AD-A132 073 PROTOTYPE FIBER OPTIC SYSTEM TO REMOTE TRACALS RADARS 1/1
(U) ELECTRONICS ENGINEERING GROUP (1842ND) SCOTT AFB IL
J A RADCLIFF ET AL. 30 JUN 83 1842 EEG/EEIT-TR-83-16-EZ

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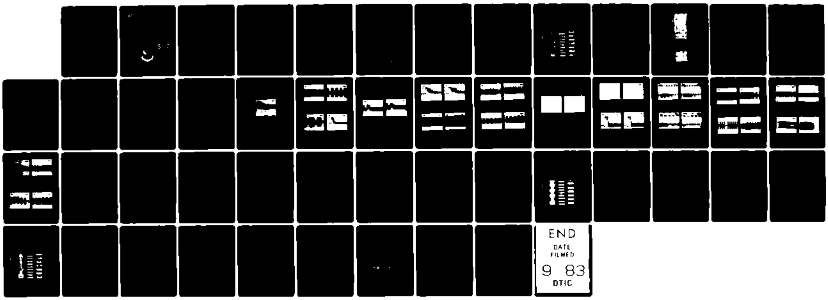

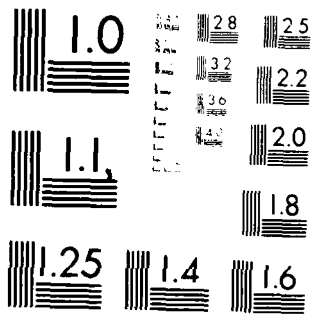

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

1842 EEG/EEIT TR 83-16-EZ
Supercedes TR 82-09-EZ
Dated 15 June 1982

AFCC TECHNICAL REPORT

PROTOTYPE FIBER OPTIC SYSTEM
TO
REMOTE TRACALS RADARS

FINAL REPORT

TRACALS & ELECTRONIC SYSTEMS BRANCH
1842 ELECTRONICS ENGINEERING GROUP (AFCC)
SCOTT AIR FORCE BASE, ILLINOIS 62225

30 JUNE 1983

1842 ELECTRONICS ENGINEERING GROUP

MISSION

The 1842 Electronics Engineering Group (EEG) has the mission to provide communications-electronics (C-E) systems engineering and consultive engineering support for AFCC. In this respect, 1842 EEG responsibilities include: Developing engineering and installation standards for use in planning, programming, procuring, engineering, installing and testing C-E systems, facilities and equipment; performing systems engineering of C-E requirements that must operate as a system or in a system environment; operating a specialized Systems Technical Applications Facility to analyze and evaluate new digital technology for application to the Defense Communications System (DCS) and other special purpose systems; operating a facility to prototype systems and equipment configurations to check out and validate engineering-installation standards and new installation techniques; providing consultive C-E engineering assistance to HQ AFCC, AFCC Divisions, AFCC Engineering Installation Center (EIC), MAJCOMS, DOD and other government agencies.

REPORT DOCUMENTATION PAGE

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This report details the installation, acceptance testing and operational testing of a prototype fiber optic remoting system for TRACALS radars.

APPROVAL PAGE

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MSgt Kennett Slatter, 1866 FCS
SSgt Danny King, 1866 FCS
Sgt James Hinchik, 1974 CG

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PROTOTYPE FIBER OPTIC REMOTING SYSTEM

FOR TRACALS RADARS

1.0 BACKGROUND.

1.1 The transmission mediums currently used to remote Traffic Control and Landing Systems (TRACALS) radars are coaxial cables (coax) or a microwave link. Problems and limitations are encountered in using either medium. Coax is susceptible to electromagnetic interference, moisture, ground loops, lightning and electromagnetic pulse (EMP). Microwave links are susceptible to electromagnetic interference, propagation anomaly, electronic warfare and EMP. The coax remoting system used on the Precision Approach Radar (PAR) is highly susceptible to interference from power lines for runway lights and has a maximum remoting distance of 12,000 ft.

1.2 Remoting TRACALS radars via a fiber optic (FO) system appeared to be a complete solution to the problems listed above. The 1842 EEG conducted a feasibility study of the use of a FO system to remote a PAR (AFCC Technical Report, 1842 EEG/EEIT-TR-80-9). The AN/FPN-62 radar was used in conducting the study. The study demonstrated that an analog FO system can handle the combined analog/digital, time and frequency multiplexed signals (see Figure 1) which are passed over the AN/FPN-62 remoting system. A FO system appeared to be a desirable alternative and warranted a full investigation.

2.0 PROTOTYPE FO SYSTEM.

2.1 A project was established in the 1842 EEG to prototype a FO remoting system for the AN/FPN-62 PAR radar. The objectives established for this project were to:

a. Demonstrate the capability of a FO system both in signal fidelity and remoting distance of at least 12,000 ft.

b. Determine the ability of AFCC installation teams/maintenance personnel to install, splice and put connectors on fiber cable with minimal training.

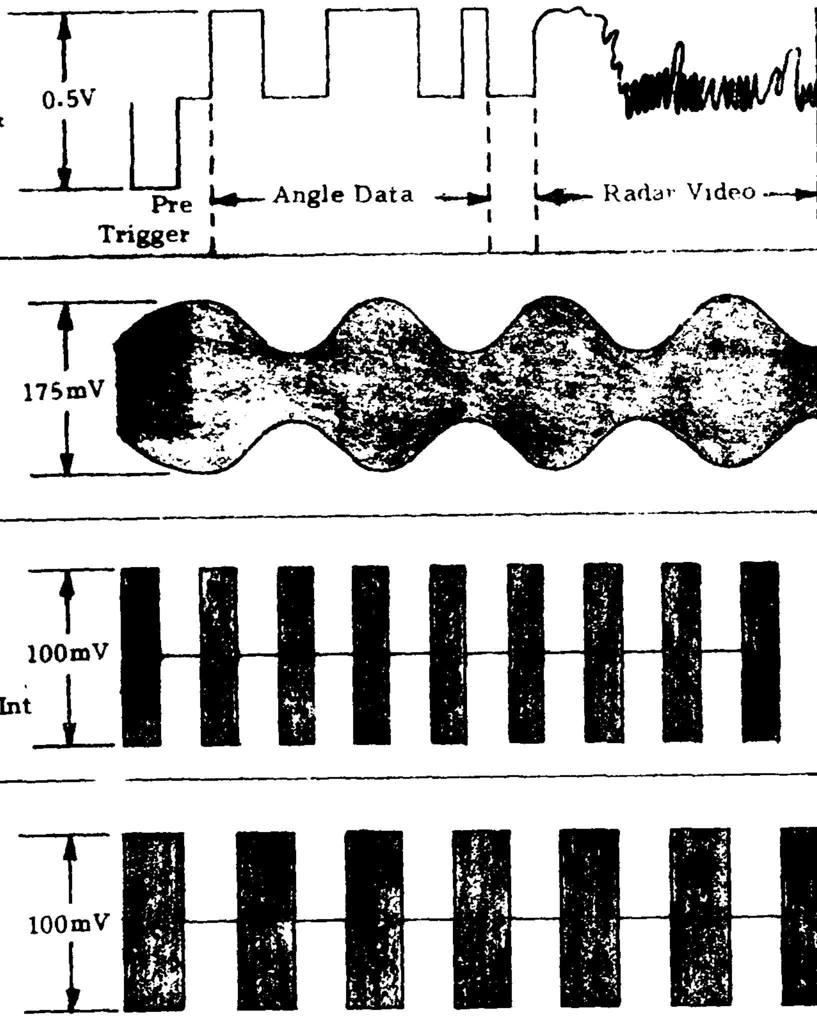
c. Determine the reliability of the fiber optic cable in all modes of installation (direct bury, in ducts and aerial) during a full cycle of seasons.

d. Determine the reliability of the FO system on an operational radar by monitoring operational problems/maintenance actions and quarterly system testing for one year.

e. Develop an interim technical report after acceptance testing and a final report after one year use of the system. The reports will furnish information on which to base decisions to replace current remoting systems at sites experiencing problems and to include a FO system in the initial procurement of new radars.

2.2 A Statement of Work (SOW) was developed to obtain the FO equipment, cable, technical training and technical assistance required for the prototype installation. See Appendix A. The contract was awarded to ITT.

2.3 The AN/FPN-62 radar located at Scott AFB was selected for the prototype installation. This site was suitable for the seasonal exposure of the cable installation and convenient for the 1842 EEG engineers to test and monitor the system's performance.



Signal	RADAR to OPS	OPS to RADAR
Combined Pre Trigger Angle Data & Radar Video	Bandwidth 0 to 6 MHz PRF 3,300	Not Used
Intercom Audio	RF Carrier - 6.95 MHz	RF Carrier - 7.01 MHz
Servo Data or Norm IF, MTI IF, MTI Int	RF Carrier - 7.07 MHz Frame Rate - 10 Hz Pulse Width - 0.35 msec	RF Carrier - 7.13 MHz Frame Rate - 10 Hz Pulse Width - 0.35 msec
Control Data	RF Carrier - 7.19 MHz Frame Rate - 15.625 Hz Pulse Width - 0.5 msec	RF Carrier - 7.25 MHz Frame Rate - 15.625 Hz Pulse Width - 0.5 msec

FIGURE 1. WAVEFORMS (Frequency Multiplexed for Transmission)

2.4 The 485 EIG/Griffiss AFB prepared an installation scheme and site concurrence letter. Installation was accomplished by a team from the 485 EIG with support from the 1974 CG/Scott AFB.

3.0 TRAINING.

3.1 The contract with ITT provided for the training of 12 people on splicing and terminating fibers, cable installation/testing and system operation/testing. The class space allocation was 7 slots for the 485 EIG Installation Team, 3 for 1974 CG maintenance and 2 for 1842 EEG engineers.

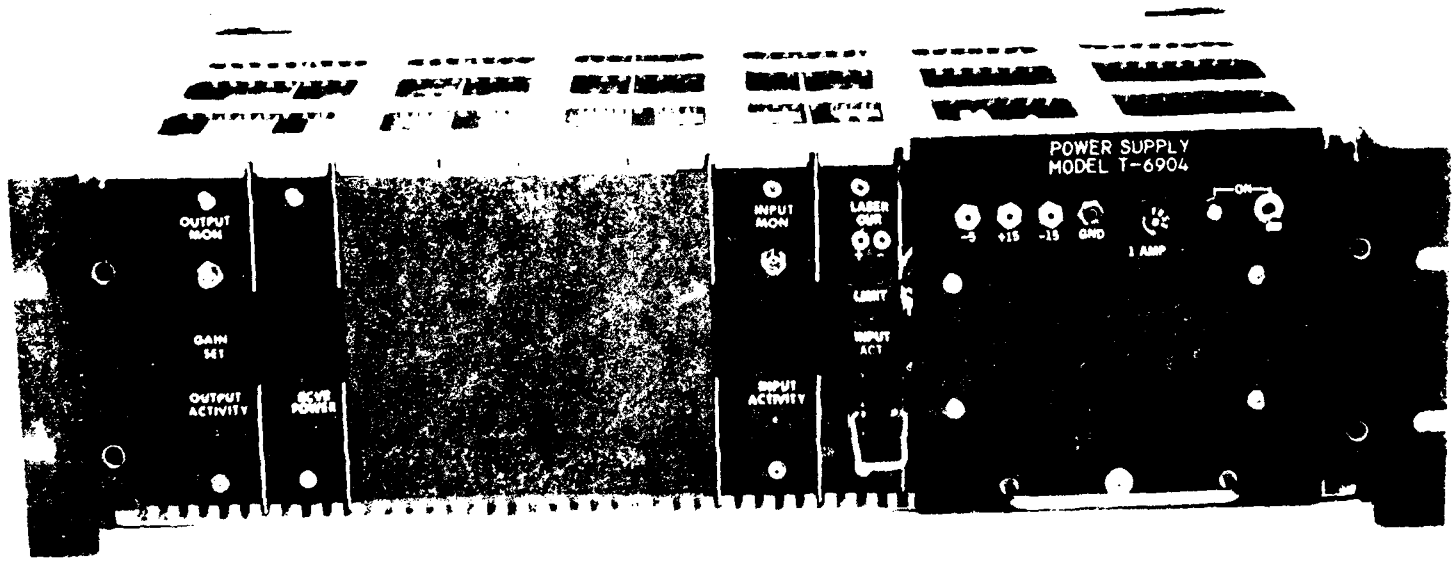
3.2 The training was conducted at Scott AFB during the week of 4 Jan 82. The technique of fiber splicing by flame fusion and assembling and polishing the jewel ferrule type connectors were demonstrated to the entire class. The hands on practice was limited to the installation team. System operation and testing was demonstrated to the 1842 EEG engineers.

