       B  * STOWED

+36 VDC       C  PAYLOAD

Chassis Ground D

Return         E  MSC  *  MSC *

Return         A  IRN Ref. Only

* LRV  *

* PLUG *

RECEPTACLE  * ZG61511-98SA
```

4. On Sheet 20 of the ICD add receptacle and plug part numbers as shown above.

5. On Sheet 21 revise Paragraph 4.4 to read:

"4.4 Electromagnetic Interference

The LRV and stowed payload shall be designed such that no electromagnetic interference (EMI) is produced by components, subsystem, or the vehicle as a whole which will adversely affect the operation of components or subsystem of the LRV or stowed payload. The LRV shall comply with the Conducted interference requirements of MIL-STD 19-3A at the LRV/LCRU interface. The LRV shall also satisfy the requirements of MIL-E-6051D."
1. On Sheet 21 of the ICD revise Table II to read as follows:

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>LRV STOPPED</th>
<th>LRV IN MOTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outlet Voltage</td>
<td>$36 +8 \text{ VDC}$</td>
<td>$36 +8 \text{ VDC}$</td>
</tr>
<tr>
<td>Voltage Ripple</td>
<td>None of Predictable Consequence</td>
<td>$0.6 \text{ V at 1500 Hz}$</td>
</tr>
<tr>
<td>Voltage Transient</td>
<td>None of predictable Consequence</td>
<td>None of predictable consequence</td>
</tr>
</tbody>
</table>

**TABLE II**

CHARACTERISTICS OF POWER AT LRV AUXILIARY CONNECTOR

**17. DESCRIPTION OF CHANGE**

<table>
<thead>
<tr>
<th>18. PREPARED BY</th>
<th>19. APPROVED BY</th>
<th>20. ORGANIZATION</th>
<th>21. DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>J. C. Cheek</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
LCRU/TELEVISION INTERFACE

- CAMERA VIDEO OUTPUT CHARACTERISTICS
- LCRU VIDEO RESPONSE
- CAMERA TO LCRU VIDEO COUPLING
- CAMERA TO LCRU f0 MATCHING
- POWER SOURCE, LCRU/CAMERA OR LCRU/GCTA.
- UPLINK COMMANDS
- POWER SWITCHING, REMOTE TV
- "Y" CABLE, LCRU TO LRV AND GCTA.
TV / EXT POWER INTERFACE

(CABLE PLUG) P3 J3 (RECEPTACLE ON LCRU)

CONNECTOR

P3 ZG6E17 17-26 SD

J3 ZG0E17 17-26 PD

32-44 VDC EXTERNAL POWER

COMMON

OVERALL CABLE SHIELD


VIDEO FROM TV CAMERA (RG 178 COAX)

70 KHz CONTROL TO TV CAMERA

29 V TO TV CAMERA

29 V FROM TV CAMERA

COMMON

NOTE:
OVERALL CABLE SHIELD NOT GROUNDED AT LCRU OR TV CAMERA, BUT GROUNDED AT LRV.
LCRU/TV INTERFACE BASELINE DESIGN

- RCA PROVIDES "Y" INTERFACE CABLE TO HANDLE VIDEO AND COMMAND SIGNALS AND DC POWER.

- LCRU PROVIDES 70KHz COMMAND SUBCARRIER.

- LCRU DESIGN INCLUDES DC COUPLING OF VIDEO LINES BETWEEN LCRU AND OCTA.

- LCRU DESIGN BASED ON PRE-EMPHASIZED VIDEO INPUT SIGNAL.

- LCRU TO PROVIDE 29 VDC POWER TO CAMERA/OCTA.

- OCTA TO PROVIDE 29 VDC POWER TO LCRU FOR REMOTE TV.

- LCRU DESIGN FOR COLOR CAMERA ONLY.

- LCRU PREMODULATION MIXER SETS MODULATION INDICES OF BASEBAND VIDEO AND 1.25 MHz SUBCARRIER.
**LCRU TV MIXER**

- **$V_{TV}$**: 1.62 V P-P @ 100 KHz
- **$V_{TV}$**: 1.82 V P-P @ 2 MHz
  
  *(INTO 46.3 OHMS)*

**TV CAMERA**

**ASSUME CURRENT GEN.**

**2 MHz CASE:**

- $I_{TV} = \frac{1.82}{46.3} = 39.3$ ma P-P NOM
- $I_{TV} - 9\% = 35.76$ ma
- $I_{TV} + 9\% = 42.84$ ma

**DEV (1.25 MHz) = ±275 KHz**

**DEV (TV) = ±1.7 MHz (AT 2 MHz)**
NOTE:

ALL BLOCKS SHOWN ARE
WITHIN CAMERA OR OCTA.
LCRU INTERFACE CHARACTERISTICS POWER OUTPUT

- 29 VOLTS ± 4 VOLTS DC

- LOAD: 23 WATTS MAXIMUM

- SOURCE IMPEDANCE = 2.0 OHMS MAXIMUM

- SHUNT CAPACITANCE = TBD uf

- LINE NOISE:
  LOAD = 8 WATTS MINIMUM
  NOISE = 0.2 VOLTS RMS MAXIMUM, 5 Hz to 20 KHz
  0.1 VOLTS RMS MAXIMUM, 21 KHz to 100 Hz

- LINE TRANSIENTS:
  TBD BUT ANTICIPATED TO BE WITHIN TRANSIENT CONDUCTED SUSCEPTIBILITY REQUIREMENTS OF IESD 19-3A.
LCRU INTERFACE CHARACTERISTICS VIDEO SIGNAL

- **INPUT SIGNAL LEVEL:** -0.75 TO +2.75 VOLTS
  (3.5 VOLTS PEAK TO PEAK)

- **SOURCE IMPEDANCE:** ESSENTIALLY INFINITE

- **INPUT IMPEDANCE:** 46.3 OHMS PRESET BY DTV

- **VIDEO SIGNAL COUPLING:** DIRECT COUPLING

- **INPUT SNR PEAK/RMS:** 35 DB MINIMUM IN 2 MHz BW

- **INPUT SIGNAL PRE-EMPHASIS:** NOMINAL 6 DB/OCTAVE, MINIMUM BREAK POINT 0.25 MHz
LCRU INTERFACE CHARACTERISTICS VIDEO TRANSMISSION (S-BAND)

- OVERALL FREQUENCY RESPONSE: ±1 db, DC to 3 MHz
- LINEARITY: +3% BSL UP TO 2.5 MHz DEVIATION
- PEAK DEVIATION: 1.7 MHz ±4% REFERENCED AT INPUT SIGNAL OF 0.1 MHz
- CARRIER CENTER FREQUENCY: 2272.5 MHz ±0.01% AT SET UP (VIA VIDEO/SCO MIXER DTV'S)
- INPUT VOLTAGE FOR $f_o$: +1.0 VDC
- DEVIATION SENSE: NEGATIVE
- EFFECTIVE RADIATED POWER: 30.0 dBW MINIMUM
LCMU INTERFACE CHARACTERISTICS

COMMAND DATA SUBCARRIER OUTPUT

° OUTPUT IMPEDANCE: 100 OHMS MAXIMUM, BALANCED AND ISOLATED

° OUTPUT LEVEL: 0.7 TO 10 VOLTS PEAK-TO-PEAK INTO A 10 KILOHMS RESISTIVE LOAD.

° FREQUENCY RESPONSE: ± 1 dB OVER 20 KHZ BANDWIDTH, REFERENCED TO 70 KHZ SUBCARRIER CENTER FREQUENCY.

° SIGNAL-TO-NOISE RATIO: SNR (rms) OF SUBCARRIER 10 db MINIMUM IN 60 TO 80 KHZ BAND FOR 70 KHZ AND 124 KHZ SUBCARRIERS DEVIATED 0.8 RADIANS

° INTERMODULATION DISTORTION: I.M. PRODUCTS GREATER THAN 30 db DOWN IN 60 TO 80 KHZ BANDWIDTH. (TWO TONE TEST OF NON-HARMONICALLY RELATED TONES WITH COMPOSITE PEAK DEVIATION OF 1.6 RADIANS.)
A conflict exists between the LCRU design baseline and the LCRU/GCTA ICD ready for release.

- First - Output Level

  LCRU designed for 3.5 volts, new ICD states camera to deliver 1.0 volt.

  Result - Inadequate deviation of LCRU S-Band carrier, ±0.49 MHz vs ±1.7 MHz, and considerable reduction in system margin (about 12 dB).

- Possible Solutions:
  1. Camera Impact
     Configure camera with low level/high level (1.0 V/3.5 V) video output switch.
     Disadvantage: Additional crew procedural task.
  2. LCRU Impact
     Increase FM transmitter modulation sensitivity to accommodate 1.0 volt video signal.
     Disadvantage: Risk of degrading noise susceptibility, increase in intermodulation distortion, increase in incidental FM, degradation of frequency stability, and increases tolerance build-up in setting carrier center frequency.
LCRU DESIGN BASELINE VS
FORTHCOMING ICD (SGB16101163) cont'd

° RECOMMENDED SOLUTION:

LCRU IMPACT - PROVIDE DC COUPLED VIDEO AMPLIFIER WITHIN LCRU TO ACCOMMODATE THE DESIRED LOWER FM TRANSMITTER MODULATION SENSITIVITY.

PROBLEM - MOST LOGICAL LOCATION FOR VIDEO AMPLIFIER IS DOWNLINK SIGNAL PROCESSOR.

ADDITIONAL CIRCUITRY REQUIRES REDESIGN AND REPACKAGING OF SIGNAL PROCESSOR AND NEGATIVE POWER SOURCE OF TIME SHARE SWITCH.

° 70 KHZ COMMAND SUBCARRIER

LCRU DESIGN BASED ON 0.8 RADIANS DEVIATION OF BOTH THE 70 KHZ AND 124 KHZ SUBCARRIERS.

NEW ICD SPECIFIES 1.1 RADIANS DEVIATION FOR 30 KHZ AND 70 KHZ SUBCARRIERS DURING COMBINED LM AND LCRU REMOTE TV OPERATIONS.

° LCRU IMPACT -

1. INCREASED INTERMODULATION DISTORTION

2. LCRU S-BAND RECEIVER USES LOW PASS FILTER FOR 70 KHZ SUBCARRIER, THIS WILL ALLOW 30 KHZ SUBCARRIER TO RIDE THROUGH.
7.0 LCRU ELECTRICAL DESIGN
-LCRU DESIGN STATUS-

- LCRU MECHANICAL MOCK-UP COMPLETE.
- ENGINEERING MODEL IN-HOUSE SUBASSEMBLIES IN PRELIMINARY TESTS. ALL DATA TAKEN TO DATE IS WITHIN DESIGN LIMITS.
- DESIGN APPROACH FOR LCRU AND HIGH GAIN ANTENNA MAST MOUNTING MECHANISM HAS BEEN FINALIZED.
- ENGINEERING MODEL DRAWINGS APPROXIMATELY 80% COMPLETE.
- IN-HOUSE DVT SUBASSEMBLY PARTS RELEASED-COMPLETE. CONTROL PANEL AND CASE DVT PARTS RELEASE SCHEDULED FOR 6/8/70.
- THERMAL MOCK-UP COMPLETION SCHEDULED FOR 6/8/70.
- DC/DC CONVERTER BREADBOARD DATA ALL WITHIN SPECIFICATION LIMITS.
- PRELIMINARY LCRU VIBRATION ANALYSIS AND TEST DATA COMPLETE
- PRELIMINARY THERMAL DESIGN ANALYSIS COMPLETE
SUBASSEMBLY PERFORMANCE CHARACTERISTICS

PERFORMANCE CHARACTERISTICS WILL BE PRESENTED ON LCRU SUBASSEMBLIES. THESE CHARACTERISTICS ARE USED TO ASSIST IN PERFORMING DESIGN ANALYSIS AND SHOULD NOT NECESSARILY BE CONSIDERED AS SUBASSEMBLY SPECIFICATIONS.
LCRU DC–DC POWER CONVERTER
(ENERGY PUMP REGULATOR)

DC INPUT FROM LRV 32–44V

MAGNETIC ENERGY STORAGE/TRANSFER

PULSE INTEGRATOR

+16.5V

+28.5V

OUTPUTS

CAPACITIVE ENERGY STORAGE

SWITCH

DIFF. AMP.

PULSE INTEGRATOR

COMM.

TO ISOLATION SWITCH
DC/DC Converter Characteristics

1. Input/Output DC Return lines
   A. EXT. Power (LRV Batt.)
   B. INT. Power (LCRU Batt.)

2. Input (at LRV interface connector)
   A. Voltage
   B. Source impedance
   C. Source Ripple
   D. Source Transients

3. Output (at converter terminals)
   A. 28.5 VDC
      1. Regulation
      2. Power
      3. Output impedance
   B. 16.5 VDC
      1. Regulation
      2. Power
      3. Output impedance
   C. Both outputs
      1. Ripple and noise

4. Efficiency

5. Overload Protection
   converter will be overload protected and provide automatic recovery.

6. Reverse Polarity Protection

7. Volume
   35.3 cu. in. max.

8. Weight
   40 oz. max.
16.5V OUTPUT 27Ω CONSTANT LOAD
28.5V OUTPUT ADJUSTED FROM OPEN CKT TO 0Ω
LCRU DC-DC POWER CONVERTER

[Diagram of the LCRU DC-DC power converter with components labeled such as Q1, Q2, Q3, CR2, CR3, CR4, CR5, FL1, FL2, L1, L2, L3, R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15, C16, VR1, VR2, and input/output connections for +28.5V and +16.5V.]
# VHF Triplexer Characteristics

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequencies and Loss</strong></td>
<td></td>
</tr>
<tr>
<td>Receiver Arm</td>
<td>259.7 MHz ±0.15 MHz</td>
</tr>
<tr>
<td>Loss</td>
<td>2 db MAX</td>
</tr>
<tr>
<td>Transmitter Arm</td>
<td>296.8 MHz ±0.15 MHz</td>
</tr>
<tr>
<td>Loss</td>
<td>2 db MAX</td>
</tr>
<tr>
<td>Third Arm</td>
<td>Terminated</td>
</tr>
<tr>
<td>VSWR (All Passbands)</td>
<td>1.3 MAX</td>
</tr>
<tr>
<td>Power – Receiver Arm</td>
<td>1.0 Watt</td>
</tr>
<tr>
<td>Power – Transmitter Arm</td>
<td>1.0 Watt</td>
</tr>
<tr>
<td>Transmitter/Receiver Isolation</td>
<td>35 db MIN</td>
</tr>
<tr>
<td>Size</td>
<td>4.75 CU IN</td>
</tr>
<tr>
<td>Weight</td>
<td>5 OZ MAX</td>
</tr>
</tbody>
</table>
259.7 MHz VHF AM RECEIVER

-0.5 dB DIODE ATTEN

+12 dB RF AMP

+12 dB RF AMP

+15 dB MIX

-4 dB XTAL OSC.

X2 MULTI

114.850 MHz

-4 dB XTAL FILTER 30 MHz

+75 dB IF AMP

AGC AMP/DET

SQUELCH

14.5 kHz SUBCARRIER INPUT

WB-PM MOD TO DL/SP

NB-PM MOD. TO S-BAND #1 XMIT

NB-PM MOD. TO S-BAND #2 XMIT

DC POWER

14 VDC 45 MA MAX.

10 VDC 33 MA MAX.
## Frequency

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Frequency</td>
<td>259.7 MHz</td>
</tr>
<tr>
<td>LO Stability</td>
<td>0.003%</td>
</tr>
<tr>
<td>IF Frequency</td>
<td>30.0 MHz</td>
</tr>
<tr>
<td>IF Bandwidth, 6 dB</td>
<td>70 KHz Min.</td>
</tr>
<tr>
<td></td>
<td>240 KHz Max.</td>
</tr>
</tbody>
</table>

## Input Signal AM Modulation

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio, 200 Hz to 3.0 KHz</td>
<td>36.5%</td>
</tr>
<tr>
<td>3.9 KHz Sub-carrier</td>
<td>8.4%</td>
</tr>
<tr>
<td>5.4 KHz Sub-carrier</td>
<td>9.3%</td>
</tr>
<tr>
<td>7.35 KHz Sub-carrier</td>
<td>16.2%</td>
</tr>
<tr>
<td>10.50 KHz Sub-carrier</td>
<td>19.0%</td>
</tr>
</tbody>
</table>

## General Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio Sensitivity for 30% 1KHz AM in 17 KHz BW</td>
<td>-132 dBW with a 10dB S/N Min.</td>
</tr>
<tr>
<td>Harmonic Distortion @ 70% AM</td>
<td>-96 dBW with a 35dB S/N Min.</td>
</tr>
<tr>
<td>2 Tone IM @ 90% Total AM in Audio Band</td>
<td>3% Max.</td>
</tr>
<tr>
<td>Dynamic Range, RF Input Connector</td>
<td>23 dB below audio</td>
</tr>
<tr>
<td></td>
<td>-139 dBW to -23 dBW</td>
</tr>
<tr>
<td></td>
<td>Selectro, right angle, male</td>
</tr>
</tbody>
</table>

## Signal Outputs

### WB-PM MOD to Downlink Sig. Processor

<table>
<thead>
<tr>
<th>Connector</th>
<th>Drive Impedance</th>
<th>3.9 KHz Sub-carrier Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Through term.</td>
<td>100 ohms</td>
<td>81 MV rms @ 30K ohm load</td>
</tr>
</tbody>
</table>

### NB-PM MOD to XMTR's (Two)

<table>
<thead>
<tr>
<th>Connector</th>
<th>Drive Impedance</th>
<th>3.9 KHz sub-carrier Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Through term.</td>
<td>100 ohms</td>
<td>81 MV rms @ 1K ohms, 30 pf load</td>
</tr>
</tbody>
</table>

### 14.5 KHz Sub-carrier Input

<table>
<thead>
<tr>
<th>Input Impedance</th>
<th>Input Connector</th>
<th>Sub-carrier Input NB-PM</th>
<th>Sub-carrier Input WB-PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>47.0K ohms</td>
<td>Through term.</td>
<td>15 MV rms</td>
<td>30 MV rms</td>
</tr>
</tbody>
</table>

## DC Power Requirements

<table>
<thead>
<tr>
<th>Input DC Voltage</th>
<th>Input DC Voltage</th>
<th>Input Current, 14 VDC</th>
<th>10 VDC</th>
<th>ON/OFF Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.0 VDC ±0.1 volts</td>
<td>10.0 VDC ±0.1 volts</td>
<td>45.0 MA Max.</td>
<td>33.0 MA Max.</td>
<td>Prime Power</td>
</tr>
</tbody>
</table>

## Volume

<table>
<thead>
<tr>
<th>Max Design Envelope Excluding Connectors</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.04 x 1.54 x 1.60 in.</td>
<td>12.4 cu. in.</td>
</tr>
</tbody>
</table>

## Weight

| Projected Weight | 8.0 ounces |
## VHF AM Receiver Power Budget

<table>
<thead>
<tr>
<th>Component</th>
<th>Current (mA)</th>
<th>Voltage (V)</th>
<th>Power (mW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF AMP</td>
<td>17</td>
<td>10</td>
<td>170</td>
</tr>
<tr>
<td>IF AMP</td>
<td>17</td>
<td>14</td>
<td>238</td>
</tr>
<tr>
<td>SQUELCH/AUDIO</td>
<td>17</td>
<td>14</td>
<td>238</td>
</tr>
<tr>
<td>DIODE ATTEN.</td>
<td>10</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>BASEBAND COND.</td>
<td>30</td>
<td>14</td>
<td>420</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>1,170</strong></td>
</tr>
</tbody>
</table>

Total Power: 1.17 Watts
CRYSTAL FILTER FREQUENCY RESPONSE

-6 dB 87.9 KHz

-60 dB 195.6 KHz

30 MHz FREQUENCY IN Hz
NOTES:
1. IF TERMINATED WITH 470Ω
2. OUTPUT MEASURED WITH A HI-Z PROBE OF BOONTON RF VTVM 91-C ACROSS 470Ω
3. AGC = 5 VDC - CONST
4. IF OUTPUT @ 30 MHz = 0 dBm
5. IF GAIN @ 30 MHz = 72.5 dB
AM REC. AUDIO GATE RESPONSE & DISTORTION

Relative Output (dB)

Harmonic Distortion (%)

Frequency (C/S)

\[ R_1 = 2.2\, \text{K} \]
\[ R_2 = 1.2\, \text{K} \]

AF OUT = 400MV

Audio Gate Circuit

% Harmonic Distortion

\[ R_1 = 2.2\, \text{K} \]
\[ R_2 = 2.1\, \text{K} \]
VHF AM RECEIVER
(RF ATTENUATION VS AGC VOLTAGE)
(PIN DIODE ATTEN.)

\[ a = 0.5 \text{ dB} \]

AGC VOLTAGE

\[ \alpha \text{ = 0.5 dB} \]

\[ \text{STRONG SIGNAL.} \]
### VHF AM Receiver RF Subassembly Test Summary

<table>
<thead>
<tr>
<th>Specification</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DC Current Drain</strong></td>
<td></td>
</tr>
<tr>
<td>+10V 17MA</td>
<td>22 MA MAX.</td>
</tr>
<tr>
<td><strong>Frequency (Oscillator)</strong></td>
<td></td>
</tr>
<tr>
<td>229.700,000 MHz ± 2,200 Hz</td>
<td></td>
</tr>
<tr>
<td><strong>RF Gain</strong></td>
<td></td>
</tr>
<tr>
<td>30 db</td>
<td>32 ±2 db</td>
</tr>
<tr>
<td><strong>Local Oscillator Output</strong></td>
<td></td>
</tr>
<tr>
<td>3 VDC</td>
<td>1.5 VDC MIN.</td>
</tr>
<tr>
<td><strong>Center Frequency</strong></td>
<td></td>
</tr>
<tr>
<td>259.699 MHz ± 0.003 MHz</td>
<td></td>
</tr>
<tr>
<td><strong>Bandwidth</strong></td>
<td></td>
</tr>
<tr>
<td>6 db 88 KHz</td>
<td>70 KHz MIN.</td>
</tr>
<tr>
<td><strong>Filter Ripple</strong></td>
<td></td>
</tr>
<tr>
<td>1 db ±1 db</td>
<td></td>
</tr>
</tbody>
</table>
VHF AM RECEIVER (259.7 MHz)
CHARACTERISTICS (EVCS)

- AUDIO OUTPUT (30% AM 1000~) 3 kHz FILTER
- SENSITIVITY - 110 dBm 1.4 µV O.C.
  (NO CHANGE WITH TEMP.)
- AUDIO OUTPUT (±1 dB -100 TO -10 dBm)
  TEMP. CHANGE LESS THAN 2 dB

Graph showing the relationship between RF input and audio output levels, with various markers for sensitivity, squelch, and AGC voltages.
DOWN LINK BASEBAND CONDITIONER

BLOCK DIAGRAM

- 14.5 KHz
  SUBCARRIER INPUT
  → PAD ISOL
  → IC AMP
  → LPF 20 KC
  → EMIT FOLL
  → WIDEBAND - PM MOD.
  TO DL / SP

- AUDIO/ DATA INPUT
  → PAD ISOL
  → IC AMP
  → LPF 20 KC
  → EMIT FOLL
  → NARROWBAND - PM MOD.
  TO S-BAND #1 XMIT.

- EMIT FOLL
  → NARROWBAND - PM MOD
  TO S-BAND #2 XMIT.
