NLC Phase and Timing Distribution Phase Reference Test System Status February 1, 2000

Josef Frisch, David Brown, Eugene Cisneros

f

Timing System Requirements Overview

Function: Provide RF phase reference and triggers for the NLC

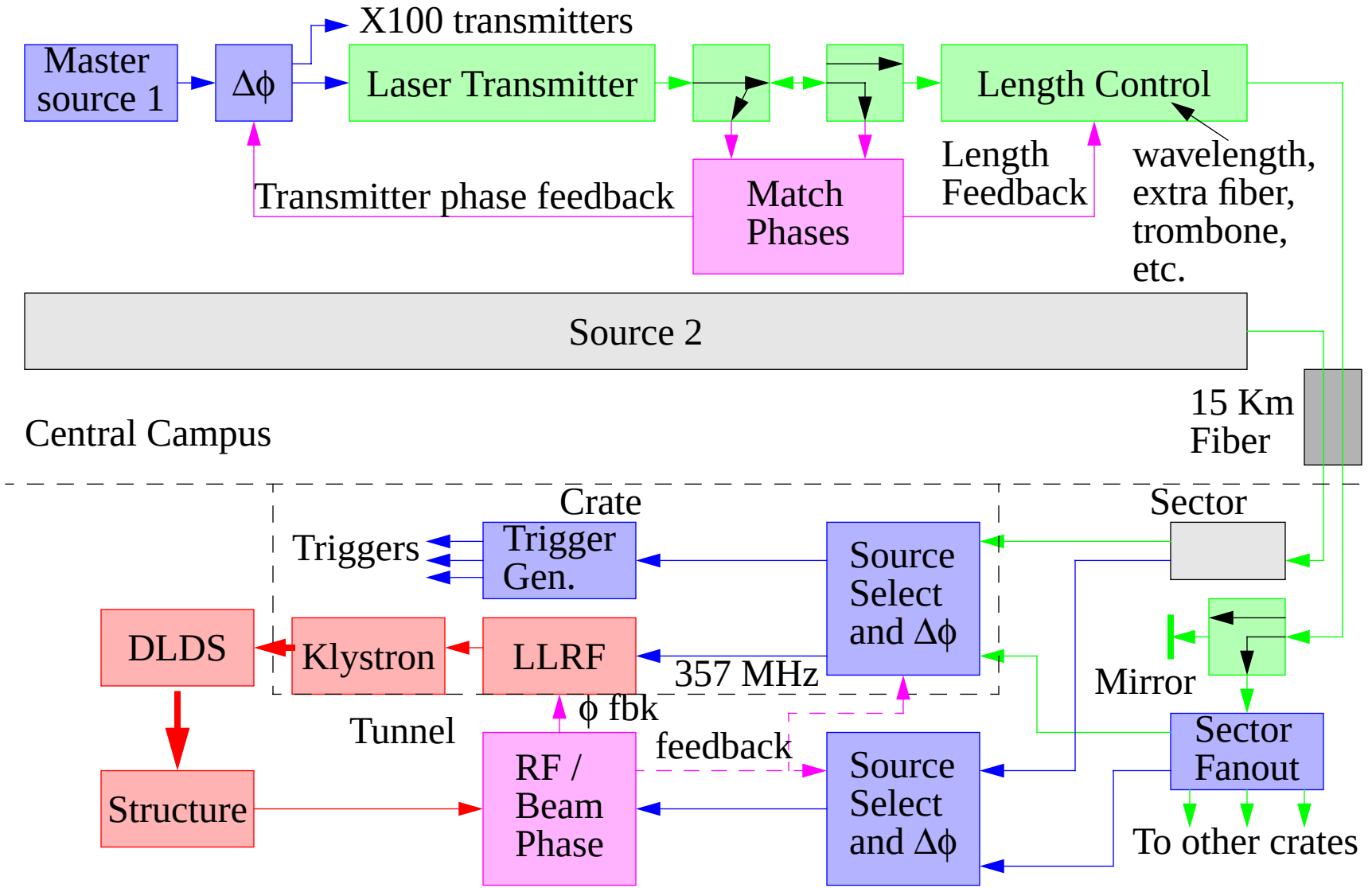
Test System: A long distance phase transmission test system has been constructed. This system does not test fiducial or timing transmission.