4.0 INSTALLATION.

4.1 The contract specified a 3 fiber heavy duty cable suitable for aerial, duct or direct bury installation. To demonstrate the capability of matching the remoting distance available from coax, four 1 kilometer spools were ordered. (4 kilometers = 13,120 ft). Each spool delivered contained more than 1 kilometer and a total of 5 kilometers or 16,400 ft was received. The ITT system, with the LASER transmitter power output of 1 m Watt (0 dBm), fiber loss of 4 dB per kilometer and avalanche photodiode (APD) receiver dynamic range of -27 dBm to -47 dBm can easily operate over a 5 kilometer link with power to spare. The entire 5 kilometers of cable was installed.

4.2 Cable installation, fiber splicing and fiber termination were accomplished by the 485 EIG installation team with support from the 1974 CG and 1842 EEG. The cable was installed with approximately 1,200 ft. buried, 1,250 ft in ducts, 2,700 ft on power poles and the remainder left on spools. Three splices were made in each fiber (9 total). A contractor representative was on site during the week of 8 Feb 82 to provide technical assistance in splicing and connector installation. The tool kits for splicing and connector installation were provided by the 1842 EEG. The 1842 EEG engineer monitored each splice with an optical time domain reflectometer to verify minimal splice attenuation. The total link attenuation was measured at 20 dB or less on each fiber. System testing and operation did reveal some problems with the connectors and their installation (See Appendix C).

4.3 The FO system consisted of modulator, transmitter, receiver and demodulator modules for each link. (radar shelter to the operations center/operations center to the radar shelter). A chassis, with power supply was installed at both locations to house the modules (see figure 2). The equipment installation required no modification to the radar. The connections to/from the AN/FPN-62 were made through existing BNC jacks (optional hookup for radio remoting) and thus channel A was provided the option of remoting via coax or fiber optics through repositioning 2 ea coax jumpers at each location (see figure 3). Channel B remained on coax.


POWER SUPPLY
MODEL T-6904
ON
-5
+15
-15
GND
1 AMP
OUTPUT MON
GAIN SET
OUTPUT ACTIVITY
RCVR POWER
INPUT MON
INPUT ACTIVITY
LASER CUR
LIMIT
INPUT ACT

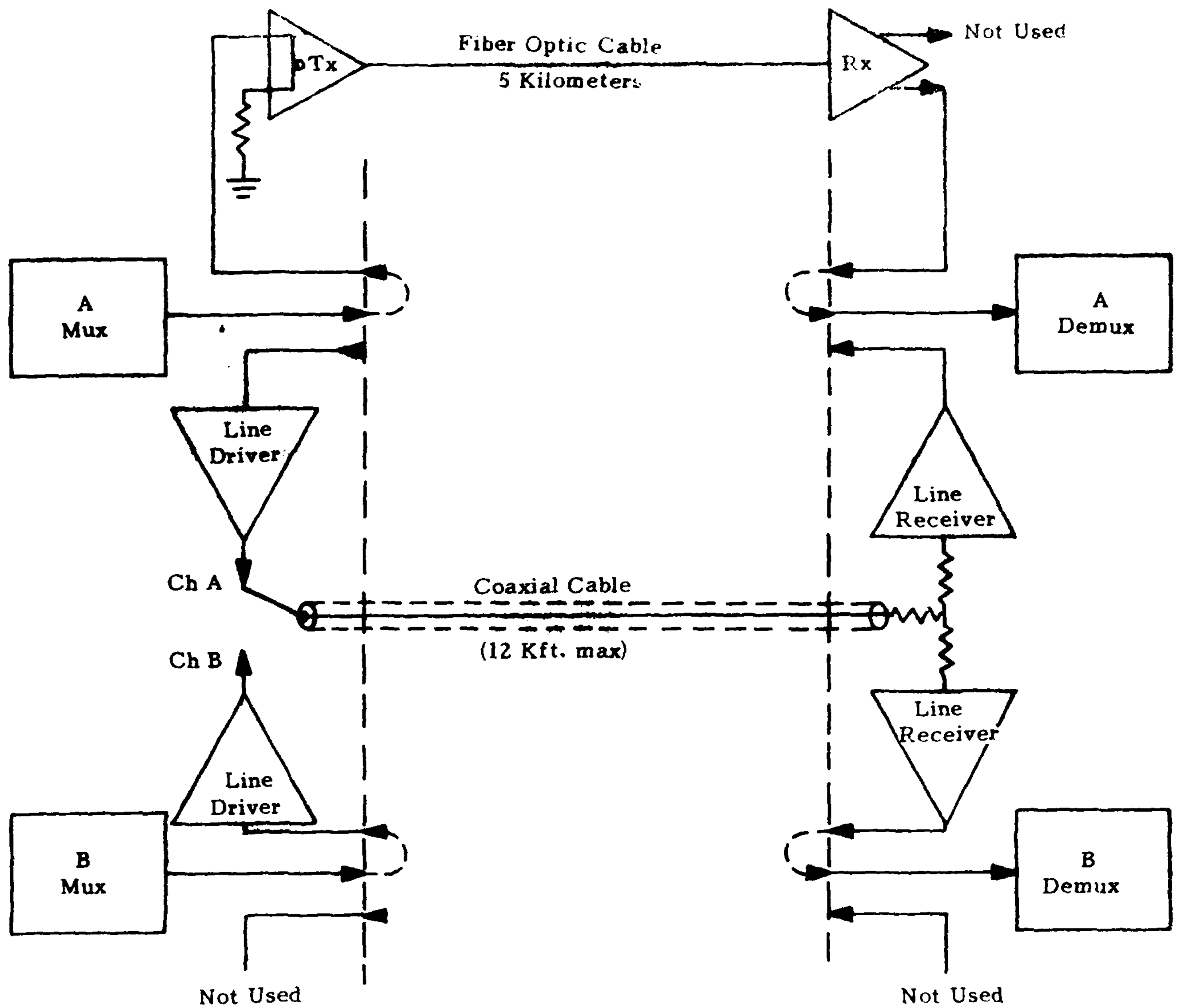


Figure 3. Configuration of Prototype Installation

5.0 ACCEPTANCE TESTING.

5.1 Required Tests. The contract called for ITT to provide system acceptance test procedures subject to approval by the project engineer. The first submittal by ITT was for production testing of individual modules and did not meet the requirements in full. A revision per project engineer's comments was acceptable. The equipment and link would be subjected to the following tests;

a. Video Modulator Modules:

   (1) Carrier Center Frequency.

   (2) Carrier Output Level.

   (3) Carrier Deviation.

b. Optical Transmitter Modules:

   (1) Optical Power Output.

   (2) Modulation Depth.

   (3) Input Activity Indicator.

c. Optical Receiver Modules:

   (1) Input Activity Indicator.

   (2) Optical Sensitivity.

   (3) Output Limiter.

d. Video Demodulator Modules:

   (1) Input Activity Indicator.

   (2) Output Level and Gain Control.

e. System:

   (1) Frequency Response.

   (2) Signal-to-Random Noise Ratio.

f. Power Supply - Voltages.

g. Optical Link - Attenuation.

5.2 Test Equipment.

Model	Function	Mfg
147A	Random Noise Meas Set	Tektronix
149A	Signal Gen (Video)	Tektronix
1410C	Signal Gen (Video)	Tektronix
1455C	Waveform Monitor	Tektronix
7704A	O'Scope	Tektronix
C-50/C-70	O'Scope Camera	Tektronix
1710A	O'Scope	Hewlett Packard
141T	Spectrum Analyzer	Hewlett Packard
8660B	Signal Gen (RF)	Hewlett Packard
461	Optical Time Domain Reflectometer	OPTIX
550	Optical Power Meter	United Detector
40X	Optical Power Meter	United Detector
313-2	Voltmeter	Simpson
	Pin Diode Detector	Local Mfg
	Test Cables	Local Mfg
	Optical Attenuators	Local Mfg

5.3 Test Results.

5.3.1 Initial testing was accomplished in the 1842 EEG laboratory by the project engineer. Table 1 lists the results of the initial testing.

5.3.2 Acceptance testing was accomplished by the 1842 EEG project engineer and the ITT system engineer. The ITT engineer had aligned the Video Modulator #001 and replaced the laser diode in Optical Transmitter #005 to correct out of spec results found in the initial tests. Table 2 lists the results of the acceptance testing.

5.3.3 The initial attempt to remote the AN/FPN-62 radar multiplexed signal over the prototype FO system revealed a problem with radar alignment. The multiplexed signal level exceeded one volt peak-to-peak which was the upper limit of the FO video modulator. Radar alignment could not be effected immediately so a temporary fix was to insert a 3 dB pad to reduce the multiplexed signal to a level which the FO video modulator would accept. This resulted in a usable signal over the FO system. It appeared the FO system would operate satisfactorily if the multiplexed signal level was less than one volt (Radar T.O. indicates a nominal 0.70 volts peak-to-peak). The ITT engineer was released and the investigation to determine radar alignment problem began. This investigation is delineated in Appendix B.

6.0 INITIAL EQUIPMENT/CABLE PROBLEMS.

6.1 As indicated in para 5 the power output of both transmitter modules was in spec. (1 $\pm$0.1 mW). The link loss on each fiber was 20 dB or less. This applied approximately -20 dBm to the receiver which was specified to operate between -27 and -47 dBm. Consideration was given to inserting a 10 dB attenuator to lower the input to the receiver range. Attenuators were provided by ITT but the ITT engineer did not feel they were required.

6.2 The transmitters suffered a loss in output power while the operational testing was in progress. Transmitter #002 power output dropped to -10.5 dBm. Transmitter #005 dropped to -11.5 dBm. These levels were verified with two different power meters and two buffered fibers. Even though these levels were out of spec, the power to the receivers was still acceptable.

6.3 The demodulator module #018 also malfunctioned. The output gain adjust stuck at max. This did not pose a problem because we had to operate with max output.

6.4 During operational testing the green fiber failed to couple the signal into the receiver. The spare, orange, fiber was put in service. Later the blue fiber also failed to couple the signal and the connector at the PAR shelter end was replaced. See Appendix C for more detail.

6.5 A decision was made to operate the system for the first three months with the problems noted above. After three months, testing will be accomplished per Appendix D. The system will then be taken out of service while any units which have failed are either replaced or repaired under the one year warranty with ITT.