BASEBAND CONDITIONER
OUTPUT VARIATION VS. TEMPERATURE

![Graph showing output variation vs. temperature.](image)
BASEBAND CONDITIONER

INPUT VS OUTPUT

(NOMINAL INPUT) PORT #1 300 MV
(NOMINAL INPUT) PORT #2 15 MV
35 MV

DISTORTION VS INPUT

PORT #1 (AUDIO)

PORT #2 (14.5 KHz)

PORT #2 (14.5 KHz)

PORT #1 (AUDIO)

PERCENT DISTORTION

OUTPUT VOLTAGE (RMS)

AMPLIFIER INPUT VRMS

0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6
A1
AMPLIFIER OR MIXER
RF OUTPUT 1
RETURN 1
GND 1
+10VDC 1
C1 1500pF
RF INPUT (50 OHMS)
A2
AMPLIFIER OR MIXER
IF INPUT 1
RETURN 1
GND 1
+10VDC 1
C1 1500pF
RETURN 3
B1
GND 1
+10VDC 1
C1 1500pF
RETURN 3
RF OUTPUT 1
RETURN 1
GND 1
+10VDC 1
C1 1500pF
RETURN 3
NOTES:
1. RESISTOR VALUES ARE IN OHM-EN-US (OHM-EN-US)
2. VALUES OF R1 THROUGH R5 SHALL BE DETERMINED AT TIME OF ASSEMBLY

HIGHEST SYMBOL USED: A1
SYMBOLS NOT USED: A2

SCHEMATIC
WIRING DIAGRAM
RECEIVER, AM (259.7 MHZ)
+14V DC

+10V

THERMAL SEN.

+29 +4V

-2V

+14V

TIME PHASE Sensor Switch

14.5 KHz VCO

10uf

1N823

45.3K

604

TO COMB. AMP

50 MVP

20 MVP

TEMPERATURE

BATTERY VOLTAGE

METER SWITCH

+14V FROM MODE SWITCH

INPUT

SHAPE FILTER

125 MHz SCO

125 MHz SCO

FROM MODE SWITCH

+14V

FROM TV CAMERA

WIDE BAND SIG.MIX.

TO FM/PM XMTR

TO PM/PM XMTR

FROM PM/PM XMTR

FM/PM XMTR

TO PM/PM XMTR

TO PM/PM XMTR

TP

TP

TP

TP

TP
DOWN LINK SIGNAL PROCESSOR

Power Input

14 V ±1 V @ 80 ma ±10%
27-29 V @ 2-7.5 ma
10 V ±1 V @ 7 ma ±10%

Time Share Sensor Switch

Switching Rate (25° C)
  Temperature Sig. ON 10 ±1 sec.
  Battery Voltage Sig. ON 20± 2 sec

Voltage Sensor Output (to 5 K meter load)
  Battery Voltage = 33 ±0.5 V 4.75 V
  Battery Voltage = 29 ±0.5 V 2.50 V
  Battery Voltage = 27 ±0.5 V 1.40 V

Temperature Sensor Output (to 5 KΩ meter load:
  Input Circuit of 14V DC in series with
  sensor 855252)

160° F 4.77 to 5.0 V
80° F 2.40 to 2.50 V
30° F 0.85 to 0.95 V
0° F 0.50 to 0.60 V

14.5 KHz VCO Output

Level Across 47 KΩ load (0V Switching) 50 MVP ±8.5%
(14V Switching) 20 MVP ±8.5%

Peak Deviation ±7.5%
Modulation Signal Alternates between voltage
and temp. sensors

Input Signals from BB Conditioner

1 KHz 3.9 KHz
Input Impedance

Input Signal From TV Camera

@ 100 KHz 1.62 V p-p
@ 2 MHz 1.82 V p-p
50 OHMS
Input Impedance
>30 K OHM

Source Impedance

PMI/WB Output

Frequency 1.25 MHz
Level (Factory Adjustable) 0.91VP-1.11VP @ 50 OHMS
Modulation (FM):
  1 KHz Dev. = 4.5 KHz RMS
  3.9 KHz Dev. = 1.97 KHz RMS

FM/TV Output (100 Load)

Frequency D.C. to 2 MHz
Level (Factory Adjustable)
  TV Signal (@ 2 MHz) 1.34 V p-p to 1.64 V p-p
  1.25 VCO Output 0.239V p-p ±10%
  1.25 MHz VCO Modulation (FM) Dev. = 4.5 KHz RMS
1 KHz
3.9 KHz

DEV. = 1.97 KHz RMS

347 MV RMS
81.3 MV RMS
>30 K OHM

1.25 MHz
0.91VP-1.11VP @ 50 OHMS
DOWN-LINK SHAPING FILTER DISTORTION
ENGINEERING MODEL DATA 5-20-70

INPUT: 2VRMS
OUTPUT: AT 700Hz 1.74 VRMS
         AT 7.35kHz 3.23 VRMS

% DIST + NOISE

0.5
0.4
0.3
0.2
0.1

300 Hz  700 Hz  2.3 kHz  7.35 kHz  20 kHz

FREQUENCY
# LCRU Sensor Switch

## Engineering Model Data

<table>
<thead>
<tr>
<th>Temperature (°F)</th>
<th>Thermal Sensor On in Sec.</th>
<th>Voltage Sensor On in Sec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>160</td>
<td>9.35</td>
<td>24.3</td>
</tr>
<tr>
<td>72</td>
<td>9.75</td>
<td>22.0</td>
</tr>
<tr>
<td>32</td>
<td>10.0</td>
<td>23.4</td>
</tr>
<tr>
<td>0</td>
<td>10.1</td>
<td>24.6</td>
</tr>
</tbody>
</table>
TIME SHARE SWITCH CHARACTERISTICS

THERMAL BRIDGE READING 71°C 159.5°F
V.M. READING AT METER OUT = 4.919V

TIME SHARE SENSOR SWITCH
ENGINEERING MODEL VOLTAGE
& THERMAL SENSORS SWITCH
OUTPUTS

TIME BASE ≈ 13 SEC./CM
The sensor switch circuit utilizing the -5.5V power supply was tested for:

1. Signal error caused by switch.
2. Error variation with temp.
3. Effects of alternate signal.

For all combinations of the above operating conditions, the maximum error observed was 0.09%.
ENGINEERING MODEL DATA 5/22/70

METER VOLTAGE IN VOLTS

VERSUS

BATTERY VOLTAGE IN VOLTS

+160°F

0°F
TEMPERATURE SENSOR

METER VOLTS VS. TEMPERATURE

- DESIRED RESPONSE
- CALCULATED NOMINAL RESPONSE
- MAX ERROR DUE TO TOL

DATA TAKEN ON ENGINEERING MODEL 5/22/70

- TEMP 50 °F
- TEMP 100 °F
- TEMP 150 °F

METER LOAD

RL360413 -5400-103
RN50E31618
5K
RN50E5111B
14 V
5 METER LOAD
14.5 KHz VCO
CHARACTERISTICS

LINEARITY
±0.15% OF DBW FROM BSL

DISTORTION
1% MAX

FREQ STABILITY
LINE VOLTAGE VARIATION
±0.25% DBW
TEHP VARIATION
±1.0% DBW
SET-UP
±1.0% DBW

INPUT SIGNAL RANGE
0 TO±5 V DC

INPUT IMPEDANCE
750 K OHM MIN

AMPLITUDE MODULATION
5% MAX

OUTPUT IMPEDANCE
LESS THAN 1000 OHMS

OUTPUT LEVEL
3.0V P-P ±5% INTO 47K OHM LOAD

POWER
10 ±0.1V DC/7 MA MAX

SIZE
2.0 CU IN MAX

WEIGHT
2.0 OUNCES MAX
# 1.25 MHz SCO CHARACTERISTICS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Linearity</strong></td>
<td>± 0.15% from BSL</td>
</tr>
<tr>
<td><strong>Distortion</strong></td>
<td>1% max</td>
</tr>
<tr>
<td><strong>Freq Stability</strong></td>
<td>± 0.25% of 1.25 MHz</td>
</tr>
<tr>
<td><strong>Input Signal Impedance</strong></td>
<td>5000 Ohm ± 10%</td>
</tr>
<tr>
<td><strong>Deviation Sensitivity</strong></td>
<td>Less than 30 pF</td>
</tr>
<tr>
<td><strong>Input Freq Range</strong></td>
<td>300 Hz to 15.6 KHz</td>
</tr>
<tr>
<td><strong>Amplitude Modulation</strong></td>
<td>3% max</td>
</tr>
<tr>
<td><strong>Intermodulation</strong></td>
<td>At least 30 dB below each applied tone</td>
</tr>
<tr>
<td><strong>Freq Response</strong></td>
<td>± 1.0 dB, 300 Hz to 15.6 KHz</td>
</tr>
<tr>
<td>(3.9 KHz REF)</td>
<td>± 0.5 dB, 3.6 KHz to 15.6 KHz</td>
</tr>
<tr>
<td><strong>Output Level Impedance</strong></td>
<td>3.0 VP-P ± 5% into 50 Ohms</td>
</tr>
<tr>
<td><strong>Incidental FM</strong></td>
<td>250 Hz RMS max in any 1 KHz band; 300 Hz to 20 KHz</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>14 ± 0.1 VDC/50 MA max</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>2.0 cu. in. max</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>2.0 ounces max</td>
</tr>
</tbody>
</table>
VHF AM TRANSMITTER (296.8 MHz)

Q2 XTAL OSC. (COLPITS) 4 MW
VHF AM TRANSMITTER (296.8 MHz)
VOX KEY
98.933 MHz
Q3 CLASS A BUF AMP
40 MW
Q4 CLASS C RF AMP
185 MW
VCO X3 MULTI (CURRENT PUMP)
EFF 40%
Q5 DRIVER CLASS C 95 MW
Q6 PA CLASS C 340 MW
700 MW
B.P.F. (0.3dB IL)
650 MW
OUTPUT
HARMONICS - 40dB
DISTORTION 10% MAX
MOD XFMR
2 STAGES AUDIO AMP
VOICE INPUT (300 Hz TO 3 kHz)
2.25 V / 100% AM
+14 VDC 280 MA MAX @ CW
360 MA MAX @ 70% 1 kHz AM

Efficiency 40%
## RCA

**LCRU VHF AM TRANSMITTER**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td></td>
</tr>
<tr>
<td><strong>Operating Frequency</strong></td>
<td>296.8 MHz</td>
</tr>
<tr>
<td><strong>Frequency Stability</strong></td>
<td>±0.003%</td>
</tr>
<tr>
<td>RF Output</td>
<td></td>
</tr>
<tr>
<td><strong>Connector</strong></td>
<td>Sealectro Bulkhead female Rec. 50 - 043 - 0000</td>
</tr>
<tr>
<td><strong>Output Impedance</strong></td>
<td>50 ohms nominal</td>
</tr>
<tr>
<td><strong>OC and SC protection</strong></td>
<td>4 hours no damage</td>
</tr>
<tr>
<td><strong>RF Power (CW)</strong></td>
<td>0.580 watts nominal</td>
</tr>
<tr>
<td><strong>C/N @ 30% AM, 1 KHz in 20 KHz BW</strong></td>
<td>0.500 watts minimum</td>
</tr>
<tr>
<td><strong>Output Control</strong></td>
<td>40 dB min. VOX operated</td>
</tr>
<tr>
<td>AM Modulation</td>
<td></td>
</tr>
<tr>
<td><strong>Percent modulation</strong></td>
<td>70% AM</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>300 Hz to 4.0 KHz</td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
<td>2.25 V/100% AM nominal subject to DTV adjustment</td>
</tr>
<tr>
<td><strong>Input Impedance</strong></td>
<td>10 K ohms nominal, subject to DTV adjustment</td>
</tr>
<tr>
<td><strong>Frequency Response, 1 KHz Ref. @ 300 Hz</strong></td>
<td>±2 dB</td>
</tr>
<tr>
<td><strong>@ 3.0 KHz</strong></td>
<td>±1 dB</td>
</tr>
<tr>
<td><strong>Modulation Linearity</strong></td>
<td>±10% of BSL</td>
</tr>
<tr>
<td><strong>Harmonic Distortion @ 70% AM, 300 Hz-3.0 KHz</strong></td>
<td>10% Max.</td>
</tr>
<tr>
<td>DC Power Requirements</td>
<td></td>
</tr>
<tr>
<td><strong>Input DC Voltage</strong></td>
<td>+14.0 VDC ±0.1 volts</td>
</tr>
<tr>
<td><strong>Input DC current</strong></td>
<td>280 MA Max.</td>
</tr>
<tr>
<td><strong>CW</strong></td>
<td>360 MA Max.</td>
</tr>
<tr>
<td><strong>70%, 1 KHz AM</strong></td>
<td>9.2 cu. in.</td>
</tr>
<tr>
<td>Volume</td>
<td>5.0 x 1.19 x 1.55 in.</td>
</tr>
<tr>
<td><strong>Volume</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Max Design Envelope excluding connectors</strong></td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>8.0 ozs.</td>
</tr>
<tr>
<td><strong>Projected Weight</strong></td>
<td></td>
</tr>
</tbody>
</table>

7-44
# VHF AM TRANSMITTER POWER BUDGET

<table>
<thead>
<tr>
<th>STAGE</th>
<th>RF POWER OUTPUT (CW)</th>
<th>MA</th>
<th>WATTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSC/AMP</td>
<td>40 MW</td>
<td>25</td>
<td>.375</td>
</tr>
<tr>
<td>IPA</td>
<td>100 MW</td>
<td>14</td>
<td>.210</td>
</tr>
<tr>
<td>PA</td>
<td>650 MW</td>
<td>97</td>
<td>1.455</td>
</tr>
<tr>
<td>MODULATOR</td>
<td>-</td>
<td>135</td>
<td>2.025</td>
</tr>
<tr>
<td></td>
<td></td>
<td>271 MA</td>
<td>4.065 W</td>
</tr>
</tbody>
</table>

% EFF (90% AM) = \( \frac{0.915}{4.065} \) = 22.5%
VHF AM TRANSMITTER
(TEMPERATURE CHARACTERISTICS)

POWER OUTPUT VARIATION (dB)

EFFICIENCY (%)

TEMPERATURE DEG. C

TEMPERATURE DEG. F

(560 MW)

POWER OUTPUT

EFF.
VHF AM TRANSMITTER
(MODULATOR CHARACTERISTICS)
VHF AM TRANSMITTER
(OVERALL CHARACTERISTICS)

MODULATION FREQ. (KHz)

OVERALL EFFICIENCY (PERCENT)

PERCENT DISTORTION

Eff.

82% MOD.

50% MOD.

DIST.

0.3 1.0 3.0 10 20
VHF AM TRANSMITTER
(PO VS COLLECTOR VOLTAGE)

TUNED FOR OPTIMUM MODULATION PERFORMANCE

TUNED FOR MAX PO (14 VDC)

(COMPARISON AT +14V CW CONDITION)
<table>
<thead>
<tr>
<th></th>
<th>Temp.</th>
<th>-10°F</th>
<th>+140°F</th>
<th>Room</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Keyer Operation</strong></td>
<td></td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>CHECK</td>
</tr>
<tr>
<td><strong>CA Power Output</strong></td>
<td></td>
<td>720</td>
<td>515</td>
<td>555</td>
<td>500 MW Min.</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td></td>
<td>+3.9</td>
<td>-7.0</td>
<td>-4.0</td>
<td>±9KHz</td>
</tr>
<tr>
<td><strong>DC Current</strong></td>
<td></td>
<td>225</td>
<td>220</td>
<td>229</td>
<td>360MA Max.</td>
</tr>
<tr>
<td><strong>Modulation Linearity</strong></td>
<td></td>
<td>1.33V</td>
<td>1.1V</td>
<td>1.13V</td>
<td>V Reference</td>
</tr>
<tr>
<td></td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>22.5 TO 27.5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>70%</td>
<td>80%</td>
<td>76.5%</td>
<td>67.5 TO 82.5%</td>
<td></td>
</tr>
<tr>
<td><strong>Harmonic Distortion</strong></td>
<td></td>
<td>3%</td>
<td>2.3%</td>
<td>2.8%</td>
<td>10% Max.</td>
</tr>
<tr>
<td>3 KHz</td>
<td></td>
<td>2.9%</td>
<td>2.4%</td>
<td>2.9%</td>
<td>10% Max.</td>
</tr>
<tr>
<td>300 Hz</td>
<td></td>
<td>3.0%</td>
<td>1.8%</td>
<td>2.5%</td>
<td>10% Max.</td>
</tr>
<tr>
<td><strong>Signal to Noise Ratio</strong></td>
<td></td>
<td>-50db</td>
<td>-50db</td>
<td>-50db</td>
<td>-40db Min.</td>
</tr>
<tr>
<td><strong>Freq. Response (3 KHz)</strong></td>
<td></td>
<td>0</td>
<td>+0.3db</td>
<td>0</td>
<td>±1db</td>
</tr>
<tr>
<td><strong>Freq. Response (300 Hz)</strong></td>
<td></td>
<td>-1db</td>
<td>-1.3db</td>
<td>-1.7db</td>
<td>±2 db</td>
</tr>
</tbody>
</table>
REGULATOR, VOLTAGE REDUNDANT

+15.6V to +19.1V

REGULATOR

REGULATOR

REGULATOR

+14V

+10V
VOLTAGE REGULATOR CHARACTERISTICS

TWO 14.0 V REGULATORS IN PARALLEL
TWO 10.0 V REGULATORS IN PARALLEL
DIODE PROTECTION IS PROVIDED TO PREVENT A SHORT AT
THE OUTPUT OF ONE REGULATOR FROM LOADING THE
ASSOCIATED REGULATOR.

INPUT VOLTAGE                     +15.6 V TO +19.1 V
OUTPUT NO. 1
10 ma. - 70 ma. LOAD               +10 V ±0.1 V

OUTPUT NO. 2
250 ma. - 600 ma. LOAD
VOLTS IN
15.8 TO 19.1                       +14 V ±0.1 V
15.6 TO 15.8                       +14 V +0, -0.3 V

SIZE (MINUS MOUNTING FEET)         4.440 x 1.16 x .60
WEIGHT                             0.25 POUNDS
14 VOLT REGULATOR REDUNDANT
ENGINEERING MODEL DATA

VOLTS OUT
VS.
VOLTS IN
(-18°C)

IL = 250 ma
IL = 500 ma
IL = 1000 ma

INPUT VOLTS

OUTPUT VOLTS
14 Volt Regulator Redundant
Engineering Model Data

VOLTS OUT vs.
VOLTS IN
(25°C)

IL = 250 ma
IL = 500 ma
IL = 1000 ma
14 VOLT REGULATOR REDUNDANT
ENGINEERING MODEL DATA

VOLTS OUT VS.
VOLTS IN
(71°C)

INPUT VOLTS

OUTPUT VOLTS

14.2
14.1
14.0
13.9
13.8
13.7
13.6
15 16 17 18 19 20
10 VOLT REGULATOR REDUNDANT
ENGINEERING MODEL DATA

OUTPUT VOLTS
VS.
LOAD CURRENT

REGULATOR OUTPUT IN VOLTS

LOAD CURRENT IN MA

10.2
10.1
10.0
9.9
9.8
9.7

+71°C
ROOM
-18°C

NOM. LOAD

50 100 150 200
UP-LINK SIGNAL PROCESSOR

- Voltage: 34 mV RMS
- Frequency: 1 kHz
- VOX THRESH. @ 1 kHz
- VOX RELEASE TIME 1.0 SEC
- VOX ATTACK TIME 10 MSEC
- VOX KEY
- DC SIGNAL
- TO VHF XMTR

Block Diagram:

1. **From S-Band Receivers**
   - (200 Hz to 3 kHz)
   - 1.5 V RMS
   - 600 OHMS
   - 510 Ω NOM.
   - MATCH NETW
   - XFMR

2. **510 Ω NOM.**
   - MATCH NETW

3. **(300 Hz to 3 kHz)**
   - -3 dBm (Knee)
   - 1.5 V RMS
   - 600 OHMS

4. **34 mV RMS**

5. **AVC AMP**
6. **VOX. GATE**
7. **12 dB CLIP**
8. **FLT.**
9. **MIX AMP.**
10. **TO VHF XMTR**

- AVC RELEASE TIME 15 SEC
- AVC ATTACK TIME 10 MSEC
# UPLINK SIGNAL PROCESSOR CHARACTERISTICS

## AUDIO INPUTS (TWO)

<table>
<thead>
<tr>
<th>Connector</th>
<th>Through terminal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Impedance</td>
<td>630 ohms nominal ±100 ohms</td>
</tr>
<tr>
<td>AF Input Level @ 1000 Hz</td>
<td>1.5 Vrms ±10% @ 600 ohms</td>
</tr>
<tr>
<td>AF Drive Impedance</td>
<td>20 ohms max.</td>
</tr>
<tr>
<td>AF Range</td>
<td>200 Hz to 3.0 KHz</td>
</tr>
<tr>
<td>Max Noise Input</td>
<td>-21 dbm in a 5.0 KHz BW</td>
</tr>
<tr>
<td>Input Attenuation</td>
<td>15 db</td>
</tr>
</tbody>
</table>

## VOX OPERATION

- VOX Threshold, 1 KHz Test Signal: -12 dbm ±1 db @ input
- VOX Release Time: 1 ±0.4 sec. (over temp. limits), 10 msec max.
- AF/VOX Attack Time: 1 ±0.4 sec. (over temp. limits), 10 msec max.

## AF OPERATION

<table>
<thead>
<tr>
<th>Frequency Response</th>
<th>Nominal Clipping</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 Hz</td>
<td>15 sec. ±5 sec.</td>
</tr>
<tr>
<td>3 KHz</td>
<td>-3.0 dbm ±1.0 db @ input</td>
</tr>
<tr>
<td>6 KHz</td>
<td>+20 dbm max. @ input</td>
</tr>
<tr>
<td>1.0 kHz</td>
<td>12 db</td>
</tr>
</tbody>
</table>

## AF OUTPUT

- AF Output Level, Clipped 12 db @ 1 KHz, +6 dbm input: 4.3 ±0.54 Vpp @ 10 K Ohm load (+9 dbm)
- Output Drive Impedance: Approx. 10 ohms, capacity coupled
- Noise Output for VOX Disabled: -35 db below audio
- Output: VOX operated 0 VDC, +12 VDC min.

## DC POWER REQUIREMENTS

- Input DC Voltage: 14 VDC ±0.1 Volts
- Input DC Current: 18 MA max.

## SIZE

- Maximum Design Envelope Excluding Connectors: 2.72 x 2.68 x 1.06 in.
- Volume: 7.72 cu. in.

## WEIGHT

- Estimated Weight: 8.0 ounces
UPLINK SIGNAL PROCESSOR

ACTUAL MEASURED VOX THRESHOLD

AVC "KNEE" SET FOR 12 dB CLIP

MAX NOISE FM RCVR (SPEC LEVEL)

MOD EM-X2 MEASURED DATA

FM RCVR OUTPUT SNR = 26.75 dB

PTT SWITCH "ON" (CORDWOOD TEST POINT)

NOMINAL AUDIO INPUT FROM FM RCVR +5.75 dB (SPEC OUTPUT)

VOX THRESHOLD -12 dB ±1 dB
SET WITH 1 KHz SIGNAL

START CLIPPING @ -15 dB

12 dB CLIPPING

9 dB SAFETY & N_{RMS}/N_{PEAK}
**NOTE:**

1. All capacitor values are in microfarads (µF), unless otherwise indicated.
2. All resistor values are in ohms (±10% tolerance).
3. Semiconductors Device type numbers are for reference only.
4. Value of R12 shall be determined at time of assembly.

**HIGHEST SYMBOL USED**

CH1, CR2, R1, R2, Z1

**UNITED SYMBOLS**

A1, A2

**SCHEMATIC**

This drawing was reidentified from RCA 8057896 Rev A by Photo Method.
