EVLA Front-End CDR

L-Band (1-2 GHz)

EVLA Receiver
Contents

• Interim L-Band Receiver
  – Block diagram, photos, axial ratio, Trx, Gain, Input return loss

• Prototype L-Band Receiver
  – Block diagram, LNA info, construction, thermal hurdles, window selection, Trx, Gain, axial ratio
First EVLA antennas were outfitted with modified VLA receivers:

- new feed
- added 90 degree hybrid coupler
- replace single LNA with low-noise / high power balanced amplifiers
EVLA Interim L-Band Photos

RF inside

window

Lisa Locke

EVLA Front-End CDR

24 April 2006
L-Band SN 32 - Antenna 14
Interim L-Band Performance
(RHH : 17 April 2006)
Effect of LNA Input Return Loss on Axial Ratio (L#21)

L#21 Axial Ratio Measurement - Effect of LNA Input Return Loss
"Perfect" Terminations vs. Real-life LNA's
(RHH : 6 April 2006)

Removed later with new OMT
Axial Ratios on EVLA Interim L-Band Receivers

L#02 : AR vs. Frequency - On EVLA Antenna 13
16 March 2006

L#32 : AR vs. Frequency - On EVLA Antenna 14
16 March 2006

L#01 : AR vs. Frequency - On EVLA Antenna 16
16 March 2006

L#21 : AR vs. Frequency - On EVLA Antenna 18
16 March 2006
EVLA L-Band Design
EVLA L Band
Block Diagram

OMT
90° Hyb

1.0 – 2.0 GHz

30 dB

4K +18

20K +18

P1>+15 dBm

+30

1-2 GHz

NF=1.5 dB

90°

Hyb

4K +18

20K +18

P1>+15 dBm

+30

Minicircuits
PIN diode
IL ~ 1.5 dB

1.0-2.0 GHz

TTE combline

1.0-2.0 GHz

Trak

1-2 GHz

15 dB isol

Micronetics
35 dB ENR

35 dB

Microcircuits
PIN diode
IL ~ 1.5 dB

+30

15 dB

Trak

1-2 GHz

15 dB isol

Lisa Locke
EVLA Front-End CDR – EVLA L-Band Receiver 24 April 2006
EVLA L-Band
Low noise / high power LNAs

- Balanced low noise block
  - provides decent S11 to prevent reflections through OMT & S22 to possible filter
  - two InP stages give 4K noise temp.

- Balanced high power block
  - provides good S11 to possible filter
  - 2 stage commercial HFET gives 20K noise temp.

• In absence of a broadband cryogenic isolator...
• Split LNAs allows for future cooled filter if RFI situation warrants
• Compromise between low noise and dynamic range
<table>
<thead>
<tr>
<th>EVLA L-Band Rx</th>
<th>P (1dB) (dBm)</th>
<th>P (1%) (dBm)</th>
<th>Temp (K)</th>
<th>NF/C (linear)</th>
<th>Loss/Gain (dB)</th>
<th>Loss/Gain (dB)</th>
<th>Delta T (K)</th>
<th>Trx BW (MHz)</th>
<th>Pnoise (dBm)</th>
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</table>
Estimated EVLA L-Band

**T\textsubscript{Rx}, Output Power & Headroom**

*Worst Case - With Lossy Vacuum Window and OMT Cooled to only 100°K*

| EVLA L-Band Rx | P (1dB) | P (1%) | Temp | NF/C | Loss/Gain | Loss/Gain | Delta T | Trx | BW | Pnoise | Pnoise | Headroom |
|----------------|---------|--------|------|------|-----------|-----------|---------|-----|-----|--------|--------|-----------|---------|
| (RHH : 28 March 2006) | (dBm) | (dBm) | (K) | (dB) | (linear) | (K) | (K) | (MHz) | (dBm) | dBm/GHz | (dB) | for Tsky of 12.0 |
| Weather Window | 300 | -0.02 | 0.9954 | 1.385 | 2000 | -94.8 | -97.8 |
| Feed Horn | 300 | -0.05 | 0.9886 | 3.490 | -94.3 |
| Vacuum Window | 300 | -0.1 | 0.9772 | 7.101 | -93.4 |
| Quad-Ridge OMT | 100 | -0.1 | 0.9772 | 2.422 | -92.0 |
| Coax Cable | 60 | -0.05 | 0.9886 | 0.739 | -91.6 |
| Hybrid Phase Shifter | 20 | -0.2 | 0.9550 | 1.015 | -91.6 |
| Coax Cable | 20 | -0.05 | 0.9886 | 0.261 | -91.6 |
| Cal Coupler (IL) | 20 | -0.2 | 0.9550 | 1.075 | -91.7 |
| Cal Coupler (Branch) | 300 | -30 | 0 | 1.0000 | 0.300 | -91.6 |
| Isolator | 20 | 0 | 1.0000 | 0.000 | -91.6 |
| Balanced LNA (16-20 dB) | -5 | -17 | 4 | 18 | 63.0957 | 4.776 | 22.56 | -73.0 | 56.0 |
| Coax Cable | 20 | -0.1 | 0.9772 | 0.009 | -73.1 |
| Transfer Switch | 20 | 0 | 1.0000 | 0.000 | -73.1 |
| Filter Hi-Q/Notch | 20 | 0 | 1.0000 | 0.000 | -73.1 |
| Coax Cable | 20 | 0 | 1.0000 | 0.000 | -73.1 |
| Balanced LNA (16-20 dB) | 13 | 1 | 20 | 18 | 63.0957 | 0.387 | -55.0 | 56.0 |
| Stainless Steel Coax | 160 | -2 | 0.6310 | 0.029 | 22.99 | -57.0 |
| Coax Cable | 300 | -1 | 0.7943 | 0.038 | -56.0 |
| Switch | 300 | 0 | 1.0000 | 0.000 | -56.0 |
| Isolator | 300 | -0.5 | 0.8913 | 0.022 | -56.5 |
| Filter (0.8-2.2 GHz) | 300 | -1 | 0.7943 | 0.053 | 1400 | -61.1 |
| Post-Amp | 15 | 3 | 229.6 | 2.5 | 30 | 1000.0000 | 0.199 | -31.0 | 34.0 |
| Isolator | 300 | -0.5 | 0.8913 | 0.000 | 23.30 | -31.5 |
EVLA L-Band
Polarizer

