EVLA LO/IF/FO
Critical Design Review

Jim Jackson, Hardware Systems Engineer
System Status

First Light
(X-Band)
October 2003
System Status

- First Fringes (X-Band) – March 2004
  - EVLA Prototype (Antenna 13) with VLA
  - Tests and evaluation on-going
  - Additional Bands available soon
First Fringes

Phase Relationship

Bandpass Shape
- From VLA T5
- BW = 12.5MHz

Center Frequency = 8.4538 GHz, Bandwidth = 12.500 MHz

Cross-power spectrum  Baseline: Antenna 8 - Antenna 13
Time: 21:41:10 to 21:41:20 IAT
EVLA Antenna IF Diagram

- T303 UX Converter
- T302 LSC Converter
- T301 4P Converter
- Band Switch
- T304 Down-converter
- D301 Digitizer DTS
- T304 Down-converter
- D302 Digitizer DTS
- T304 Down-converter
- D303 Digitizer DTS
- T304 Down-converter
- D304 Digitizer DTS
- WDM Mux
- Fiber

Conversions:
- Q: 8-18GHz
- Ka: 8-12GHz
- K: 8-12GHz
- Ku: 8-12GHz
- X: 8-12GHz
- C: 4-8GHz
- S: 2-4GHz
- L: 1-2GHz
- 4&P: 327MHz, 74MHz
- UX Converter: 8-18GHz
- LSC Converter: 8-12GHz
- 4P Converter: 8-12GHz
- Digitizers: D301-D304
- Fiber to Control Building
EVLA Antenna LO Diagram

L304 LO Receiver

L305 Antenna Reference Generator

LO to T304’s

L302 10.8-14.8GHz Synthesizer (4 Copies)

LO Band Switch

L301 12-20GHz Synthesizer

LO Band Switch

L304 LO Fiber From Building

LO Fiber To Building

512MHz +SYNC

Timing

128MHz

1024MHz

4096MHz

9.6Hz to FE Rack

19.2Hz to FE Rack & ACU

19.2Hz to MIB’s

4096MHz to T304

1024MHz to T301

To D301-4

512MHz

19.2Hz

128MHz

LO to T302

LO to T303

LO to Q-Band FE

LO to K-Band FE

LO to Ka-Band FE

LO to Ku-Band FE

LO to MIB’s

4096MHz to T304

1024MHz to T301

19.2Hz to FE Rack & ACU

5/18/2004
Jim Jackson

EVLA LO/IF/FO CDR
19-21 May 2004
Hardware Status

- Hardware currently installed and operating in the VLA control building:
  - L350 Central Reference Generator
  - L351 Master Offset Generator
  - L352 Round Trip Phase Measurement
  - L353 LO Transmitter
  - DTS Receiver Board
  - P301 Power Supply
  - 48 VDC Bulk Power Supply and Batteries
Hardware Status

- Hardware currently installed and operating in Antenna 13:
  - L301/L302 Synthesizers
  - L304 LO/Reference Receiver
  - L305 Antenna Reference Generator
  - T304 Downconverter
  - D301 Sampler/DTS Module
  - P301 Power Supply (2)
  - 48 VDC Bulk Power Supply and Batteries
Hardware Status

• Fiber optics
  – Fiber burial on all three arms complete
  – Antenna 13 connected and operational at master pad
  – Fiber spliced to end of west arm for round trip phase testing
  – LO/Reference fiber phase characterization continuing
RFI Protection

• Layered approach
  – Implement low noise PCB design techniques
    • MIB, DTS and other PCB’s exceptionally quiet
  – Custom shielded and filtered enclosures
  – Use of DoD “Tempest” certified RFI racks
  – Use of differential signaling or fiber for digital signals
  – RFI chamber tests of all hardware
PCB Design

• Low noise printed circuit boards
  – Ground planes
  – Impedance matched traces
  – High speed traces on inner layers
  – Stitched vias
  – Differential signaling (LVDS/ PECL)
  – Layered voltage regulators
  – Final regulators at load
  – Filtered I/O signals
PCB Design