UP LINK SIGNAL PROCESSOR TEST SUMMARY

UP LINK SIGNAL PROCESSOR MODULES 8659426, AND 865947 WERE TESTED AS A COMPLETE UNIT AS PER EVCS TEST PROCESS TP 1-8659426. A SUMMARY OF THE TEST RESULTS ARE SHOWN AS FOLLOWS.

AVC RELEASE TIME
10 SEC MIN 20 SEC MAX

VOX RELEASE TIME 1 ±0.1 SEC

AUDIO/VOX ATTACK TIME
LESS THAN 10 MS

AVC THRESHOLD 9 ±1 dbm MAX

VOX THRESHOLD 18 ±1 dbm

HARMONIC DISTORTION 8.0% MAX

FREQUENCY RESPONSE
1000 Hz
300 Hz -1.0 db
3000 Hz -3.0 db
6000 Hz NLT
-3 db

14.8 SECONDS
0.94 SEC
2MS
-9.5 dbm
-17.8 dbm
2.7%
-0.6 db
-1.2 db
-4.4 db
LCRU RECEIVER BLOCK DIAGRAM

RF CONVERTER MODULE

2101.802 MHz

PRE-AMP

FLTR

120.758 MHz

FLTR

10.7 MHz

IF AMPL 1ST DSCRM

2ND DSCRM AUDIO

IF/AUDIO MODULE

1981.044 MHz

X9

110.058 MHz

X2

OSC

220.116 MHz
# FM RECEIVER CHARACTERISTICS

## General
- Frequency: 2101.6-802 MHz
- IF Noise BW: 830 KHz
- LO Stability: ± 0.0027 max.
- LO Output Radiation: -70 dBm max.
- Image Rejection: 60 dB Min.
- Ultimate Rejection: 80 dB
- Sensitivity for 23 dB S/N Quieting: -128 dBW
- Dynamic Range: -180 dBW to -95 dBW
- Max Tolerable RF Input: -30 dBW
- RF Input Impedance: 50 ohms, AMERICAN 2054-0000

## RF Input Signal
- Carrier Modulation: 0.7 radians peak, PM
- Subcarriers: 124 KHz SC Modulation
- 134 KHz SC BW

## Audio Output Signal
- Baseline Output Response: 124 KHz and 70 KHz
- 1.5 VRMS @ 600 OHM LOAD
- 35 Max.
- 26 dB below audio
- Audio Baffle: -130 dBW max, RF Input
- Audio "On": -1 DBM min, noise in Audio Channel
- Audio "Off": 50 mae max.

## Switching Time
- 10 KHz DC Output: 0.7 VRMS @ 10 Kohms Load
- 100 ohms balanced to Gnd.
- 0 to 5.0 volts DC @ 5000 ohm load
- 75% of Total Output
- 63% of change in 0.1 sec.
- 5 dB steps from -130 dBW to
- -95 dBW
- ≤ 1 dB

## DC Power Requirements
- +14 VDC: 0.1 Volts
- (100) MA max
- +14 VDC Prime Power
- Built In

## Size
- 24 CU IN MAX
- 3.15 X 5.26 X 1.04 IN

## Approximate Weight
- 1.3 lb. MAX
LCRU RF CONVERTER
(SCHEMATIC DIAGRAM)
LCRU FM RECEIVER
SIGNAL & NOISE POWER LEVEL DISTRIBUTION
(CALCULATED)
LCRU RECEIVER (THEORETICAL PERFORMANCE)

NOISE FIGURE = 8 DB

- \( B_{SC} = 30 \text{ KHz} \)
- \( B_{LP} = 3 \text{ KHz} \)

- \( B_{IF} = 410 \text{ KHz} \)
- \( B_{IF} = 800 \text{ KHz} \)

(S/N)\(_0\) VOICE

(S/N)\(_{SUBCARRIER}\)
IF FILTER BANDWIDTH ANALYSIS

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATA BW 2 X 124 + 2 X 7.5</td>
<td>263 KHz</td>
</tr>
<tr>
<td>RECEIVED SIGNAL UNCERTAINTY ±0015%</td>
<td>63 KHz</td>
</tr>
<tr>
<td>LOCAL OSCILLATOR UNCERTAINTY (INCLUDING AGING)</td>
<td>90 KHz</td>
</tr>
<tr>
<td>FILTER UNCERTAINTY ±30 KHz</td>
<td>60 KHz</td>
</tr>
<tr>
<td>TOTAL BANDWIDTH REQUIRED</td>
<td>476 KHz</td>
</tr>
<tr>
<td>NOISE BANDWIDTH</td>
<td>530 KHz</td>
</tr>
</tbody>
</table>
RCA AUDIO DEMODULATOR FREQUENCY RESPONSE
ACTIVE 5 KHz LOW PASS FILTER

![Graph showing frequency response of an active 5 KHz low pass filter. The frequency axis ranges from 100 Hz to 100,000 Hz, and the gain response is plotted in dB. The graph indicates a cutoff frequency of 5 KHz.](image)
HARMONIC DISTORTION OF AUDIO AMPLIFIER

% AUDIO DISTORTION

FREQUENCY (Hz)

RCVR OUTPUT 5 V PK-PK
RCVR OUTPUT 4 V PK-PK
RCVR OUTPUT 2.5 V PK-PK
# FM/PM Transmitter Characteristics

## Frequency

**Operating Frequency**<br>2272.5 MHz<br>**Frequency Stability, Either Modulator, one year**<br>0.003% (FM), ± 0.02% (PM)<br>**RF Bandwidth**<br>(15 MHz min.)

## RF Output

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Connector</td>
<td>MOD AMERICAN 2054-0000</td>
</tr>
<tr>
<td>Output Impedance</td>
<td>50 ohms nominal</td>
</tr>
<tr>
<td>Output VSWR</td>
<td>1.3 to 1</td>
</tr>
<tr>
<td>RF power</td>
<td>10 watts (8.4 watts minimum)</td>
</tr>
</tbody>
</table>

## R-Band Modulators

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>FM Modulation</td>
<td>+ 2.5 MHz peak</td>
</tr>
<tr>
<td>Connector</td>
<td>SELECTRO 50-075-0018</td>
</tr>
<tr>
<td>Range</td>
<td>DC - 3 MHz</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>2.0 MHz/Volt peak ± 10%</td>
</tr>
<tr>
<td>Input</td>
<td>100 ohms ± 10% + 30 pf max.</td>
</tr>
<tr>
<td>Nominal DC Input</td>
<td>DC Coupled</td>
</tr>
<tr>
<td>Incidental AM</td>
<td>(+2 Volts DC)</td>
</tr>
<tr>
<td>Incidental FM, Max. Noise Density</td>
<td>5% max.</td>
</tr>
<tr>
<td>Incidental FM, Total</td>
<td>1 KHz rms/200 Hz</td>
</tr>
<tr>
<td>2 Tone IM @ 2.5 Mils Combined Deviation</td>
<td>5 KHz rms</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>34 dB min.</td>
</tr>
<tr>
<td>Deviation Linearity</td>
<td>± 1 dB DC - 3 MHz</td>
</tr>
<tr>
<td>Harmonic Distortion</td>
<td>3% up to 2.5 MHz Dev.</td>
</tr>
<tr>
<td>PM Modulation</td>
<td>2%</td>
</tr>
<tr>
<td>Connector</td>
<td>2 rad peak</td>
</tr>
<tr>
<td>Range</td>
<td>SELECTRO 50-075-0019</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>200 Hz - 20 KHz</td>
</tr>
<tr>
<td>Input Impedance</td>
<td>2 rad/volt ± 10% up to 2 radians peak</td>
</tr>
<tr>
<td>Phase Noise</td>
<td>1000 ohms ± 10% + 30 pf max.</td>
</tr>
<tr>
<td>Incidental AM</td>
<td>4° rms non vibrating</td>
</tr>
<tr>
<td>2 Tone IM @ 2.5 Rad Combined Deviation</td>
<td>5% Max.</td>
</tr>
<tr>
<td>Power Supply</td>
<td>26 dB min.</td>
</tr>
<tr>
<td>Power Supply Voltage</td>
<td>27 - 33 VDC, 29 VDC Nominal</td>
</tr>
<tr>
<td>DC Current Requirement</td>
<td>1.85A max.</td>
</tr>
<tr>
<td>FM/PM Modulator Control</td>
<td>Prime Power, 29 VDC, 10 Mt Max</td>
</tr>
<tr>
<td>REVERSED POLARITY PROTECTION</td>
<td>INCLUDED IN UNIT</td>
</tr>
<tr>
<td>Volume</td>
<td>41.5 cubic inches max.</td>
</tr>
<tr>
<td>Weight</td>
<td>42 oz max.</td>
</tr>
</tbody>
</table>
### PM/PM Transmitter Characteristics

<table>
<thead>
<tr>
<th>Category</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>2272.5 MHz</td>
</tr>
<tr>
<td>Operating Frequency</td>
<td>0.003%</td>
</tr>
<tr>
<td>Frequency Stability, One year</td>
<td>18 MHz min.</td>
</tr>
<tr>
<td>RF Output</td>
<td></td>
</tr>
<tr>
<td>Connector</td>
<td>MOD AMERICAN 2054-0000</td>
</tr>
<tr>
<td>Output Impedance</td>
<td>50 ohms nominal</td>
</tr>
<tr>
<td>Output VSWR</td>
<td>1.3 to 1</td>
</tr>
<tr>
<td>RF Power</td>
<td>5.0 watts (6.6 watts min.)</td>
</tr>
<tr>
<td>Incidental AM</td>
<td>5% max.</td>
</tr>
<tr>
<td>NR-PM Modulation Connector</td>
<td>SELLACTRO 50-073-0019</td>
</tr>
<tr>
<td>Range</td>
<td>200 Hz - 20 KHz</td>
</tr>
<tr>
<td>Modulation Sensitivity</td>
<td>2 Radians/Volt peak + 10% up to 2 radians peak</td>
</tr>
<tr>
<td>Input Impedance</td>
<td>1000 ohms + 10%, 30 pf max.</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>± 0.5 dB, 200-20000 Hz</td>
</tr>
<tr>
<td>Deviation Linearity</td>
<td>3% up to 2.5 radians peak</td>
</tr>
<tr>
<td>Phase Noise</td>
<td>4° rms non-vibration</td>
</tr>
<tr>
<td>2 Tone IM @ 2.5 rad. Combined Deviation</td>
<td>26 dB min.</td>
</tr>
<tr>
<td>WB-PM Modulation Connector</td>
<td>SELLACTRO 50-073-0019</td>
</tr>
<tr>
<td>Range</td>
<td>1.19 MHz to 1.31 MHz</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>± 0.5 dB 1.19-1.31 MHz</td>
</tr>
<tr>
<td>Deviation Linearity</td>
<td>3% up to 2.0 radians peak</td>
</tr>
<tr>
<td>Input Impedance</td>
<td>50 ohms + 10%, 30 pf max.</td>
</tr>
<tr>
<td>Modulation Sensitivity</td>
<td>1.85 radians/volt + 10% up to 2 radians peak</td>
</tr>
<tr>
<td>2 Tone IM @ 2.0 Rad. dev. in 200-20000Hz Band</td>
<td>40 dB min.</td>
</tr>
<tr>
<td>Phase Noise</td>
<td>4° rms non-vibrating</td>
</tr>
<tr>
<td>Power Supply</td>
<td>27 - 33 VDC, 29 VDC nominal</td>
</tr>
<tr>
<td>Power Supply Voltage</td>
<td>1.65 Amp max.</td>
</tr>
<tr>
<td>DC Current Requirement</td>
<td>Prime Power, 29 VDC, 10 Ma max.</td>
</tr>
<tr>
<td>Modulator Control</td>
<td>Included in Unit</td>
</tr>
<tr>
<td>Reversed Polarity Protection</td>
<td>44.5 cu in max.</td>
</tr>
<tr>
<td>Volume</td>
<td>42 oz. max.</td>
</tr>
</tbody>
</table>
FM-PM TRANSMITTER

-20 0 20 40 60 80 100 120 140 160
TEMPERATURE (°F)

7 8 9 10
RF POUT (W)

0°F TEMP. LIMIT (VENDOR SPEC)
SPEC LIMIT 8.4W MIN.

160°F TEMP. LIMIT (VENDOR)
SPEC LIMIT 8.4W MIN.

34 MW 378.75 MHz INPUT
26 VDC = CONST

P_{OUT} \text{ MAX} = 9.8 \text{ W}
REQUIRED THERMAL RESISTANCE OF 2N5921

Eps = 26 VDC
\( \eta_{PA\ HOT} = 36.3\% \)
\( \theta_{CHASSIS} = 2.2 \degree C/W \)

TRANSMITTER DESIGN INCL.
0.3 dB ATP LOSS
0.6 dB ISO + LPF + COMB.

**RCA SOMERVILLE SCREENING LIMITS (DC HEAT)**

**COLLECTOR COOLING LIM**

PM/PM XMTR SPEC POUT

+49 \degree C
+63 \degree C
+120 \degree F COOLING PLATE TEMP
+145 \degree F
+160 \degree F

**VENDOR SCREENING RANGE (RF HEATING)**

CURVES USE
\( T_{PA} = +70 \degree C \)
\( T_{j} = +150 \degree C \) MAX

**TRANSMITTER POWER OUTPUT (W)**
NOTES ON 2N5921 (TA7205) THERMAL RESISTANCE REQUIREMENTS

- 2N5921 IS SOLD COMMERCIAL WITH A SPECIFIED THERMAL RESISTANCE OF 12° C/W.
- RCA SOMERVILLE CAN PERFORM ADDITIONAL SCREENING REDUCING THERMAL RESISTANCE TO 10° C/W.
- IF COLLECTOR COOLING IS EMPLOYED, THERMAL RESISTANCE CAN BE REDUCED FURTHER TO 9.5° C/W.
- THE ABOVE THERMAL RESISTANCE VALUES ARE BASED UPON MEASUREMENTS USING DC HEATING; THESE VALUES INCLUDE SAFETY FACTOR.

- DISPLAYED CURVES USE A CONSERVATIVE THERMAL RESISTANCE FOR THE CHASSIS = 2.2° C/W; CONIC THERMAL ANALYSIS = 1.2° C/W.
- XMTR DESIGN REQUIRES A 2N5921 TRANSISTOR WITH A THERMAL RESISTANCE OF 6.4° C/W MAXIMUM, IF COOLING PLATE DOES NOT EXCEED 133° F.
- CONIC DATA SHOWS THAT 2 TRANSISTORS OUT OF 11 MEASURED DO MEET LCRU THERMAL REQUIREMENTS.
- CONIC IS CAPABLE OF PERFORMING R.F. HEATING SCREENING TO FIND THERMAL RESISTANCES BETTER THAN 6.4° C/W.
- TRANSMITTER DESIGN IS FEASIBLE PROVIDED TRANSISTOR SCREENING WITH R.F. HEATING IS EMPLOYED.
S-BAND DIPLEXER CHARACTERISTICS

Frequencies and Loss

Receiver Arm

Loss \( f_R \)

\((f_R \pm 7.5 \text{ MHz})\)

Transmitter Arm

Loss \( f_T \)

\((f_T \pm 7.5 \text{ MHz})\)

VSWR (all pass bands)

POWER - Receiver Arm

Transmitter Arm

Isolation

Transmitter Port to Receiver Port:

\((f_R - 247.5 \text{ MHz}) \text{ to } (f_R - 232.5 \text{ MHz})\)

\((f_R - 7.5 \text{ MHz}) \text{ to } (f_R + 7.5 \text{ MHz})\)

\((f_T - 7.5 \text{ MHz}) \text{ to } (f_T + 7.5 \text{ MHz})\)

VOLUME

18 cu. in. max.

WEIGHT

12 oz. max.

2101.8 MHz \pm 7.5 MHz

0.85 dB max

1.0 dB max

2277.5 MHz \pm 7.5 MHz

0.60 dB max

0.70 dB max

1.3 max

0.5 Watt

15 Watts
## S Band Diplexer
### (STE Units)

#### Measured Insertion Loss

<table>
<thead>
<tr>
<th>S/N Freq (MHz)</th>
<th>SPEC</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21</th>
</tr>
</thead>
<tbody>
<tr>
<td>2094.3</td>
<td>1.0</td>
<td>0.65</td>
<td>0.60</td>
<td>0.65</td>
<td>0.65</td>
<td>0.60</td>
</tr>
<tr>
<td>2101.8</td>
<td>0.85</td>
<td>0.65</td>
<td>0.60</td>
<td>0.65</td>
<td>0.65</td>
<td>0.60</td>
</tr>
<tr>
<td>2109.3</td>
<td>1.0</td>
<td>0.65</td>
<td>0.60</td>
<td>0.65</td>
<td>0.65</td>
<td>0.60</td>
</tr>
<tr>
<td>2264.0</td>
<td>0.7</td>
<td>0.40</td>
<td>0.40</td>
<td>0.40</td>
<td>0.45</td>
<td>0.40</td>
</tr>
<tr>
<td>2272.5</td>
<td>0.60</td>
<td>0.40</td>
<td>0.40</td>
<td>0.40</td>
<td>0.45</td>
<td>0.40</td>
</tr>
<tr>
<td>2280.0</td>
<td>0.7</td>
<td>0.45</td>
<td>0.45</td>
<td>0.40</td>
<td>0.45</td>
<td>0.45</td>
</tr>
</tbody>
</table>
UHF ANTENNA CHARACTERISTICS
(MODIFIED EVCS ANTENNA)

VERTICAL MONOPOLE BLADE

<table>
<thead>
<tr>
<th>TYPE</th>
<th>OPERATING FREQ</th>
<th>VSWR AT 259.7 MHz</th>
<th>296.8 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>259.7 AND 296.8 MHz</td>
<td>1.25 MAX</td>
<td>2.30 MAX</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FREQ</th>
<th>ELEV ANGLE</th>
<th>GAIN (MIN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>259.7 MHz</td>
<td>PEAK (45 DEG TYP)</td>
<td>-0.5 db</td>
</tr>
<tr>
<td>259.7 MHz</td>
<td>90 DEG</td>
<td>-3.0 db</td>
</tr>
<tr>
<td>296.8 MHz</td>
<td>PEAK (48 DEG TYP)</td>
<td>-1.0 db</td>
</tr>
<tr>
<td>296.8 MHz</td>
<td>90 DEG</td>
<td>-5.0 db</td>
</tr>
</tbody>
</table>

▷ GAIN INCLUDES 1 db TOL FOR MEASUREMENT ERRORS

POWER CAPABILITY: 500 MW MIN
POLARIZATION: VERTICAL
CABLE: RG1428/U
CONNECTOR: GREYMAR 10743
MFG/PART NO.: MOTOROLA 85-25933K03
WEIGHT (INCLUDES CABLE/CONN): 4.0 OZ-MAX
RCA

PLSS VHF ANTENNA
ELECTRICAL TUNING AND PERFORMANCE VERIFICATION TEST

for the

APOLLO BACK PACK (FLSS/OPS) ANTENNA SYSTEM

PART NO. SV-713932

Prepared by

G. H. Nelson

Approved by

D. S. Eagles, Head
Antenna Systems Section

Approved by

E. L. Chioine, Chief
Electromagnetic Systems Branch

Approved by

R. A. Tremant, Subsystem Manager
for CSM Crew Equipment Communications

Approved by

NC32/Quality Engineering

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Manned Spacecraft Center
February 1969
## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>PAGE</th>
<th>PARAGRAPH</th>
<th>SUBJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>I</td>
<td>PURPOSE</td>
</tr>
<tr>
<td>2</td>
<td>II</td>
<td>SCOPE</td>
</tr>
<tr>
<td>2</td>
<td>III</td>
<td>PERSONNEL</td>
</tr>
<tr>
<td>3</td>
<td>IV</td>
<td>EQUIPMENT</td>
</tr>
<tr>
<td>3</td>
<td>V</td>
<td>PROCEDURE</td>
</tr>
<tr>
<td>3</td>
<td>Va</td>
<td>TUNING AND VSWR MEASUREMENTS</td>
</tr>
<tr>
<td>4</td>
<td>Vb</td>
<td>RADIATED POWER MEASUREMENT</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>FIGURES 1 and 2</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>PROCEDURE DEVIATION SHEET</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>REVISION SHEET</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>DATA SHEET</td>
</tr>
</tbody>
</table>

7-92
I. PURPOSE

The purpose of this test is to tune the antenna and then verify the electrical performance of the Apollo back pack antenna system, part no. SV-713932, with its mounting on the Portable Life Support System/Oxygen Purge System (PLSS/OPS).

II. SCOPE

This test includes tuning the antenna and a VSWR and radiated power measurements.

III. PERSONNEL

a. NASA Test Conductor

b. Receiver Operator

c. Quality Assurance Representative

IV. EQUIPMENT

The following equipment is a minimum requirement and should be an exact or equivalent.

<table>
<thead>
<tr>
<th>NAME</th>
<th>MANUFACTURER</th>
<th>MODEL NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal Generator</td>
<td>HP</td>
<td>6006</td>
</tr>
<tr>
<td>SWR Meter</td>
<td>PRD</td>
<td>277B</td>
</tr>
<tr>
<td>Receiver</td>
<td>Stoddart</td>
<td>NF105</td>
</tr>
<tr>
<td>Shunted Line</td>
<td>Alford</td>
<td>21BIA6</td>
</tr>
<tr>
<td>Reference Dipoles</td>
<td>Empire</td>
<td>T2</td>
</tr>
</tbody>
</table>
V. PROCEDURE

a. Tuning and VSWR Measurements

(1) Use test setup as shown in Figure 1

(2) Turn on equipment, allow 30 minutes warmup, and connect back pack antenna to slotted line.

(3) Adjust signal generator to frequency of 299.7 Mc, 40.5 Mc and 1000 cyc. modulation

(4) Adjust slotted line carriage until a maximum is reached on the SWR meter.

(5) Set maximum level to 1.0 on SWR meter.

(6) Adjust carriage to a minimum level on SWR meter and read VSWR

(7) Adjust signal generator to 296.8 Mc, 40.5 Mc, and 1000 cyc. modulation.

(8) Repeat steps 4, 5, and 6

(9) If it is determined that antenna needs tuning:

(a) use test setup in Figure 1

(b) trim a small amount from antenna top maintaining round edges.

(10) Repeat steps 3 through 8.

(11) Repeat steps 3 through 10 until a VSWR of no more than 2.0:1 is met at both frequencies. RECORD data at 299.7 Mc and 296.8 Mc.

b. Radiated Power Measurement

(1) Use test setup as shown in Figure 2.
(2) Connect a vertically polarized reference dipole to signal generator and adjust to 259.7 Mc, ±0.5 Mc, and 0 dbm power level.

(3) Connect a vertically polarized reference dipole to receiver. RECORD RF level in db.

(4) Substitute the backpack antenna for the dipole at the signal generator. RECORD RF level in db.

