EVLA Front-End CDR

Low Noise Amplifier Procurement
Welcome to the CDL! (What I expected)
What I Found
(The “old” CDL)
The New NTC / CDL
(Since early 2004)

10 year lease
What Does the CDL Need to Provide?

- Thanks to Bob Hayward’s clear forecast we know that the requirement is basically to supply 80 Amplifiers per year for 2007 thru 2010.

- If we’re able to do that then 35-40 Amps per year, in the later years, (2011-2014) is easy.
## LNA Forecast for EVLA Rx’s

<table>
<thead>
<tr>
<th>Antenna Serial Number</th>
<th>Date LNA’s Required</th>
<th>Date of Ant Commission</th>
<th>L-Band</th>
<th>S-Band</th>
<th>C-Band</th>
<th>X-Band</th>
<th>Ku-Band</th>
<th>K-Band</th>
<th>Ka-Band</th>
<th>Q-Band</th>
<th>Amps per Year</th>
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<tbody>
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<td>Antenna 14 (Az Bearing)</td>
<td>All In-House</td>
<td>Jan 31, 2005</td>
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**Sub-Total**: 132, 66, 66, 66, 28, 24, 35, 24, 59, 573
## Amplifiers per year

<table>
<thead>
<tr>
<th>Year</th>
<th>New Builds</th>
<th>Upgrades</th>
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<td>2006</td>
<td>24</td>
<td>8</td>
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<tr>
<td>2007</td>
<td>58</td>
<td>14</td>
</tr>
<tr>
<td>2008</td>
<td>70</td>
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<td>2009</td>
<td>66</td>
<td>14</td>
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<tr>
<td>2010</td>
<td>68</td>
<td>12</td>
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<td>2011 thru 2014</td>
<td>35-40/year</td>
<td>na</td>
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The CDL “Track Record” with Amplifiers

- Hundreds of LNAs produced over the past 20+ years.
- VLA, VLBA, GBT, and many outside observatories use CDL LNAs
- The WMAP experience
- Near 100% reliability for post-WMAP units, no clear MTBF since they seldom fail, so no statistics
- Failures that do happen appear in early testing (typically the first cool down) and are corrected.
CDL Resources for Amplifier Production

- Design talent – Marian Pospieszalski, Richard Bradley (low frequencies)
- Production talent – Bill Lakatosh, Mitch Wharam
  - Todd Boyd, Mike Lambeth, or a “to be hired”
- Manufacturing capability
  - Machine shop, CNCs
  - Plating shop, new in 2004
  - Electronics assembly, wirebonding
  - Testing, 8510s, ADIOS, new systems
How Do We Build an Amplifier?

• Buy parts (ugghhh, it used to be so easy)
• Machine the chassis ---- 8 hours
• Prep and plate chassis ---- 3 hours
• Assemble ---- 3 to 4 per month per Tech
• Test and Document ---- 4 to 8 hours
• Ship It!!!
CDL Machine Shop
40% non - ALMA
$150,000
ALMA Precision
Milltronics Amplifier Chassis
Chemistry / Plating Lab
Gold Baths
ALMA IF Amp Chassis Freshly Plated
K-Connector Plates

07/27/2005
Copper Electroforming
Phase Shifter
Amplifier Assembly
Two Techs = 80 LNAs/year
Wirebonding
Older Bonder

Two bonders available
Assembly Area 2

Gerry Petencin
CDL

EVLA Front-End CDR – LNA Procurement
April 24, 2006
Single ended - Balanced
K-band LNA (WMAP)
ADIOS Lives!
Band Specifics
Coaxial Amps

- L- LNA in production, no issues
- L- HP in production, no issues
- 2-4 GHz (S) in production, FHX-45 vs C3
- 4-8 GHz (C) in production, no issues
- 4-12 GHz (X) in production, no issues
  - 8-12 version designed, use if 4-8 gain not desired
- 8-18 GHz (Ku) in production, no issues
  - 12-18 version designed, use if 8-12 gain not desired
Waveguide Amps

- 18-26 GHz (K) in production, no issues
- 26-40 GHz (Ka) in production, no issues
- 40-50 GHz (Q) in production, no issues

Both 18-26 and 26-40 GHz designs will be improved for gain flatness.

- Commercial components and vendors are all proven
- No device availability issues
Q-band Upgrade
Q-band Upgrade
Comparison of Measured and Modeled S Parameters for QM89 at 20 K

- $|S(1,1)|$ (L) QMAPAmplifier
- $|S(2,2)|$ (L) QMAPAmplifier
- $|S(2,1)|$ (R) QMAPAmplifier
- $|S(1,1)|$ (L) QM89C15
- $|S(2,2)|$ (L) QM89C15
- $|S(2,1)|$ (R) QM89C15

Frequency (GHz)
Fallbacks??

