SOLID STATE S-BAND POWER AMPLIFIER

FINAL REPORT

CASE FILE COPY

for the

NASA
Marshall Space Flight Center
Huntsville, Alabama

CONTRACT NAS-8-28763

ADVANCED DEVELOPMENT

DEFENSE COMMUNICATIONS
492 River Road, Nutley, New Jersey 07110

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1. INTRODUCTION

The following is a report on the final design approach and specifications for the solid state S-band power amplifier in accord with the specifications of contract NAS-8-28763. Modifications from the design proposed in ITT Defense Communications proposal 34024 have been incorporated to improve efficiency and meet input overdrive and noise floor requirements.

2. SYSTEM DESIGN

2.1 SYSTEM BLOCK DIAGRAM

The driver and power amplifier block diagrams are shown in Drawings 1261662 and 663. A number of key features of this design should be noted. To safely apply up to one watt of power to the input 6 db of attenuation has been incorporated. Since the 12 db isolation resulting from this attenuator provides adequate input standing wave ratio, the input circulator has been eliminated. An additional stage of gain has been incorporated in the driver amplifier to compensate for the loss. There is no impact on the system noise floor, because measurements on the MSC 80064 have shown a noise figure of 7.9 db per stage, which gives a driver amplifier noise figure for two stages of 8.45 db from the formula

\[
NF = F_1 + \frac{F_2 - 1}{G}
\]

where \( NF \) = noise figure for the total system
\( F_1, F_2 \) = noise figure of the first and second stages
\( G \) = gain of the first stage

The total system noise floor, with an amplifier gain of 39.4 db is

\[
\text{Noise Floor} = kTB \frac{\text{dbm}}{\text{hz}} + NF + G_{\text{amp}} + \text{Bandwidth factor}
\]

\[
NF_{\text{tot}} = -174 + 8.45 + 39.4 + 70
\]

\[
= -56.15 \text{ dbm}
\]

10 mhz

To meet the out of band noise floor specification of -95 dbm/10 mhz at 2104 mhz, an additional 38.85 db of rejection must be supplied by the output filter. This is within the limits of the filter specification.

The total amplifier efficiency has been improved to 36% by newer transistors.
2.2 SYSTEM SPECIFICATIONS

The system specifications are summarized below.

<table>
<thead>
<tr>
<th>Title</th>
<th>NASA Spec. Requirements</th>
<th>ITT Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power consumption</td>
<td>95 watts max.</td>
<td>73 watts</td>
</tr>
<tr>
<td>Primary voltage</td>
<td>28 ± 4 vdc</td>
<td>28 ± 4 vdc</td>
</tr>
<tr>
<td>Performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drive power</td>
<td>25 to 50 mw, no damage</td>
<td>25 to 50 mw drive to</td>
</tr>
<tr>
<td></td>
<td>should occur by input</td>
<td>obtain 20 watt, min.</td>
</tr>
<tr>
<td></td>
<td>power levels from 0.0</td>
<td>output</td>
</tr>
<tr>
<td></td>
<td>to 1.0 watts, cw</td>
<td>1 watt input drive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>capability</td>
</tr>
<tr>
<td>Output power</td>
<td>20 watts min. at</td>
<td>23.5 watts @</td>
</tr>
<tr>
<td></td>
<td>optimum efficiency</td>
<td>efficiency</td>
</tr>
<tr>
<td>Life</td>
<td>Mtbf = 10,000 hrs</td>
<td>29,200 hour</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mtbf</td>
</tr>
<tr>
<td>Terminal impedances</td>
<td>Input swr 1.3:1 max</td>
<td>Input swr 1.25:1</td>
</tr>
<tr>
<td></td>
<td>Output swr 1.5:1 max</td>
<td>Output swr 1.5:1</td>
</tr>
<tr>
<td></td>
<td>with all d-c removed</td>
<td>with or without</td>
</tr>
<tr>
<td></td>
<td>from power amplifier</td>
<td>d-c applied</td>
</tr>
<tr>
<td>Phase stability</td>
<td>add no more than 0.05</td>
<td>0.05 radians rms</td>
</tr>
<tr>
<td></td>
<td>radian rms phase jitter</td>
<td>phase jitter to</td>
</tr>
<tr>
<td></td>
<td>to r-f input signal</td>
<td>input signal</td>
</tr>
<tr>
<td>Center frequency</td>
<td>2,250.5 mhz</td>
<td>2,250.5 mhz</td>
</tr>
<tr>
<td>Passband requirements</td>
<td>100 mhz, ± 1 db</td>
<td>100 mhz, ± 1 db</td>
</tr>
<tr>
<td></td>
<td>centered at 2,250.5 mhz</td>
<td>bandwidth center on 2,250.5 mhz</td>
</tr>
</tbody>
</table>
### Environmental Temperature