Table 1. Initial Test Results

UNIT	RESULTS BY SERIAL #		SPECIFICATION
VIDEO MODULATOR MODULE	#001	#002	
1. Carrier Center Frequency	*63.8 MHz	47.2 MHz	50 ±5 MHz
2. Carrier Output Level	-3 dBm	0 dbm	-3 ±3 dBm
3. Carrier Deviation	Not Tested	Not Tested	12 ±2 MHz
OPTICAL TRANSMITTER MODULE	#002	#005	
1. Optical Power Output	0.93 mW	0.94 mW	1 ±0.1 mW
2. Modulation Depth	100%	*65%	70% min
3. Input Activity Indicator	Not Tested	Not Tested	-6 to 0 dBm
4. Laser Drive Current	165 mA	113 mA	100 mA
OPTICAL RECEIVER MODULE	#007	#008	
1. Input Activity Ind.	Not Tested	Not Tested	-27 to -47 dBm
2. Optical Sensitivity	Not Tested	Not Tested	-47 dBm
3. Output Limiter	Not Tested	Not Tested	-9 to +3 dBm
VIDEO DEMODULATOR MODULE	#017	#018	
1. Input Activity Indicator	ON from 10 to 90%	ON from 10 to 90%	APL 10 to 90%
2. Output Level & Gain Cont.	*0.5 to 1.0 V	*0.5 to 1.0 V	1 ±0.25 Volts
POWER SUPPLY	#002	#012	
	+15.1 Volts	+15.0 Volts	+15 ±5%
	-15.1 Volts	-15.1 Volts	-15 ±5%
	-5.0 Volts	-5.0 Volts	-5 ±5%

Note:

1. "Not Tested" was due to test equipment availability.
2. Results annotated * were out of specification.

Table 2. Acceptance Test Results

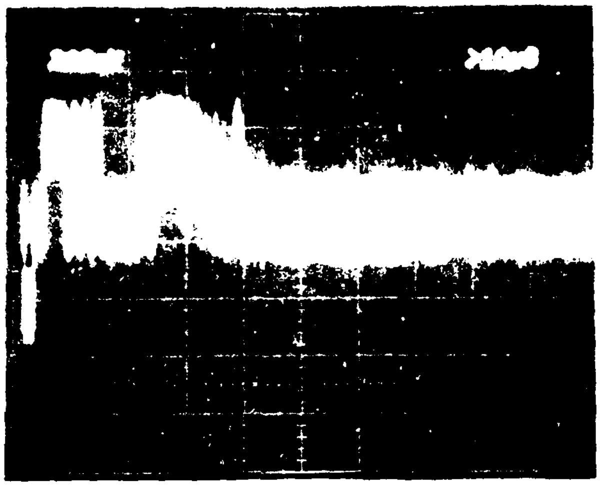
UNIT/SYSTEM/LINK	RESULTS BY SERIAL #		SPECIFICATION
VIDEO MODULATOR MODULE	#001	#002	
1. Carrier Center Frequency	50.0 MHz	46.3 MHz	50 ±5 MHz
2. Carrier Output Level	-1 dBm	*+0.9 dBm	-3 ±3 dBm
3. Carrier Deviation	*9.8 MHz	12.24 MHz	12 ±2 MHz
OPTICAL TRANSMITTER MODULE	#002	#005	
1. Optical Power Output	0.91 dBm	0.90 dBm	1 ±0.1 mW
2. Modulation Depth	70.7%	71%	70%
3. Input Activity Indicator	ON from -6 to 0 dBm	ON from -6 to 0 dBm	-6 to 0 dBm
4. Laser Drive Current	178 mA	67 mA	Approx 100 mA
OPTICAL RECEIVER MODULE	#007	#008	
1. Input Activity Indicator	ON -47 dBm	ON -47 dBm	-27 to -47 dBm
2. Optical Sensitivity	-47 dBm	-47 dBm	-47 dBm
3. Output Limiter	Not Tested	Not Tested	-9 to +3 dBm
VIDEO DEMODULATOR MODULE	#017	#018	
1. Input Activity Indicator	ON from 10 to 90%	ON from 10 to 90%	APL 10 to 90%
2. Output Level & Gain Cont.	*0.5 to 1 Volt	*0.5 to 1 Volt	1 ±0.25 Volts
POWER SUPPLY	#002	#012	
	+14.9 V	+14.9 V	+15 ±5%
	-14.9 V	-14.9 V	-15 ±5%
	-4.9 V	-4.9 V	-5 ±5%

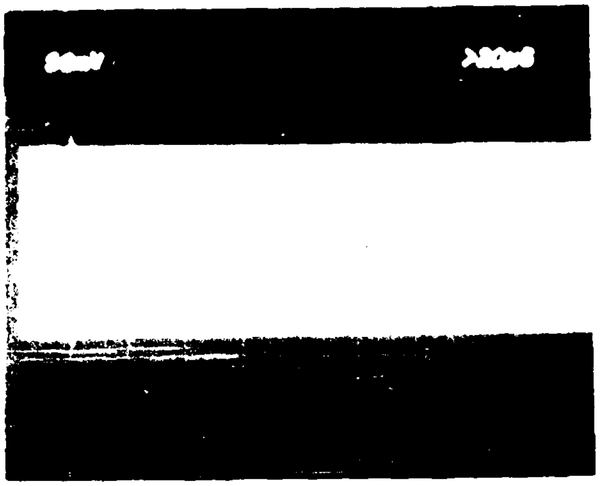
SYSTEM	RESULTS	SPECIFICATION
1. Frequency Response	*1.4 dB at 10 MHz	±1 dB up to 10 MHz
2. Signal to Random Noise Ratio	50 dB	50 dB

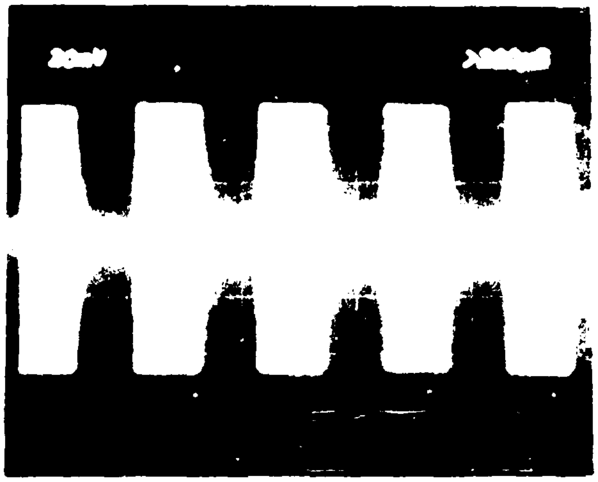
LINK LOSS	RESULTS	SPECIFICATION
Orange Fiber	17.8 dB	30 dB
Green Fiber	20.0 dB	30 dB
Blue Fiber	19.5 dB	30 dB

Note:

Results annotated * were out of spec. Of these only the Video Demodulator output level and gain control appeared to be a problem in the overall performance of this prototype system. This could be compensated for by adjustment of the radar if required.

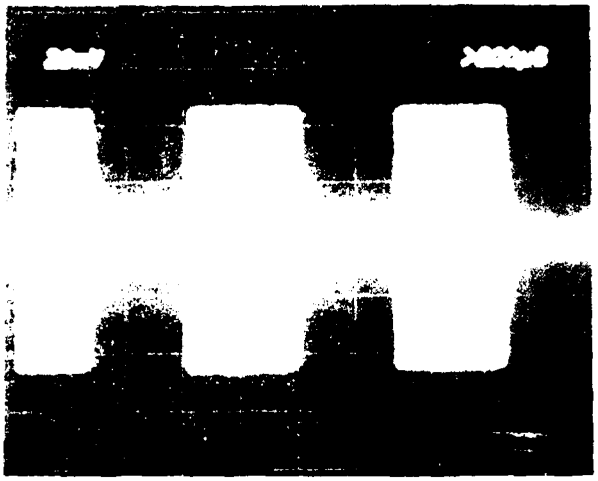


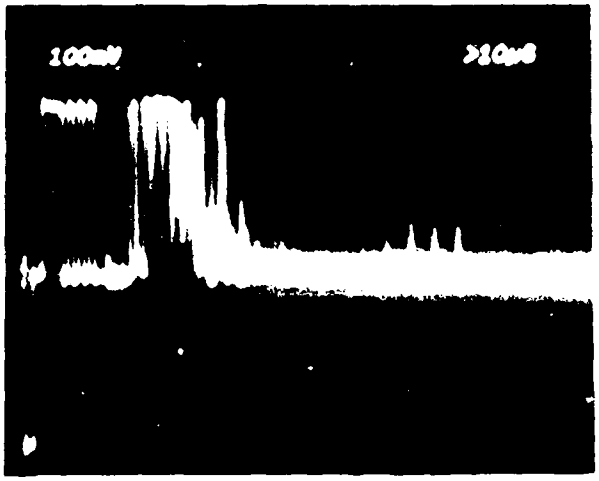




[illegible] carrier (6.95 [illegible])

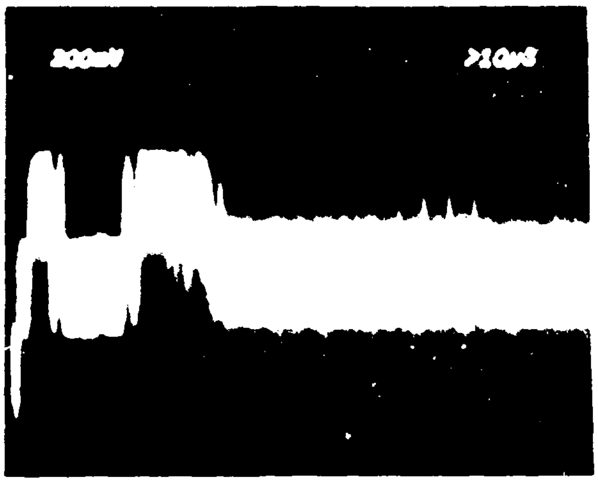
[illegible]

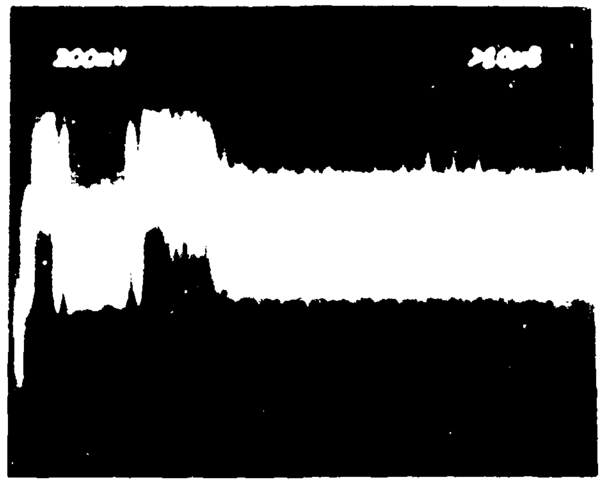


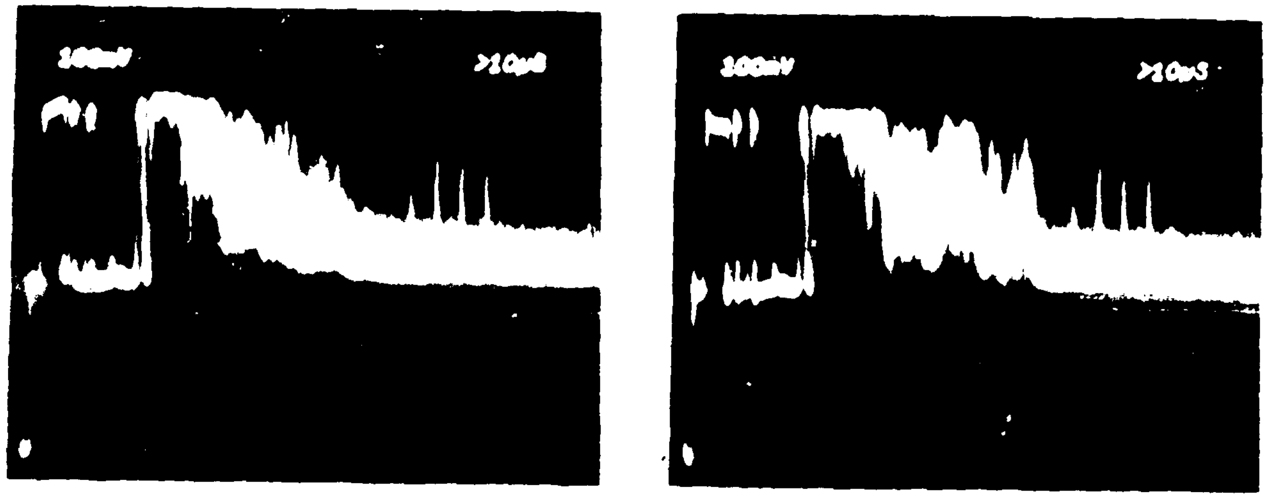


[illegible] Data
[illegible] modulated rf carrier (7.19 [illegible])

Pretrigger – [illegible]
Angle Data – The first [illegible]
pulses [illegible]
[illegible] 18 µsec.
Radar Video – [illegible]
beyond [illegible] µsec.