Module Interface Board
PCB Design

Test Results (in dBuV/m)

Frequency in MHz

EUT: HIB
Manufacturer: NRAO
Tester: wa
SPID: 040407_777
EUT Level: rev 2?
EUT Information: tabletop, Class B setup
Test information: self test, 3m, 5VDC, FCC Part 15 Class B
Electronics Packaging

• LO/IF/FE Modules
  – Set of hardware components configurable to produce a number of enclosure types
  – Integrated RFI/EMC gaskets and filters
  – Heatsinks for thermal control
  – Fit existing VLA bins
  – Recent decision eliminated all blind mate connectors from EVLA electronics
Typical LO/IF Module
Hardware

DC-DC Converter Housing
Electronics Packaging

P302 DC-DC Converter
Electronics Packaging

L353
Chamber Results

L353 with Type II shielding

-140
-135
-130
-125
-120
-115
-110
-105
-100
Mhz
1000 1500 2000 2500 3000 3500 4000 dbm

5/18/2004
Jim Jackson

EVLA LO/IF/FO CDR
19-21 May 2004
Electronics Packaging

• D301-4 DTS/Sampler Modules
  – Highly shielded module designed to contain digitizers and data transmission system
  – Better than 80dB shielding
  – Brass honeycomb filters for high air flow
  – All I/O on fiber and coax
Electronics Packaging

• D301-4 DTS/Sampler Module
Projected
DTS Module with Cover On  BW=0.1Mhz

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Amplitude (dBW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>-180</td>
</tr>
<tr>
<td>2000</td>
<td>-170</td>
</tr>
<tr>
<td>3000</td>
<td>-160</td>
</tr>
<tr>
<td>4000</td>
<td>-150</td>
</tr>
<tr>
<td>5000</td>
<td>-140</td>
</tr>
<tr>
<td>6000</td>
<td>-130</td>
</tr>
<tr>
<td>7000</td>
<td>-120</td>
</tr>
<tr>
<td>8000</td>
<td>-110</td>
</tr>
<tr>
<td>9000</td>
<td>-100</td>
</tr>
<tr>
<td>10000</td>
<td>-90</td>
</tr>
</tbody>
</table>

- DTS PCB RFI
- EVLA harmful level
- Maximum allowed EIRP in vertex room

ITU Standard
• LO/IF and Front End Racks
  – Commercial RFI racks
  – DoD “Tempest” rated
    • (approx 55dB @ 5GHz)
  – All I/O signals filtered or on fiber
DC Power

- 48 VDC power system
  - Commercial bulk power products
  - Designed for telecom
  - 52.5 Amp cont. capacity
  - N+1 redundant design for reliability
  - Battery backup for 1 hour
  - Installed in “Tempest” rated RFI shielded rack in antenna pedestal room
  - Reuses existing Square-D “QO” breakers and panels
DC Power

- **P301/302 DC/DC Converter**
  - Using 2’nd Generation Vicor DC-DC converter modules- low noise, zero switching design
  - Extensive input & output filtering
  - New flexible PCB design allows for various configurations
  - Used for antenna and control building electronics
  - Provides voltage & current monitoring, protection
DC Power

• DC Power Distribution PCB
  – Attaches to back of P301/302 modules
  – Quick connection of modules
  – Individual fusing
  – Power on and blown fuse indicators
Digitizers

• 8-bit, 2 Gsps digitizer
  – Installed in DTS module and in use on Antenna 13
  – Dual Maxim MAX104, each running at 1Gsps
  – New single chip design in progress using Atmel 8 bit, 2 Gsps device
  – Used for transition and observation in high RFI bands
Digitizers

- 3-bit, 4 Gsps digitizer
  - ALMA device under development in France
    • Prototype being tested in DTS lab
- Potential alt source of high speed A/D
  - Atmel - 8 bit, 4 Gsps, 4GHz BW A/D in development
    • This device could replace both EVLA digitizers
Questions?