DSN Array Microwave Subsystem (LNA/Cryogenics/Feeds) Technical Peer Review

December 18, 2003

MMIC Packaging and Test

Jack L. Prater, Jet Propulsion Laboratory, California Institute of Technology
Javier J. Bautista, Jet Propulsion Laboratory, California Institute of Technology
Performance Goals for X- and Ka-band MMIC Amplifiers.


Compare results of NGCST IRAD and CIT1 wafers.

Noise and Gain performance versus physical temperature.

Design Objectives, Schematic, and Drawing for X-band MMIC Chassis.

CST Simulation of X-band Chassis.

Schedule

Plans

Issues and risks
Anticipated Performance for MMIC Modules at 15 K physical Temperature.

<table>
<thead>
<tr>
<th>Band</th>
<th>Frequency, GHz</th>
<th>Noise Temp, K</th>
<th>Noise Temp, K</th>
<th>Gain, dB</th>
<th>Input Power -1 db</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ka-band</td>
<td>31.8-32.3</td>
<td>15</td>
<td>22</td>
<td>38</td>
<td>-38 dBm</td>
</tr>
<tr>
<td></td>
<td>and 37.0-38.0</td>
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<tr>
<td>X-band</td>
<td>8.4-8.62</td>
<td>4</td>
<td>7</td>
<td>37</td>
<td>-37 dBm</td>
</tr>
</tbody>
</table>
Outer dimensions of module = 1.75 x 1.5 x 0.9"
Noise/Gain response of Ka-band MMIC LNA at 13.6 and 50 K physical temperature.

Ka-band module with absorber.
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S-Parameter Results for Ka-band Module at 290 K.

Tang, Morgan, Weinreb

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J.L. Prater - 8
VD=1.2 V, ID=22.4 mA (P1dB=0dBm Psat=2.78dBm, at 32 GHz)
Noise/Gain response of several NGCST IRAD Ka-band MMIC LNAs in test fixture at 13.6 K physical temperature.

Fujiwara, Long, Morgan, Tsai, Weinreb, DeKorte
Noise/Gain response of several NGCST CIT Ka-band MMIC LNAs in test fixture at 13.6 K physical temperature.
Noise and Gain vs Physical Temp: DSN Ka-band Cryo3 LNA (MIC-99-4stage), TRW-IRAD MMIC LNA Test Fixture (MMIC-3stage) and Array Prototype LNA (2xMMIC-6stage)
Bias Board

MMIC Chip

Noise/Gain Response of X-band MMIC LNA module (NGCST IRAD).

X-band MMIC LNA test fixture.
MMIC Input Return Loss
- At 8.45 GHz < -20 dB
- From 8-9 GHz < -15 dB

Coupler Input Return Loss
- At 8.45 GHz < -20 dB
- From 8-9 GHz < -15 dB

Coupler Coupling Factor
- 30 dB at 8.45 GHz

High Pass Filter
- Cut off Frequency 7.5 GHz
- 30 dB Rejection at 7.2 GHz

Physical size
- Less than 4” x 2.5” x 2”
X-band Module with Interfaces

Base of split block construction.

- Output Connector
- MMIC Channel
- Termination
- DC connector channel
- Injection Input
- WR112 Input
- Linear transition to output waveguide

2.45"

4"

1.8"

S. Weinreb, L. Fowler

J.L.Prater.-16
WR 112 Input and 30 dB Coupler

CST 3-D Model

WR 112 Input
Linear Transition to
7.5 GHz Cutoff Waveguide

Thru Channel
Injection Port 4

MMIC Input
Port 2

Termination
Port 3
CST 3-D Model

To MMIC

50 Ohm Line

¼ Wave Transformer

High Impedance Line

Waveguide to Microstrip Transition

7.5 GHz Cutoff Waveguide

Port 2

CST Modeled S-Parameters
CST 3-D Model

CST Modeled S-Parameters

7.5 GHz Cutoff Waveguide Port 2

Coaxial Injection Input to Waveguide Transition

Frequency, GHz

Return Loss (S11), dB

Insertion Loss (S21), dB
<table>
<thead>
<tr>
<th>Task Name</th>
<th>2004</th>
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</thead>
<tbody>
<tr>
<td><strong>Array LNA Modules</strong></td>
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</tr>
<tr>
<td><strong>Ka-BAND MMIC MODULE</strong></td>
<td></td>
</tr>
<tr>
<td>1. PIZA MMIC EVALUATION</td>
<td></td>
</tr>
<tr>
<td>2. CITA MMIC EVALUATION</td>
<td></td>
</tr>
<tr>
<td>3. ALH 244A MMIC EVALUATION</td>
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</tr>
<tr>
<td>4. Ka MODULE #1 ASSY, TEST - CIT</td>
<td></td>
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<tr>
<td><strong>Ka MODULE #2 - JPL</strong></td>
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<tr>
<td>5. PRODUCE/FAB COMPONENTS</td>
<td></td>
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<tr>
<td>6. ASSEMBLE/TEST</td>
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<tr>
<td>7. Ka FUTURE WAFER EVALUATION</td>
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</tr>
<tr>
<td>8. REDESIGN KA-BAND MODULE</td>
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<tr>
<td><strong>X-BAND MMIC MODULE</strong></td>
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<tr>
<td>9. DESIGN</td>
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</tr>
<tr>
<td>10. FABRICATE CHASSIS, SUBSTRATES</td>
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<tr>
<td>11. X MODULE #1 ASSY, TEST</td>
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<tr>
<td>12. X MODULE #2 ASSY, TEST</td>
<td></td>
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<tr>
<td>13. COAX TEST FIXTURE ASSY</td>
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<tr>
<td>14. COAX PIZA EVALUATION</td>
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<tr>
<td>15. COAX CITA EVALUATION</td>
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<tr>
<td>16. UPGRADE X-BAND MODULE</td>
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<tr>
<td>17. X FUTURE WAFER EVALUATION</td>
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</tbody>
</table>
• X-band design very compact (limited by dewar size needed to maintain minimal footprint on reflector). May need more room to terminate coupled port.

• High pass filter may impact X-band performance.

• X-band chassis, and substrates for waveguide transitions to be shipped December 19th.

• If there are any problems will have to use X-band coaxial test fixture without noise injection 30 dB coupled port.
Complete CIT wafer evaluation.

Replace voltage divider with diode to allow current measurement for Ka-band design.

Modify X- and Ka-band chassis design based on measured results.
  - Increase contact around MMIC area in Ka-band module.
  - Provide solder feed hole for K-connector glass bead on Ka-band module.
  - Test commercial (ALH244C Velocium) chip as second stage in Ka-band LNA.
  - Evaluate NGCST Cryo-3 devices as first stage.

Evaluate future MMIC wafer.

Fabricate and test amplifiers as needed for 2nd and 3rd antennas.