EVLA Front-End CDR

EVLA
K-Band (18-26 GHz)
Receiver
EVLA K-Band Receiver Overview

1) EVLA Upgrade
   - Existing VLA Configuration
   - Required Modifications
   - New Upgraded EVLA Block Diagram

2) Block Converter Scheme

3) Noise & Headroom Model

4) Upgrade Details

5) Test Results
   - Swept LO1 vs. Block Converter Mode
   - Equalization
   - Ellipticity
VLA K-Band Receiver

Current Configuration
(No WVR)

- LO Ref: 16-20 GHz
  - NF < 4 dB
  - Po = +8 dBm
- IF Out: 4.5-5.0 GHz
  - +15 dBm
  - Po = +9 dBm
- 18-26.5 GHz
  - NF < 4 dB
  - Po = +9 dBm
- 18-26 GHz
  - LNA: 35 dB
  - Po = +9 dBm
K-Band Receiver

VLA to EVLA Modifications

- Switch to High-side LO injection
  - Requires new Mixers (Miteq RF/LO=4-40 GHz, IF=DC-20 GHz)
  - Requires new Limiting Frequency Doubler for LO Reference
- Adopt Block Converter Scheme (18-26.5 → 8-16.5 GHz)
- Remove narrow 4.5-5.0 GHz IF components
- Replace 38 dB Miteq post-amps with 32 dB Quinstar units
  - To avoid compromising Headroom
  - Already have 47% (28 out of 60) of the Quinstar QLN-2240J0 amps that will be required
- Add Isolators on RF, IF & Cal signals
  - To reduce passband and $T_{\text{Cal}}$ ripple
EVLA K-Band Receiver
Baseline Configuration
(without WVR capability)
K-Band Block Conversion Frequency Diagram

- Translation of 18-26.5 GHz down to 8-16.5 GHz
- LO Ref 17.250 GHz × 2 = 34.5 GHz
  - Closest L301 Lock Point is actually 17.280 GHz
## Estimated EVLA K-Band

**$T_{Rx}$, Output Power & Headroom**

<table>
<thead>
<tr>
<th>EVLA K-Band Rx</th>
<th>P (1dB) (dBm)</th>
<th>P (1%) (dBm)</th>
<th>Temp (K)</th>
<th>NF/C (dB)</th>
<th>Loss/Gain (dB)</th>
<th>Loss/Gain (linear)</th>
<th>Delta T (K)</th>
<th>Trx BW (MHz)</th>
<th>Pnoise (dBm)</th>
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*Note: For $T_{sky}$ of 25.0 K.*
Old vs. New K-Band

- Longer legs
- New Card Cage
- Block Converter
- New bottom Feed section
- Easy access to fridge & manifold
Feed Horn & Receiver Mounting Modifications

- In the EVLA configuration the receiver is essentially hung from the Vertex Cabin roof by the feed.
- New bottom section of feed is more robust to carry the receiver’s weight.
- New thicker Top Plate.
- New anti-cocking flange addresses the problem with the old boss/deboss mating system which caused large broad bumps in $T_{Rx}$.
- New Ring-Load section has improved compression system to eliminate their distortion.
EVLA 18-26.5 GHz Receiver

- 15º Kelvin Cold Stage
- Cold Straps
- LCP LNA
- Cryo Isolator
- Cal Coupler
- Stainless Steel Coax
- Thermal Gap
- Phase-Shifter
- RCP LNA
- Cryo Isolator
- Cal Coupler
- Ortho-Mode Transducer
Replace old-style GaAsFET cooled amplifiers with new MAP-style InP units as well several existing MAP units which have inferior performance.