Parameter	NLC System	Test System - measured
Transmission distance	1 to 15 Kilometers	15 Kilometers
Fiber temperature range	+/- 5^{o}C*	+/- 1^{o}C
Long term phase stability	+/- 20^{o} X-band	+/- 3^{o} X-band (3 day test)
Phase temperature coefficient	< 4^{o} X-band / ^{o}C*	<5^{o} X-band / ^{o}C
Phase Noise	<0.3^{o} X-band, 100Hz BW	4.5^{o}X-band, 100 Hz BW**

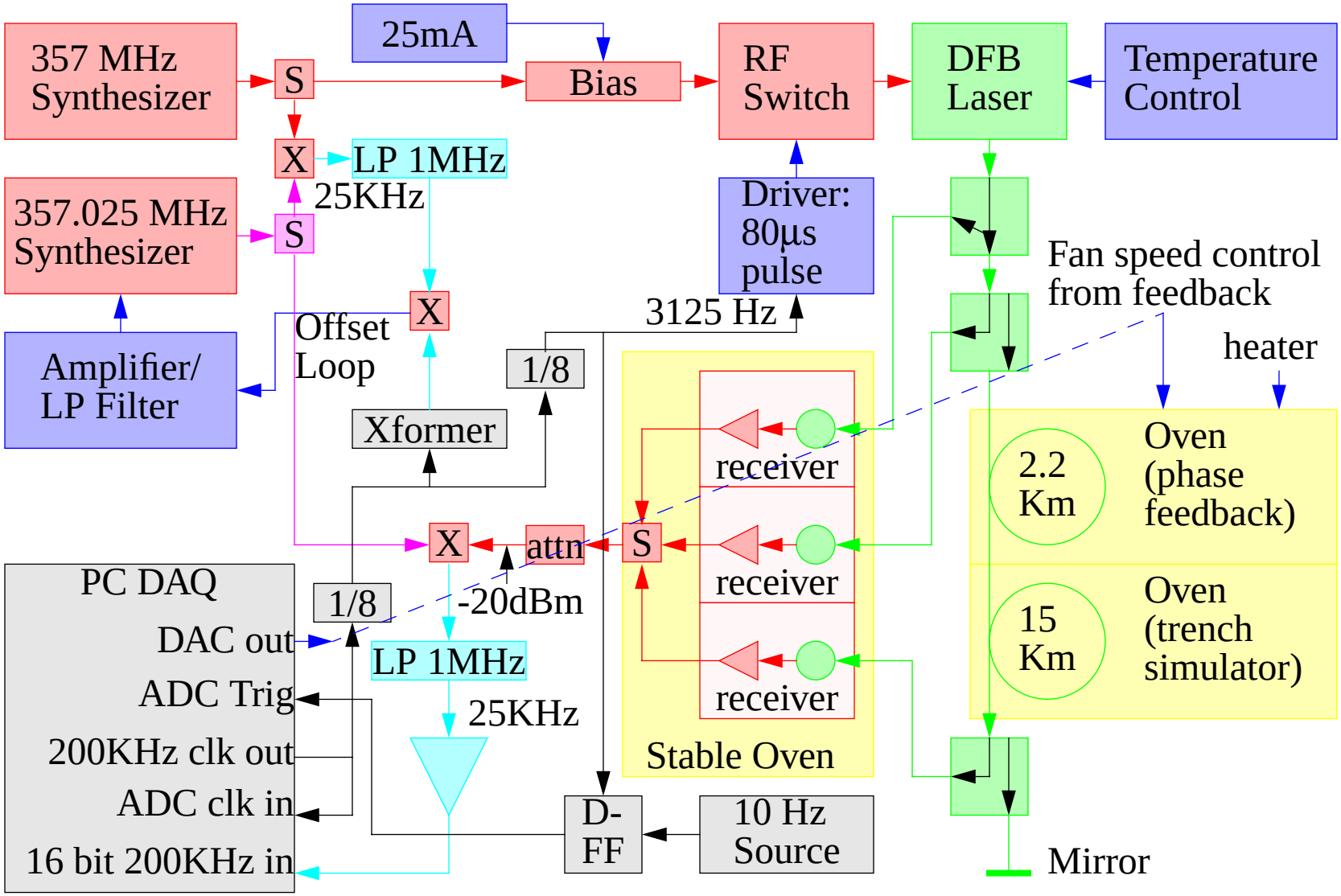
*Based on SLAC summer / winter temperatures and 1 Meter burial depth