(5) Substitute the dipole for the backpack antenna at the signal generator and adjust to 296.8 Mc, ±0.5 Mc, and 0 dbm power level.

(6) Repeat Step 3

(7) Repeat Step 4

(8) Disconnect back pack antenna from equipment.
FIGURE 1 - Tuning and VSWR Measurement Setup

FIGURE 2 - Radiated Power Measurement Setup
PROCEDURE DEVIATION SHEET

Any deviations from this procedure shall be approved by NASA cognizant engineer and NASA Quality Engineering Office.

<table>
<thead>
<tr>
<th>PARAGRAPH</th>
<th>DEVIATION</th>
<th>ENGR. INITIAL</th>
<th>DATE &amp; QS STAMP</th>
</tr>
</thead>
</table>
all__________ VSWR, no more than 2.0:1 @ 259.7 Mc
all__________ VSWR, no more than 2.0:1 @ 296.8 Mc
b3 Ref. Dipole ___________ db @ 259.7 Mc
b4 Back pack antenna ________ db, no more than -8.5 db from Step b3
b6 Reference dipole ___________ db @ 296.8 Mc
b7 Back pack antenna__________ db, no more than -8.5 db from Step b6

TEST EQUIPMENT USED

<table>
<thead>
<tr>
<th>NAME</th>
<th>SERIAL NUMBER</th>
<th>CAL. DUE DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PES S/N__________________________
OIES S/N________________________
Antenna S/N_____________________
Test Date_______________________
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Band Transmit Receive</td>
<td>2272.5 MHz ±10 MHz 2101.802 MHz ±10 MHz</td>
</tr>
<tr>
<td>VSWR Transmit Receive</td>
<td>1.5 MAX 2.0 MAX</td>
</tr>
<tr>
<td>Axial Ratio</td>
<td>2.0 db ON AXIS 4 db MAX ±30 DEG OF AXIS</td>
</tr>
<tr>
<td>Power Capability</td>
<td>15 Watts</td>
</tr>
<tr>
<td>Connector Type</td>
<td>TNC</td>
</tr>
<tr>
<td>Gain AT 2272.5 MHz AT 2101.802 MHz</td>
<td>6.5 db MIN ±30 DEG 6.0 db MIN ±30 DEG -5 db MIN ±57.5 DEG ±3 DEG FOR 60 DEG CONE ±5 DEG FOR 115 DEG CONE MORE THAN 12 db BELOW MAIN</td>
</tr>
<tr>
<td>Electrical Axis Relative To</td>
<td>Weight</td>
</tr>
<tr>
<td>Mechanical Axis</td>
<td>0.82 POUNDS MAX 9.5 IN MAX VERT/5.2 IN MAX HOR</td>
</tr>
<tr>
<td>Sidelobe Level</td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td></td>
</tr>
</tbody>
</table>
### S Band Low Gain Antenna

**Measured Data**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Gain at 60 Deg BW</th>
<th>Gain at 115 Deg BW</th>
<th>Boresight Error at 60 Deg BW</th>
<th>Boresight Error at 115 Deg BW</th>
<th>Axial Ratio on Axis ±30 Deg</th>
</tr>
</thead>
<tbody>
<tr>
<td>2272 MHz</td>
<td>6.9 db</td>
<td>N/A</td>
<td>-3 Deg</td>
<td>-3 Deg</td>
<td>0.8 db</td>
</tr>
<tr>
<td></td>
<td>N/A</td>
<td>N/A</td>
<td>±3 Deg MAX</td>
<td>±5 Deg MAX</td>
<td>3.0 db</td>
</tr>
<tr>
<td>2101 MHz</td>
<td>6.5 db MIN</td>
<td>6.8 db</td>
<td>-4.1 db</td>
<td>-5.0 db MIN</td>
<td>2.0 db MAX</td>
</tr>
<tr>
<td></td>
<td>1.0 db</td>
<td>2.8 db</td>
<td>4.0 db MAX</td>
<td>4.0 db MAX</td>
<td></td>
</tr>
</tbody>
</table>
FR = 2101
CIRCULAR POLARIZATION
S BAND LOW GAIN ANTENNA
$F_T = 2272 \text{ MHz}$

CIRCULAR POLARIZATION

S - BAND LOW GAIN ANTENNA
<table>
<thead>
<tr>
<th>BATTERY CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VOLTAGE:</strong> 29V (\pm 4) TAP AT 16.8V (\pm 2.3)</td>
</tr>
<tr>
<td><strong>PEAK VOLTAGE:</strong> 35.10V MIN 24 HRS AFTER ACTIVATION</td>
</tr>
<tr>
<td><strong>RATING</strong></td>
</tr>
<tr>
<td><strong>NOM VOLTAGE</strong></td>
</tr>
<tr>
<td><strong>NOM CURRENT</strong></td>
</tr>
<tr>
<td><strong>NOM POWER</strong></td>
</tr>
<tr>
<td><strong>CAPACITY</strong></td>
</tr>
<tr>
<td><strong>AMB PRESSURE DRY</strong></td>
</tr>
<tr>
<td><strong>ACTIVATED</strong></td>
</tr>
<tr>
<td><strong>OPERATING TEMP</strong></td>
</tr>
<tr>
<td><strong>STORAGE DURATION DRY</strong></td>
</tr>
<tr>
<td><strong>ACTIVATED</strong></td>
</tr>
<tr>
<td><strong>CONNECTOR TYPE</strong></td>
</tr>
<tr>
<td><strong>SIZE</strong></td>
</tr>
<tr>
<td><strong>WEIGHT (WET)</strong></td>
</tr>
</tbody>
</table>
YARDNEY PM5-13 CELL
VOLTAGE VS TIME

DISCHARGE RATE
1.66 AMP 1st 15 MIN
2.75 AMP TO CUTOFF (1.42V)
PLATEAU VOLTAGE CHANGE VS TEMP.
PM 5-13 CELL

TEMP. °F

CELL VOLTAGE
CELL CAPACITY AND DIP VOLTAGE vs. TEMPERATURE

DATA TAKEN FROM PM5-13 CELLS DISCH. AT +50°F AND +90°F INVERTED AFTER 12 DAY WET STAND.

% DIFF: +90°F TO PROJECTED +30°F
a) OUTPUT CAPACITY: 14.1% LOWER
b) DIP VOLTAGE: 6.9% LOWER

NOTE:
DIP VOLTAGE ONLY SHOWN
PLATEAU AT 50°F AND 90°F IS 1.50 V/C AND 1.52 V/C

AMPERE HOUR OUTPUT TO 1.45V/C CUT-OFF
(MINIMUM VOLTAGE AT 3.45 A LOAD) (ON PER CELL BASIS)
BATTERY SECTION A CELL VOLTAGE

OPEN CIRCUIT VOLTAGE

2.33A - 1.51V
3.16A - 1.50V

TIME (HOURS)

CELL VOLTAGE
BATTERY SECTION B CELL VOLTAGE

OPEN CIRCUIT VOLTAGE

2.49A - 1.51V
1.66A - 1.50V

CELL VOLTAGE

TIME (HOURS)
BATTERY HEAT GENERATOR VS TIME

TIME (HRS)

CELL HEAT GENERATED (BTU)

SECTION A  X  11 CELLS
SECTION B  O  8 CELLS

0  10  20  30  40  50  60  70  80  90  100  110  120  130  140  150
HEAT GENERATOR VS TIME FULL BATTERY

- HEAT GENERATED (BTU)
  - 200
  - 190
  - 180
  - 170
  - 160
  - 150
  - 140
  - 130
  - 120
  - 110
  - 100
  - 90
  - 80
  - 70
  - 60
  - 50
  - 40
  - 30
  - 20
  - 10
  - 0

- TIME (HOURS)
  - 0
  - 1
  - 2
  - 3
  - 4
  - 5
  - 6

- 2.75 AMPS - 11 CELLS
- 1.55 AMPS - 8 CELLS

400WH
Problem: Determine temperature profile of LCRU battery at 6 hour of constant operation.

Method of Attack:

1) Determine heat generation for cells during discharge.
   See Table I

2) Determine thermal conductivity through cell A-back cell pad.

3) Determine thermal conductivity through cell B-front cell pad.

4) Determine thermal conductivity through heating element and cold plate (20% maximum).

5) Calculate heating temperature profile at 6 hours.
   a) Assume heating temperature is linear throughout.
   b) Determine heat transfer coefficient on the side of heating.
   c) Calculate heating temperature for the heating element.
   d) Use a table to determine the cooling temperature.
   e) Calculate the final temperature of the heating element.

6) Discuss effect of thermal profile at 6 hours. See Fig. 3
<table>
<thead>
<tr>
<th>T</th>
<th>SECT.</th>
<th>SECT.</th>
<th>SECT.</th>
<th>SECT.</th>
<th>SECT.</th>
<th>SECT.</th>
<th>SECT.</th>
<th>SECT.</th>
<th>SECT.</th>
<th>SECT.</th>
<th>SECT.</th>
<th>SECT.</th>
<th>SECT.</th>
<th>SECT.</th>
<th>SECT.</th>
<th>SECT.</th>
<th>SECT.</th>
<th>SECT.</th>
<th>SECT.</th>
<th>SECT.</th>
<th>SECT.</th>
<th>BATT.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>V</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>V</td>
<td>A</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1.25</td>
<td>1.563</td>
<td>1.583</td>
<td>1.525</td>
<td>1.675</td>
<td>2.025</td>
<td>2.063</td>
<td>2.052</td>
<td>1.675</td>
<td>2.025</td>
<td>2.063</td>
<td>2.052</td>
<td>2.025</td>
<td>1.675</td>
<td>1.525</td>
<td>1.563</td>
<td>1.583</td>
<td>1.525</td>
<td>1.675</td>
<td>2.025</td>
<td>2.063</td>
<td>2.052</td>
</tr>
<tr>
<td>3</td>
<td>1.25</td>
<td>1.563</td>
<td>1.583</td>
<td>1.525</td>
<td>1.675</td>
<td>2.025</td>
<td>2.063</td>
<td>2.052</td>
<td>1.675</td>
<td>2.025</td>
<td>2.063</td>
<td>2.052</td>
<td>2.025</td>
<td>1.675</td>
<td>1.525</td>
<td>1.563</td>
<td>1.583</td>
<td>1.525</td>
<td>1.675</td>
<td>2.025</td>
<td>2.063</td>
<td>2.052</td>
</tr>
<tr>
<td>4</td>
<td>1.25</td>
<td>1.563</td>
<td>1.583</td>
<td>1.525</td>
<td>1.675</td>
<td>2.025</td>
<td>2.063</td>
<td>2.052</td>
<td>1.675</td>
<td>2.025</td>
<td>2.063</td>
<td>2.052</td>
<td>2.025</td>
<td>1.675</td>
<td>1.525</td>
<td>1.563</td>
<td>1.583</td>
<td>1.525</td>
<td>1.675</td>
<td>2.025</td>
<td>2.063</td>
<td>2.052</td>
</tr>
<tr>
<td>5</td>
<td>1.25</td>
<td>1.563</td>
<td>1.583</td>
<td>1.525</td>
<td>1.675</td>
<td>2.025</td>
<td>2.063</td>
<td>2.052</td>
<td>1.675</td>
<td>2.025</td>
<td>2.063</td>
<td>2.052</td>
<td>2.025</td>
<td>1.675</td>
<td>1.525</td>
<td>1.563</td>
<td>1.583</td>
<td>1.525</td>
<td>1.675</td>
<td>2.025</td>
<td>2.063</td>
<td>2.052</td>
</tr>
<tr>
<td>6</td>
<td>1.25</td>
<td>1.563</td>
<td>1.583</td>
<td>1.525</td>
<td>1.675</td>
<td>2.025</td>
<td>2.063</td>
<td>2.052</td>
<td>1.675</td>
<td>2.025</td>
<td>2.063</td>
<td>2.052</td>
<td>2.025</td>
<td>1.675</td>
<td>1.525</td>
<td>1.563</td>
<td>1.583</td>
<td>1.525</td>
<td>1.675</td>
<td>2.025</td>
<td>2.063</td>
<td>2.052</td>
</tr>
</tbody>
</table>

**HEAT GENERATION LCU BATTERY**

**TABLE I**
Conductance Through Cell A

**Basis:** 1 cell, conductance through 1/4 cell

Heat Flows A A - Conductance Paths:

1) Cell wall: \(0.75 \times 2.50 \times 0.00\) \(\text{in} \times \text{in} \times \text{in}^2\)  
2) Length of RH: \(0.62 \times 1.75 \times 0.00\) \(\text{in} \times \text{in} \times \text{in}^2\)

3) Parallel:

- 24 layers C-19  
- 12 layers P-3  
- 2 cell walls (avg)  
- 1 cell core  
- 1 cell bottom  

Conductance Through cell:

\[
\frac{1}{U_e} = \frac{1}{U_{\text{wall}}} + \frac{1}{U_{\text{RH}}} + \frac{1}{U_2}
\]

\[
U = \frac{KA}{L}
\]

\[
U_{\text{wall}} = \frac{(0.75 \times 0.75 \times 2.50 \times 0.12)}{(0.00 \times 0.00 \times 144)} = 0.89 \text{ Btu} \text{/in} \times \text{hr} \times \text{F}
\]

\[
U_{\text{RH}} = \frac{(0.3 \times 0.25 \times 0.75)}{(0.06 \times 0.12)} = 4.55 \text{ Btu} \text{/in} \times \text{hr} \times \text{F}
\]

\[
U_2 = 6U_e + 24U_{\text{cell}} + 12U_{\text{P-3}} + 2U_{\text{wall}} + 10U_{\text{core}} + 10U_{\text{bottom}}
\]

\[
U_+ = \frac{(24 \times 0.01 \times 1.75)}{(0.86 \times 0.12)} = 0.72 \text{ Btu} \text{/in} \times \text{hr} \times \text{F}
\]
\[ T U_e = 6 U_{2n} + 7 U_{c0} \]

- \[ U_{2n} = \frac{(65 \times 0.15 \times 1.78)}{(89 \times 12)} = 0.162 \]
- \[ U_{c0} = \frac{(320 \times 0.002 \times 1.78)}{(89 \times 12)} = 0.73 \]
- \[ T U_e = (6 \times 0.162) + (7 \times 0.73) = 0.97 + 5.1 = 1.48 \text{ Btu/h, } ^\circ\text{F} \]

- \[ U_{c19} = \frac{(3 \times 2.06 \times 0.003)}{(9 \times 12)} = 0.00017 \]
- \[ U_{p.2} = \frac{(3 \times 2.06 \times 0.002)}{(9 \times 12)} = 0.00017 \]
- \[ U_{w-\text{wet}} = \frac{(0.725 \times 3.55 \times 0.006)}{(10 \times 12)} = 0.0091 \]
- \[ U_{w-\text{dry}} = \frac{(0.725 \times 3.55 \times 0.006)}{(10 \times 12)} = 0.0092 \]
- \[ U_{o.1} = \frac{(6 \times 0.725)}{(10 \times 12)} = 0.432 \]
- \[ T U_e = \frac{(24 \times 0.0007)}{(10 \times 0.0017)} + 0.0041 \]
- \[ U_{p.1} = \frac{(2 \times 0.0007)}{(10 \times 0.0017)} = 0.0026 \]
- \[ U_{w-\text{wet}} = \frac{(2 \times 0.0091)}{(10 \times 12)} = 0.0027 \]
- \[ U_{w-\text{dry}} = \frac{(2 \times 0.0091)}{(10 \times 12)} = 0.0027 \]
- \[ U = \frac{5.8250}{1.189 + 0.438 + 5.82} = 5.3 + 2.2 + 1.7 = 7.67 \]

- \[ U_e = \frac{1}{7.67} = 0.130 \text{ Btu/h, } ^\circ\text{F} \text{ (for } \frac{4}{5} \text{ of total cell length)} \]
Conductance through Cell B

Basic 1 cell

Conductance through Cell B - B

\[
\frac{1}{U_{BB}} = \frac{1}{U_{\text{well side}}} + \frac{1}{U_4 + 2U_{\text{cell membr}} + U_{\text{air}} + U_{\text{air}}}
\]

\[
\frac{1}{U_4} = \frac{1}{U_{\text{cln}}} + \frac{1}{U_{\text{air}}} + \frac{1}{U_{\text{air}}} + \frac{1}{U_{\text{air}}}
\]

\[
U_{\text{well side}} = \frac{(0.725 \times 2.0 \times 12)}{(0.6 \times 12)} = 5.02 \text{ ft}
\]

\[
U_{\text{cln}} = \frac{(3 \times 2.05 \times 1.65)}{(0.2 \times 12)} = 1.36
\]

\[
U_{\text{air}} = \frac{(0.0 \times 1.78 \times 1.78)}{(0.78 \times 12)} = 2.78
\]

\[
U_{\text{air}} = \frac{(55 \times 1.78 \times 1.78)}{(38 \times 12)} = 59.5
\]

\[
U_{\text{air}} = \frac{(2 \times 2.05 \times 1.05)}{(0.3 \times 12)} = 2.66
\]

\[
\frac{1}{U_4} = \frac{1}{1.36} + \frac{1}{2.66} + \frac{1}{278} + \frac{1}{59.5} = 0.735 + 0.376 + 0.0036 + 0.016
\]

\[
\frac{1}{U_4} = 1.12 \quad U_4 = \frac{1}{1.12} = 0.885 \text{ BU} 14.5^\circ F
\]
\[ U_{\text{cell, base}} = \frac{(0.025 \times 0.06 \times 12)}{(75 \times 12)} = 0.0012 \]

\[ U_{\text{cell, thin}} = U_{\text{cell, base}} + \frac{1}{(75 \times 12)} = 0.00092 \]

\[ \frac{1}{U_{BB}} = 2 \left( 0.502 + \frac{1}{805.10024 + 001.101} \right) = \frac{2}{0.502} + \frac{1}{805.1} = 3.98 + 1.13 \]

\[ \frac{1}{U_{BB}} = 5.11 \quad U_{BB} = \frac{1}{5.11} = 0.196 \text{ Btu} / \text{hr} / \text{°F} \text{ cell} \]

On heated cell A section (75 wide), \[ U_{BB} = (1.96 \times \frac{75}{20}) = 0.0735 \text{ Btu} / \text{hr} / \text{°F} \]

**heat staking & doubling base line & cold plate**

**heat loss**

- Cell A section
- R-Adiabatic = \( 0.079 \text{ Btu} / \text{hr} / \text{°F} \)
- R-RTA = \( 0.15 \text{ Btu} / \text{hr} / \text{°F} \)

\[ \frac{1}{U_{5}} = \frac{1}{U_{\text{cell, thin}}} + \frac{1}{U_{\text{case}}} + \frac{1}{U_{\text{cold, plade}}} \]

\[ U_{\text{cell, thin}} = \frac{(0.079)(2.5 \times 75)}{(11 \times 12)} = 0.112 \]

\[ U_{\text{cell, thin}} = \frac{(4.5 \times 2.5 \times 75)}{(0.75 \times 12)} = 2.80 \]

**cold plate side**

- Cover cold plate area = \( 2.87 \times 3.02 = 8.64 \text{ in}^2 \)
- Side cold plate area = \( 2.5 \times 8.5 = 21.2 \text{ in}^2 \)

\[ U_{\text{cold plate, cov}} = 2.41 \text{ Btu} / \text{hr} / \text{°F} \]

\[ U_{\text{cold plate, side}} = (2.41 \times \frac{0.12}{5.5})(\frac{75}{8.5}) = 0.192 \text{ Btu} / \text{hr} / \text{°F} \]
\[
\frac{1}{U_5} = \frac{1}{1.12} + \frac{1}{28} + \frac{1}{0.192} = 8.81 + 0.0256 + 5.2 = 14.04
\]

\[U_5 = \frac{1}{14.04} = 0.0711 \text{ Btu/h \cdot \circ F} \quad \text{using adiabatic}
\]

\[
\frac{1}{U_{5R}} = \frac{1}{6.25} + \frac{1}{28} + \frac{1}{0.192} = 1.46 + 0.035 + 5.2 = 5.38
\]

\[U_{5R} = \frac{1}{5.38} = 0.186 \text{ Btu/h \cdot \circ F} \quad \text{using RTA}
\]
Thermal Studies at 611 hrs of Battery Operation

![Diagram of cells](image)

**Fig 1**

**Basis:** Cell A 

- \( U_{\text{cell A}} = 0.065 \text{ Btu/hr}^\circ\text{F} \) (for cell cell path)
- \( U_{\text{cell B}} = 0.0735 \text{ Btu/hr}^\circ\text{F} \) (for 15x25 panes)
- \( U_5 = 0.186 \text{ Btu/hr}^\circ\text{F} \)

**Heat Gain:**

- Cell A: \( 11.2 \text{ Btu} \)
- Cell B: \( (0.6 \times \frac{75}{20}) = 3.56 \text{ Btu} \) (75" width only)

**Heat Capacity:**

- For 75" section across battery:
  \( (2.14 \times \frac{4453}{(11 \times 3.5)} = 153 \text{ Btu} \)
- For cell B, panes only:
  \( (187 \times \frac{75}{3.5}) = 0.04 \text{ Btu/°F} \)

**Total Heat Gain:**

\( 11.2 + 3.56 + 13.56 - 18.3 \text{ Btu} \)
Rough estimate of mean temperature of 6 hrs

Total thermal resistance path = $15.4 + 13.6 + 13.6 + 5.38 = 48 h^0F$

Mean path resistance = $48/2 = 24 h^0F/\text{Btu}$

Assume mean A $T = 30^0F$ or final average temperature $60^0F$ above initial.

Heat required to bring oil to $60^0F$ above ambient $= (60 \times 1.87) = 112 \text{ Btu}$

Heat through floor from heating $Q = \frac{A \Delta T}{8} = \frac{(30 \times 6)}{24} = \frac{7.5}{18} \text{ Btu/pair}$

Rough estimate of temperature in second area $18.3 \text{ Btu}$ gained $\approx 18.7 \text{ Btu}$

Calculation - Final Temperature at 6 Hours

1. Assume mean temperature at ends of cell A as $38^0F$ (above ambient) every hour.

2. Assume heat a linear function with time. Since heat transfer goes down, place mounted outside cell A.

3. Heat required to bring cell temperature to $76^0F = (76 \times 1.87 - 0.6) \approx 8.05 \text{ Btu}$

4. Heat generated per side $= 11.2 \text{ Btu}$

5. Heat transferred from cell $= 11.2 - 8.05 = 3.15 \text{ Btu}$ in 6 hrs

6. Heat transferred per hour $= \frac{3.15}{6} = 0.525 \text{ Btu/hr}$

7. Since heat is generated uniformly through all mean path, the rate of heat is $0.065 \times 1.2 = 0.130 \text{ Btu/hr}$

8. Temperature differential required to change $18.3\text{ Btu}/\text{hr} / U = \frac{525}{130} = 4^0F$

: mean slope of point B and C cell A and cell B is $38.4 = 21$

Cell C

1. Assume mean temperature at ends of cell B to be $29^0F$. Final temperature will be $29 \times 2 = 58^0F$.
10. Heat required to raise all temperature 58°F = (58X04) = 2.32 Btu

11. Heat generated by \( \frac{75}{9} \cdot 0.02 \) of cell = 3.56 Btu

12. Therefore, heat transferred across cell = 3.56 - 2.32 = 1.24 Btu/hr (from cell A)

13. Heat transferred per hour = \( \frac{1.24}{6} \) = 0.21 Btu/hr

14. Temperature differential required to transfer \( \frac{231 Btu}{1.0735} \) = 9.9°F.

15. Therefore, mean temperature of point between cell A and cell B2 is 34.10°F.

16. Mean temperature of each of cell is \( \frac{24 + 74}{2} = 29°F \) which checks with above assumption

Cell B2

17. Assume mean temperature at center of cell B2 to be 16°F.

18. Final temperature will be 16 + 20 = 36°F.

19. Heat required to raise all a temperature 32°F = (32X04) = .64 Btu

20. Heat generated by \( \frac{75}{9} \cdot 0.02 \) of cell = 3.56 Btu

21. Therefore, heat transferred across cell = 3.56 - 0.64 + 4.39 = 7.31 Btu/hr

22. Temperature differential required to transfer \( \frac{122 Btu}{0.0735} \) = 16.

23. Therefore, mean temperature at point between cell B2 and passing

24. Mean temperature of each of cell is \( \frac{24 + 74}{2} = 15.7°F \)


Problem 28: Cold Place

25. Heat transferred across passing area of cold place = 1.22 Btu/hr

26. Temperature differential required to transfer \( \frac{122 Btu}{1.0735} \) = 6.6°F

27. Temperature differential from (23) is 7.4°F. Difference shows 7.4°F and 6.6°F are less than 1°F. Therefore, assumption is valid.