200mV

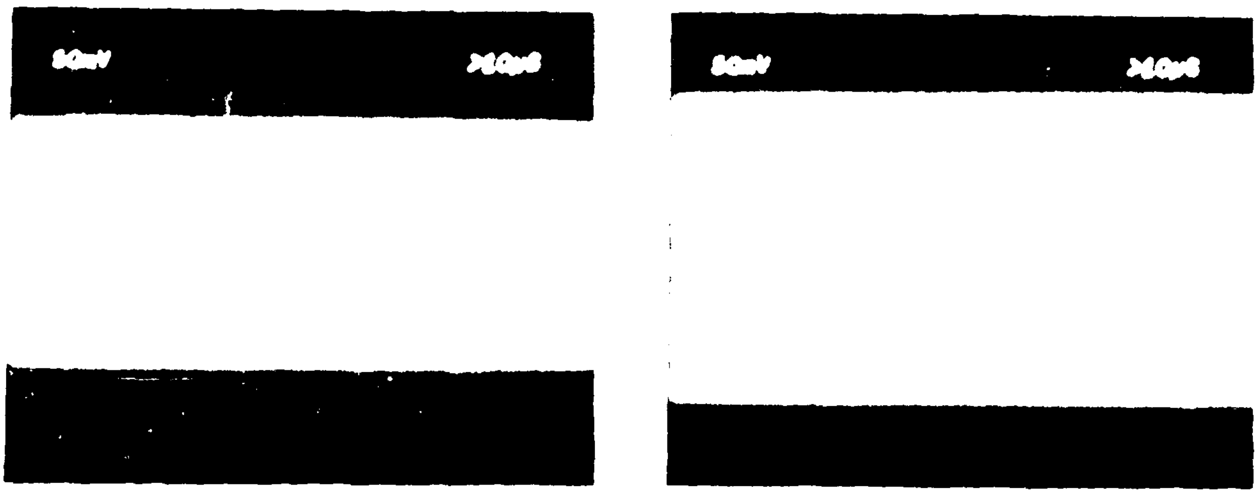

200mV



Coax

Fiber Optic

[illegible] ultiplexed Pretrigger, Angle Data and Radar Video (rf carriers [illegible] for [illegible])



[illegible]

[illegible]

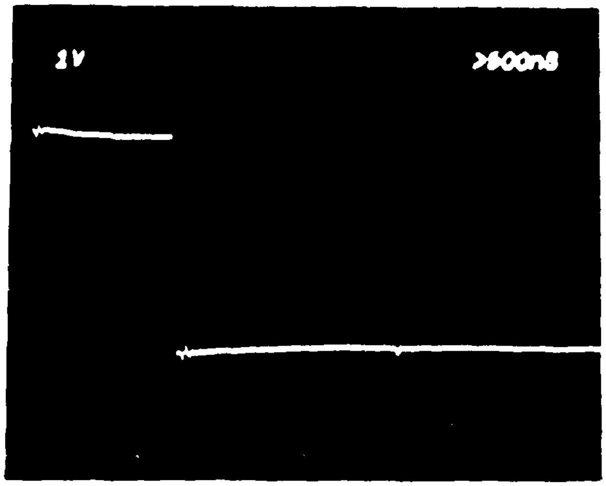
Audio

[illegible] modulated rf carrier (6.5 [illegible])

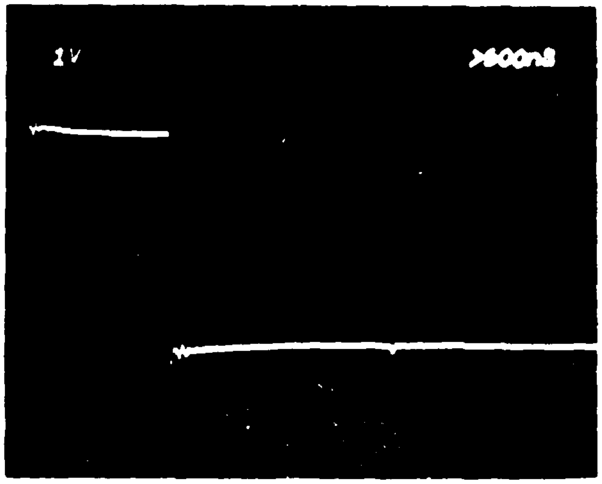
[illegible] Data
[illegible] modulated [illegible]

[illegible]