**Initial experiments, noise not optimized.

NLC Phase and Timing System Overview



Phase Transmission Test Setup



Test Results - Electronics Only

from 11/29/1999 report

Phase Calibration: A trombone was used to check the phase measurement calibration for major errors. The phase calibration error was <7%, consistent with zero.

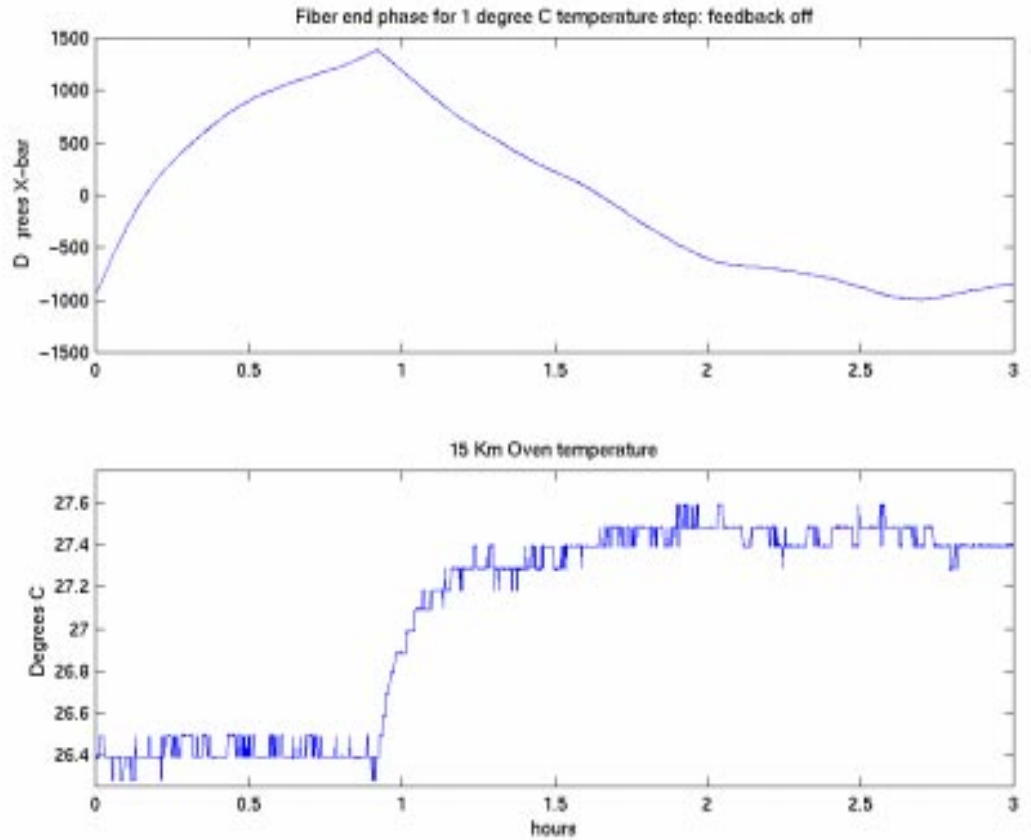
Phase Noise: 0.11^{o} X-band RMS, 10 Hz data, for 1 minute. (0.04^{o}X-band/$Hz^{1/2}$).

Phase Drift - Single Channel: +/- 3^{o} X-band over 4 days. Not that this drift is to a large extent nulled by the phase difference measurement in the real system.

Phase Drift - Channel Difference: 0.28^{o} X-band RMS over 4 days. Note that no channel difference is expected since the same components are used to measure each phase.