28 new LNA’s

Upgrade existing 4-stage MAP amps by returning to them to CDL for substitution of Cryo-3 device in the first stage

24 upgraded LNA’s
The New RF/IF Box

R. Hayward

EVLA Front-End CDR – EVLA K-Band Receiver
24 April 2006
K-Band SN 27 - First EVLA Prototype
Swept LO1 vs. Block Converter Mode
27 May 2004

Swept LO 1 Mode: LO1 = 29.0 to 37.0 GHz, LO2 = 11.0 GHz
Block Converter Mode: LO1 = 34.0 GHz, LO2 = 16.0 to 8.0 GHz

Original MAP LNA design only intended to cover 20-25 GHz
K-Band SN 27 - First EVLA Prototype

Gain Flatness in 2 GHz Bandwidths - No Equalization
Swept LO1 Mode (LO1 = 14.5-18.5 GHz, LO2 = 11 GHz)

27 May 2004

Normalized Gain
Frequency & Gain Slope Equalization
- 18-20 GHz with 0 dB
- 20-22 GHz with 0 dB
- 22-24 GHz with 0 dB
- 24-26 GHz with 0 dB

Normalized Gain
Frequency & Gain Slope Equalization
- 18-20 GHz with 0 dB
- 20-22 GHz with 0 dB
- 22-24 GHz with 0 dB
- 24-26 GHz with 0 dB

LCP
(KL273C29.373)

RCP
(KR273C29.423)
Planned T304 Downconverter Programmable ±15 dB Equalizer with 2 dB Steps
K-Band SN 27 - First EVLA Prototype
Gain Flatness in 2 GHz Bandwidths - Simulated T304 Equalizer
Swept LO1 Mode (LO1 = 14.5-18.5 GHz, LO2 = 11 GHz)

15 March 2006

Normalized Slope
Frequency & Gain Slope Equalization
- 18-20 GHz with -7 dB
- 20-22 GHz with +3 dB
- 22-24 GHz with -5 dB
- 24-26 GHz with +3 dB

Normalized Gain
Frequency & Gain Slope Equalization
- 18-20 GHz with -11 dB
- 20-22 GHz with +3 dB
- 22-24 GHz with -3 dB
- 24-26 GHz with +3 dB

LCP
(KL273C29.373)

RCP
(KR273C29.423)
Typical K-Band Axial Ratio Measurement

Measured Axial Ratio on K#22 LCP & RCP Channels using the Iso-KETF versus Calculated Axial Ratio for Phase-Shifter #23 based on Differential Phase Shift Test Data (Assumes 0 dB Amplitude Inbalance)

15 April 2005

1 dB Axial Ratio Spec
LCP (Unsmoothed)
LCP Smoothed
RCP (Unsmoothed)
RCP (Smoothed)
Phase-Shifter #23
EVLA K-Band Summary

- Incremental upgrade to an existing VLA receiver band
- EVLA design improves sensitivity and broadband performance
- New/upgraded LNA’s will provide even more improvement
- M&S Budget - $289.1K already spent out of $445.5K allotment
  - Remaining large ticket items
  - LNA’s
  - Cables
  - New Card Cages

- To keep within the EVLA Project spend profile, it was felt that the upgraded design was low risk and that we could confidently proceed with mass production
- We hope the FE CDR Panel agrees…
Questions ?
Backup Slides
Frequency Doubler

Norden Millimeter Limiting Doubler N03-2084

- Input Frequency: 15-18 GHz
- Output Frequency: 30-36 GHz
- $P_{\text{in}}$ (min): -3 dBm
- $P_{\text{in}}$ (max): +3 dBm
- $P_{\text{out}}$ (min): +17 dBm
- $P_{\text{out}}$ (max): +19 dBm
- O/P Variation over I/P Drive (max): "0.5 dB
- Power Flatness with Freq (max): "0.5 dB
- Max Input No Damage: +13 dBm
- Fundamental Rejection (min): -50 dBc
- Harmonic: -40 dBc
- Spurious: -65 dBc
IF Filter (8-16.5 GHz)

TTE K4905-8/16.5G-A

- Insertion Loss: 1 dB
- Flatness: 0.5 dB
- Rejection: -1 dB at 8.00 & 16.50 GHz; -3 dB at 7.80 & 16.70 GHz; -30 dB at 6.11 & 18.39 GHz; -50 dB at 4.40 & 19.60 GHz
- Upper -50 dB Stopband: 35 GHz
VLA/EVLA K-Band Receiver
SN 26
(28 April 2003)