- meet all performance requirements when heat sink is maintained at -20 to -70 C. Thermal shock three cycles -20, +85 C.

### Vibration

- **Random noise (5 min/plane):**
  - 20–59 hz: 0.04 g²/hz
  - 59–126 hz: -9 db/octave
  - 126–700 hz: 0.40 g²/hz
  - 700–900 hz: -18 db/octave
  - 900–2Khz: 0.09 g²/hz

- **Sinusoidal sweep (1 octave/min.):**
  - 5–48 hz: 0.125 inch
  - 48–165 hz: 15 g peak
  - 165–2000 hz: 10 g peak

- **Shock:**
  - eight shocks per plane, 3 planes, 50 g for 11 msec.

### Acceleration

- 1 min of 100 g in each of three planes

### Vacuum and pressurization

- within 24 hr. period leak rate shall be less than 1.0 psi when pressurized to 15 psig in a vacuum of 1.5 x 10⁻⁶ mmhz

### Humidity

- MIL-STD-810, Method 507.1 Procedure 1

### R-F interference

- per MIL-I-6181

### Acoustical noise

- per MIL-STD-810

### Output load isolator

- 20 db isolation over passband

### ITT Performance

- -20 to +70 C output power and all operational characteristics

- Designed to Humidity specs

- per MIL-I-6181

- per MIL-STD-810

- 20 db, minimum
- 25 db, typical over passband
<table>
<thead>
<tr>
<th>Title</th>
<th>NASA Spec. Requirements</th>
<th>ITT Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-band spurious responses</td>
<td>60 db below output carrier measured within a 4 mhz bandwidth at output frequency 2,250.5 mhz</td>
<td>60 db below rated output at 2250.5 mhz</td>
</tr>
<tr>
<td>Output noise level</td>
<td>Internal noise gen. 2104 ± 5 mhz, less than -95 dbm</td>
<td>-95 dbm, minimum</td>
</tr>
<tr>
<td>Output filter</td>
<td>Bandpass filter to reduce output noise spectrum of power amplifier</td>
<td>Output noise floor -95 dbm/10 mhz, Harmonics -60 db</td>
</tr>
</tbody>
</table>

2.3 **SYSTEM MECHANICAL LAYOUT**

The system mechanical layout is shown in the sketch, Drawing 1261673-B. The input circulator has been replaced by a fixed attenuator and an additional preamplifier stage has been incorporated.

Sketches and drawings used in the construction of this amplifier are bound together at the end of this document.
3. DRIVER AMPLIFIER SECTION

The driver section consists of the following components:

- input attenuator
- 3 stage amplifier
- matching networks

The specified input standing wave ratio of 1.3:1 has been satisfied as summarized in the following table.

<table>
<thead>
<tr>
<th>Specification</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Preamplifier input standing wave ratio</td>
<td>2.0:1 max.</td>
</tr>
<tr>
<td>Input standing wave ratio of fixed attenuator, variable attenuator and preamplifier</td>
<td>1.28:1 max.</td>
</tr>
<tr>
<td>Specification requirements</td>
<td>1.3:1 max.</td>
</tr>
</tbody>
</table>

For 1 watt or +30 dbm applied to the input, the preamplifier receives 126 mw or +21 dbm, which is within acceptable limits.