Field A is 38°F in error.

For profile of mean and final temperatures see Fig. 2.
Figure 2

- Director of heat flow

* Potting cases cold plate

Final Temperature (GHK)

Mean Temperature
## Heat Capacity

<table>
<thead>
<tr>
<th>Item</th>
<th>Weight (lbs)</th>
<th>CP</th>
<th>WC x CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ag Strip</td>
<td>6.27</td>
<td>.056</td>
<td>3.5</td>
</tr>
<tr>
<td>2. Ag Wire</td>
<td>1.1</td>
<td>.056</td>
<td>.06</td>
</tr>
<tr>
<td>3. Zinc</td>
<td>32.9</td>
<td>.092</td>
<td>3.02</td>
</tr>
<tr>
<td>4. Manganese Oxide</td>
<td>.6</td>
<td>.057</td>
<td>.03</td>
</tr>
<tr>
<td>5. Copper Sheet</td>
<td>6.5</td>
<td>.093</td>
<td>.60</td>
</tr>
<tr>
<td>6. P-3 (50mil)</td>
<td>1.1</td>
<td>.5</td>
<td>.55</td>
</tr>
<tr>
<td>7. G-19 (97mil)</td>
<td>3.1</td>
<td>.5</td>
<td>1.55</td>
</tr>
<tr>
<td>8. Galvanized</td>
<td>24.2</td>
<td>.688</td>
<td>16.6</td>
</tr>
<tr>
<td>9. Cast, Cor, Charcoal</td>
<td>26.5</td>
<td>.36</td>
<td>9.5</td>
</tr>
<tr>
<td>10. Cast Iron</td>
<td>160.7</td>
<td>.03</td>
<td>35.47</td>
</tr>
</tbody>
</table>

**Specific Heat**: \( \frac{35.47}{160.7} = 0.222 \text{ Btu/lb} \text{°F} \)

**Heat capacity of steel**: \( (0.222)(160.7) = 0.0785 \text{ Btu/°F} - \text{lb} \text{C} \)

7-25
### Battery Heat Capacity

<table>
<thead>
<tr>
<th>Item</th>
<th>Weight</th>
<th>( \rho )</th>
<th>( c_p )</th>
<th>( W_{cp} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Battery Case &amp; Covers</td>
<td>540</td>
<td>.125</td>
<td></td>
<td>67.5</td>
</tr>
<tr>
<td>2) Cells (19X100)</td>
<td>3040</td>
<td>.22</td>
<td></td>
<td>670.0</td>
</tr>
<tr>
<td>3) Pedestal</td>
<td>660</td>
<td>.3</td>
<td></td>
<td>198.0</td>
</tr>
<tr>
<td>4) Miscellaneous Hardware</td>
<td>( \frac{21.0}{4450} )</td>
<td>1</td>
<td></td>
<td>21.0</td>
</tr>
</tbody>
</table>

\[
\text{Total Heat} = \frac{956}{4450} = .214 \text{ Btu/\textdegree F}
\]

Heat capacity of Pedestal: \((21.4)(4,450)\) = 2.1 Btu/\textdegree F
CELL CASE TEMPERATURE VS SORTIE TIME

400W HOURS DISCHARGED IN 6 HOURS

HEAT SINK AT BOTTOM OF BATTERY CASE
(COUPLING 3.0 BTU/HR °F TO RADIATOR)
40 % KOH
BOILING POINT VS ALTITUDE

°C

130
120
110
100
90
80
70
60
50
40
30
20
10
0
700 600 500 400 300 200 100 mm Hg

mm Hg
HIGH GAIN ANTENNA

AREA - GAIN ≥ 23dB

AREA - GAIN < 23dB
### 4. ELECTRICAL DESIGN

#### A. PERFORMANCE SPECS.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>ERECTABLE ANTENNA SPEC</th>
<th>LCRU ANTENNA SPEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>WEIGHT</td>
<td>≤ 13.5 #</td>
<td>≤ 3.5 #</td>
</tr>
<tr>
<td>DIAMETER</td>
<td>120&quot;</td>
<td>≤ 38&quot; MAX</td>
</tr>
<tr>
<td>TRANSMIT FREQ. $f_t$</td>
<td>2282 MHz</td>
<td>2272.5 ±10 MHz</td>
</tr>
<tr>
<td>RECEIVE FREQ. $f_r$</td>
<td>2102 MHz</td>
<td>2101.802 ±10 MHz</td>
</tr>
<tr>
<td>POLARIZATION</td>
<td>RH</td>
<td>RH</td>
</tr>
<tr>
<td>ELLIPTICITY</td>
<td>≤ 2 DB, ±1.3°BW</td>
<td>≤ 2 DB, ±2°BW</td>
</tr>
<tr>
<td>TRANSMIT GAIN</td>
<td>&gt; 32 DB, ±1.3°BW</td>
<td>≥ 23 DB, ±2.5°BW</td>
</tr>
<tr>
<td>RECEIVE GAIN</td>
<td>&gt; 31.2 DB, ±1.3°BW</td>
<td>≥ 18.5 DB, ±2.5°BW</td>
</tr>
<tr>
<td>SIDE LOBE LEVEL</td>
<td>&gt; 20 DB</td>
<td>&gt; 16 DB</td>
</tr>
<tr>
<td>TRANSMIT VSWR</td>
<td>≤ 1.2</td>
<td>≤ 1.2</td>
</tr>
<tr>
<td>RECEIVE VSWR</td>
<td>≤ 1.8</td>
<td>≤ 1.5</td>
</tr>
<tr>
<td>IMPEDANCE</td>
<td>50 OHM</td>
<td>50 OHM</td>
</tr>
<tr>
<td>POWER HANDLING</td>
<td>30 W CW</td>
<td>15 W CW</td>
</tr>
</tbody>
</table>
ANTENNA IN DEPLOYED CONFIGURATION

WT. = 3.7 LBS
f/D = .382

OPEN MESH
ANTENNA RIBS (12)
LINKS
PUSH-PULL DEVICE
INTERFACE NUT

FEED
OPTICAL DEVICE

38 DIA.

23

8.9

4.75

6.3
HI-GAIN ANTENNA IN STOWED CONFIGURATION

OPTICAL DEVICE

FEED

5.50 MAX. DIA.

ANTENNA RIBS

LINKS

PUSH-PULL DEVICE

SUPPORT NUT
4. ELECTRICAL DESIGN

B. DESIGN PARAMETERS

(1) OVERALL
   \( f/D \)  \( \sim 0.4 \)
   EFFICIENCY  \( \geq 0.5 \)

(2) REFLECTOR
   EFFECTIVE DIAMETER  36.4''
   SURFACE TOLERANCE  0.146'' RMS

(3) FEED
   10 DB BEAMWIDTH  \( \sim 135^0 \)
   ELLIPTICITY  \(< 1\) DB
CUP HELIX FEED

- 4"
- 50Ω COAX. LINE
- FIBERGLASS TUBE
- HELIX WINDING
- CUP REFLECTOR
- 2"
LOSS OF AREA BY SCALLOPING

RCA

19'

R_{eff}
### EFFECTIVE DIAMETER VS PERFORMANCE

**For worst case Xmit frequency frequency of 2202 MHz**

<table>
<thead>
<tr>
<th>DE (INCHES)</th>
<th>G₀ (DB)</th>
<th>φ₀ (DEG)</th>
<th>G₀ - 23 DB</th>
<th>φ₀ / G₀</th>
<th>φ₀/2 (DEG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>23.47</td>
<td>9.90°</td>
<td>0.47</td>
<td>0.40</td>
<td>1.98°</td>
</tr>
<tr>
<td>35-1/2</td>
<td>23.59</td>
<td>9.78°</td>
<td>0.59</td>
<td>0.45</td>
<td>2.20°</td>
</tr>
<tr>
<td>36</td>
<td>23.71</td>
<td>9.62°</td>
<td>0.71</td>
<td>0.495</td>
<td>2.38°</td>
</tr>
<tr>
<td>36-1/2</td>
<td>23.87</td>
<td>9.51°</td>
<td>0.83</td>
<td>0.535</td>
<td>2.54°</td>
</tr>
<tr>
<td>37</td>
<td>23.95</td>
<td>9.35°</td>
<td>0.95</td>
<td>0.57</td>
<td>2.67°</td>
</tr>
<tr>
<td>37-1/2</td>
<td>24.07</td>
<td>9.25°</td>
<td>1.07</td>
<td>0.61</td>
<td>2.82°</td>
</tr>
<tr>
<td>38</td>
<td>24.19</td>
<td>9.15°</td>
<td>1.19</td>
<td>0.645</td>
<td>2.95°</td>
</tr>
</tbody>
</table>
GAIN = 23 dB @ $\pm \phi/2$
1/2 POWER BANDWIDTH AND GAIN LOSS VS EFFECTIVE DIAMETER

**Beamwidth**

- $f_R = 2092$ MC
- $f_T = 2262$ MC

**Off-axis Gain Loss (2262 MHz)**

- $\theta = 2.5^\circ$
- $\theta = 2.0^\circ$

Gain Reduction dB
LCRU - TRANSMIT
GAIN OVER SECTOR VS DIA.

\[ f = 2262 \text{ Mc} \]

\[ n = \begin{align*}
0.55 \\
0.525 \\
0.50
\end{align*} \]

GAIN dB
@ \( \theta = \pm 2.0^\circ \)

\[ f = 2262 \text{ Mc} \]

GAIN dB
@ \( \theta = \pm 2.5^\circ \)

\[ \text{DIA. - INCHES} \]

\[ \text{SPEC.} \]
LCRU - RECEIVE
GAIN OVER SECTOR VS DIA.

\[ f = 2092 \text{ Mc} \]

GAIN dB
@ \( \theta = \pm 2.0^\circ \)

\[ n = 0.55, 0.525, 0.50 \]

\[ n = 0.55, 0.525, 0.50 \]

DIA. - INCHES

f = 2092 Mc

GAIN dB
@ \( \theta = \pm 2.5^\circ \)
GAIN OVER SECTOR VS OPENING FORCE

(f = 2262 MHz)

GAIN dB
θ = ± 2.0°

n = .50

SPEC

# RIBS =
12
10

GAIN dB
θ = ± 2.5°

n = .50

SPEC

# RIBS =
12
10
LCRU

12 RIBS

MAXIMUM GAIN (100% EFF.) = 27.19 DB FOR DIA. = 38" AT 2262 MC

AT 50% EFF., GAIN = 24.19 DB

FOR 7 LBS DEPLOYMENT FORCE, EFF. DIA. = 36.4"

GAIN LOSS DUE TO REDUCING DIA. TO 36.4" .39 DB

GAIN LOSS AT $\theta = \pm 2.5^\circ$ .80

\[ \frac{24.19}{-1.19} \]

TRANSMIT GAIN = 23.00 DB AT $2.5^\circ$ FOR 7 LBS PULL

RECEIVE GAIN = 22.4 DB AT $2.5^\circ$ FOR 7 LBS PULL
ANTENNA CONSTRUCTION

PERIPHERAL TENSION WIRE

MESH

RIB

WIRE INSERT

TEFLON TAPE

RIB

SECTION A-A
DEPLOYMENT MECHANISM AND LOCKING DEVICE

- FEED COAX
- TNC TYPE CONNECTOR
- ANTENNA RIB STOWED
- ANTENNA RIB DEPLOYED
- HUB
- LIFTER
- ACTUATION GRIP AND LOCKING CAM

RCA
<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>WT.</th>
<th>X</th>
<th>W X</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERFACE NUT</td>
<td>.13</td>
<td>.75</td>
<td>.10</td>
</tr>
<tr>
<td>CONNECTOR</td>
<td>.10</td>
<td>.50</td>
<td>.05</td>
</tr>
<tr>
<td>HAND GRIP</td>
<td>.25</td>
<td>.88</td>
<td>.22</td>
</tr>
<tr>
<td>CENTRAL SUPPORT</td>
<td>.16</td>
<td>2.00</td>
<td>.32</td>
</tr>
<tr>
<td>LOCKING CAM</td>
<td>.08</td>
<td>1.62</td>
<td>.13</td>
</tr>
<tr>
<td>LINKAGE HUB</td>
<td>.46</td>
<td>1.75</td>
<td>.81</td>
</tr>
<tr>
<td>LINKS (12)</td>
<td>.05</td>
<td>3.50</td>
<td>.18</td>
</tr>
<tr>
<td>PIVOT HUB</td>
<td>.12</td>
<td>4.25</td>
<td>.51</td>
</tr>
<tr>
<td>RIBS (12)</td>
<td>.60</td>
<td>8.00</td>
<td>4.80</td>
</tr>
<tr>
<td>MESH</td>
<td>.40</td>
<td>9.00</td>
<td>3.60</td>
</tr>
<tr>
<td>COAX FEED STEM</td>
<td>.40</td>
<td>11.50</td>
<td>4.60</td>
</tr>
<tr>
<td>FEED HELIX</td>
<td>.15</td>
<td>19.00</td>
<td>2.85</td>
</tr>
<tr>
<td>FEED CAP</td>
<td>.15</td>
<td>20.00</td>
<td>3.00</td>
</tr>
<tr>
<td>OPTICAL ASSEMBLY</td>
<td>.40</td>
<td>22.00</td>
<td>8.80</td>
</tr>
<tr>
<td>MISC. HARDWARE</td>
<td>.25</td>
<td>11.50</td>
<td>2.87</td>
</tr>
</tbody>
</table>

3.70

C.G. \[
\frac{32.84}{3.70} = 8.9 \text{ INCHES MEASURED FROM TIP OF INTERFACE NUT}
\]
STRUCTURAL NODAL MODEL
LCRU ANTENNA

LEGEND:

- BAR
- BEAM
- RIGID CONNECTION
- ELASTOMECHANIC NODAL POINT
- DYNAMIC NODAL POINT
LCRU ANTENNA THERMAL ANALYSIS

APPROACH

• CORRELATE DATA AND RESULTS FROM LEM ERECTABLE ANTENNA ANALYSIS

• ADDITIONAL ANALYSIS FOR UNIQUE PARTS (OPTICAL DEVICE)

• LCRU ANTENNA IS QUITE SIMILAR TO THE LEM ERECTABLE ANTENNA IN BOTH MATERIALS USED AND CONSTRUCTION

ANTICIPATED RESULTS

• WORST CASE DEFLECTIONS - WILL BE LESS THAN LEM ERECTABLE

  RIBS\) DEFLECTIONS ARE WELL WITHIN

  FEED\) ALLOWABLE MICROWAVE LIMITS
THERMAL DEFLECTION

SOLAR VECTOR

DEFLECTED BEAM

\[ \alpha = \frac{\delta}{\text{DIA OF REFL}} \]

RIB DEFLECTION

FEED DEFLECTION

\[ \alpha = \frac{\delta}{\text{FEED LENGTH}} \]
ANTENNA POINTED AT SUN - NO DANGEROUS HEATING OF FEED AREA DUE TO THE FOCUSING OF REFLECTED SUNLIGHT WILL TAKE PLACE. THE REFLECTOR SOLID AREA IS SMALL.

COMPARISON BETWEEN LEM ERECTABLE AND LCRU ANTENNAS

<table>
<thead>
<tr>
<th></th>
<th>ERECTABLE</th>
<th>LCRU</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MAXIMUM TEMPERATURES:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RIBS:</td>
<td>200°F</td>
<td>200°F</td>
</tr>
<tr>
<td>MESH:</td>
<td>500°F</td>
<td>500°F</td>
</tr>
<tr>
<td>OPTICAL:</td>
<td>-</td>
<td>200°F</td>
</tr>
<tr>
<td><strong>MAXIMUM FEED TIP DEFLECTION:</strong></td>
<td>0.14 INCH</td>
<td>0.005 INCH</td>
</tr>
<tr>
<td><strong>MAXIMUM FEED TIP ROTATION:</strong></td>
<td>0.115°</td>
<td>0.040°</td>
</tr>
<tr>
<td><strong>MAXIMUM RIB TIP DEFLECTION:</strong></td>
<td>0.078 INCH</td>
<td>0.030 IN</td>
</tr>
</tbody>
</table>
LCRU BORESIGHT ANALYSIS

SUMMARY OF ANTENNA AIMING ERRORS

THIS SPECIFICATION, LRSP-SA/H-1, REQUIREDS THAT THE OVERALL POINTING ERROR TO THE ANTENNA SHALL BE \( \pm 0.80^\circ \) MAXIMUM AS MEASURED BETWEEN THE RF BORESIGHT AND OPTICAL SIGHT.

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Peak Error (°)</th>
<th>RMS Error (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Optical Sighting Unit and RF Beam Shift Due to Feed Displacement</td>
<td>0.160</td>
<td>0.053</td>
</tr>
<tr>
<td>B.</td>
<td>Thermal Distortion</td>
<td>0.060</td>
<td>0.035</td>
</tr>
<tr>
<td>C.</td>
<td>Beam Position Determination and Boresighting Accuracy</td>
<td>0.200</td>
<td>0.067</td>
</tr>
<tr>
<td>D.</td>
<td>Optical Device Accuracy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Internal Line of Sight Acc.</td>
<td>0.083</td>
<td>0.028</td>
</tr>
<tr>
<td>2.</td>
<td>Mounting Accuracy</td>
<td>0.250</td>
<td>0.083</td>
</tr>
<tr>
<td>3.</td>
<td>Feed to RF Beam Alignment</td>
<td>0.100</td>
<td>0.033</td>
</tr>
<tr>
<td>4.</td>
<td>Rotational Accuracy</td>
<td>0.160</td>
<td>0.053</td>
</tr>
<tr>
<td>E.</td>
<td>Centering of Earth Within Reticle</td>
<td>0.200</td>
<td></td>
</tr>
<tr>
<td>F.</td>
<td>Redeployment Accuracies</td>
<td>0.100</td>
<td></td>
</tr>
</tbody>
</table>

The above errors are in accord with specification LRSP-SA/H-1.
THE OBJECTIVE LENS AXIS IS ALIGNED TO THE EARTH IN CENTERING THE EARTH IMAGE IN THE RETICLE CIRCLE.

OPTICAL CONCEPT PROJECTING IMAGE ON A GROUND GLASS PLATE

OBJECTIVE LENS (FOCAL LENGTH OF 4.5 INCHES) PATH-FOLDING MIRROR

GROUND GLASS RETICLE PATTERN (LUMINOUS)

GROUND GLASS VIEWING PLATE

EARTH IMAGE (.15 INCH DIAMETER)
High Gain Antenna

Structural Analysis
COMPUTATIONS

DEFENSE ELECTRONIC PRODUCTS
MOorestown, NEW JERSEY

SUBJECT: LCRU ANTENNA – REFLECTOR
ITEM: FORCES AND DEFLECTIONS

THE CALCULATIONS PRESENTED IN THE FOLLOWING PAGES CAN BE USED AS A CRITERION FOR THE RIB SHAPE AND RIB CROSS-SECTION OF THE LCRU ANTENNA. FOR AN ERROR BUDGET ANALYSIS WAS PERFORMED TO FIND HOW MANY RIBS ARE NEEDED TO APPROXIMATE THE PARABOLIC DISH SHAPE WITHIN RMS SPECIFICATIONS. A SUMMARY OF THIS CALCULATION IS SHOWN ON PAGE 11 INDICATING TEN RIBS TO BE SUFFICIENT.

THE CALCULATIONS BEGINNING ON PAGE 1 ASSUME TEN RIBS, AN 8:1 RATIO OF .375 INCH DIAMETER AND CIRCUMFERENTIAL MEAN TENSION OF .04 IN. THE FORCES EXERTED BY THE MESH PERIPHERY WIRE ON THE RIBS ARE IN THE ORDER OF .5 OR LESS. THE MOMENTS OF THESE FORCES ARE BETTER O AND 2.5 IN. THE MAXIMUM STRESS IS 1025 PSI, WELL WITHIN THE YIELD STRESS OF 35,000 PSI (A CROSS-SECTION OF 4 INCH ALUMINUM SQUARE TUBING WITH .01 INCH THICKNESS AND A SLOTTED INSEPT IS ASSUMED). THE DESIGNED FINAL SHAPE OF THE RIBS IS CALCULATED IN A CORRECTED FORM MADE TO MINIMIZE THE GEOMETRICAL DEVIATION FROM THE PARABOLIC SHAPE. THE WEIGHT OF EACH RIB IS LESS THAN .03 LB.


BUCKLING IS CONSIDERED AND THE CALCULATIONS SHOW NO PROBLEM. FORCES IN THE MEMBERS ARE FOUND TO BE IN THE AREA OF 1.0 LB TENSION WHEN IN THE ERECTED POSITION AND LESS THAN .5 LB COMPRESSION WHILE CLOSED. THE REFLECTOR. CLOSING THE REFLECTOR ON THE MESH WILL REQUIRE ABOUT .1 LB EXERTED BY THE ASTRONAUT. OPENING THE ANTENNA TO THE TENSIONS PRESCRIBED ON PAGE 1 REQUIRE ABOUT 2.7 LB FORCE (TEN= .713%). FOR THE CASE OF TEN = 1.229 LB, 10.25 LB ARE REQUIRED TO OPEN IT.