- Quad-ridge OMT + 90 degree hybrid
- Increased frequency range
- Improved performance
- Details discussed by Paul Lilie

1 of 4 ridges inside OMT
EVLA L Band Prototype
EVLA L-Band Prototype

Construction

- Modify a VLA L-Band dewar to evaluate OMT performance
  - reused mounting plate, bottom can
  - new can over OMT
  - 350 fridge replaced with 1020 from A-rack
EVLA L-Band Prototype

Vacuum Windows

- Blue Eccofoam
  - classic foam used in older receivers
  - RF: excellent
  - strength: good
  - thermal: excellent
  - has been deteriorating, replacing with Zotefoam

- Zotefoam HD30
  - used in smaller (L,C) windows for years
  - RF: excellent
  - strength: good
  - thermal: excellent

- Nidacore
  - new honeycomb material
  - RF: moderate
  - strength: excellent
  - thermal: poor
EVLA L-Band Prototype
Vacuum Window Test

Dewar Vacuum Window
Nidacore Honeycomb Plug
vs. Zotefoam Plug alone

Effect on TRx

L-Band (SN 11) Measurements with Nidacore Honeycomb Plug
using Lilie Noise Standard (Off/On = 100/675 K)
14 Feb 2006

- No Plug
- Single 0.5" Honeycomb Plug
- Double 0.5" Honeycomb Plug
Dewar Thermal Designs
VLA vs EVLA

Original VLA = Interim EVLA

Current EVLA prototype

- 300K can
- 50K can
- 15K can
- Floating can
- ~2" x 3" x 1/8" clamp
- 12 mil thermal gap

- 300K can
- 50K can
- 15K can
- 4 x 1"x6" straps
- 25 mil thermal gap

- Gold-plated (50 microns?) copper
- Braided copper (OHFC)
- Solid copper (OHFC)
- 6061 aluminum

nn n layers of "space blanket"
**EVLA L-Band Prototype**

**Thermal Progress**

- 50K stage cools to 99K
- 15K stage cools to 20K
- Insulated 50K radiation shield with veil/space blanket layers
- Added Zotefoam to inside of OMT to add thermal insulation.
- Tie OMT to 50K instead of 15K stage
- Replace Nidacore window with Zotefoam
EVLA L-Band Prototype

OMT Temp vs Trx
Window Loss vs Trx

Effect of Vacuum Window Insertion Loss on Trx

Effect of OMT Physical Temperature on Trx
EVLA L-Band Prototype
RF through Thermal Gap

- A “bump” was caused by RF leaking out the thermal gap
- Resonant cavity conditions inside dewar can
- Solved with strip of absorber around thermal gap
EVLA L-Band Prototype

Effect of LNA Input Return Loss on Axial Ratio

L-Band Prototype Axial Ratio Measurement -
Effect of LNA Input Return Loss
"Perfect" Terminations vs. Real-life LNA's

Previous Axial ratio plot

Setup:
Narrowband 1.3 – 1.8 GHz OMT as input

Lisa Locke
EVLA Front-End CDR – EVLA L-Band Receiver 24 April 2006
Prototype vs Interim L#32
Preliminary Results with Narrowband Hot/Cold Test Load

- RCP and LCP very similar results
- Interim receiver has physical temperature 45K/15K
- Prototype 99K/15K, needs to be reduced
- Response of receiver below 1300 MHz unknown due to narrowband test OMT
Conclusions

• OMT under continued testing
  – between 1.3 – 1.8 GHz, performance acceptable
  – at band-edges performance to be tested
• Second OMT almost ready for use as a test fixture instead of narrow band OMT
• Re-evaluate dewar thermal design to reduce OMT physical temperature from 100K
• Reduce Trx from 20K to 15K