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Title: **INTERFEROMETER ANALOG OPTICAL LINKS**

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Introduction

The interferometer analog optical links provide for transmission of broadband IF signals from the receivers on the antennas to the control rooms and send local oscillator reference signals to the receivers. The system was designed to transmit the 85-3 antenna receiver outputs to the 140-foot control room so the MK III equipment could be used for the initial VLBI experiments. A transmission path was also provided between the 85-3 receiver and the interferometer control building for use when the VLBA recording equipment is obtained. Additional links from the 85-1 and 85-2 antenna to the control building were planned for use when the new S and X Band Receivers are installed on those antennas.

Analog Optical Transmitters and Receivers

The analog optical system provides for linear transmission of RF signals over the 10 MHz to 1000 MHz band. The units used are General Optronics Corporation model AS1300/1500. The transmitters and receivers operate at a wavelength of 1300 nanometers. The laser diode transmitter is amplitude modulated by the RF input signals. Thermoelectric cooling is used to help stabilize the light output. An InGaAs pin-diode photo detector is used in the receiver. To minimize the noise from the transmitters the reflections in the fiber transmission must be low. General Optronics had low-reflection optical-fiber connectors installed on pigtail fibers connected to the transmitters and receivers. The transmission loss with the transmitter output connected directly to the receiver is about 15 dB. The maximum RF input power level is +10 dBm, and with narrow band signals the S/N at the receiver output is greater than 70 dB. However, when broadband signals are transmitted the noise level at the receiver output increases due to intermodulation. The largest bandwidth signals which must be transmitted are the 200 MHz and 400 MHz wide S and X band IF outputs from the 85-3 receiver to the VLBI equipment at the 140-foot. With fiber losses of 12 dB the signal-to-noise is 26 dB or more even when these large bandwidth signals are transmitted.

Fiber Optic Cable

The cable selected for the runs between the base of the antennas and the control rooms was designed for direct burial. It contains four single mode fibers and four multimode fibers and has a rodent proof steel jacket covered with polyethylene. This cable is Optical Cable Corporation part number B08-110D-4S1XC-4A4FB/2FC/900-CST.

The lengths of the installed cable are:

140-foot to 85-1 Control Room	720 meters
85-1 to Interferometer Control Bldg.	1670 meters
85-2 to Interferometer Control Bldg.	900 meters
85-3 to Interferometer Control Bldg.	150 meters

This cable was buried 18 inches deep to minimize rapid temperature changes.

A weather-proof polyurethane-jacketed cable consisting of four single-mode fibers was installed from the base of the antennas to the focal points. This cable is Optical Cable part number B04-080C-S1XC/900. The length of these cables is 65 meters. The loss in the single mode fiber at the 1300 nanometer wavelength is 1 dB optical power loss per kilometer. The fiber cross section is an 8.7 micrometer core with 125 micrometer cladding. A tight polyethylene buffer 900 micrometer in diameter covers the cladding. Aramid strength members surround the buffer which are covered with a 2.5 millimeter jacket.

Low Reflection Optical Cable Connectors

A special connector developed by Radiall is used to connect the transmitters and receivers to the fiber. Radiall specifies the return loss of these connectors at 55 dB with a typical insertion loss of 0.7 dB. They achieve this low reflection by polishing the fiber end at an angle so reflected signal is absorbed in the fiber cladding. The equipment needed for installation of these DF series connectors, centering the fiber core and polishing at the required angle is very expensive. The 65 meter and 3 meter pigtails were shipped to Radiall to have the connectors installed.