3.1 INPUT ATTENUATOR

The fixed input attenuator satisfies the following specifications:

<table>
<thead>
<tr>
<th>Specification</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Attenuation</td>
<td>dB</td>
</tr>
<tr>
<td>Input standing wave ratio</td>
<td>1.15:1</td>
</tr>
<tr>
<td>Power rating</td>
<td>1 watt at 75 C</td>
</tr>
<tr>
<td>Impedance</td>
<td>50</td>
</tr>
<tr>
<td>Frequency range</td>
<td>2.250 ghz ± 50 mhz</td>
</tr>
<tr>
<td>Size</td>
<td>5/16&quot; diam., 1.5&quot; long</td>
</tr>
<tr>
<td>Connectors</td>
<td>SMA</td>
</tr>
</tbody>
</table>

3.2 LOW LEVEL DRIVER AMPLIFIER STAGES

A circuit diagram of the three stage amplifier is shown in Drawing 12616b2.

The nominal output power is 3.5 watts with 3 mw input giving a gain of 30.7 db.
The overall specifications required for this amplifier chain are:

<table>
<thead>
<tr>
<th>Specification</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency range</td>
<td>2.2-2.3 ghz</td>
</tr>
<tr>
<td>Gain</td>
<td>30 db</td>
</tr>
<tr>
<td>Gain flatness</td>
<td>1.5 db over band</td>
</tr>
<tr>
<td>Max. power output</td>
<td>5 watts (saturated)</td>
</tr>
<tr>
<td>Input standing wave ratio</td>
<td>2:1</td>
</tr>
<tr>
<td>Impedance</td>
<td>50 (nominal)</td>
</tr>
<tr>
<td>Maximum permissible load mismatch</td>
<td>1.5:1 standing wave ratio</td>
</tr>
<tr>
<td>Maximum power in.</td>
<td>150 mw.</td>
</tr>
<tr>
<td>Efficiency</td>
<td>33%</td>
</tr>
<tr>
<td>Power requirements:</td>
<td>23-28 vdc and (last stage)</td>
</tr>
<tr>
<td></td>
<td>22 vdc zener regulated</td>
</tr>
</tbody>
</table>

The driver amplifier was optimized and tested for -20 to +72 C. Minimum power output was 3.6 watts sufficient to drive the power amplifier. The power output variation was less than ±0.5 db and the power consumption less than 14 watts.

The driver amplifier was driven with 1 watt of CW from 2.2 to 2.3 ghz with no apparent deterioration in performance. The second amplification stage is designed to saturate and cut off drive to the power stages to prevent catastrophic failure. From 25 watts to 50 watts drive the amplifier performed satisfactorily.

The input standing wave ratio with d-c power applied was less than 1.25:1. With d-c disconnected it was less than 1.5:1 over the band.

The amplifier matching networks and chassis are shown in Drawings 1261666, 1261667, and 1261661; the schematic is shown in Drawing 1261662.
4. POWER AMPLIFIER SECTION

The power amplifier consists of

- hybrid dividers
- hybrid combiners
- power stages
- output isolator
- output filter

The design and specification of these modules are discussed in the following sections.

4.1 HYBRID DIVIDERS

The 2:1 divider modules composing the 4:1 hybrid meet the following specifications:

- Coupling: 3 db ± .1 db
- Frequency band: 2.25 ghz ± 50 mhz
- Insertion loss: .07 db
- Power rating: 30 watts @ 20 C
- Impedance: 50
- Standing wave ratio: 1.25:1 max.
- Isolation: 20 db min.

The dividers are of stripline construction using 1/8" thick glass impregnated teflon. The top and bottom substrate drawings for these hybrids are shown in drawings 12611671 and 1261672.

4.2 HYBRID COMBINER

The hybrid 4:1 combiner consists of three 2:1 combiners meeting specifications as shown in section 4.1. The substrate views are drawings 1261669 and 1261670.

4.3 POWER STAGES

The individual power stages consist of an MSC 4005 transistor. They are hybrid combined as shown in the following figure giving 29 watts output and 9.2 db gain.
The total of 4 stages hybrid combined, meet the following specifications:

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency band</td>
<td>2.2 - 2.3 GHz</td>
</tr>
<tr>
<td>Gain</td>
<td>db</td>
</tr>
<tr>
<td>Gain flatness</td>
<td>0.5 db</td>
</tr>
<tr>
<td>Max. power out.</td>
<td>watts</td>
</tr>
<tr>
<td>Input standing wave ratio</td>
<td>1.5:1 max.</td>
</tr>
<tr>
<td>Efficiency</td>
<td>%</td>
</tr>
<tr>
<td>Max load mismatch</td>
<td>1.5:1</td>
</tr>
<tr>
<td>Power requirements</td>
<td>23-28 vdc</td>
</tr>
</tbody>
</table>

Temperature data on the Solid State S Band Amplifier is shown in Table 4-I.