7.1.3 Demultiplexed signals at OPS:

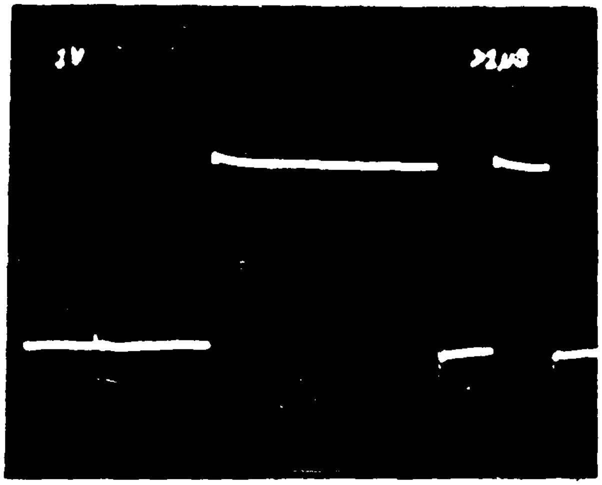


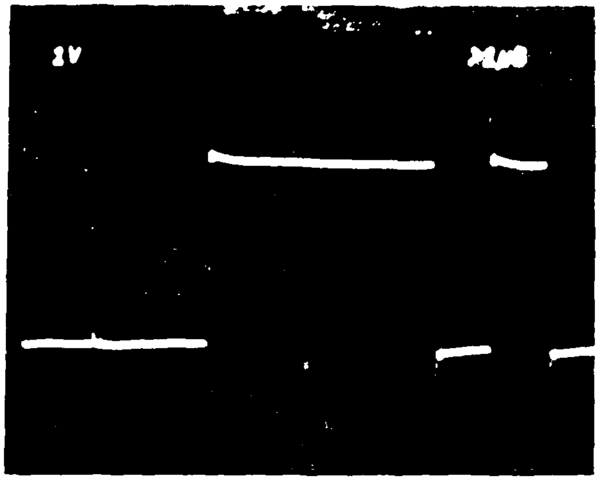
Coax

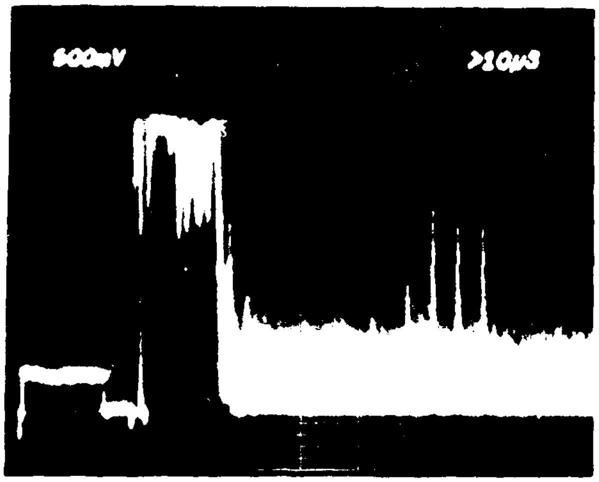


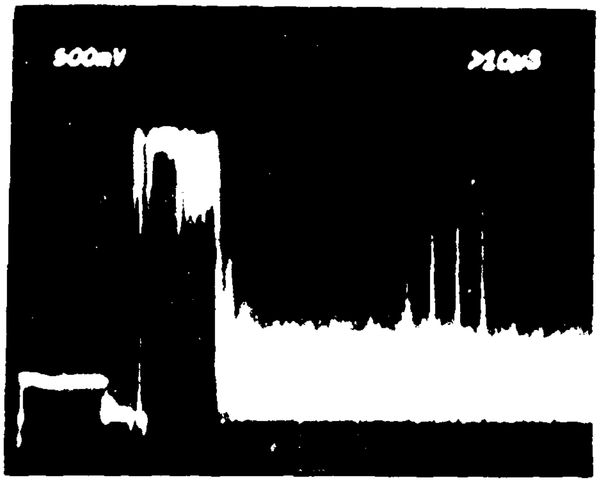
Fiber Optic

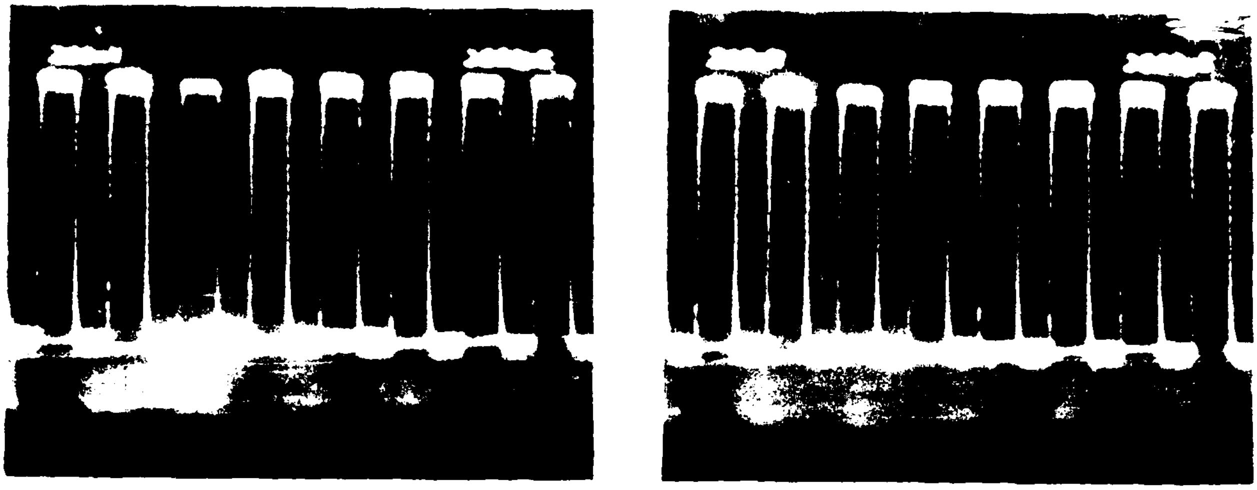
Pretrigger

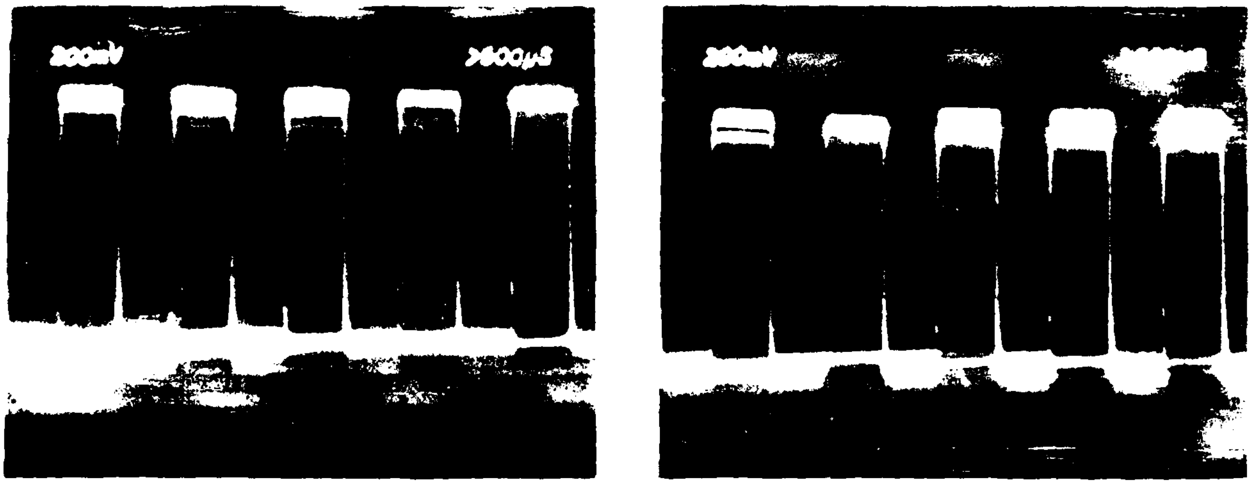

1V
>1µS


1V
>1µS


500mV
>10µS


500mV
>10µS





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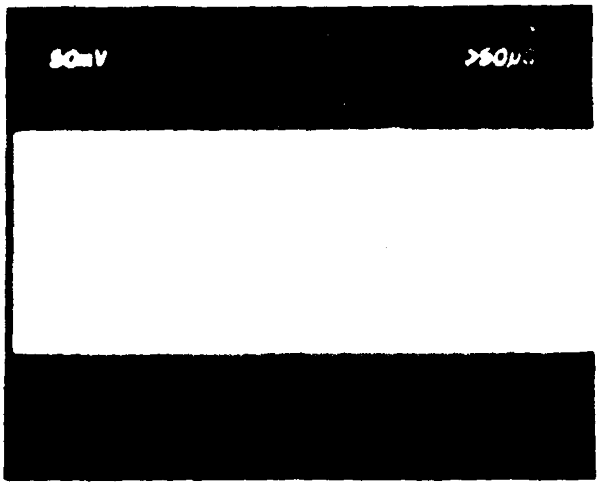
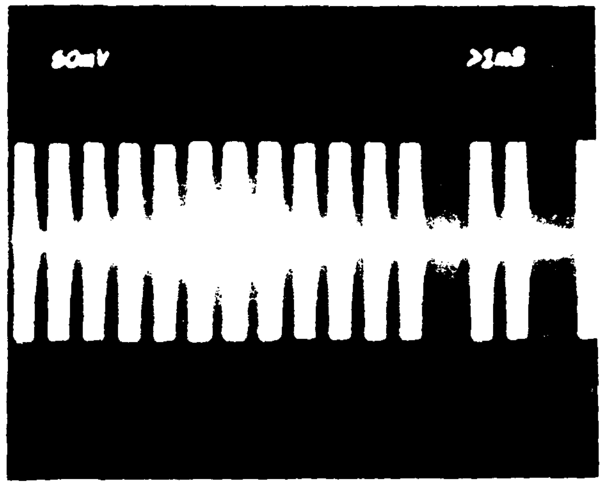
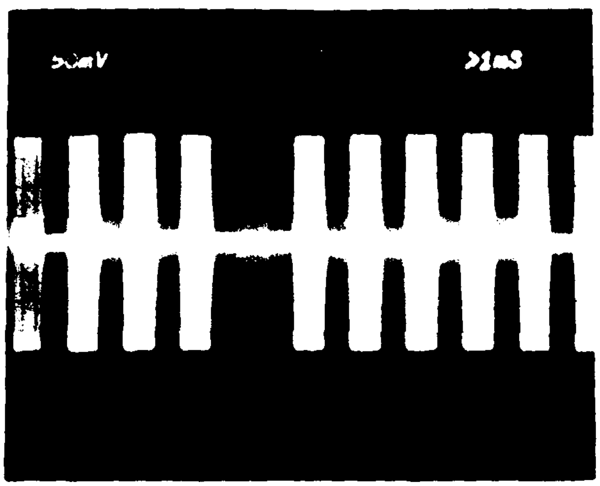
7.1.4 Signals originating at the OPS:





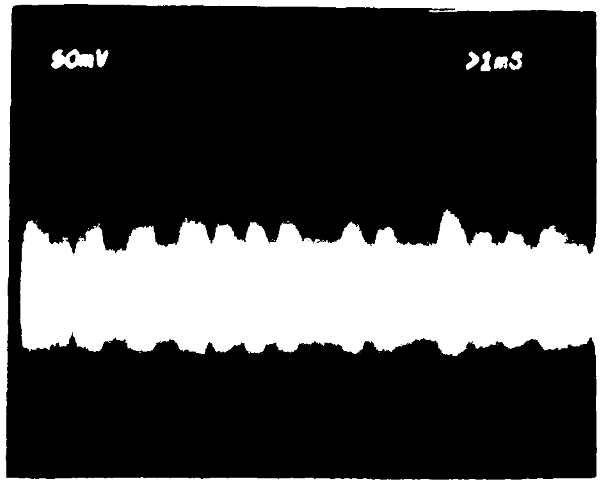


Control Data
Digital modulated rf carrier (7.25 MHz)

Combined rf carriers
applied to the remoting system

7.1.5 Output signals from OPS to PAR remoting systems.

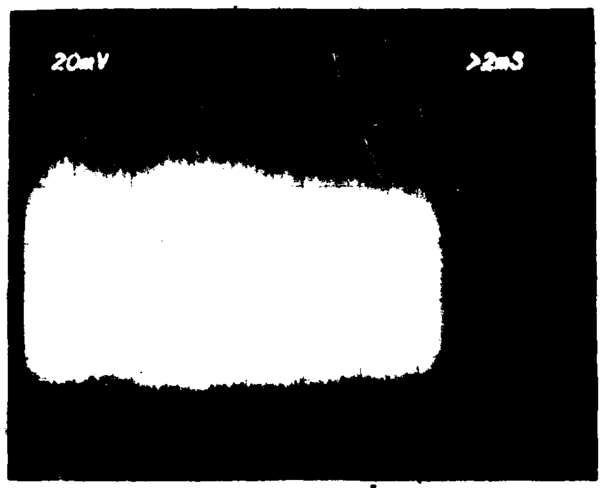
Coax



Fiber Optic

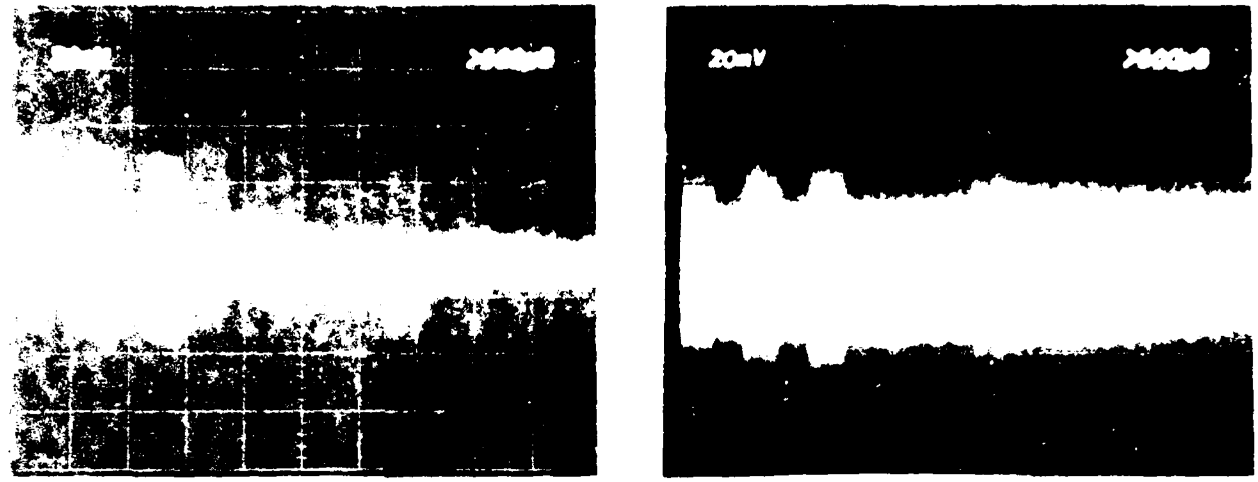
Combined rf carriers

Coax



Fiber Optic

Audio
Unmodulated rf carrier (7.01 MHz)



[illegible] Fiber Optic

[illegible] interval
Digital [illegible] rf carrier (7.13 [illegible])

Control Data
Digital modulated rf carrier (7.25 MHz)

7.2 A comparison of the PAR TO OPS Coax vs Fiber optic remoting systems outputs follows. Referring to the sequence of photographs in 7.1.2;

a. There is more "noise" in the multiplexed signal out of the FO system. However breaking the signal down reveals this "noise" to be three rf carriers which have greater amplitude over the FO system.

b. There is no noticeable difference in the time multiplexed Pretrigger, Angle Data and Radar Video with three rf carriers removed.

c. The audio rf carrier has greater amplitude over the FO system (275 mV vs 215 mV).

d. The Servo Data is made up of a random bit stream thus the variation in bit position/pattern. The rf carrier has a greater amplitude over the FO system (175 mV vs 130 mV). The rf pulses have a positive shift over the FO system.

e. The Control Data rf carrier has a greater amplitude over the FO system (170 mV vs 135 mV). The rf pulses have a positive shift over the FO system.

This comparison does show some difference in the remoted signals arriving at OPS to be demuxed. This difference is apparent in the rf pulses representing digital words for servo and control data. A close look at the demuxed signals (7.1.3) however shows no difference.

7.3 A comparison of the OPS to PAR Coax vs Fiber Optic Remoting Systems outputs follow. Referring to the sequence of photographs in paragraph 7.1.5;

a. The combined rf carriers do not show an appreciable difference when the 1 msec vs 0.5 msec time base is considered.

b. The audio rf carriers show no appreciable difference when the 2 msec vs 0.5 msec time base is considered.

c. Both the Norm IF, MTIIF, MTI Interval and Control Data rf carriers show a high amplitude noise in the FO system.

This comparison does show a noise problem in the FO system. The system was functioning over this link. This problem is attributed to receiver module #008 which later became very noisy and was repaired (see paragraph 8.2).

8.0 OPERATIONAL TESTING.

8.1 Operational testing started on 19 March 1982. After the intermittent 75 ohm terminator was replaced and our hook-up was modified (see Appendix B) to apply the same signal to both CHA and CHB Demux, the prototype FO system functioned properly. There was no detectable difference in the radar display or functional control.

8.2 In addition to the problems known to exist at the start of operational testing (see paragraph 6) the following equipment/cable malfunctions occurred during the first three months.

a. Three of the six optical connectors failed (see Appendix C).

b. Both lasers continued to lose power (#002 had -11 dBm, #005 had -13 dBm).

c. Receiver module #008 became noisy and the activity light was inoperative.

d. Power supply #002 ON light was intermittent.

At the end of three months (2 July 1983) the system was returned to ITT for warranty repair of items b, c and d above. In addition, ITT was asked to correct the overall system gain and gain control shown deficient in acceptance testing.