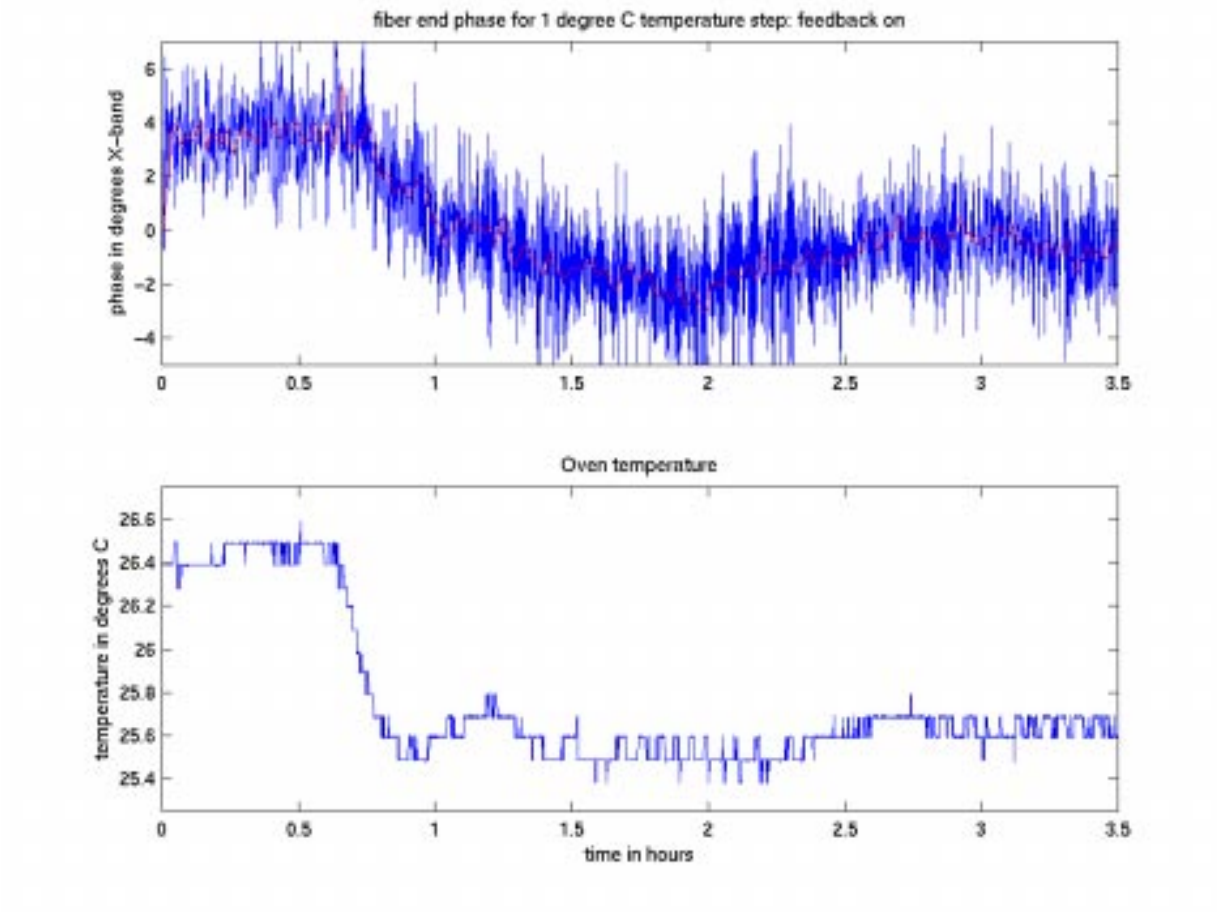
Fiber Response Open Loop

The temperature coefficient phase for fused silica fiber results from the expansion coefficient $5x10^{-7}/^{o}C$ (small), and the index change $\sim 10^{-5}/^{o}C$ (dominates). For a 15Km fiber, we expect a phase sensitivity of 2800^{o}X-band/^{o}C. We observe $\sim 2200^{o}$X-band/^{o}C.