The power amplifier schematic and matching networks are shown in Drawings 1261663 and 1261665.

4.4 OUTPUT ISOLATOR

The output isolator was tested to and meets the following specifications:

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal frequency</td>
<td>2.2 - 2.3 ghz</td>
</tr>
<tr>
<td>Bandwidth for 20 db isolation.</td>
<td>100 mhz</td>
</tr>
<tr>
<td>Input &amp; output impedance</td>
<td>50 ohms</td>
</tr>
<tr>
<td>Standing wave ratio (max.)</td>
<td>1.2</td>
</tr>
<tr>
<td>Insertion loss in passband</td>
<td>.25 db max. (at 25 watts)</td>
</tr>
<tr>
<td>Load capability</td>
<td>30 watts cw @ 75 C</td>
</tr>
<tr>
<td>The above specifications</td>
<td>-20 to +70 C</td>
</tr>
<tr>
<td>Addington part number</td>
<td>101101203</td>
</tr>
<tr>
<td>Probe coupling</td>
<td>-40 db ± 2 db</td>
</tr>
<tr>
<td>Temp, C</td>
<td>R-F Pout, W</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>20</td>
<td>22.8</td>
</tr>
<tr>
<td>10</td>
<td>22.8</td>
</tr>
<tr>
<td>5</td>
<td>23.6</td>
</tr>
<tr>
<td>0</td>
<td>24.0</td>
</tr>
<tr>
<td>5</td>
<td>24.0</td>
</tr>
<tr>
<td>10</td>
<td>23.7</td>
</tr>
<tr>
<td>15</td>
<td>23.7</td>
</tr>
<tr>
<td>20</td>
<td>23.5</td>
</tr>
<tr>
<td>25</td>
<td>23.1</td>
</tr>
<tr>
<td>30</td>
<td>22.7</td>
</tr>
<tr>
<td>35</td>
<td>22.5</td>
</tr>
<tr>
<td>40</td>
<td>22.1</td>
</tr>
<tr>
<td>45</td>
<td>22.0</td>
</tr>
<tr>
<td>50</td>
<td>21.5</td>
</tr>
<tr>
<td>55</td>
<td>21.4</td>
</tr>
<tr>
<td>60</td>
<td>21.0</td>
</tr>
<tr>
<td>65</td>
<td>20.8</td>
</tr>
<tr>
<td>70</td>
<td>20.3</td>
</tr>
<tr>
<td>75</td>
<td>20.2</td>
</tr>
</tbody>
</table>

Test Set-Up, Block Diagram
4.5 OUTPUT BANDPASS FILTER

The specifications given below ensure that the system will have the required -95 dbm/10 mhz noise floor at 2104 mhz with 5 db margin to allow for excess drive conditions.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center freq</td>
<td>2.25 ghz</td>
</tr>
<tr>
<td>Passband</td>
<td>2.2 to 2.3 mhz</td>
</tr>
<tr>
<td>Ripple</td>
<td>0.2 db</td>
</tr>
<tr>
<td>Attenuation</td>
<td>45 db at 2.104 ghz ± 5 mhz</td>
</tr>
<tr>
<td></td>
<td>40 db from 4.0 to 10 ghz</td>
</tr>
<tr>
<td>Insertion loss</td>
<td>0.4 db msx., target 0.25</td>
</tr>
<tr>
<td>Input standing wave ratio</td>
<td>1.25:1</td>
</tr>
<tr>
<td>Power capability</td>
<td>30 watts max.</td>
</tr>
<tr>
<td>Phase deviation from linear</td>
<td>± 6 degrees over the 100 mhz band</td>
</tr>
<tr>
<td>Temperature</td>
<td>-20 to +70 C</td>
</tr>
<tr>
<td>Reliability</td>
<td>10^8 hrs.</td>
</tr>
</tbody>
</table>

The filter was tested to and meets these specifications. The outline drawing for the filter is shown in 1261674.
5. VOLTAGE AND CURRENT LIMITER

The voltage and current limiter is shown in figure 5-1. It provides voltage limiting to a maximum of 27.3 Vdc by a saturated series transistor. Current limiting is provided by a monostable multivibrator triggered by an excess current flow and acting as crowbar to reduce the voltage to zero and protect the series pass transistor. The regulator will recover automatically upon removal of the overload.