8.3 The repaired equipment was placed in service again on 14 September 1982. Both lasers had been replaced and output power was 0 dBm per specification. The overall gain and gain control had been modified to provide unity gain adjustable $\pm 50\%$ which exceeded the specification. The additional gain (above spec) was not required and in fact could not be used as a noticeable increase in noise occurred. Link attenuation at this time was 17.1 dB, 18.8 dB and 18.9 dB for the green, blue and orange fibers respectively.

8.4 Due to the time lost for warranty repair and some down-time on the radar the test period was extended to 30 June 1983.

8.5 During the remainder of the operational test only one malfunction occurred. The demodulator module at the OPS position had a loss in gain sufficient to be apparent on the radar display. To continue the test this module was used at the radar position where it had sufficient gain for control signals.

8.6 To conclude the test the link attenuation was checked and the equipment was removed for bench test. Results are recorded in Table 3 (Final Test Results).

9.0 CONCLUSIONS.

a. The FO remoting operated with no detectable difference in the radar display nor in the operation/control of the radar.

b. The FO cable was installed using standard cable installation techniques. The fiber splicing and termination required special tools and was a tedious process but was accomplished by the 485 EIG installation team without too much difficulty. There was no indication of any problem in either the cable or fiber splices. The end connectors are questionable (see Appendix C). Other methods of splicing and terminating are available and appear less tedious and more reliable.

c. The transmitter/receiver combination in this system would operate with a link loss up to 47 dB. The loss of this 5 km link was approximately 20 dB. This indicates a possibility of remoting 10 km with a 7 dB margin.

d. The FO remoting is capable of remoting the TRACALS radars. Based on initial prototype performance, an exhibit was provided to ALC for an Analog Fiber Optic Modem suitable for a remoting system. ALC is now procuring the modems and AFCC is procuring fiber cable. This option should be available for use in the near future.

Table 3. Final Test Results

UNIT/SYSTEM/LINK	RESULTS BY SERIAL #		SPECIFICATION
VIDEO MODULATOR MODULE	#001	#002	
1. Carrier Center Frequency	48.5 MHz	*58.8 MHz	50 ±5 Mhz
2. Carrier Output Level	*0.88 dBm	-2.04 dBm	-3 ±3 dBm
3. Carrier Deviation	Not Tested	Not Tested	12 ±2 MHz
OPTICAL TRANSMITTER MODULE			
1. Optical Power Output	0.3 dBm	0.4 dBm	1 ±0.1 mW
2. Modulation Depth	*44%	*56%	70%
3. Input Activity Indicator	ON from -6 to 0 dBm	ON from -6 to 0 dBm	-6 to 0 dBm
4. Laser Drive Current	105 mA	135 mA	Approx 100 mA
OPTICAL RECEIVER MODULE			
1. Input Activity Indicator	ON -47 dBm	ON -47 dBm	-27 to -47 dBm
2. Optical Sensitivity	*-35 dBm	*-38 dBm	-47 dBm
3. Output Limiter	Not Tested	Not Tested	-9 to +3 dBm
VIDEO DEMODULATOR MODULE	#017	#018	
1. Input Activity Indicator	Not Tested	Not Tested	APL
2. Output Level & Gain Cont.	*0.54 to 1.1 Volt	0.5 to 1.4 Volt	1 ± 0.25 Volts
POWER SUPPLY	#002	#012	
	Within Spec	Within Spec	

LINK LOSS	RESULTS	SPECIFICATION
Orange Fiber	17.5 dB	30 dB
Green Fiber	19.1 dB	30 dB
Blue Fiber	18.2 dB	30 dB

NOTE:

Results annotated * were out of spec. Of these only Video Demodulator #017 output level was detected as a problem in overall system performance (see paragraph 8.5).

Appendix A

STATEMENT OF WORK

FOR

FIBER OPTIC SYSTEM TO

REMOTE AN/FPN-62 RADAR

1842 EEG/EEICB
Scott AFB IL 62225

AFCC-C-7014
AMENDMENT 1
20 April 1981

AMENDMENT TO
STATEMENT OF WORK
FOR
FIBER OPTIC SYSTEM TO
REMOTE AN/FPN-62 RADAR

This amendment forms a part of Statement of Work
AFCC-C-7014, dated 18 November 1980

Page 1, Paragraph 3.2.1.b. Delete and substitute: "Frequency response: 10 Hz to 10 MHz $\pm$ 1.0dB."

1842 EEG/EEICB
Scott AFB IL 62225

AFCC-C-7014
18 November 1980

STATEMENT OF WORK FOR FIBER OPTIC SYSTEM TO REMOTE AN AN/FPN-62 RADAR

1. SCOPE.

1.1 This Statement of Work establishes the requirements to furnish:

a. A fiber optic system capable of remoting the AN/FPN-62 Radar a distance of 4 km.

b. Written instructions for fiber cable installation, splicing, terminating, testing and system performance testing.

c. On-site technical assistance/training during installation and acceptance testing (acceptance to be by Project Engineer, Mr. J. Radcliff, 1842 EEG/EEITE).

1.2 This system is to be installed and tested by Air Force personnel with the technical assistance of the contractor's representative. Scott AFB is the selected site.

2. APPLICABLE DOCUMENTS. There are no applicable documents.

3. REQUIREMENTS.

3.1 <u>General Requirements for Equipment, Training and Assistance</u>.

3.1.1 The fiber optic system shall consist of two transmitter/receiver/power supply assemblies, 4 km of 3-fiber optical cable and the required connectors/splice housings. This system shall accept the electrical remoting signals, transfer them the 4 km distance and provide a valid reproduction of the original electrical signals. See Figures 1 and 2.

3.1.2 The training/technical assistance shall be provided by an on-site representative and shall encompass both installation and testing.

3.2 <u>Specifications</u>.

3.2.1 System Specifications. The remoting system shall transfer the time/frequency multiplexed electrical signals from the radar to the operations center (OPS) and from OPS to the radar. The electrical signals nomenclatures, voltage levels, frequencies and/or bandwidths are provided in Figure 2. The system shall meet the following requirements:

a. Type: analog, duplex operation.

b. Frequency response: 10 Hz to 10 MHz $\pm$ 0.5 dB.

c. Signal-to-noise ratio: 50 dB (min).

d. Distance: 4 km (13,000 feet), repeaterless.

e. Electrical input/output impedance: 75 ohms, unbalanced.

f. Input signal level: 0.6 Vpp (max)

g. Output signal level: 0 to 1.0 Vpp (min), adjustable in 100 mV steps (max).

h. Electrical signal input/output connector type: BNC type UG-625 or equivalent, located at rear of assembly.

i. Optical connector type: demountable, 3.0 dB maximum attenuation located at ·ar of assembly.

j. Electrical power: 115 Vac $\pm$ 10%, 47-63 Hz, single phase, a 3 conductor power cord (with plug), approximately 2 meters long, shall be located at rear of assembly.

k. Fiber cable type: 3-fiber, direct bury/aerial with 50 micron diameter core, 125 micron diameter cladding, 6.0 dB/km attenuation (max), 200 MHz-km bandwidth (min).

l. Splice housings: Housings to protect fusion splices shall be provided.

m. Terminating connectors: Connectors to terminate the fiber and mate with the optical connectors on the units (specified in i above) shall be provided.

n. Mounting: Transmitter/receiver/power supply assemblies are to be mountable in the existing in-place 19 inch racks (GFE) with a maximum height of 8 inches.

o. Equipment operating temperature range: 0° to $40^{\circ}C$.

3.2.2 Data. Data shall be provided in accordance with the attached DD Form 1423.

3.2.3 Specification of Services. The contractor shall provide technical assistance and training to Air Force personnel in cable installation, fiber splicing/terminating, cable testing and system performance testing. Air Force personnel are to accomplish the installation/acceptance testing with technical direction provided by the contractor's representative. The training shall consist of classroom instruction/demonstrations and student participation in fiber fusion splicing/terminating and testing. The classroom instruction is to be followed by on-the-job training/technical assistance in the actual installation and testing of the fiber cable and fiber optic system. Training is to be provided in accordance with the contractor's training plan which is to be approved by the contracting officer.

4. QUALITY ASSURANCE PROVISIONS. System Acceptance: A performance test of the fiber optic system will be accomplished immediately after installation. This test will be designed to ascertain overall system gain, frequency response and signal to noise ratio.

4.1 System performance test procedures shall be provided in accordance with the attached DD 1423.

4.2. Acceptance of the system will be based on these test results and meeting the other physical/electrical parameters of para 3.2.1. Acceptability of the system is to be determined by the Project Engineer (Mr. J. Radcliff, 1842 EEG/EEITE).