7/59
DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

SUBJECT: LCRU ANTENNA — REFLECTOR
ITEM: ERROR BUDGET

<table>
<thead>
<tr>
<th>DEVIATION</th>
<th>PEAK</th>
<th>RMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEOMETRY</td>
<td>3X</td>
<td>X</td>
</tr>
<tr>
<td>WRINKLES</td>
<td>.09</td>
<td>.03</td>
</tr>
<tr>
<td>TOLERANCES</td>
<td>.015</td>
<td>.005</td>
</tr>
<tr>
<td>ASSEMBLY</td>
<td>.24</td>
<td>.08</td>
</tr>
<tr>
<td>DEPLOYMENT</td>
<td>.03</td>
<td>.01</td>
</tr>
<tr>
<td>THERMAL</td>
<td>.18</td>
<td>.06</td>
</tr>
</tbody>
</table>

$$0.1875 = \sqrt{x^2 + 0.03^2 + 0.005^2 + 0.08^2 + 0.01^2 + 0.06^2}$$

$$x = 0.1595 \text{ (RMS)}$$
$$3x = 0.478 \text{ (PEAK)}$$

GEOMETRY LOSSES: $$\Delta S + \Delta T = \left(\frac{\pi}{N}\right)^2 \left(\cos \alpha + \cos ^3 \alpha\right)$$

$$\alpha = \tan ^{-1} \left(\frac{1}{\frac{4}{3} D}\right) = \tan ^{-1} \left(\frac{1}{4.15}\right) = 33.7^\circ$$

$$\cos \alpha = 0.221 \quad \cos ^3 \alpha = 0.574$$

IF THE GEOMETRY LOSSES ARE SPLIT ON BOTH SIDES OF THE PARABOLIC SHAPE, THE PEAK DEVIATION CAN BE DOUBLE:

$$2(0.478) = \left(\frac{\pi}{N}\right)^2 \left(z\right) \left(0.231 + 0.574\right)$$

$$z = \text{DEPTH OF DISH} = 6.33$$

$$0.956 = \frac{3.14^2}{N^2} \left(6.33\right)\left(1.405\right)$$

$$N^2 = 92.1$$
$$N = 9.6$$

10 RIBS REQUIRED

GAIN LOSS DUE TO IMPERFECT PARABOLIC SHAPE (0.1875 IN. RMS)

$$\Delta d = 4.9 \left(10^2\right) = 4.9 \left(2.28 \text{ CPS} \times 0.1875 \text{ IN}\right)^2 = 0.892 \text{ dB}$$

LESS THAN 1 dB LOSS—O.K.
COMPUTATIONS

DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

SUBJECT: LCRU ANTENNA-REFLECTOR
ITEM: AXIAL LOADS ON RIBS

1. RADIAL MESH TENSION:

\[ F_R = T_R \cos \alpha \]
\[ F_R = 0.04 \frac{H}{16} (17 \sin 18^\circ)(2) \]
\[ F_R = 0.47 \text{ lb} \]

AXIAL COMPONENT = \( F_R \cos \alpha \)

AT HUB \( F_R \approx 0.47(0.2) \approx 0.39 \text{ lb} \)

2. PERIPHERY WIRE TENSION:

\[ T_a = \frac{T_R D^2 \sin^2 \beta}{8H} \]
\[ T_a = \frac{0.04(33)^2(0.31)^2}{8(1.7)} \]
\[ T_a = 0.41 \text{ lb} \]

\( T_a \) IS CAUSED IN PART BY THE RADIAL MESH TENSION. THIS PORTION IS \( \frac{F_R}{2} \sin \beta \)

Therefore, the portion due to wire pretension is:

\[ T_p = T_a - \frac{F_R}{2} \sin \beta = 0.41 - \frac{0.47}{2} (0.31) \]
\[ T_p = 0.34 \text{ lb} \]

\[ F_p = 2T_p \sin \beta = 2(0.34)(0.31) = 0.21 \text{ lb} \]

AXIAL COMPONENT = \( F_p \cos \psi \)

3. CHORDWISE MESH TENSION:

FORCE PER UNIT LENGTH \( T_c = 2T_s \sin \beta \)
\[ T_c = 2(0.04)(0.31) = 0.0247 \text{ lb/ft} \]

TOTAL FORCE \( F_c = T_c \) (LENGTH OF RIB)
\[ F_c = 0.0247(20) = 0.49 \text{ lb} \]

AXIAL COMPONENT = \( F_c \cos \psi \)
1. **Periphery Wire Tension:**

\[ M_p = F_p(H) \]

Moment at hub is approximately:
\[ M_c \approx 0.21 \text{ lb}(6 \text{ in}) = 1.26 \text{ in lb} \]

2. **Chordwise Mesh Tension:**

\[ M_c = T_c(l)(\text{distance to force centroid}) \]

Moment at hub: \[ M_c \approx 0.0247(20)(\frac{d}{3}) \]
\[ M_c \approx 0.99 \text{ in lb} \]

3. **Radial Mesh Tension:**

\[ M_R = -F_R(L) \]

At hub: \[ M_R \approx -47 \text{ lb}(5 \text{ in}) \]
\[ M_R \approx -2.35 \text{ in lb} \]


1. **PERIPHERY WIRE TENSION:**

\[ P_p = F_p \sin \psi \]

Shear at tip: \( P_p \approx 0.21(0.57) \approx 0.12 \text{ lb} \)

Shear at hub: \( P_p \approx 0 \)

2. **CHORDWISE MESH TENSION:**

\[ P_c = F_c \sin \psi \]

At tip: \( P_c \approx 0.49(0.57) \approx 0.28 \text{ lb} \)

At hub: \( P_c \approx 0 \)

3. **RADIAL MESH TENSION:**

\[ P_r = F_r \sin \alpha \]

At hub: \( P_r \approx 0.47(0.57) \approx 0.27 \text{ lb} \)

At tip: \( P_r \approx 0 \)
AXIAL FORCE AT JOINT ≈ 0.39 + 0.21 + 0.49 = 1.09 lb

MOMENT AT JOINT ≈ 0.21(6) + 0.047(15)(6/22) - 2.8(17) = 1.0 in lb

SHEAR AT JOINT ≈ 0.27/16

\[ \frac{A}{4} \left( \frac{4}{n} \right) + \frac{1}{4} + \frac{1}{4} + 2(0.1) + \frac{1}{n} + 0.23 + \frac{1}{8} \]

\[ A = 0.01(1.43) = 0.0143 \text{ in}^2 \]

\[ I = \frac{1}{12} \left[ (\frac{4}{n})^4 \cdot (0.23)^3 \right] + \frac{1}{12} \left[ (0.01)(0.23)^3 \right] + 2 \left[ (1.05)(0.01)(0.12) \right] \]

\[ I = \frac{1}{12} \left[ 0.0031 - 0.0025 \right] + \frac{1}{12} \left[ 1.21 \times 10^{-4} \right] + 2 \left[ 0.0105 \cdot 1 \right] \]

\[ I = 9.17 \times 10^{-5} + 1.01 \times 10^{-5} + 3.03 \times 10^{-5} \]

\[ I = 1.321 \times 10^{-4} \text{ in}^4 \]

\[ (\text{NORMAL STRESS}) \sigma = \frac{F}{A} + \frac{MC}{I} \]

\[ \sigma = \frac{1.09 \text{ lb}}{0.0143 \text{ in}^2} + \frac{1.0 \text{ in lb}(2.8 \text{ in})}{1.321 \times 10^{-4} \text{ in}^4} \]

\[ \sigma = 80 \text{ psi} + 945 \text{ psi} = 1025 \text{ psi} \]
COMPUTATIONS

DEFENSE ELECTRONIC PRODUCTS
MOOHESTOWN, NEW JERSEY

SUBJECT: LCPU ANTENNA - REFLECTOR
ITEM: LENGTH OF RIBS

\[ \chi = \frac{\gamma^2}{12F} \left[ \sec^2 \beta + 2 \right] \]

\[ \chi = \frac{\gamma^2}{12(14.25)} \left[ (1.05)^2 + 2 \right] \]

\[ \chi = \frac{\gamma^2}{171} \left[ 3.105 \right] \]

\[ \chi = 0.0181617 \gamma^2 \]

where \( \gamma = r \cos \beta \)

\[ \chi = 0.0181 \left( 95 \right)^2 \]

\[ \chi = 0.0164275 \ r^2 \]

**LENGTH:** 

\[ L = \int_0^\chi ds = \int_0^\chi \left( \sqrt{1 + \left( \frac{dz}{d\chi} \right)^2} \right) d\chi = \int_0^\chi \left( \sqrt{1 + (0.0329 \ r)^2} \right) d\chi \]

\[ L = 0.0229 \int_0^\chi \left( \sqrt{926 + r^2} \right) d\chi \]

\[ L = 0.01643 \left[ 19 \sqrt{926 + 926} + 926 \left( \ln \left( 19 + \sqrt{926} \right) - \ln \sqrt{926} \right) \right] \]

\[ L = 0.01643 \left[ 683 + 926 \left( \ln 54.9 - \ln 30.1 \right) \right] = 11.22 + 15.21 (4.00 - 3.41) \]

\[ L = 11.22 + 8.98 = 20.20 \text{ in} \]

**WEIGHT:** 

\[ W = \frac{\pi}{2} L = 0.1 \ lbf \ \frac{n}{in^3} \left( 0.0143 \ in^2 \right) \left( 20.20 \ in \right) \]

\[ W = 0.0289 \ lbf \ \text{(per rib)} \]
DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

SUBJECT: LCRU ANTENNA - REFLECTOR
ITEM: FORCES IN MEMBERS AND SUPPORTS

\[ F = \text{FORCE IN MEMBER} \quad 0 \]
\[ R = \text{REACTION FORCE} \]

\[
\sum F_y \Rightarrow R_y = F \sin 41^\circ = F_P + F_c + F_R \cos \psi
\]
\[ F \sin 41 = R_y - .21 - .49 - .47(.83) \]
\[ F = \frac{R_y}{.656} - 1.09/656 \]

\[
\sum F_x \Rightarrow R_x = F \cos 41^\circ + F_R \sin \psi
\]
\[ R_x = .755F + .55F_R \]

\[
\sum M_R \Rightarrow 2.1875F = 7F_P - 4.6F_R + 3F_c
\]
\[ F = \frac{7(.21) - 4.6(.47) + 3(.49)}{2.1875} \]
\[ F = .356 \text{ lb} \]

\[
R_x = .755F + .55F_R = .755(.356) + .55(.526) \]
\[ R_x = .526 \text{ lb} \]

\[
R_y = .356(.656) + 1.09 = .23 + 1.09 \]
\[ R_y = 1.32 \text{ lb} \]
DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

SUBJECT: LCRU ANTENNA - REFLECTOR DEFLECTIONS

ASSUME A LOAD "P" AT POINT A IN THE DIRECTION OF THE DESIRED DEFLECTION \( \delta_A \).

COORDINATES OF POINTS: A (6.23, 19)  B (1.37, 5.155)

\[
U = \frac{1}{2} \int_B^A \frac{N^2}{EA} \, ds + \frac{1}{2} \int_B^A \frac{M^2}{EI} \, ds
\]

WHERE \( N = \) NORMAL FORCE
\( M = \) BENDING MOMENT

\[
\delta_A = \frac{2u}{\partial P} = \int_B^A \frac{N}{EA} \, \phi \, ds + \int_B^A \frac{M}{EI} \, \phi \, ds
\]

\[
M = (F_P + 0.83F_R + 0.56P)(5.93 - x)
+ (0.83P - 0.56F_R)(19 - y)
+ T_e(\xi)(\frac{5.93 - x}{2.1})
\]

\[
N = (F_P + 0.83F_R + 0.56P) \cos \psi
+ (0.55F_R - 0.83P) \sin \psi
+ T_e(\xi)(\cos \psi)
\]

\[
\lambda = \int_B^A \, ds = \int_B^A \sqrt{1 + \left(\frac{\partial y}{\partial x}\right)^2} \, ds = \int_B^A \sqrt{1 + 0.0329y^2} \, dy
\]

\[
\tan \psi = \frac{\Delta y}{\Delta x} = 0.0329 \frac{y}{x}
\]

\[
\sin \psi = \frac{\tan \psi}{\sqrt{1 + \tan^2 \psi}} = \frac{0.0329y}{\sqrt{1 + (0.0329y)^2}}
\]

\[
\cos \psi = \frac{1}{\sqrt{1 + \tan^2 \psi}} = \frac{1}{\sqrt{1 + (0.0329y)^2}}
\]
DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

- SUBJECT: LCRU ANTENNA - REFLECTOR
- ITEM: DEFLECTIONS

\[ F_p = 0.21, \quad F_R = 0.47, \quad T_e = 0.0247, \quad l \approx 19 - y \]

\[ M = \left( 6.5 \cdot 10^{-8} \right) \left( 5.93 \cdot 10^{-6} y^2 \right) + (1.83 \cdot 1.8) (19 - y) \]

\[ N = (0.97 + 0.56) \left( \frac{1}{\sqrt{1 + (0.0329 y)^2}} \right) + (0.26 - 0.83) \left( \frac{0.0329 y}{\sqrt{1 + (0.0329 y)^2}} \right) \]

\[ J_A = \frac{1}{5.16} \left( \frac{0.97}{\sqrt{1 + (0.0329 y)^2}} \right) \left[ 0.56 - 0.83 \left( \frac{0.0329 y}{\sqrt{1 + (0.0329 y)^2}} \right) \right] \]

\[ + \frac{1}{5.16} \left( 1.22 \cdot 10^{-8} \left( 5.93 \cdot 10^{-6} y^2 \right) - 2.6 (19 - y) \right) \left[ 0.56 \left( 5.93 \cdot 10^{-6} y^2 \right) + 2.6 (19 - y) \right] \]

\[ J_A = \frac{1}{5.16} \left( \frac{1.54 \cdot 10^{-8} \cdot 1.0032^2 y^2}{\sqrt{1 + (0.0329 y)^2}} \right) \left[ 1.0032 - 0.12 \cdot 10^{-8} \cdot 1.0032^2 y^2 \right] \]

\[ J_A = \frac{1}{5.16} \left( \frac{1.54 \cdot 10^{-8} \cdot 1.0032^2 y^2}{\sqrt{1 + (0.0329 y)^2}} \right) \left[ 1.0032 - 0.12 \cdot 10^{-8} \cdot 1.0032^2 y^2 \right] \]

\[ J_A = \frac{1}{5.16} \left( \frac{15.5 \cdot 20 (y + \sqrt{926 + y^2}) - 0.65 \cdot 926 + y^2 - 0.07 \cdot \frac{y}{2} \cdot \sqrt{926 + y^2} - 0.03 \cdot \frac{y}{2} \cdot \sqrt{926 + y^2}}{\sqrt{926 + y^2}} \right) \]

\[ + \frac{1}{5.16} \left[ -C \cdot \sqrt{926 + y^2} + 926 \ln \left( y + \sqrt{926 + y^2} \right) \right] + C \left( \sqrt{926 + y^2} \right)^3 \]

\[ -0.04 \cdot \frac{y}{2} \left( \sqrt{926 + y^2} \right)^3 + 0.05 \cdot \frac{y}{2} \left( \sqrt{926 + y^2} \right)^3 \]

\[ + 1.0 \cdot \frac{y^2}{2} \left( \sqrt{926 + y^2} \right)^3 \]

\[ -0.00000013 \left( 7 \cdot \frac{y^4}{2} \cdot \sqrt{926 + y^2} + 0.516 \cdot \frac{y^4}{2} \cdot \sqrt{926 + y^2} \right) \]

\[ -0.00000005 \left( 7 \cdot \frac{y^4}{2} \cdot \sqrt{926 + y^2} + 0.516 \cdot \frac{y^4}{2} \cdot \sqrt{926 + y^2} \right) \]

\[ \frac{1}{5.16} \]
COMPUTATIONS

DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

S.O. No. -------- PAGE 9

ENG. \S. Mathi\'is \ CHKD --------

DATE 4/1/70 REV. --------

SUBJECT: LCRU ANTENNA - REFLECTOR

ITEM: DEFLECTIONS

\[ S_A = \frac{1}{EA} \left[ 15.6 \left( \ln 53.7 - \ln 34.6 \right) - 0.072 \left( 9.5 (34.7) - 2.5 \right) - 4.2 (\ln 53.7 - \ln 34.6) \right] \\
+ \frac{1}{EI} \left[ -0 \left\{ 19(34.7) - 5.16(27.4) + 726 (\ln 53.7 - \ln 34.6) \right\} + 0.94 (46.171 - 2.9) \\
- 0.04 (4.751(46.171) - 1.3(27.420) - 116(19) 35.9 + 110(5.16) 30.9 \\
- 107,184 (\ln 54.7 - \ln 36.0) \right\} \\
+ 0.0909 \left( 61(46.171) + 118 (27.420) \right) - 0.9553 (3.7) \left( 19(35.9) - 5.16 \right) \\
- 0.000005 \left( \right) \left( 19(35.9) - 5.16 \right) (30.9) \right] \\

\[ S_A = \frac{1}{EA} \left[ 15.6,44\right] - 0.657 (5.3) - 0.072 (6.8) \right] \\
+ \frac{1}{EI} \left[ +0.042 (167.51) - 0.043 (75.764) + 0.0094 \left\{ 11.17,010 \right\} - 0.00091 (1.053,002) \\
- 0.0000035 (61,105,002) \right] \\

\[ S_A = \frac{1}{EA} \left[ 2.89 \right] + \frac{1}{EI} \left[ 11.6 \right] = \frac{2.89}{10x10^6 (0.043)} + \frac{40.8}{10x10^6 (1.32x10^{-4})} \\

\[ S_A = 2.02x10^{-5} + 3.1 \times 10^2 \]

\[ S_A = 0.031 \text{ in} \]

7-163
DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

SUBJECT: CPU ANTENNA - REFLECTOR
ITEM: DEFLECTIONS

\[
\begin{align*}
(P, \psi) & \xrightarrow{P=0} (D, \psi) \\
F_C & \left[5.16 \leq y \leq C\right] \\
& \text{SETTLING THE DUMMY LOAD "P" TO ZERO, WE HAVE:}
\end{align*}
\]

\[
S = \frac{1}{EI} \int_{5.16}^{C} \left[ G \left(5.93 - F_{y}^2\right) \left(D - F_{y}^2\right) - 0.31 F_{R} \left(D - F_{y}^2\right) \left(19 - y\right) \\
+ 0.83 G \left(5.93 - F_{y}^2\right) \left(C - y\right) - 0.46 F_{R} \left(C - y\right) \left(19 - y\right) \right] ds
\]

\[
ds = 2F \sqrt{926 + y^2}, \quad G = F_{P} + 0.83 F_{R} + 9.1 T_{C}
\]

\[
S = \frac{1}{EI} \int_{5.16}^{C} \left( K_{0} + K_{1} y + K_{2} y^2 + K_{3} y^3 + K_{4} y^4 + K_{5} y^5 \right) 2F \sqrt{926 + y^2} ds
\]

WHERE:

\[
\begin{align*}
K_{0} &= 3.30 D + 5.90 F_{R} + 4.90 G - 8.7 C F_{R} \\
K_{1} &= 0.310 D + 4.90 G + 4.60 F_{R} (19 + C) - 1.60 D T_{C} - 2.3 C T_{C} \\
K_{2} &= -0.56 F_{R} (D + 5.93) + 5.9 F_{R} F_{C} - 0.83 C F_{G} - 0.46 F_{R} + 2.3 T_{C} \\
K_{3} &= -0.31 F_{R} + 0.83 G F + 0.27 F T_{C} (D + 5.93) + 0.40 C F T_{C} \\
K_{4} &= 0.56 G F^2 - 0.40 F T_{C} \\
K_{5} &= -2.7 F^2 T_{C}
\end{align*}
\]
COMPUTATIONS

DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

SUBJECT: LCPU ANTENNA - REFLECTOR
ITEM: DEFLECTIONS

\[ S = \frac{2F}{EI} \left[ \frac{K_0}{2} \left\{ y \sqrt{926+y^2} + 926 \ln(y+\sqrt{926+y^2}) \right\} \right. \\
+ K_1 \left\{ \frac{i}{3} \left( \sqrt{926+y^2} \right)^3 \right\} \\
+ K_2 \left\{ \frac{a^2}{4} \left( \sqrt{926+y^2} \right)^3 - 116y \sqrt{926+y^2} - 107,184 \ln(y+\sqrt{926+y^2}) \right\} \\
+ K_3 \left\{ \left( \frac{a^2}{2} - 123 \right) \left( \sqrt{926+y^2} \right)^3 \right\} \right] \\
+ K_4 \left[ \left( c - 5.16 \right) \left( c \sqrt{926+c^2} + 5.16 \sqrt{926+5.16^2} \right) \right] \\
+ K_5 \left[ \left( c - 5.16 \right) \left( c \sqrt{926+c^2} + 5.16 \sqrt{926+5.16^2} \right) \right] \\
\]

\[ S = \frac{2F}{EI} \left[ K_0 \left( Z_0 \right) + K_1 \left( Z_1 \right) + K_2 \left( Z_2 \right) + K_3 \left( Z_3 \right) + K_4 \left( Z_4 \right) + K_5 \left( Z_5 \right) \right] \\
\]

WHERE:

\[ Z_0 = \frac{1}{2} CQ + 463 \ln(C+Q) - 1739 \]
\[ Z_1 = \frac{1}{3} Q^3 - 9807 \]
\[ Z_2 = \frac{1}{4} CQ^3 - 116CQ - 107,184 \ln(C+Q) + 364,733 \]
\[ Z_3 = \left( \frac{C^2}{2} - 123 \right) Q^3 + 3,471,536 \]
\[ Z_4 = \left( C - 5.16 \right) \left( C^4 Q + 2,624 \right) \]
\[ Z_5 = \left( C - 5.16 \right) \left( C^5 Q + 112,923 \right) \]
\[ Q = \sqrt{926+C^2} \]
COMPUTATIONS

DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

SUBJECT: LCRRU ANTENNA - REFLECTOR
ITEM: TELCOMP PROGRAM FOR DEFLECTIONS

TR = RADIAL MESH TENSION
TS = CIRCUMFERENTIAL MESH TENSION
TEN = TENSION IN PERIPHERY WIRE
TA = CHORDWISE COMPONENT OF TEN
H = SAG OF PERIPHERY WIRE
D = X VALUE OF DEFLECTION POINT
C = Y VALUE
DEFL = DEFLECTION AT (D,C) NORMAL TO RIB

1.10 F = .0164275
1.12 FR = 11.75 * TR
1.13 TEN = SQRT(TA^2 + .618 * TA * FR + FR^2)
1.14 FP = .618 * (TA - .154 * FR)
1.15 TC = .618 * TS
1.16 E = 100000000; I = 0001321
1.17 G = FP + .23 * FR + .91 * TC
1.18 TFI = FORM 1
1.19 D0... ART 2 FOR D = 5.5... .5:19

2.01 D = .0164275 * C^2
2.1 K0 = 3.38 * D - 5.9 * D + FR + .7 * C * FR
2.2 K1 = 3.38 * D - .49 * FR + (1+C) - 1.6 * D * TC - 2.3 * C * TC
2.3 K2 = -.56 * C * FR + (D + 5.93) + .53 * C * FR - .83 * C * FG - .46 * FR + 2.3 * TC
2.4 K3 = -.56 * FG + .23 * FG + 2.7 * FG * TC + (D + 5.93) + .4 * C * FG + TC
2.5 K4 = .56 * C * FG + 2.4 * FG * TC
2.55 K5 = -.27 * TC * FG + 2
2.6 R = (2 * F / (E1)) * (SQRT [1 + (.0164275 * 2 * D) / 2]) / (83 + .019 * D)
2.605 Q = SQRT (926 + C12)
2.61 Z0 = .5 * C * Q + 46.3 * LN (C + Q) - 1739
2.62 Z1 = (Q - 3) / 9807
2.63 Z2 = .25 * C * Q + 116 * C * Q + 107184 * LN (C + Q) + 364733
2.64 Z3 = (2 * C + 123) * Q + 3 + 471 - 536
2.65 Z4 = (C - 5.16) * (Q * C + 230) / 2000
2.66 Z5 = (C - 5.16) * (Q * C / 15 + 112923) * 5
2.7 DEFL = R * (Z0 * K0 + 2 * K1 * 532 * K2 + 2 * K3 + 2 * K4 + Z5 * K5)
2.8 TYPE TR, TS, TEN, H, D, C, DEFL IN FORM 2

3.1 DO PART 1 FOR TR = .04 FOR TS = .04 FOR TA = .41, 1.0
FORM 1 TR TS TEN H D C DEFL
FORM 2...