The voltage limiter—current limiter was tested and performed satisfactory. The total drop across the regulator was measured 1.15 volts. A 6 ampere current tripped the current limiter. It reset automatically when the current was reduced to normal. The voltage limiter was set to an upper limit of 28 volts and remained exactly 28 volts for inputs up to 40 volts.
6. TEST PROGRAM

The following document lists all test procedures which adequately verify that the breadboard will meet specification requirements. These test procedures are submitted to MSFC for approval in compliance with Exhibit A Scope of Work, Contract No. NAS8-28763.

6.1 LIST OF TESTS REQUIRED AND SPECIFICATION LIMITS

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1.1 Input standing wave ratio</td>
<td>1.3:1 (17.8 db return loss)</td>
</tr>
<tr>
<td>Output standing wave ratio (without drive)</td>
<td>1.5:1 (14 db return loss)</td>
</tr>
<tr>
<td>6.1.2 Power output (2.28 ghz)</td>
<td>20 watts min.</td>
</tr>
<tr>
<td>6.1.3 D-C power input</td>
<td>95 watts max.</td>
</tr>
<tr>
<td>6.1.4 Input overdrive (R-F) Normal drive</td>
<td>1 watt max.</td>
</tr>
<tr>
<td>6.1.5 Bandwidth (± 1 db)</td>
<td>100 mhz</td>
</tr>
<tr>
<td>6.1.6 Output noise</td>
<td>-95 dbm of 2104 mhz, 10 mhz band</td>
</tr>
<tr>
<td>6.1.7 Spurious outputs</td>
<td>60 db below carrier within 4 mhz band centered at 2.250.5 mhz</td>
</tr>
<tr>
<td>6.1.8 Temperature (Meeting performance requirements)</td>
<td>-20 to +70 C</td>
</tr>
</tbody>
</table>

6.2 DESCRIPTION OF TESTS

The test equipment shown in the block diagram are suggested and alternate equipment can be used.

6.2.1 Input, Output Standing Wave Ratio

To measure input and output impedances, a Wiltron 610-C Signal Generator and Narda Directional Coupler were set up as shown in Figure 6-1. Measurements are fast
and accurate; the Narda High Directivity Coupler has a directivity of greater than 40 db from 10 yo 3500 mhz and the accuracy of the readout (Return Loss) is ±0.3 db.

6.2.2 Power Output

The power output is measured using a Thermoelectric calorimeter power meter. The power into the calorimeter is reduced using calibrated attenuators as shown in Figure 6.2.

For the overdrive test, a travelling wave tube Servo 2220 is used to amplify the output of the signal generator and provide 1 watt to the input of the S-Band power amplifier. The normal input is 25-50 mwatts at 2.25 ghz.

6.2.3 D-C Power Input

The input power is measured accurately using a digital voltmeter and a millimeter. Since the power input can be calculated at 28 ± 4 vdc, the efficiency can also be calculated using the set up shown in Figure 6.3.

6.2.4 Input Overdrive

According to specification, the S-Band amplifier should survive 1 watt overdrive. This drive is derived using a travelling wave tube amplifier following the signal generator as shown in Figure 6.2. During overdrive all parameters are monitored.

