Fiber Phase Stability Status

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OFS BrightWave Cable

- Double armor loose tube cable
  - Corrugated, copolymer coated carbon, steel tape applied longitudinally

- Polyethylene jacket
  - 1.4 mm Outer, 1.2 mm Middle, 1.0 mm Inner

- Glass/epoxy composite dielectric rod core
Cable Cross Section
OFS Matched Cladding Fiber

- Matched cladding single-mode
  - Nonzero-dispersion optical fiber

- Gel-filled buffer tubes
  - Installed in a reverse oscillation lay
  - 12 fibers per tube
OFS Matched Cladding Specifications @ 1310 nm

- Attenuation coefficient: 0.31-0.35 dB/km
- Chromatic dispersion: -9 ps/nm-km
- Dispersion slope: 0.088 ps/nm²-km
- Group index of refraction: 1.471
- Polarization M dispersion: ≤0.5 ps/(km)¹/²
- Rayleigh Backscattering: -49.6 dB
- Coefficient of Expansion*: 6 PPM/°C

* NRAO Estimate
LO Technical Requirements
Based on the Scientific Goals after all Round-Trip Corrections

• Short Term:  < 0.5 ps RMS per second

• Long Term:   < 1.4 ps per 30 minutes
   ~20 degrees at 40 GHz

• Delta Slope: < 0.2 ps change per minute
   Over 30 minutes
Phase Error Allocation

- Front End: 0.4 ps per 30 Min
- LO Converters: 0.6 ps per 30 Min
- Fiber System: 0.4 ps per 30 Min
  - RTP measurement accuracy*: 0.05 ps
  - 512 MHz + 128 Hz jitter*: 0.1 ps
  - Fiber induced errors: 0.25 ps

*NRAO estimates
Verification

- Is the magnitude and rate of change of the phase caused by the 22Km tolerable?
- How identical are the two fibers used in the round trip phase measurement system?

Or Is the un-compensated difference in phase uncertainty tolerable?
RTP Test Setup

Test designed and operated by Doug Gerrard and Don Haenichen
RTP Test Hardware
Analog Mixer as a Phase Detector
65 Km Spool Test

5 cycles X 360° / 13° = 137 Ratio

6 ppm / °C
Calculated Temperature Effects on Phase

- **22 Km Length Change per** (6 ppm / °C)
  - 30 minutes = 5.4 um → 0.028 ps
  - 6 months = 1.4 m → 6677 ps (3.4 cycles)
- **30 meters in Control Building per**
  - 30 minutes = 10.4 mm → 49 ps
- **28 meters up the Antenna per**
  - 30 minutes = 10.7 mm → 51 ps

  Total ~ 100 ps/30 min  (EVLA Memo – 44)

\[
\frac{100 \text{ ps} / 30 \text{ min}}{137 \text{ Ratio}} = \sim 0.73 \text{ ps} / 30 \text{ min}
\]
Master Pad Fiber Enclosure
Fiber Enclosure Temperature

Temperatures

Date/Time

Ambient Temp  Equip Temp  Ground Temp  Box Temp
Master Pad Fiber Enclosure

Slope represents 0.5 ps / 30 minutes
½ for 2 way trip = 0.25 ps / 30 minutes

1° Phase Shift = 5.4 ps
Master Pad Fiber Enclosure with Insulation
Insulated Fiber Box Temperatures

Temperatures

Date/Time

Ambient Temp  Box Temp  Equip Temp  Ground Temp
Test Apparatus drift is +/- 0.5 ° per day

~ 0.22 ps per 30 minutes

1° Phase Shift = 5.4 ps
Cable Wrap Test Fixture

- Antenna
  - 540 ° Total
  - 40 ° / minute

- Test Fixture test results:
  < 0.5 ° shift
  @ 1.2 GHz
Conclusion

- The magnitude and rate of change of the phase shift caused by the buried 22Km is tolerable.
  
  6 ppm / °C or Total ~ 0.028 ps / 30 min
  
  ~ 3.4 cycles per 6 months
  
  May have a problem with CB and Antenna fiber

- The un-compensated difference of two fibers is
  
  Measured less than ~.73 ps / 30 min

- The cable wrap may also work.
Elevation Cable Bend
LO Optical Loss Budget

1310 nm Laser Modulator

6 dBm → -6.2 dB

22 km Fiber

-8.8 dBm

Connections and Splices

Optical Receiver

-25 dBm

-6.2 dB

22 km Fiber

-8.8 dBm

Connections and Splices

Splitter

95%

5%

-1 dB → 14 dB

Optical Receiver

-23 dBm

-30 dBm
EVLA Fiber

EVLA North Arm Fiber
Cable Plan

Symbol Key
- Splice
- Manhole
- Trunk Cable
- Homerun Cable

SJD/JJ Advisory - Sept 2003
Base Splice Enclosure

Sampler RACK

LO System

Vertex Splice Enclosure

12 Single Mod Fiber

MCB RACK

24 Multi

Hybrid Cable

Elevation Cable Bend

To MIBs

~92 Multi

Vertex Room

Azimuth Cable Wrap

12 Multi

Pedestal Splice Enclosure

Lower Ped Room

Upper Ped Room

12 Single Mode Fibers to Control Building