<table>
<thead>
<tr>
<th>TR</th>
<th>TS</th>
<th>TEN</th>
<th>H</th>
<th>D</th>
<th>C</th>
<th>DEFL</th>
</tr>
</thead>
<tbody>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>.497</td>
<td>5.5</td>
<td>.00337</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>.591</td>
<td>6.0</td>
<td>.00363</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>.694</td>
<td>6.5</td>
<td>.00404</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>.805</td>
<td>7.0</td>
<td>.00459</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>.924</td>
<td>7.5</td>
<td>.00529</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>1.051</td>
<td>8.0</td>
<td>.00614</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>1.187</td>
<td>8.5</td>
<td>.00715</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>1.331</td>
<td>9.0</td>
<td>.00829</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>1.483</td>
<td>9.5</td>
<td>.00958</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>1.643</td>
<td>10.0</td>
<td>.01100</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>1.811</td>
<td>10.5</td>
<td>.01254</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>1.988</td>
<td>11.0</td>
<td>.01419</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>2.173</td>
<td>11.5</td>
<td>.01594</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>2.366</td>
<td>12.0</td>
<td>.01775</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>2.567</td>
<td>12.5</td>
<td>.01962</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>2.776</td>
<td>13.0</td>
<td>.02151</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>2.994</td>
<td>13.5</td>
<td>.02340</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>3.220</td>
<td>14.0</td>
<td>.02524</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>3.454</td>
<td>14.5</td>
<td>.02701</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>3.696</td>
<td>15.0</td>
<td>.02866</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>3.947</td>
<td>15.5</td>
<td>.03015</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>4.205</td>
<td>16.0</td>
<td>.03141</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>4.472</td>
<td>16.5</td>
<td>.03240</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>4.743</td>
<td>17.0</td>
<td>.03305</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>5.031</td>
<td>17.5</td>
<td>.03330</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>5.323</td>
<td>18.0</td>
<td>.03306</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>5.622</td>
<td>18.5</td>
<td>.03226</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>.713</td>
<td>1.683</td>
<td>5.930</td>
<td>19.0</td>
<td>.03081</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TR</th>
<th>TS</th>
<th>TEN</th>
<th>H</th>
<th>D</th>
<th>C</th>
<th>DEFL</th>
</tr>
</thead>
<tbody>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>.497</td>
<td>5.5</td>
<td>.00550</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>.591</td>
<td>6.0</td>
<td>.00627</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>.694</td>
<td>6.5</td>
<td>.00761</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>.805</td>
<td>7.0</td>
<td>.00952</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>.924</td>
<td>7.5</td>
<td>.01199</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>1.051</td>
<td>8.0</td>
<td>.01503</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>1.187</td>
<td>8.5</td>
<td>.01864</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>1.331</td>
<td>9.0</td>
<td>.02281</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>1.483</td>
<td>9.5</td>
<td>.02753</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>1.643</td>
<td>10.0</td>
<td>.03279</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>1.811</td>
<td>10.5</td>
<td>.03859</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>1.988</td>
<td>11.0</td>
<td>.04489</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>2.173</td>
<td>11.5</td>
<td>.05169</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>2.366</td>
<td>12.0</td>
<td>.05896</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>2.567</td>
<td>12.5</td>
<td>.06668</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>2.776</td>
<td>13.0</td>
<td>.07481</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>2.994</td>
<td>13.5</td>
<td>.08333</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>3.220</td>
<td>14.0</td>
<td>.09221</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>3.454</td>
<td>14.5</td>
<td>.10139</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>3.696</td>
<td>15.0</td>
<td>.11085</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>3.947</td>
<td>15.5</td>
<td>.12053</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>4.205</td>
<td>16.0</td>
<td>.13038</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>4.472</td>
<td>16.5</td>
<td>.14035</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>4.743</td>
<td>17.0</td>
<td>.15039</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>5.031</td>
<td>17.5</td>
<td>.16042</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>5.323</td>
<td>18.0</td>
<td>.17037</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>5.622</td>
<td>18.5</td>
<td>.18019</td>
</tr>
<tr>
<td>.040</td>
<td>.040</td>
<td>1.229</td>
<td>.690</td>
<td>5.930</td>
<td>19.0</td>
<td>.18977</td>
</tr>
</tbody>
</table>
COMPUTATIONS

DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

S.O. No. ___________ PAGE ___________
ENGR. ___________ CHECK ___________
DATE ___________ REV. ___________

SUBJECT: LCRU ANTENNA - REFLECTOR
ITEM: DEFLECTIONS

\[ D' = D + \Delta y = D + (\text{DEFL}) \cos \psi \]
\[ C' = C - \Delta x = C - (\text{DEFL}) \sin \psi \]

\[ \cos \psi = \frac{1}{\sqrt{1 + (0.0324C)^2}} \]
\[ \sin \psi = \frac{0.0324C}{\sqrt{1 + (0.0324C)^2}} \]

\( (D', C') \) are the coordinates of a point on the unloaded rib which would deflect to the point \((D, C)\) when loaded by the pretension of the mesh and periphery wire.

\[ \Delta x, \Delta y \]

(LOADED SHAPE)

(SHAPE OF RIB TO CORRECT FOR DEFLECTIONS)
COMPUTATIONS

DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

S.O. No. PAGE 15
ENGR. S. MACEWICZ CHK'D
DATE 4/16/70 REV.

SUBJECT: LCRU ANTENNA - REFLECTOR
ITEM: ROTATION AT PIVOT

\[ M_0 = 15 \cdot \frac{(5.5)}{21} + 5.5(F_R) - 3.18 \quad F_R = 2.24 \]
\[ A = F \cos(54) + F_R \sin(54) = 0.41 \]
\[ B = F \sin(54) + T_e(1) + F_p + F_R \cos(54) = 1.21 \]

\[ \frac{\partial M}{\partial M_0} = 1 \]

\[ \Theta = \frac{1}{EI} \int_{5.16}^{11} \left[ (M_0 - 5.16 A - 3.57 B + 1.2 T_e) + (A - 7.55 F - 2.33 T_e) + (0.1075 F - 0.1643 F - 0.1937 T_e) \right] + 0.001934 \theta^2 + 2.5 \theta \]

\[ \Theta = \frac{2(0.014)}{EI} \int_{5.16}^{11} \left[ 1.83 \right] + 1.3 (5.83) - 0.1706 (75.764) + 0.043(117) \]

\[ \Theta = \frac{0.032655}{1321} \left[ 1.83 \right] + 1.3 (5.83) - 0.1706 (75.764) + 0.043(117) \]

\[ \Theta = 0.00672 = 0^\circ 2.3' \]
**COMPUTATIONS**

DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

**SUBJECT:** LCRU ANTENNA - REFLECTOR
**ITEM:** BUCKLING OF RIB

**COMPRESSION:**

Critical buckling stress is:

\[ f_c = \frac{\pi^2 E}{(K L)^2} \]

(Reynolds Aluminum Structure: Nov 1960, p. 31)

For this case the side is constrained less than a fixed case and more than a pinned case.

Therefore

\[ (K L)^2 = \left( \frac{5.1 + 2.9}{2} \frac{b}{t} \right)^2 = 16 \left( \frac{b}{t} \right)^2 \]

\[ f_c = \frac{(3.14)^2 10 \times 10^6 \text{ psi}}{16 (\frac{10}{0.01})^2} \]

\[ f_c = \frac{3.14 (3.14)}{1.6} \times 10^4 \text{ psi} \]

\[ f_c = 61700 \text{ psi} \]

**BENDING:**

For this case (between simply supported and clamped) the critical bending stress is:

\[ f_{cr} = \frac{51.84}{2} (\frac{E}{b})^2 \] (Reynolds Aluminum Structure, p. 42)

\[ f_{cr} = \frac{67,500,000 (0.01)}{0.24} \]

\[ f_{cr} = 117,000 \text{ psi} \]
SUBJECT: LCRU ANTENNA - REFLECTOR

ITEM: FORCES NECESSARY TO CLOSE ANTENNA

RIB WEIGHT = .0289 lb
WITH MESH W = .03 lb

\[ \Sigma M_R \Rightarrow W(3 \text{ in}) = F(2.3) \]
\[ F = .04 \text{ lb.} \]

\[ \Sigma M_R \Rightarrow 14.5 W = 1.3 F \]
\[ F = .33 \text{ lb.} \]

\[ \Sigma M_R \Rightarrow 14 W = 2.3 F \]
\[ F = .183 \text{ lb.} \]

FORCE EXERTED TO CLOSE THE ANTENNA IN THE VERTICAL POSITION IS:

\[ P = 10 (F \cos 41) \]
\[ P = 1.83(1.755) = 1.38 \text{ lb.} \]

ON MOON \( P = .23 \text{ lb.} \).
FORCE NEEDED TO OPEN DISH

FOR THE CASE OF (WIRE TENSION) $TEN = 7.13$:

FORCE TO BE APPLIED BY ASTRONAUT TO DEPLOY ANTENNA IS:

\[ P = 10 \cdot (F \cos 41^\circ) \]
\[ P = 10 \cdot (0.356) \cdot (0.755) \]
\[ P = 2.69 \text{ lb.} \]

FOR $TEN = 1.229 \text{ lb}$:

\[ F = 1.36 \text{ lb} \]
\[ P = 10 \cdot (1.36) \cdot (0.755) = 10.25 \text{ lb} \]
PROPOSED NAVEL SIGHT CONCEPT
OPTICAL CONCEPT USING A BEAMSPLITTER TO REFLECT THE EARTH IMAGE

ACQUISITION AREA, FULLY REFLECTIVE (SPHERICAL)

BEAMSPLITTER AIMING AREA (FLAT) 50% REFLECTING 50% TRANSMITTING

EARTH IMAGE

RETICLE PATTERN

EARTH

GROUND GLASS RETICLE PLATE

ILLUMINATED RETICLE PATTERN

COLLIMATING LENS SYSTEM - RETICLE PLATTER IS FOCUSED AT INFINITY ELIMINATING PARALLAX BETWEEN THE EARTH & RETICLE IMAGES
# S-Band RF Losses & Heat

<table>
<thead>
<tr>
<th>Component</th>
<th>RF Power</th>
<th>IL</th>
<th>Loss</th>
<th>Heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>FM/PM XMTR</td>
<td>10.0 dBW</td>
<td></td>
<td>0.24 db</td>
<td>0.26 W</td>
</tr>
<tr>
<td>LCRU CABLE</td>
<td>9.69 dBW</td>
<td>0.65</td>
<td>1.45 W</td>
<td></td>
</tr>
<tr>
<td>Diplexer</td>
<td>8.95 dBW</td>
<td>1.0</td>
<td>1.75 W</td>
<td></td>
</tr>
<tr>
<td>Antenna CABLE</td>
<td>7.84 dBW</td>
<td>1.5</td>
<td>1.8 W</td>
<td></td>
</tr>
<tr>
<td>Antenna</td>
<td>6.1 W</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
1. Room Temp
2. FM/PM XMTR
3. Nominal XMTR Power

**Actual FM/PM XMTR RF Power to EIRP:**

- **Total Loss:** 0.24 db + 0.26 db + 0.65 db + 0.09 db = 2.16 db
- **Total Heat:** 0.26 W + 1.75 W = 2.01 W

**Iso Load:** LCRU Cable

**Diagrams:**
- RCA
- RF Losses & Heat Diagram
- Actual FM/PM XMTR RF Power to EIRP
## SUMMARY OF RF LOSSES

**ALL VALUES IN dB**

<table>
<thead>
<tr>
<th>ANTENNA</th>
<th>S-BAND XMTR</th>
<th></th>
<th>S-BAND RCVR</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LO</td>
<td>HI</td>
<td>LO</td>
<td>HI</td>
</tr>
<tr>
<td>LCRU CABLE</td>
<td>0.07</td>
<td>0.07</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>UT-141, 0.14 dB/FT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIPLEXER</td>
<td>0.65</td>
<td>0.65</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>ANTENNA CABLE</td>
<td>1.00</td>
<td>0.80</td>
<td>1.00</td>
<td>0.80</td>
</tr>
<tr>
<td>LSC-380-601-2, 0.14 dB/FT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VSWR MISMATCH</td>
<td>0.44</td>
<td>0.44</td>
<td>0.45</td>
<td>0.45</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>2.16</td>
<td>1.96</td>
<td>2.42</td>
<td>2.22</td>
</tr>
<tr>
<td><strong>VALUES USED IN LINK ANAL.</strong></td>
<td>2.2</td>
<td>2.0</td>
<td>2.5</td>
<td>2.3</td>
</tr>
</tbody>
</table>
2 ASSUMPTIONS

(a) CABLES CUT FOR MAXIMUM MISMATCH OF INDIVIDUAL UNITS. THIS IS A FAIR ASSUMPTION BECAUSE $\frac{\lambda}{2}$ IN CABLE (6.225) AT XMTR FREQUENCY IS 1.72 IN OR 4.37 CM. AT AN ANTENNA CABLE LENGTH OF 5 TO 6 FEET (ON ROVER) IT WILL BE DIFFICULT TO CONTROL THE LENGTH WITH THE REQUIRED PRECISION.

(b) ANTENNA CABLE $IL = 10 \text{ dB}$. THIS CORRESPONDS TO 4 FT OF RG142 CABLE OR 7 FT OF LSC-380 - 601-2 CABLE (LEM ANTENNA CABLE).

(c) VSWR IS ASSUMED TO BE UNIFORM THROUGH EACH UNIT. THIS ASSUMPTION IS BEHAVING AS A 38.5 $\Omega$ OR A 65 $\Omega$ SYSTEM CABLE VSWR OF 1:1.2 IS DUE TO CONNECTOR AND BEND MISMATCH.

(d) XMTR OUTPUT IS CALCULATED FOR ROOM TEMPERATURE

(e) FM-PM XMTR IS USED TO CALCULATE HEAT LOSSES, BECAUSE IT REQUIRES SLIGHTLY HIGHER RF OUTPUT.

(f) HEAT DISTRIBUTION IN DIPLExER IS ASSUMED FOR A BUTTERWORTH TYPE FILTER

NOTE(1) FOLLOWING NOTATION IS USED, FOR VSWR: $\text{VSWR} = \frac{\text{ISWR}}{\text{S}}$

EXAMPLE: $\text{VSWR} = 1.13 \Rightarrow S = 1.3$

(2) ALL VSWRs ARE REFERENCED TO 50 $\Omega$ SYSTEM
CALCULATION OF MISMATCHES & INSERTION LOSSES

(a) CONDITIONS AT A

\[ S_A = 1.5 \quad \text{given by antenna specification} \]

\[ S_T = S_A \times S_{\text{cable}} = \text{total resultant VSWR at A, worst} \phi \]

\[ S_T = 1.5 \times 1.2 = 1.8 \]

\[ M_T = \frac{(S_T + 1)^2}{4S_T} = \text{mismatch loss at A due to VSWR } S_T = 1.8 \]

\[ M_T = \frac{(1.8 + 1)^2}{4 \times 1.8} = 0.37 \text{ dB} \quad \text{(from a table } M_T = f(S_T) \text{)} \]

(b) CONDITIONS AT B

\[ S_R = \frac{R(S_T + 1) + (S_T - 1)}{R(S_T + 1) - (S_T - 1)} = \text{resultant VSWR at the input of the} \]

\[ \text{unit terminated with a VSWR of } S = S_T \text{ and having insertion} \]

\[ \text{loss ratio of } R. \quad \text{Note that } R \text{ is a ratio, not in } \text{dB.} \]

\[ S_T = 1.8 \]

\[ R = 1.0 \text{ dB} = 1.26 \]

\[ S_R = \frac{1.26 (1.8 + 1) + (1.8 - 1.0)}{1.26 (1.8 + 1) - (1.8 - 1.0)} = 1.59 \quad \text{(as seen by cable } S=1.2 \text{ system)} \]

\[ M_{R_B} = \frac{(S_R + 1)^2}{4S_R} = \text{mismatch loss at the antenna input due to term} \]

\[ \text{VSWR } S = S_T = 1.8 \text{ and due to cable VSWR } S = S_{\text{cable}} = 1.2 \]

\[ M_{R_B} = \frac{(1.59 + 1)^2}{4 \times 1.59} = 0.26 \text{ dB} \]

\[ M_T - M_{R_B} = \text{heat dissipation in cable in addition to the conventional} \]

\[ \text{matched load insertion loss. (see also } \text{IT\textsc{t} handbook,} \]

\[ \text{pages 569-573 where it corresponds to } A-A_0) \]

\[ = 0.37 - 0.26 = 0.11 \text{ dB} \quad \text{(in addition to } IL=1.0 \text{ dB)} \]
\[ S_{T_b} = \frac{S_R \times S_{\text{cable}}}{S_{\text{cable}}} = \text{MAX VSWR AT } \textcircled{B}. \text{ NOTE THAT VSWR HAS TO BE NORMALIZED TO 50 \, \Omega \, \text{SYSTEM FIRST} } (\frac{S_R}{S_{\text{cable}}}) \]

\[ = \frac{1.59 \times 1.3}{1.2} = 1.72 \]

\[ M_{T_b} = \frac{(S_T + 1)^2}{4S_T} - \frac{(1.72 + 1.0)^2}{4 \times 1.72} = 0.32 \text{ dB} \]

(c) CONDITIONS AT \( \textcircled{C} \)

\[ R_{\text{diplexer}} = 0.65 \text{ dB} = 1.16 \times \]

\[ S_{R_c} = \frac{R_d (S_{T_b} + 1) + (S_{T_b} - 1)}{R_d (S_{T_b} + 1) - (S_{T_b} - 1)} = \frac{1.16 (1.72 + 1.0) + (1.72 - 1.0)}{1.16 (1.72 + 1.0) - (1.72 - 1.0)} = 1.59 \]

\[ M_{R_c} = 0.23 \text{ dB} \quad \text{(FROM TABLE FOR } S = 1.59) \]

\[ M_{T_b} - M_{R_c} = 0.32 \text{ dB} - 0.23 \text{ dB} = 0.09 \text{ dB} \quad \text{(IN ADDITION TO DIPLEXER LOSS OF 0.65 dB)} \]

\[ S_{T_c} = \frac{S_{R_c} \times S_{\text{cable}}}{S_{\text{diplexer}}} = \frac{1.59 \times 1.2}{1.3} = 1.47 \quad \text{(MAX VSWR AT } \textcircled{C}) \]

(d) CONDITIONS AT \( \textcircled{D} \)

\[ S_{R_d} = S_{T_c} = 1.47 \quad \text{(BECAUSE CABLE LOSS } = 0.07 \text{ dB IS TOO SMALL TO REDUCE VSWR NOTICEABLY; FOR THE SAME REASON THERE IS NO ADDITIONAL HEAT LOSS IN LCRU CABLE)} \]

\[ S_{T_d} = \frac{S_{R_d} \times S_{\text{infr}}}{S_{\text{cable}}} = \frac{1.42 \times 1.3}{1.2} = 1.60 \]
\[ M_T = \frac{(S_2 + 1)^2}{4S_2} = 0.24 \text{ dB} \]

This is the final mismatch loss as affected by insertion losses of the antenna cable, the diplexer and the most unfavorable cable lengths.

Note that antenna VSWR of \( S_\tau = 1.5 \) is only slightly smaller than the final VSWR of \( S_\tau = 1.6 \). Cable mismatch and attenuation apparently offset each other.

**Total Transducer Loss**

**Summary of Losses:**

<table>
<thead>
<tr>
<th>Loss</th>
<th>Value in dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ant. Cable insertion</td>
<td>1.00 dB</td>
</tr>
<tr>
<td>Additional heat loss</td>
<td>0.11 dB</td>
</tr>
<tr>
<td>Matched load diplexer</td>
<td>0.65 dB</td>
</tr>
<tr>
<td>Additional diplexer</td>
<td>0.09 dB</td>
</tr>
<tr>
<td>LCRU cable ins loss</td>
<td>0.07 dB</td>
</tr>
<tr>
<td>Final XMTR mismatch</td>
<td>0.24 dB</td>
</tr>
</tbody>
</table>

\[ 2.16 \text{ dB} \quad \text{Total loss of the mismatched system} \]

For a matched system total loss would have been:

\[ 1.00 \text{ dB} + 0.65 \text{ dB} + 0.07 \text{ dB} = 1.72 \text{ dB} \]

\[ 2.16 \text{ dB} - 1.72 \text{ dB} = 0.44 \text{ dB} \quad \text{(Difference mismatch/match)} \]

VSWRs of antenna, diplexer and cables combined with maximum mismatch cable lengths thus increase the total transducer loss by 0.44 dB.

**Calculation of RF Power & Heat**

Conic XMTR is specified to produce 9.25 dBW RF output at +70°C into a VSWR of \( S = 1.5 \) load. The nominal, matched load XMT output at room temp is recalculated including ATP meter error and production tolerance.

\[ +9.25 \text{ dBW} + 0.20 \text{ dB} + 0.25 \text{ dB} + 0.20 \text{ dB} + 0.10 \text{ dB} = 10.00 \text{ dBW} \]

\[ \text{XMT} \quad \text{VSWR} \quad \text{Room Temp} \quad \text{ATP Prod Var} \quad \text{Nom XMT} \]

7-180
**S-BAND RF LOSSES & HEAT**

**LOSS SUMMARY & HEAT**

**TOTAL LOSS = 0.24 dB + 0.07 dB + 0.65 dB + 0.03 dB + 1.00 dB + 0.11 dB = 2.16 dB**

**TOTAL HEAT = 0.55 W + 0.15 W + 1.45 W + 1.75 W = 3.9 WATTS**

**NOTES:**
1. ROOM TEMP
2. FM/PM XMT
3. NOMINAL XMT POWER

---

**INDIVIDUAL CAVITY HEAT DISTRIBUTION ACCORDING TO:**

\[
\frac{Q_L}{Q_{tot}} = \sin \frac{2\pi - 1}{2N} \]

\(N = 4\)

1. **15th & 9th CAVITY**
   \(-0.373 \times 0.21\) WATTS

2. **2nd & 3rd CAVITY**
   \(-0.925 \times 0.516\) WATTS

**FIG-2**
6. Open Circuit at LCRU Output

This condition exists during a change of the antenna with XMTR left working of prime interest is the heat dumped into isolator load, LCRU cable and WPLEVER. Terminating VSWR is $S = \infty$. See Fig 3.