- Machining
  - J&E already doing ALMA mixers
- Plating
  - Alexandria Metal Finishers, cost 10-15X
- Assembly
  - ACC? Difficult experience for ALMA, they might be OK for bias components, in a pinch
- Testing
  - In house only
End of Presentation

Spare slides below
Backup Slides
Bubble Trouble
LB5 AT ROOM TEMPERATURE

- DB(|S(1,1)|) (L)
- DB(|S(2,1)|) (R)
- DB(|S(2,2)|) (L)

Frequency (GHz)

Gain (dB)

IRL, ORL (dB)
L-Band Balanced Amplifier at Ta=15 K

![Graph showing Gain and Noise Temperature vs Frequency](image)
Balanced L-band Low Noise Amplifier
S_04 AT 297 K

- IRL and ORL (dB)
- GAIN (dB)

- DB(|S(1,1)|) (L) SB04V2
- DB(|S(2,1)|) (R) SB04V2
- DB(|S(2,2)|) (L) SB04V2

Frequency (GHz)
S_BAND BALANCED AMPLIFIER AT 15 K

FREQUENCY (GHz)

NOISE TEMPERATURE (K)

GAIN (dB)
2-4 GHz Amplifier at 297 K
4_8 GHz Amplifier at Room Temperature

Frequency (GHz)

Gain (dB)

IRL and ORL (dB)

DB(|S(1,1)|) (L) C03V3
DB(|S(2,1)|) (R) C03V3
DB(|S(2,2)|) (L) C03V3
4_8 GHz AMPLIFIER AT 15 K

FREQUENCY (GHz)

NOISE TEMPERATURE (K)

GAIN (dB)

NOISE

GAIN

3 4 5 6 7 8 9

0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40

Gerry Petenchik
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EVLA Front-End CDL = ENA Procurement
April 24, 2006
GHz 4-12 Amplifier at 15 K

Noise and Gain at 15 K

- \( \text{DB}(\text{S}(2,1)) \) (L)
- 4_12GHzAmp
- \( \text{TE}(\text{R}) \)
- 4_12GHzAmp
- \( |\text{Eqn}()| \) (R)
- TAMPmin
- \( |\text{Eqn}()| \) (R)
- T4200min
- \( \text{PlotCol}(1,4) \) (R)
- 4_12_01Noise15k
- \( \text{PlotCol}(1,5) \) (L)
- 4_12_01Noise15k
8-18 GHz Amplifier
8-18 GHz Amplifier at 15 K

U18 and U21 Noise and Gain at 14 K

- PlotCol(1,2) (L) U21noise
- PlotCol(1,3) (R) U21noise
- PlotCol(1,2) (L) U18noise
- PlotCol(1,3) (R) U18noise
U18 and U21 S_Parameters at 297 K

- **DB(|S(1,1)|) (L)**
  - U18V2
- **DB(|S(2,1)|) (R)**
  - U18V2
- **DB(|S(2,2)|) (L)**
  - U18V2
- **DB(|S(1,1)|) (L)**
  - U21
- **DB(|S(2,1)|) (R)**
  - U21
- **DB(|S(2,2)|) (L)**
  - U21

**Frequency (GHz)**

- **DB(|S(1,1)|) (L)**
- **DB(|S(2,1)|) (R)**
- **DB(|S(2,2)|) (L)**

**DB(|S|)** (L)

- **DB(|S(1,1)|)**
  - U18V2
- **DB(|S(2,2)|)**
  - U18V2
- **DB(|S(1,1)|)**
  - U21
- **DB(|S(2,1)|)**
  - U21
- **DB(|S(2,2)|)**
  - U21
K-Band Amplifier at 15 K

- **DB(|S(1,1)|) (L)**
  - KM54C
  - KM55C
- **DB(|S(2,1)|) (R)**
  - KM54C
  - KM55C
- **DB(|S(2,2)|) (L)**
  - KM54C
  - KM55C
- **DB(|S(1,1)|) (L)**
  - KM56C
- **DB(|S(2,1)|) (R)**
  - KM56C
- **DB(|S(2,2)|) (L)**
  - KM55C

**KMS4, KMS5, and KMS6 S Parameters at 20 K**

- Frequency (GHz)
- IRL and ORL (dB)
- Gain (dB)
K-Band Amplifier at 15 K

KM54 KM55 KM56 Gain and Noise at 20 K

Frequency

Noise Temperature (K)

Gain (dB)

Gerry Petencin
CDL

EVLQ Front-End CDR – LNA Procurement
April 24, 2006
Ka-BAND CRYOGENIC RECEIVER NOISE TEMPERATURE
(AM13)

Noise Temperature (K)

Frequency (GHz)

CDL
April 24, 2006
EVLA Ka-BAND AMPLIFIERS WITH 4080 CRYO3 DEVICE
AT 19 K

Frequency (GHz)

Noise Temperature (K)
Comparison of Measured and Modeled S Parameters for QM89 at 20 K

- $\text{DB}(|S(1,1)|)$ (L) QMAPAmplifier
- $\text{DB}(|S(2,2)|)$ (L) QMAPAmplifier
- $\text{DB}(|S(2,1)|)$ (R) QMAPAmplifier
- $\text{DB}(|S(1,1)|)$ (L) QM89C15
- $\text{DB}(|S(2,1)|)$ (R) QM89C15
- $\text{DB}(|S(2,2)|)$ (L) QM89C15

Frequency (GHz)

IRL and ORL (dB)

Gain (dB)
Comparison of Gain and Noise of QM89 at 20 K

- DB(|S(2,1)|) (R)
- QMAPAmplifier
- TE() (L)
- QMAPAmplifier.$FPRJ
- |Eqn()| (L)
- Tminamp
- PlotCol(1,2) (L)
- QM89noise20K
- DB(|S(2,1)|) (R)
- QM89C15