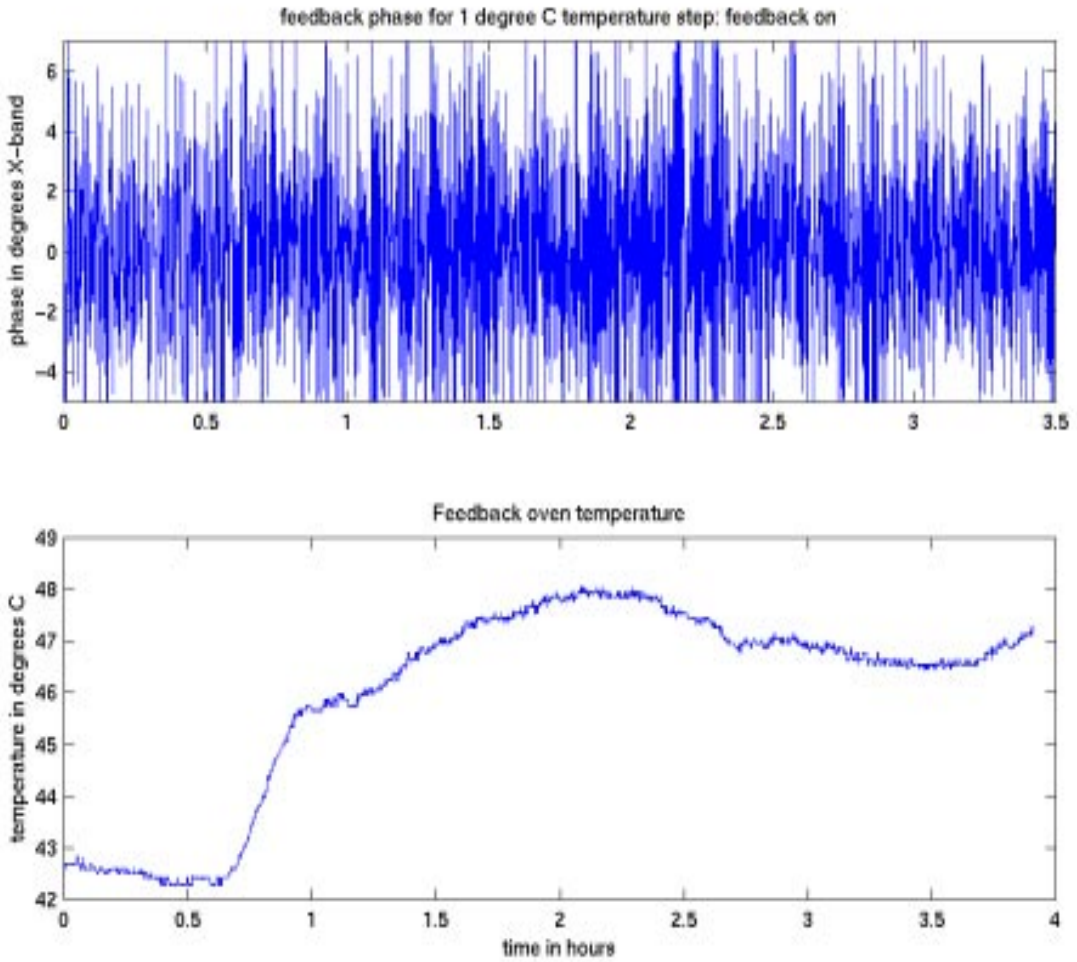


Fiber phase output: Feedback on

With the feedback on, the reflected phase signal shows no variation (other than broadband noise). The Feedback oven temperature is controlled. Output shows ~5^{o}X-band/^{o}C. This residual may be instrumental.