6.2.5 Bandwidth

The instantaneous bandwidth is measured using a Wiltron sweep generator as shown in Figure 6.3 set-up. The detected output is displayed on the calibrated screen of the oscilloscope for the nominal input power of 25 watts. A frequency counter is provided to calibrate the marker of the sweep generator. Photos can be taken of the 100 mhz bandwidth or greater to shown the bandpass characteristic of the amplifier filter.
6.2.6 Output Noise

Measurement of noise at 2104 mhz is accomplished using a spectrum analyzer and applying the necessary correction factors. This measurement has to be performed under signal conditions in order to excite the class-C power amplifiers. Only 10 db of attenuation is used at the output of the amplifier in order to maintain a margin since the noise level of the spectrum analyzer at 2.1 ghz is -117 dbm. To prevent overloading of the spectrum analyzer, a bandpass filter is used at 2104 mhz reflecting the 2.25 ghz output signal by at least 40 db. The set-up is shown in Figure 6.4. The yig filter is set manually to 2104 mhz.

6.2.7 Spurious Outputs

Spurious outputs within a bandwidth of 4 mhz centered at 2,250.5 mhz is measured using the spectrum analyzer and necessary attenuator to reduce the level and prevent overloading of the spectrum analyzer. The set-up is shown in Figure 6.5.

6.2.8 Temperature

The set-up of Figure 6.6 is used for the temperature test. All monitoring cables are brought out and continues monitoring of chassis temperature and power output is performed during the temperature variation. As shown all performance requirement can be checked during the test.
### 6.3 TEST DATA SHEET

<table>
<thead>
<tr>
<th>(a)</th>
<th>Input standing wave ratio</th>
<th>1.28</th>
<th>(18 db return loss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(b)</td>
<td>Output standing wave ratio</td>
<td>1.12</td>
<td>(25 db return loss)</td>
</tr>
<tr>
<td>(c)</td>
<td>Pout (2.25 ghz)</td>
<td>23.0</td>
<td>watts</td>
</tr>
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<td>(d)</td>
<td>Pin - Vin</td>
<td>28.14</td>
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<tr>
<td></td>
<td>fin</td>
<td>2.9</td>
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<td>Pin</td>
<td>81.0</td>
<td>watts</td>
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<td>(e)</td>
<td>Output Noise</td>
<td>&gt; 87</td>
<td>dbm/10 mhz</td>
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<td>(f)</td>
<td>Spurious Output</td>
<td>No Spur &gt; 70</td>
<td>db at 2250.5 mhz</td>
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*Limited by Spectrum Analyzer*
Photograph
(Instantaneous Bandwidth)
6.4 LIST OF TEST EQUIPMENT REQUIRED

1. Attenuator, 20 db, 10 db, 50 watt; Narda Model 765-20, 765-10.
3. Attenuator, Variable 0 to 20 db, Narda Model 792 FM.
4. Clip-on millimeter 0 to 10 amps, Hewlett Packard Model 428B.
5. Crystal Detector, Hewlett Packard Model 423A.
6. Digital Voltmeter, Hewlett Packard Model 3440A.
7. DC Multifunction unit, Hewlett Packard Model 3444A.
8. Frequency counter, Systron Donner Model 6316A.
9. Thermoelectric Calorimeter Model N-685-2 PRD.
10. Power Meter Model 6685 PRD.
11. Signal Generator, S-Band, Hewlett Packard Model 8616A.
13. Tektronix Model 531A.
14. VSWR Autotester, Mode 62N50 Wiltron
15. Logarithmic Level Meter Model 601 Wiltron
16. Power Supply, Lambda Model LH125 FM.
17. Spectrum Analyzer
   RF Section Model 8555A Hewlett Packard
   IF Section Model 8552A Hewlett Packard
   Display Section Model 141 S Hewlett Packard
   Automatic Preselector Model 8445 Hewlett Packard
18. Directional Coupler, Model 3043-20 Narda.

Note 1: Item 14 was deleted prior to test
      Item 15 was changed to NARDA 3093 High Directivity Coupler.

Note 2: All equipment used for this test was under current calibration.
Figure 6.1 Input & Output Standing Wave Ratio
POWER OUTPUT AND EFFICIENCY MEASUREMENTS

PLUS INPUT OVERDRIVE

FIG 6.2
6.2
BANDWIDTH MEASUREMENT, SWEPT

FIGURE 6.8
20 WATT S-BAND AMP.