5. PREPARATION FOR DELIVERY. Delivery requirements shall be in accordance with the provisions of the contract.

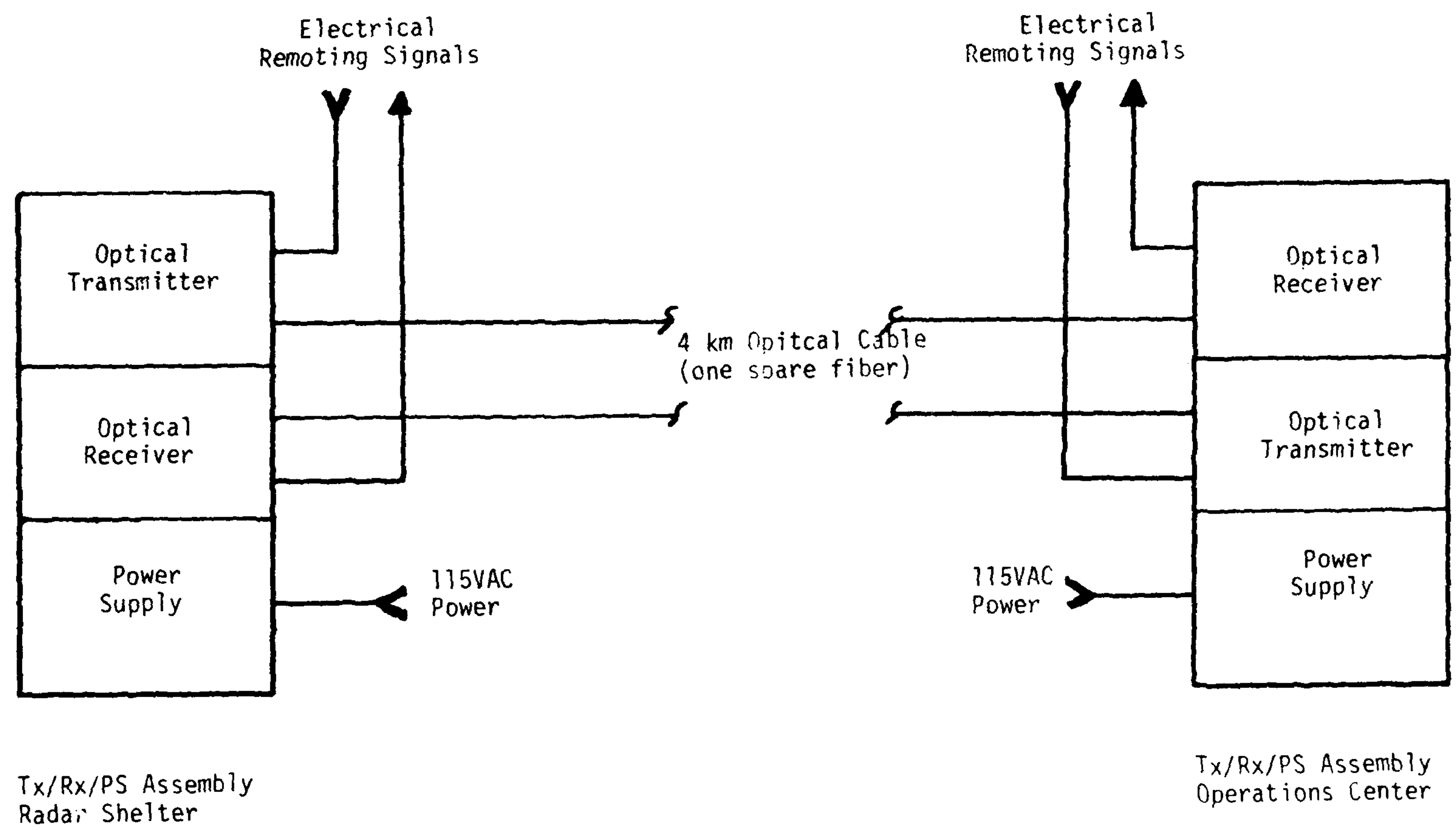


Figure 1. Optical Remoting System

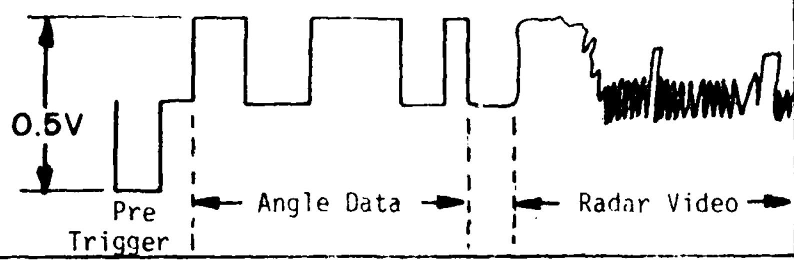
Signal	Waveform	RADAR to OPS	OPS to RADAR
Combined Pre Trigger, Angle Data & Radar Video		Bandwidth 0 to 6 MHz PRF≈3,300	Not Used
Intercom Audio		RF Carrier - 6.95 MHz	RF Carrier - 7.01 MHz
Servo Data		RF Carrier - 7.07 MHz Frame Rate - 10 Hz Pulse Width - 0.35msec	RF Carrier - 7.13 MHz Frame Rate - 10 Hz Pulse Width - 0.35msec
Control Data		RF Carrier - 7.19 MHz Frame Rate - 15.625 Hz Pulse Width - 0.5 msec	RF Carrier - 7.25 MHz Frame Rate - 15.625 Hz Pulse Width - 0.5 msec

FIGURE 2. WAVEFORMS (Frequency Multiplexed for Transmission)

CONTRACT DATA REQUIREMENTS LIST

EXHIBIT A

TO CONTRACT F11628-81-C-0026

CATEGORY N/A (Prepared IAW AFR 310-1)

SYSTEM/ITEM Fiber Optic System to Remote an AN/FPN-62

CONTRACTOR ITT EOPD Roanoke, VA

1. Sequence Number	2. Title or Description of Data / 3. Subtitle	4. Authority (Data Item Number)	5. Contract Reference	6. Technical Office	7. DD250 Req	8. App Code	9. Input to IAC	10. Frequency	11. As of Date	12. Date of 1st Submission	13. Date of Subsequent Subm/Event ID	14. Distribution and Addressees (Addressee—Regular Copies/Repro Copies)	15. Total
A001	Fiber Optic Cable Installation Practices	UDI-E-1000	Para 3.2.2 of SOW AFCC-C-7014	1842EEG/EEITE	DD	A		OTIME		See 16		1842EEG/EEITE Scott AFB, IL 62225 — 6/1; 1842EEG/EEICI Scott AFB, IL 62225 — 1/0	7/1
A002	System Performance Test Procedures	UDI-T-1001	Paras. 3.2.2 and 4 of SOW AFCC-C-7014	1842EEG/EEITE	DD	A		ONE/R		See 16		1842EEG/EEITE Scott AFB, IL 62225 — 4/1	4/1

16. REMARKS (A001)

lock 12: Not later than (NLT) 60 days prior to cable/equipment delivery.

16. REMARKS (A002)

Block 12: Two draft copies NLT 60 days prior to delivery of cable/equipment. Finals NLT 30 days after receipt of Government comments. Finals will incorporate Government comments to draft.

PREPARED BY ROBERT LUTZ/1842 EEG/EEISD — **DATE** 18 Nov 80

APPROVED BY George A. Hanna — GEORGE A. HANNA/1842 EEG/EEISD — **DATE** 18 Nov 80

DD FORM 1 JAN 78 1423

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S)	
	AGENCY	NUMBER
1. TITLE Fiber Optic Cable Installation Practices	USAF	UDI-E-1000
3. DESCRIPTION/PURPOSE To effect the operational installation of a fiber optic cable system which will be used to remote an AN/FPN-62 Radar.	4. APPROVAL DATE 18 November 1980	
	5. OFFICE OF PRIMARY RESPONSIBILITY AFCC/1842 EEG/EEITE	
	6. DDC REQUIRED	
	8. APPROVAL LIMITATION	
7. APPLICATION/INTERRELATIONSHIP	9. REFERENCES (Mandatory as cited in block 10)	
	MCSL NUMBER(S)	

10. PREPARATION INSTRUCTIONS

10.1 The contractor shall furnish detail data concerning the installation practices and techniques associated with fiber optic cable installation (direct burial, underground duct, and aerial). This data shall include, but shall not necessarily be limited to:

a. Safety precautions.

b. Special tools and materials required.

c. Environmental considerations.

d. Installation precautions such as bonding, securing, stressing, flexing, etc.

e. Fiber fusion-splicing instructions.

f. Connector termination instructions.

g. Instructions for using tests equipment to locate fiber, splice, or connector faults and to determine attenuation.

10.2 Available commercial literature, prepared in accordance with prevailing commercial practices (with or without supplemental data) may be furnished in response to this requirement.

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S)	
	AGENCY	NUMBER
1. TITLE System Performance Test Procedures	USAF	UDI-T-1001
3. DESCRIPTION/PURPOSE Describes the tests required to demonstrate that all functional requirements of the SOW have been met.	4. APPROVAL DATE 18 November 1980	
	5. OFFICE OF PRIMARY RESPONSIBILITY AFCC/1842 EEG/EEITE	
	6. DDC REQUIRED	
	8. APPROVAL LIMITATION	
7. APPLICATION/INTERRELATIONSHIP Used to provide acceptance criteria for the fiber optic remoting system.	9. REFERENCES (*Mandatory as cited in block 10*)	
	MCSL NUMBER(S)	

10. PREPARATION INSTRUCTIONS

The contractor shall prepare test procedures which describe the tests that are to be used as acceptance criteria for the system. These procedures shall be geared to demonstrate conformance to applicable specifications in paragraph 3.2.1 of SOW AFCC-C-7014. A separate test procedure is required for each different test, and each procedure shall contain the test objective, test criteria, test equipment required, the test set-up, and a step-by-step procedure for performing the test. Contractor format is acceptable.

DD FORM 1664

Appendix B

AN/FPN-62 RADAR ALIGNMENT

1. During initial testing of the prototype Fiber Optic (FO) remoting system the signal level from the A Channel MUX in the PAR shelter exceeded 1 volt peak-to-peak. The maximum level the FO Video Modulator will accept is 1 volt.

2. The radar TO indicated the level should be a nominal 0.700 volts. This is not stated in the TO but would be the level when all three rf carriers summed in phase to 375 mVp-p and this was riding the 0.5 Vp-p Pretrigger/Video signal (See Figure B1). The 375 Vp-p sum for the three rf carriers is derived by adding the individual carrier level out of the 3 channel AM Modulator (8A3A15);

Audio rf carrier	-350 mVp-p
Servo Data rf carrier	-200 mVp-p
Control Data rf carrier	-200 mVp-p
	750 mVp-p

This level is then reduced 50% (375 Vp-p) by R2 in the Dual Transmitter - Distribution (8A3A13) module.

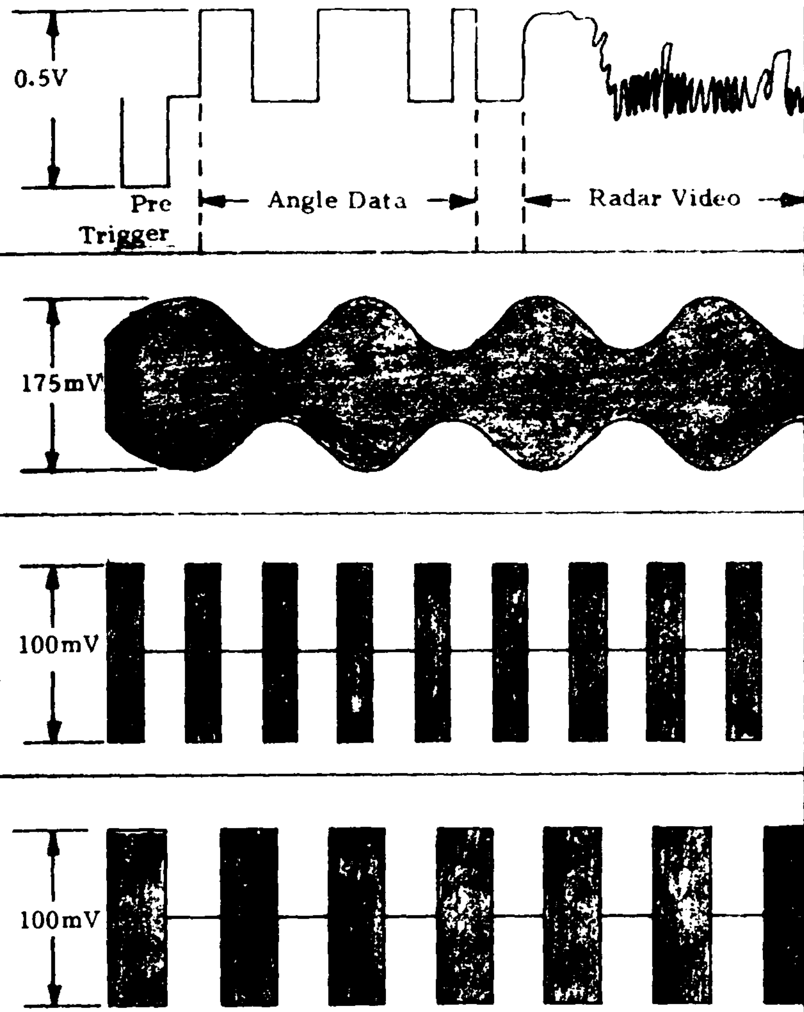
3. The 1974 CG/Radar Maintenance worked with 1842 EEG engineers to align the radar MUX/DEMUX for Channel A. In the first alignment per the radar TO it was noted that Change 1 (1 Feb 80) para 6-46c. specified 8A3A13R2 be adjusted for 100 ±10 mVp-p with a 200 mVp-p input. Prior to this change 200 mVp-p was specified. The radar technician stated the Demux would not function at the lower (100 mVp-p) level. Alignment was completed per the TO and the Demux would not accept the Servo and Control Data. The alignment was reaccomplished using the 200 mVp-p level. The Demux functioned properly over the coax remoting system (See Figure B2). The measured Channel A Mux output was approximately 0.95 Vp-p.

4. The FO system was connected (See figure B3) and at first appeared to function properly. After a short time, as a functional check of the radar controls over the FO system was in progress, the FO link from PAR shelter to OPS appeared to be overdriven. The Channel A Mux output was measured at approximately 1.5 Vp-p. Alignment of the Channel A Mux was reaccomplished and the output remained at 1.5 Vp-p.

Note: During this measurement of the Channel A Mux output was connected to the FO system. The FO link from OPS to PAR functioned with no problem.