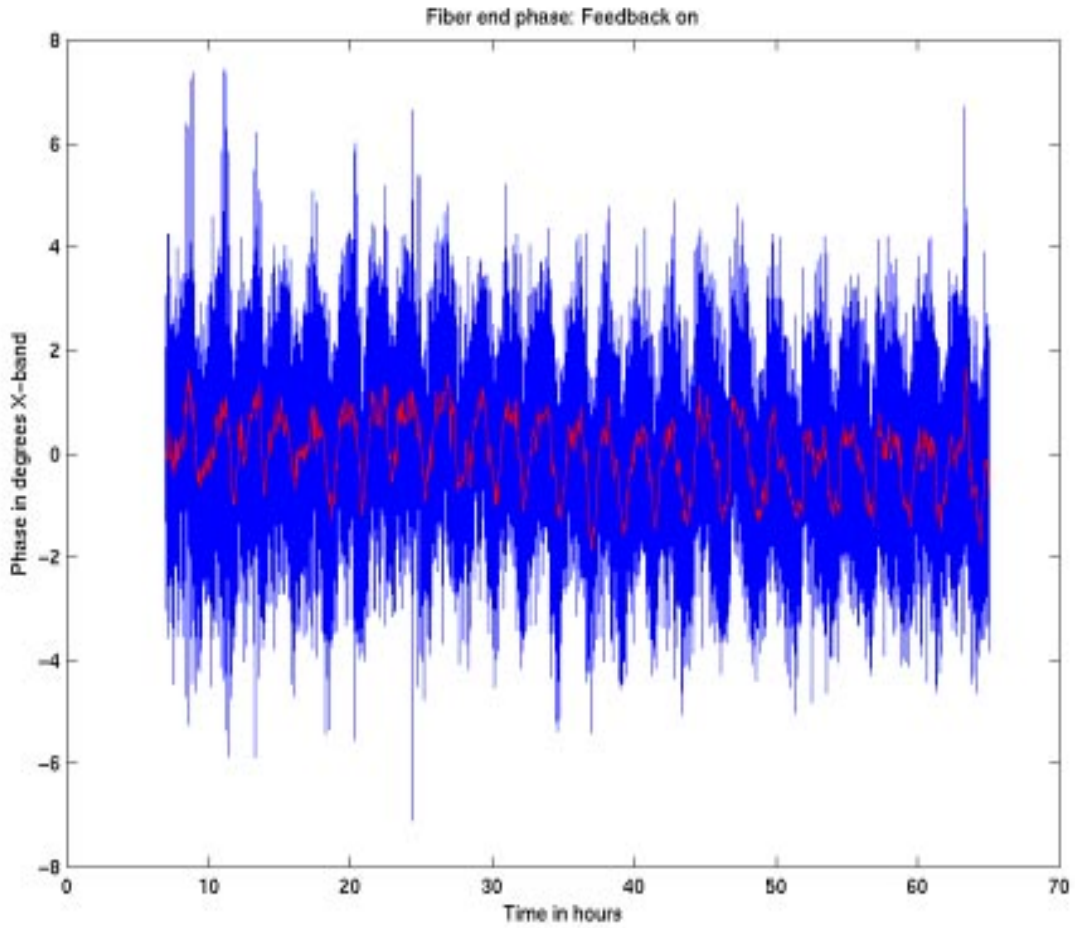


Feedback Signals for Temperature Change



Fiber Phase Stability, Feedback on

A 3 day run with the 15Km fiber oven temperature constant (to <0.1^{o}C) was done to look at the long term stability. Note that the noise of the output is ~1.4^{o} X-band RMS.



Phase Transmission System: Phase Noise

The measured phase noise (~0.5^{o}X-band/Hz$^{1/2}$), is approximately 10X the system specification.

The Phase noise resulting from the receiver noise (3pw/Hz$^{1/2}$ spec, 6pw/Hz$^{1/2}$ measured) and shot noise (~4pw/Hz$^{1/2}$), should be 0.001^{o} X-band/Hz$^{1/2}$. This should not significantly increase the measured electronic phase noise of 0.04^{o}X-band/Hz$^{1/2}$ measured for the (non-optical) electronics.

Low Frequency Noise: The oven feedback system does not have sufficient bandwidth to correct >0.1Hz noise. This should be fixed by the diode bias feedback.