HIGH POWER ATTEN M-765-10 NAADA

ITT BAND PASS FILTER 2104 MHZ

SPECTRUM ANOMIZER HP

MEASUREMENT OF OUT PUT NOISE LEVEL AT 2104 MHZ

FIGURE 6.4
TEMPERATURE TEST, TELEMETRY OUTPUTS PLUS TURN-OFF CAPABILITY.

FIGURE 6.6
LIST OF DRAWINGS

The following drawings are bound in order and referred to by drawing number:

1261674  Bandpass Filter Outline
1261673  Mechanical Layout
1261672  90 Degree Input Hybrids (Top)
1261671  90 Degree Input Hybrids (Bottom)
1261670  90 Degree Output Hybrids (Top)
1261669  90 Degree Output Hybrids (Bottom)
1261664  Telemetry & Functions, Circuit Diagram
1261668  0.8 Watt Amplifier Matching Networks
1261667  3.5 Watt Amplifier Matching Networks
1261666  Class A Amplifier Matching Networks
1261665  8 Watt Amplifier Matching Networks
1261663  Solid State Power Amplifier, Block Schematic *
1261662  Solid State Driver Amplifier, Block Schematic *
1261661  Driver Amplifier Chassis
1261659  Power Amplifier Chassis
1261673-B  Engineering Sketch of Main Frame

*Sheets 2, 3, and 4 of both Drawings are parts lists; because of size differences, these are bound following the package of C Size Drawings.
INPUT 3 DB 40° HYBRIDS (189)
20 WATT S BAND
INPUT 3 DB, 90° HYBRIDS (BOTTOM)
20 WATT S-BAND
3.5 WATT AMPLIFIER MATCHING NETWORKS
20-WATT S-BAND
CLASS-A AMPLIFIER MATCHING NETWORKS
20-WATT S-BAND
8-WATT AMPLIFIER MATCHING NETWORKS
20-WATT S-BAND
CHASSIS
DRIVER AMPLIFIER MECHANICAL LAYOUT
20-WATT G-SAND
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<th>SPECIFICATION NO.</th>
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In Part No. Col. denotes vendor item. See source or specification control dwg.
## PARTS LIST

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**ITEM OR FIND NO.**

**CODE IDENT**

**SIZE**

**PART OR IDENTIFYING NO. OTHER THAN ITTDCD**

**SIZE**

**SPECIFICATION NO. ITTDCD PART NO.**

**NOMENCLATURE OR DESCRIPTION**

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**U OF M**

**1 PIECE 6 PAIR 32 FEET 52 U.S. FLUID OZ. 55 U.S. GAL.**

**IN PART NO. COL. DENOTES VENDOR ITEM: SEE SOURCE OR SPECIFICATION CONTROL DWG.**
## PARTS LIST

### 20-WATT S-BAND AMP (DRIVER AMPLIFIER)

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C 1261662 SCHEMATIC

---

U OF M | 1 PIECE 6 PAIR 32 FEET 52 U.S. FLUID OZ. 55 U.S. GALL. 68 LB AVDP
CODE | 5 SET 20 REF DOC 54 U.S. LIQUID QT. * IN PART NO. COL. DENOTES VENDOR ITEM: SEE SOURCE OR SPECIFICATION CONTROL DWG.
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*IN PART NO. COL. DENOTES VENDOR ITEM. SEE SOURCE OR SPECIFICATION CONTROL DWG.*
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**101102233**

**ISOLATOR, 2.2-2.3GHz, ADDINGTON HY1**

---

**U OF M** | **1 PIECE 6 PAIR 32 FEET 52 U.S. FLUID OZ. 55 U.S. GAL.**
**CODE** | **5 SET 20 REF DOC 54 U.S. LIQUID QT. 68 LB AVDP**

*IN PART NO. COL. DENOTES VENDOR ITEM: SEE SOURCE OR SPECIFICATION CONTROL DWG.*
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**Comments:**
- U OF M: 1 PIECE 6 PAIR 32 FEET 52 U.S. FLUID OZ. 55 U.S. GAL.
- Code: 5 SET 20 REF DOC 54 U.S. LIQUID QT. 68 LB AVDP
- *IN PART NO. COL. DENOTES VENDOR ITEM: SEE SOURCE OR SPECIFICATION CONTROL DWG.