(a) Conditions at A

\[ S \gg 1 \]

\[ S_R = \frac{R(S+1)+(S-1)}{R(S+1)-(S-1)} = \frac{RS+S}{RS-S} = \frac{R+1}{R-1} \]

\[ R_A = 0.65 \text{dB} = 1.16 \times \text{ (Diplexer Loss) } \]

\[ S_{R_a} = \frac{1.16 + 1.0}{1.16 - 1.0} = \frac{2.16}{0.16} = 13.5 \] (Resulting VSWR—open circ reduced by diplex loss)

\[ S_{T_A} = \frac{13.5 \times 1.2}{1.3} = 12.5 \] (Total VSWR at A)

\[ M_{T_A} = 5.6 \text{ dB} \] (Mismatch at A)

(b) Conditions at B

\[ R_B = 0.07 \text{dB} = 1.0165 \]

\[ S_{R_B} = \frac{1.0165 (12.5 + 1.0) + (12.5 - 1.0)}{1.0165 (12.5 + 1.0) - (12.5 - 1.0)} = 11.4 \]

\[ M_{R_B} = 5.3 \text{dB} \]

\[ M_{T_A} - M_{R_B} = 5.6 \text{dB} - 5.3 \text{dB} = 0.3 \text{dB} \] (Additional heat loss for LCRU cable)

7-182
\[ S_{TB} = \frac{11.4 \times 1.3}{1.2} = 12.3 \]

\[ M_{TB} = \frac{(12.3 + 0.2)^2}{4 \times 12.3} = 5.6 \text{ dB} \]

**Final Mismatch at LCRU Cable Input**

(C) RF Power Levels & Heat Losses

![Diagram showing power flow and losses](image)

**FM/PM**
- 10.45 W
- 110 W

**XMTR**
- 10.0 W
- 10.0 dBW
- -23 dB
- 2.75 W

**ISO LOAD**
- 7.25 W
- 8.6 dBW
- 0.35 W
- 0.2 dB
- 0.8 dB
- 6.9 W
- 8.4 dBW

**LCRU CABLE**
- 2.75 W
- -7.2 dB
- 0.2 dB

**ISO Load**
- 10.0 W
- 10.0 dBW
- XMTR
- 2.75 W
- LOAD
- 7.25 W
- 8.6 dBW
- ISO IN
- 0.35 W
- 0.2 dB
- ISO LOSS
- 0.8 W
- 8.4 dBW
- ISO LOAD

**ISOLOAD**
- 0.45 W
- 0.35 W

**CABLE**
- Dissipates 0.23 W

**DIPLEXER**
- Dissipates 2.52 W

**Note that heat increases almost twice above matched load case. This is due to the reflected power at the open circuit.**

**Individual Cavity Heat is proportional to cavity loading, here assumed to be of the Butterworth type**

\[ Q_l = \sin \frac{2\pi \cdot 1}{2} = 0.925 \] for 2nd, 4th, 6th

\[ Q_{tor} = \frac{0.925}{2} \] for 2nd, 4th, 6th

\[ Q_{tor} = 0.36 \text{ Watts} \]

\[ Q_{tor} = 0.90 \text{ Watts} \]
### METER CHARACTERISTICS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>5 VDC/0.2 MA Full Scale</td>
</tr>
<tr>
<td>Scale Marking</td>
<td>0, 1, 2, 3, 4, 5 over 240 Deg</td>
</tr>
<tr>
<td>Sealing</td>
<td>Hermetic</td>
</tr>
<tr>
<td>Accuracy</td>
<td>±5% of Full Scale at 0 to 150 Deg F</td>
</tr>
<tr>
<td>Terminals</td>
<td>Solder Type</td>
</tr>
<tr>
<td>Illumination</td>
<td>None</td>
</tr>
<tr>
<td>Similar To</td>
<td>North American Aviation ME432-0170 0001</td>
</tr>
<tr>
<td>Size</td>
<td>1.735 IN SQ x 3.055 IN Long</td>
</tr>
<tr>
<td>Weight</td>
<td>0.47 Pounds</td>
</tr>
<tr>
<td>Characteristic</td>
<td>Specification</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>NUMBER POLES</td>
<td>1</td>
</tr>
<tr>
<td>NOMINAL AMPS</td>
<td>10</td>
</tr>
<tr>
<td>VOLTAGE DROP AT 77 DEG F</td>
<td>0.2V</td>
</tr>
<tr>
<td>WATTS AT 77 DEG F</td>
<td>2.0</td>
</tr>
<tr>
<td>ULTIMATE TRIP CURRENT MAX</td>
<td>14.5 AT 77 DEG F</td>
</tr>
<tr>
<td>MIN</td>
<td>11.5A</td>
</tr>
<tr>
<td>TRIP TIME AT 77 DEG F (MIN-MAX)</td>
<td>15-40 SEC AT 200% NOM CURRENT</td>
</tr>
<tr>
<td>MANUAL OPERATE FORCE</td>
<td>PULL OUT 8 LBS MAX/2 LBS MIN</td>
</tr>
<tr>
<td></td>
<td>RESET 10 LBS</td>
</tr>
<tr>
<td>PART NO.</td>
<td>NORTH AMERICAN AVIATION ME454 0011-0033</td>
</tr>
<tr>
<td>VENDOR</td>
<td>MECHANICAL PRODUCTS 700 085 10</td>
</tr>
<tr>
<td>WEIGHT</td>
<td>1.6 OZ MAX</td>
</tr>
<tr>
<td>SIZE (REAR PROJECTION)</td>
<td>1.09 X 0.687 X 1.84 INCH</td>
</tr>
<tr>
<td>TRIP INDICATOR</td>
<td>CLOSED 0.86 IN/OPEN 1.06 IN</td>
</tr>
</tbody>
</table>
## Rotary Switch Characteristics

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Poles</strong></td>
<td>6</td>
</tr>
<tr>
<td><strong>Number of Positions</strong></td>
<td>5</td>
</tr>
<tr>
<td><strong>Number of Decks</strong></td>
<td>3</td>
</tr>
<tr>
<td><strong>Detent Angle</strong></td>
<td>36 °D WITH STOP</td>
</tr>
<tr>
<td><strong>Leak Rate</strong></td>
<td>$1 \times 10^{-8}$ CC/SEC AT 1 ATMOSPHERE DIFF</td>
</tr>
<tr>
<td><strong>Operating Force</strong></td>
<td>48-96 IN-OZ</td>
</tr>
<tr>
<td><strong>Circuit Resistance</strong></td>
<td>40 MILLIOHMS MAX</td>
</tr>
<tr>
<td><strong>NASA Spec</strong></td>
<td>95 M10110 AND 95 M10109</td>
</tr>
<tr>
<td><strong>Current Carrying Cap</strong></td>
<td>28 VDC/5 AMP RESISTIVE</td>
</tr>
<tr>
<td><strong>Make/Break Rating</strong></td>
<td>28 VDC/2 AMP RESISTIVE</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>0.5 POUNDS</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>1.25 DIAM/2.75 LONG</td>
</tr>
<tr>
<td><strong>Vendor/DWG</strong></td>
<td>DAVEN/A-37010</td>
</tr>
</tbody>
</table>
FROM J3 TV/EXT POWER

32-44 VDC

RETURN

DC-DC CONVERTER

28.5V COMMON

S2 POWER

1 EXT OFF

2 INT

CIRCUIT BREAKER

+29V

VOLTAGE REGULATOR

10V 14V COMMON

BATTERY

+29V

16.8V

16.5V

16.8V
<table>
<thead>
<tr>
<th>Specification</th>
<th>Specification Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Poles</td>
<td>3</td>
</tr>
<tr>
<td>Operation</td>
<td>Maintain-Off-Maintain</td>
</tr>
<tr>
<td>Lock</td>
<td>Center (Off) Position</td>
</tr>
<tr>
<td>Classification</td>
<td>30 Vdc Resistive 15 Amp Inductive 10 Amp</td>
</tr>
<tr>
<td>Contact Resistance</td>
<td>0.06 ohm Max</td>
</tr>
<tr>
<td>Leak Rate</td>
<td>Less than $10^{-4}$ CC/Sec @ 1 Atmos Differential</td>
</tr>
<tr>
<td>Operating Force</td>
<td>1 Pound Min/8 Pound Max</td>
</tr>
<tr>
<td>Pullout to Change Position</td>
<td>0.09 Pounds Max</td>
</tr>
<tr>
<td>Part Number</td>
<td>Not Listed in NAA ME 452-0102</td>
</tr>
<tr>
<td>Potential Vendor</td>
<td>Texas Instruments/Pt No 13LS3-41</td>
</tr>
<tr>
<td>Size</td>
<td>1.735 In Sq x 3.055 In Long (Est)</td>
</tr>
<tr>
<td>Weight</td>
<td>0.47 Pounds (Est.)</td>
</tr>
</tbody>
</table>
27-33V FROM S2 (POWER CONTROL) → VOLTAGE CONDITIONER

FROM TEMP SENSOR HEATSINK

TO 14.5 KHz VCO (IN DLSP)

S-BAND AGC (FROM S3) → MONITOR SWITCHING

VOLT/TEMP SWITCH

AGC

TEMP VOLTS

4.99K

R3

3.09K

R1

3.16K

R2

M

1

2

3

4

5

6

7

8

9

10

11

12
TOGGLE SWITCH CHARACTERISTICS
(AGC/RAD TEMP/POWER)

NUMBER OF POLES 3
OPERATION ON-ON-ON
CLASSIFICATION
30 VDC RESISTIVE 15 AMP
INDUCTIVE 10 AMP
CONTACT RESISTANCE 0.06 OHM MAX
LEAK RATE LESS THAN 10^-4 CC/SEC
AT 1 ATMOS DIFFERENTIAL
OPERATING FORCE 1 POUND MIN/8 POUND MAX
PART NUMBER
NORTH AMERICAN AVIATION ME452-0102-1306
VENDOR TEXAS INSTRUMENTS 23LS4-2
SIZE 1.779 X 1.354 X 1.550
WEIGHT 0.20 POUNDS MAX

INACTIVE FOR NEW DESIGN
HOT MISSION - I SORTIE

TOTAL WATT HOURS vs. TIME - HOURS

TIME - HOURS

0 1 2 3 4 5 6 7

TOTAL WATT HOURS

0 100 200 300 400 500
WATT HOURS VS TIME
TIMELINE 1

TOTAL WATT HOURS

0 400 800 1200 1600 2000

TIME - HOURS

0 8 16 24 32 40 48 56 64 72

HOT MISSION
COLD MISSION
WATT HOURS VS TIME

TIMELINE 2

TOTAL WATT HOURS

HOT MISSION

COLD MISSION

TIME - HOURS

0 8 16 24 32 40 48 56 64 72
## LCRU Power Requirements - Watts

<table>
<thead>
<tr>
<th>Subassembly</th>
<th>Mode 1 PM1/NB</th>
<th>Mode 2 PM1/WB</th>
<th>Mode 3 FM/TV</th>
<th>Mode 4 TV RMT (STANDBY)</th>
<th>Mode 5 PM2/NB</th>
</tr>
</thead>
<tbody>
<tr>
<td>VHF Receiver</td>
<td>1.17</td>
<td>1.17</td>
<td>1.17</td>
<td>1.17</td>
<td>1.17</td>
</tr>
<tr>
<td>VHF Transmitter</td>
<td>4.10</td>
<td>4.10</td>
<td>4.10</td>
<td>.35</td>
<td>4.10</td>
</tr>
<tr>
<td>S-Band Receiver</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>PM/PM Transmitter</td>
<td>47.8</td>
<td>47.8</td>
<td>0.29</td>
<td>0.29</td>
<td>0.29</td>
</tr>
<tr>
<td>FM/PM Transmitter</td>
<td>0.29</td>
<td>0.29</td>
<td>53.7</td>
<td>0.29</td>
<td>53.7</td>
</tr>
<tr>
<td>Up Link Signal Processor</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>Down Link &quot; &quot;</td>
<td>0.76</td>
<td>1.46</td>
<td>1.46</td>
<td>1.46</td>
<td>0.76</td>
</tr>
<tr>
<td>Voltage Regulator</td>
<td>2.20</td>
<td>2.35</td>
<td>2.35</td>
<td>2.35</td>
<td>2.20</td>
</tr>
<tr>
<td>Camera Assembly (Still)</td>
<td>-</td>
<td>-</td>
<td>21.0</td>
<td>6.00</td>
<td>-</td>
</tr>
<tr>
<td>Camera Assembly (In Motion)</td>
<td>-</td>
<td>-</td>
<td>21.0+2.0</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Total Watts</strong></td>
<td><strong>57.5</strong></td>
<td><strong>58.4</strong></td>
<td><strong>87.2</strong></td>
<td><strong>13.1</strong></td>
<td><strong>63.4</strong></td>
</tr>
</tbody>
</table>

### Watts at Nominal Battery Voltage

- LCRU: 57.5
- DC DC Converter: 11.5
- Total Watts: 69.0

### Power Requirements Using External Power

- LCRU: 57.5
- DC DC Converter: 11.5
- Total Watts: 69.0
## LCRU Heat Dissipation - Watts - Internal Battery

### Worst Case - Maximum Voltage Supply

<table>
<thead>
<tr>
<th>Subassembly</th>
<th>Mode 1 PM1/NB</th>
<th>Mode 2 PM1/WB</th>
<th>Mode 3 FM/TV</th>
<th>Mode 4 TV RMT (STANDBY)</th>
<th>Mode 5 PM2/NB</th>
</tr>
</thead>
<tbody>
<tr>
<td>VHF Receiver</td>
<td>1.17</td>
<td>1.17</td>
<td>1.17</td>
<td>1.17</td>
<td>1.17</td>
</tr>
<tr>
<td>VHF Transmitter</td>
<td>3.45</td>
<td>3.45</td>
<td>3.45</td>
<td>0.35</td>
<td>3.45</td>
</tr>
<tr>
<td>S-Band Receiver</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>PM Transmitter</td>
<td>46.6</td>
<td>46.6</td>
<td>0.29</td>
<td>0.29</td>
<td>0.29</td>
</tr>
<tr>
<td>FM/PM Transmitter</td>
<td>0.29</td>
<td>0.29</td>
<td>52.0</td>
<td>0.29</td>
<td>52.0</td>
</tr>
<tr>
<td>Up-Link Signal Processor</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>Down-Link &quot;&quot;</td>
<td>0.76</td>
<td>1.46</td>
<td>1.46</td>
<td>1.46</td>
<td>0.76</td>
</tr>
<tr>
<td>Voltage Regulator</td>
<td>3.45</td>
<td>3.45</td>
<td>3.70</td>
<td>3.70</td>
<td>3.45</td>
</tr>
<tr>
<td>DC-DC Converter Idler</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>59.9</strong></td>
<td><strong>60.6</strong></td>
<td><strong>66.2</strong></td>
<td><strong>11.4</strong></td>
<td><strong>65.3</strong></td>
</tr>
</tbody>
</table>

### Nominal Voltage Supply

<table>
<thead>
<tr>
<th>Subassembly</th>
<th>Mode 1 PM1/NB</th>
<th>Mode 2 PM1/WB</th>
<th>Mode 3 FM/TV</th>
<th>Mode 4 TV RMT (STANDBY)</th>
<th>Mode 5 PM2/NB</th>
</tr>
</thead>
<tbody>
<tr>
<td>VHF Receiver</td>
<td>1.17</td>
<td>1.17</td>
<td>1.17</td>
<td>1.17</td>
<td>1.17</td>
</tr>
<tr>
<td>VHF Transmitter</td>
<td>3.45</td>
<td>3.45</td>
<td>3.45</td>
<td>0.35</td>
<td>3.45</td>
</tr>
<tr>
<td>S-Band Receiver</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>PM Transmitter</td>
<td>41.0</td>
<td>41.0</td>
<td>0.29</td>
<td>0.29</td>
<td>0.29</td>
</tr>
<tr>
<td>FM/PM Transmitter</td>
<td>0.29</td>
<td>0.29</td>
<td>45.7</td>
<td>0.29</td>
<td>45.7</td>
</tr>
<tr>
<td>Up-Link Signal Processor</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>Down-Link &quot;&quot;</td>
<td>0.76</td>
<td>1.46</td>
<td>1.46</td>
<td>1.46</td>
<td>0.76</td>
</tr>
<tr>
<td>Voltage Regulator</td>
<td>2.20</td>
<td>2.35</td>
<td>2.35</td>
<td>2.35</td>
<td>2.35</td>
</tr>
<tr>
<td>DC-DC Converter Idler</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>53.0</strong></td>
<td><strong>53.9</strong></td>
<td><strong>58.6</strong></td>
<td><strong>10.1</strong></td>
<td><strong>57.7</strong></td>
</tr>
</tbody>
</table>
### LCRU MODE USAGE

<table>
<thead>
<tr>
<th>Nomenclature</th>
<th>Operating Modes/Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary (PMI/WB)</td>
</tr>
<tr>
<td>VHF Antenna</td>
<td>V/D</td>
</tr>
<tr>
<td>VHF Triplexer</td>
<td>V/D</td>
</tr>
<tr>
<td>VHF Receiver</td>
<td>V/D</td>
</tr>
<tr>
<td>Up Link Proc.</td>
<td>V</td>
</tr>
<tr>
<td>PRI S-Band Revcr</td>
<td>V</td>
</tr>
<tr>
<td>Sec S-Band Revcr</td>
<td>V/D</td>
</tr>
<tr>
<td>S-Band Diplexer</td>
<td>V/D</td>
</tr>
<tr>
<td>Signal Mixer</td>
<td></td>
</tr>
<tr>
<td>Diode Atten.</td>
<td></td>
</tr>
<tr>
<td>Shape Filter</td>
<td>V/D</td>
</tr>
<tr>
<td>Time Share Switch</td>
<td>D</td>
</tr>
<tr>
<td>1, 25 MHz VCO</td>
<td>V/D</td>
</tr>
<tr>
<td>1, 25 MHz VCO</td>
<td></td>
</tr>
<tr>
<td>14.5 kHz VCO</td>
<td>D</td>
</tr>
<tr>
<td>VHF Transmitter</td>
<td>V</td>
</tr>
<tr>
<td>S-Band PM/PM Xmtr</td>
<td>V/D</td>
</tr>
<tr>
<td>S-Band PM/PM Xmtr</td>
<td></td>
</tr>
<tr>
<td>Voltage Reg.</td>
<td>P</td>
</tr>
<tr>
<td>DC/DC Converter</td>
<td>P*</td>
</tr>
<tr>
<td>Mode Switch</td>
<td>P/D</td>
</tr>
<tr>
<td>Power Switch</td>
<td>P</td>
</tr>
<tr>
<td>Monitor Switch</td>
<td>D</td>
</tr>
<tr>
<td>Monitor Meter</td>
<td>D</td>
</tr>
<tr>
<td>Circuit Breaker</td>
<td>P</td>
</tr>
<tr>
<td>Temp Sensor</td>
<td>D</td>
</tr>
<tr>
<td>Battery</td>
<td>P*</td>
</tr>
<tr>
<td>High Gain Antenna</td>
<td>V/D</td>
</tr>
<tr>
<td>Low Gain Antenna</td>
<td>V/D</td>
</tr>
</tbody>
</table>

Key: V = Voice, D = Data, T = Television and P = Power

( ) Indicates S-Band FM/PM Transmitter A10 Activated via Earth command and TV camera control switch in remote position. Not normally used for V/D communications.

*Denotes alternate power sources
# TABLE 2 - SUMMARY TABLE OF SINGLE POINT FAILURES

## CORRECTIVE ACTIONS AND RECOMMENDATIONS

<table>
<thead>
<tr>
<th>SINGLE POINT FAILURE</th>
<th>CORRECTIVE ACTION REMARKS AND RECOMMENDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Single S-Band Receiver used in all modes - Failure results in loss of up link communications in all modes.</td>
<td>1. Employed use of redundant receiver.</td>
</tr>
<tr>
<td>2. +29 VDC Buss is common to redundant S-Band Transmitters - Shorted +29 VDC Buss in one transmitter is propagated to other transmitter in mode selection.</td>
<td>2. Employed use of mode selection switch to independently switch +29 VDC Buss to applicable S-Band transmitter.</td>
</tr>
<tr>
<td>3. Filter capacitor (C13) is common to +10 VDC output of voltage regulator after steering diodes - Failure of capacitor affects all modes. Similar situation exists for feedthru capacitors C14 on +14 VDC line and C15 on +10 VDC line.</td>
<td>3. Employed separate filter capacitors on the +10 VDC Buss of each voltage regulator prior to the steering diodes. Feedthru capacitors C14 and C15 remain unchanged since they are necessary for hi-frequency filtering on DC regulator lines and have low failure history.</td>
</tr>
<tr>
<td>4. VHF up and down link, consisting of VHF antenna, receiver, transmitter, triplexer and processors. Antenna or triplexer failure affects all modes. Transmitter or up link processor failure affects up link communications. Receiver or down-link processor affects down-link communications.</td>
<td>4. Hard-line between PLSS and LCRU to bypass VHF receiver and transmitter portion of LCRU link has been proposed, considered and rejected.</td>
</tr>
<tr>
<td>5. S-Band Receiver Switch - used in all modes. Failure could prevent operation of either S-Band Receiver.</td>
<td>5. Deleted from Design.</td>
</tr>
</tbody>
</table>
SINGLE POINT FAILURE

6. Mode Selector Switch - Used in all modes:
   Contact #17 (Rotor of one deck) is used to
   switch 29V control lines to the PM transmitter
   modulators in primary and secondary modes and
   the FM/PM transmitter modulators in TV and
   back up modes. Damaged or open rotor
   contact would inhibit down link communications
   in all of these modes.

   6.1 Contact #24 (Rotor of one deck) is used to
   switch +14 VDC to the primary and secondary
   receivers in all modes. Damaged or open
   rotor contact would inhibit up link communica-
   tions in all modes.

   All other contacts are for individual modes or
   LCRU AGC monitoring. Failure effects
   are minimal.

7. Power Switch - Used in all Modes: Switch
   is of double pole, three position construction,
   locked in each position. Selects prime power
   source from internal battery or LRV battery
   through the DC/DC Converter.

8. LCRU Thermal and Battery Voltage Status
   Circuitry common to all modes: Temperature
   sensor, time share switch 14.5 MHZ VCO
   and Diode Attenuator.

   These items are listed in this category because
   of the critical thermal aspects of LCRU opera-
   tion. Failure of any of these items will
   result in the loss of ground monitoring capa-
   bility and possible permanent damage to the
   LCRU.

CORRECTIVE ACTION REMARKS AND
RECOMMENDATIONS

6. See Note 6.1 below. However, TV Standby Mode
   could be used in emergency conditions such as
   this. Implementation would be via procedures to
   be followed by Astronauts for indicated symptoms
   and additional checks indicating satisfactory oper-
   ation of other LCRU functions by Monitor Meter.

   6.1 Probability of failure occurrence is low since low
   currents are switched and switch using No. 24 wire
   from switch contacts to rear soldering lugs, has
   been NASA qualified for Random Vibration Level
   of 0.4G²/Hz, 60 G shock and 20 G acceleration.
   This switch uses No. 22 Stranded wire for LCRU
   application.

7. No action recommended. Switch has been qualified
   and used previous Apollo Applications.

8. Procedural standard, which would require immediate
   ground to Astronaut notification of thermal and
   battery voltage data loss and subsequent check by
   Astronauts via the monitor meter is recommended.

   The use of temperature and battery voltage
   sensing circuitry completely isolated from the time
   share switch circuitry is also suggested for use
   with the meter. Although this might present a
   slight discrepancy between the meter reading and
   the thermal data relayed to Earth, it would preclude
SINGLE POINT FAILURE

9. Circuit Breaker - This item is used in all modes. Inability of the circuit breaker to be reset results in loss of down link communications capability in all modes.

10. DC short on input side of either 14 VDC regulator would drain +16 VDC battery power and cause loss of LCRU capability in all modes.

CORRECTIVE ACTION REMARKS AND RECOMMENDATIONS

the total loss of thermal and battery voltage monitoring capability for a temperature sensor failure or switching transistor (Q7, Q8) failure in the output of the time share switch assembly.

9. This failure mode has been experienced in previous Apollo usage and has been attributed to supplier workmanship for which corrective action has been taken. Other analyses indicated that care in installation (Torque requirements, application of conformal coating, etc.) will be necessary.

10. Replacement of reverse polarity blocking diodes with fuses is recommended. Similarly, S-Band transmitter input lines could be fused and circuit breaker eliminated.