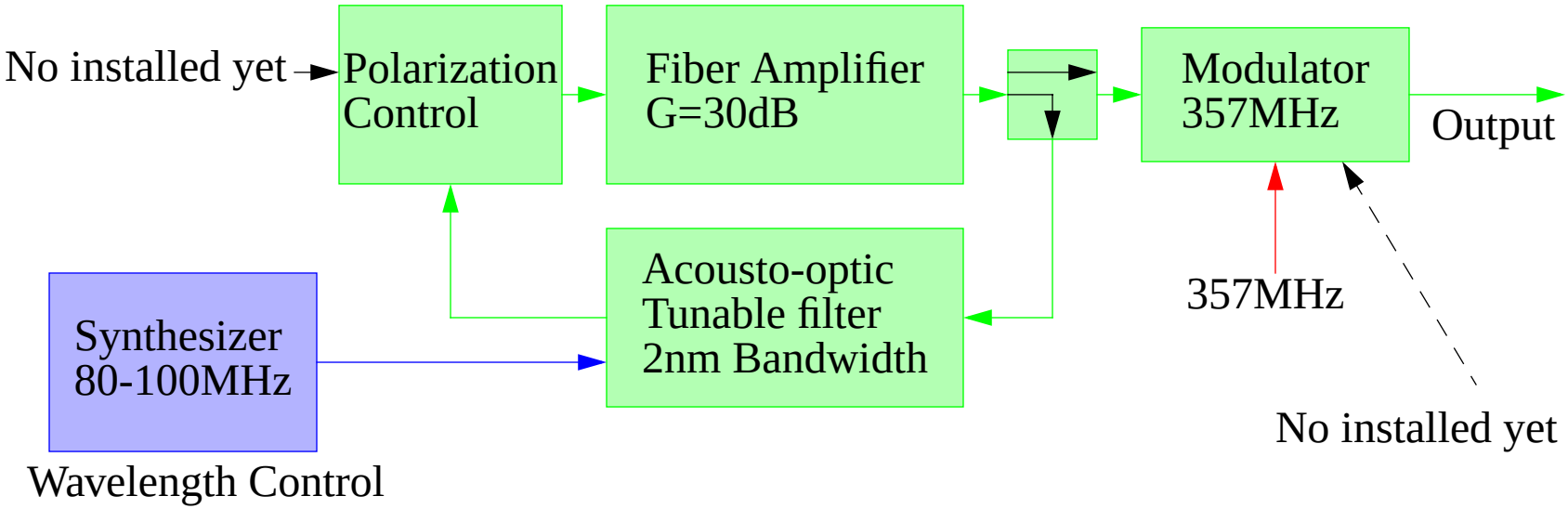
Laser Diode Noise: The manufacturer admits to 20dB excess noise in this diode (above shot noise). Other vendors have diodes that are near shot noise limited.

Laser Diode Wavelength Noise: Due to bias current, or temperature variations. We have a precision spectrometer, but have not yet investigated this.

Electronic noise: We have been concentrating on the feedback stability, there may be electronic noise problems from improper signal levels.

Tunable Laser Progress

The alternate (and preferred) fiber length adjustment is through laser wavelength adjustement. A wavelength tunable fiber laser is being constructed.



Parameter	Requirement	Demonstrated
Tuning Range	40nm	50nm
Wavelength step size	<0.5pm	<1pm (measurement limit)
Noise		Not measured

Phase Test System: Tasks

Add bias current feedback: Will increase system bandwidth and reduce noise. System is ready for testing, however there may be problems with non-linearity in the detectors.

Use improved frequency source: The current source is specified at $10^{-9}/^{o}C$. This would produce 0.3^{o}X-band/^{o}C. We cannot verify this performance, if it is out of spec, it could be responsible for the observed temperature sensitivity. We have ordered a Rubidium source with 10^{-10} Stability.

I**mprove electronic temperature stabilization:** The electronics oven is very crude. We will improve the temperature stability.

Check system performance at 714MHz: All the electronics is compatible with this frequency.

Measure the diode intensity and wavelength noise: We recently purchased a high resolution spectrometer.

Test tunable laser system: System should be ready for testing in a couple of months.

Long Term Tasks

- Add fiducial and pattern broadcast
- Test improved detectors
- Construct / test local low noise PLLs (lock to pulsed optical signal)
- Construct / test high stability frequency multipliers.
- Test system on “real” buried fiber