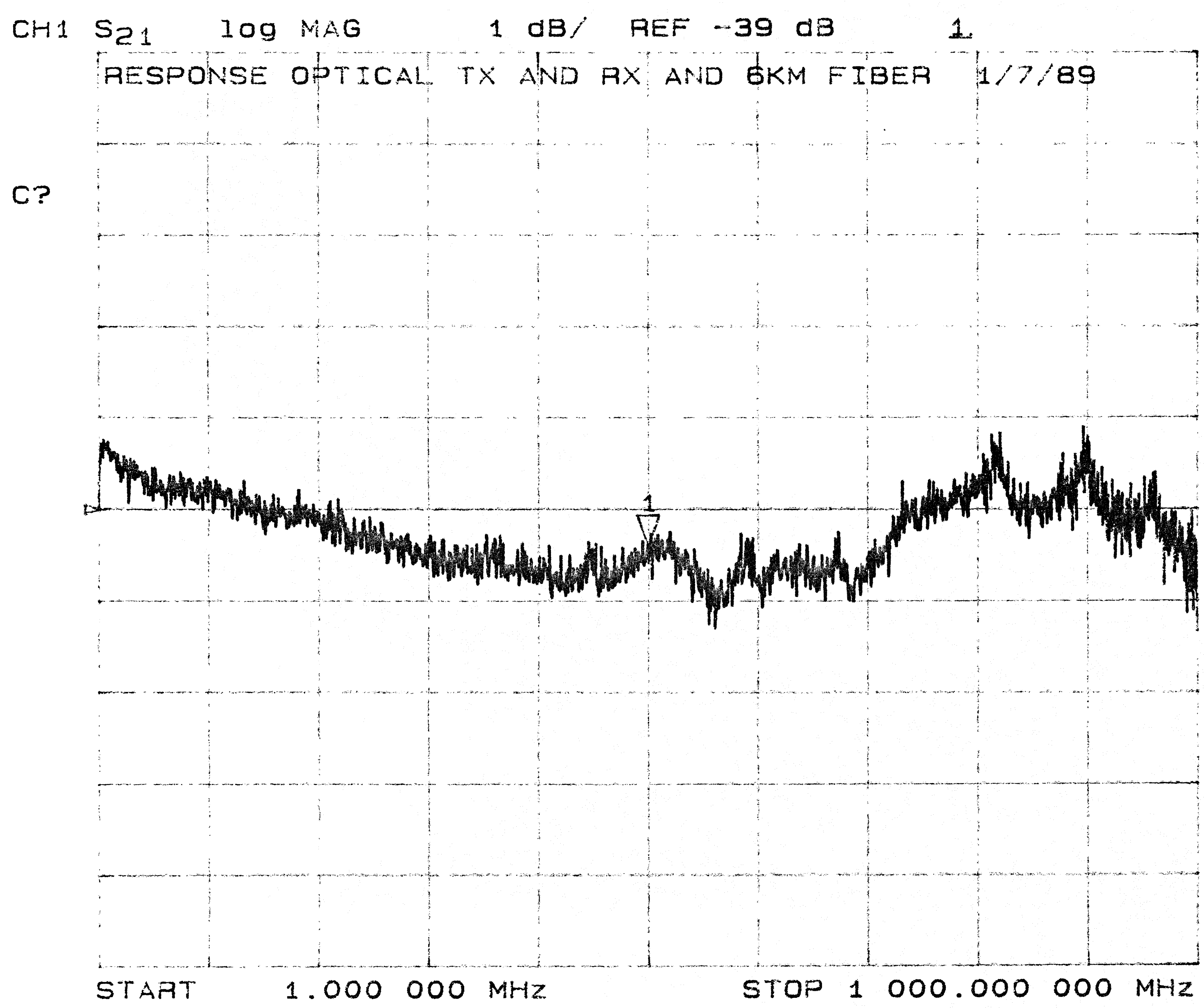
Fiber Optic Splicing

Initially, mechanical splices were used to connect the pigtail fibers to the buried fiber runs. These splices were installed according to the manufacturers instructions. The losses were too high and subsequent measurements with an optical time domain reflectometer showed large reflections. Fusion splices were then installed and the losses in the fiber paths were reduced to acceptable levels. The optical loss from 85-3 to the 140-foot through 2.5 kilometers of fiber, 4 splices and two connector pairs is 6 dB. The RF transmission loss is 12 dB. The RF current out of the receiver photodetector is proportional to the optical power received.

Analog Optical Link Response

The amplitude and phase response of a 6 kilometer loop of fiber was measured. This loop had 12 splices and five connector pairs. The RF loss was about 30 dB and electrical delay was 27.8 microseconds. The amplitude response varies less than 1.5 dB from 10 MHz to 1000 MHz as shown in Figure 1. The phase response variation from linear phase with frequency is less than 5 degrees from 100 MHz to 800 MHz as shown in Figure 2. Measurements were also made of the difference in phase shift between two parallel transmission systems with 3 km of fiber subjected to temperature variations and antenna movement. The phase change at 500 MHz was less than .25 degree rms during a 50 hour test run.

FIGURE 1



CH1 S21 log MAG 1 dB/ REF -39 dB 1
RESPONSE OPTICAL TX AND RX AND 6KM FIBER 1/7/89
C?
1
START 1.000 000 MHz
STOP 1 000.000 000 MHz

1-9-89

FIGURE 2