5. Assistance to resolve the apparent radar alignment problem was provided by MSgt Slater and SSgt King of the 1866 Facility Checking Squadron. Sgt Slater had been instrumental in the changes made in the TO alignment procedure. Sgt Slater aligned the radar using the 100 mVp-p specified for 8A3A13R2. However, he discovered an alignment step for the Demux 33A6A18 had not been incorporated in the TO change. When he aligned the 33A6A18 the Demux accepted the Servo and Control Data. The measured Channel A Mux output was now approximately 0.85 Vp-p when connected either to the coax or FO system. The previous 1.5 Vp-p level could not be accounted for. The change in A13R2 setting did not have much affect.

6. The FO system was connected and at first functioned properly. We then experienced malfunctions in changing channels and other functions. Each time we monitored the Channel A Mux output and FO system output, no discrepancy could be pinpointed. As we attempted to locate a specific malfunction it cleared itself and a new problem would appear. The system functioned on the coax remoting system.



Signal	RADAR to OPS	OPS to RADAR
Combined Pre Trigger Angle Data & Radar Video	Bandwidth 0 to 6 MHz PRF 3,300	Not Used
Intercom Audio	RF Carrier - 6.95 MHz	RF Carrier - 7.01 MHz
Servo Data or Norm IF, MTI IF, MTI Int	RF Carrier - 7.07 MHz Frame Rate - 10 Hz Pulse Width - 0.35 msec	RF Carrier - 7.13 MHz Frame Rate - 10 Hz Pulse Width - 0.35 msec
Control Data	RF Carrier - 7.19 MHz Frame Rate - 15.625 Hz Pulse Width - 0.5 msec	RF Carrier - 7.25 MHz Frame Rate - 15.625 Hz Pulse Width - 0.5 msec

FIGURE B1. WAVEFORMS (Frequency Multiplexed for Transmission)

7. As shown in Figure B2 the normal coax remoting system applies remoting signals from the selected Mux to both the Ch A and Ch B Demux through a resistive divider. By disconnecting the input to one Demux channel we found that channel selection and other functions were normal. Only the radar indicator sweeps were missing when that channel was selected. This meant that each Demux would act as an on-line backup to the other channel for Servo and Control data. This also meant that if the selected Demux failed to accept the control signals the malfunction would not be observable because the on-line backup would complete the operation.

8. The FO link applied the signal only from Ch A Mux to Ch A Demux with no crossfeed to Ch B. With the insight gained from paragraph 7 above we had a possibility of a failure in the Ch A Demux resulting in system malfunction when remoted by FO and not being observed when remoted by coax. This theory was tested on coax remoting by first disconnecting Ch B Demux. Channel A selection failed occasionally just as it had on FO.

9. We connected the Ch A Mux output to both the FO and coax (See Figure B4). This allowed Ch A Demux to receive over FO and Ch B Demux to receive over coax when Ch A was selected. Channel A selection functioned properly. This demonstrated that when the intermittent failure occurred in Ch A Demux, Ch B Demux acted as an on-line backup.

10. The FO Modulator "through input" was terminated with 75 ohm to continue testing (See Figure 3). Again the problem of overdriving the modulator appeared. The Ch A Mux output was again at 1.5 Vp-p. This problem had not occurred during the time the line driver was connected to the "through-input" as a load in place of the 75 ohm terminator. We found the 75 ohm terminator was intermittent, providing a high resistance load at times. This caused the Ch A Mux output to increase to 1.5 Vp-p. The terminator was replaced and the system functioned except for an occasional failure to change channels. This was attributed to the Ch A Demux operating without the on-line backup by Ch B Demux. We reconnected the Ch A Mux output to the Line Driver and FO as in Figure B4. The system functioned without the occasional change channel problem. This configuration was used to put the system in operation 19 March 82. The problem of an individual Demux occasionally failing to complete a change channel will be investigated.

11. In conclusion, the radar alignment was not the main problem. Some minor adjustments were made and a deficiency in the TO alignment procedure discovered. What appeared to be an alignment problem (the Mux output of 1.5 Vp-p) was caused by the intermittent failure of the 75 ohm terminator varying the load resistance.

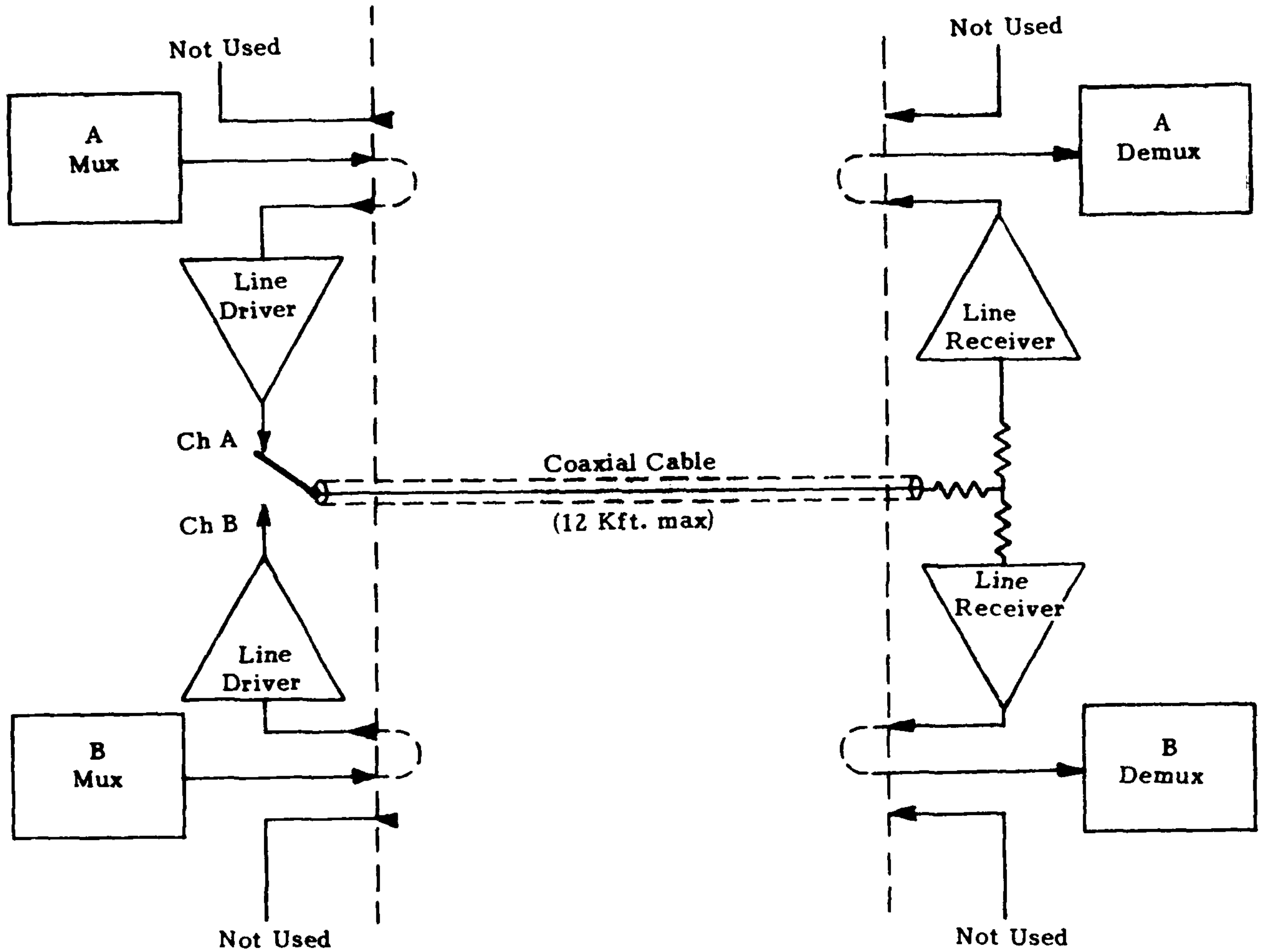


Figure B2. Normal Coax Cable Remoting System

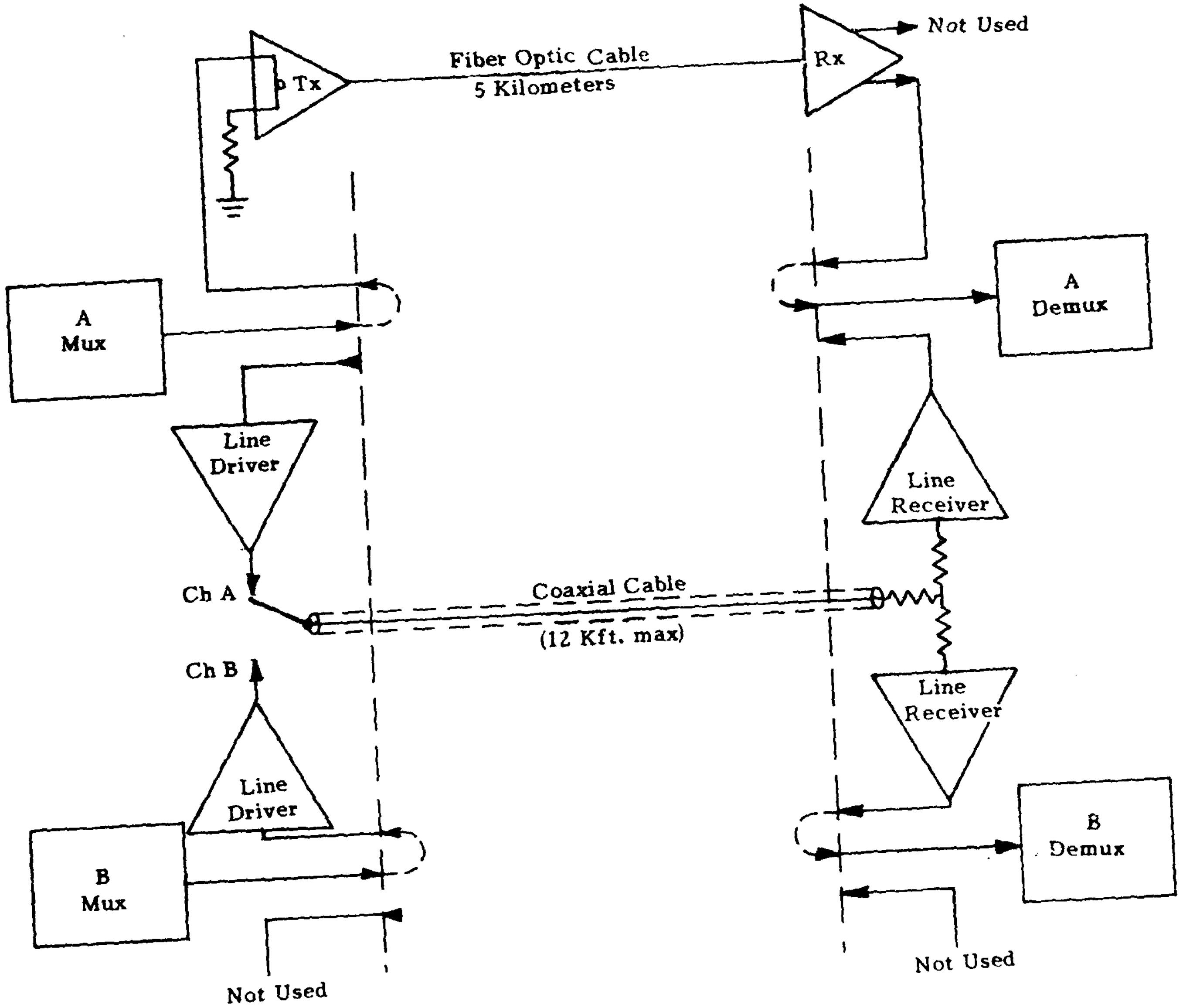


Figure B3. Combination FO and Coax Remoting per Scheme

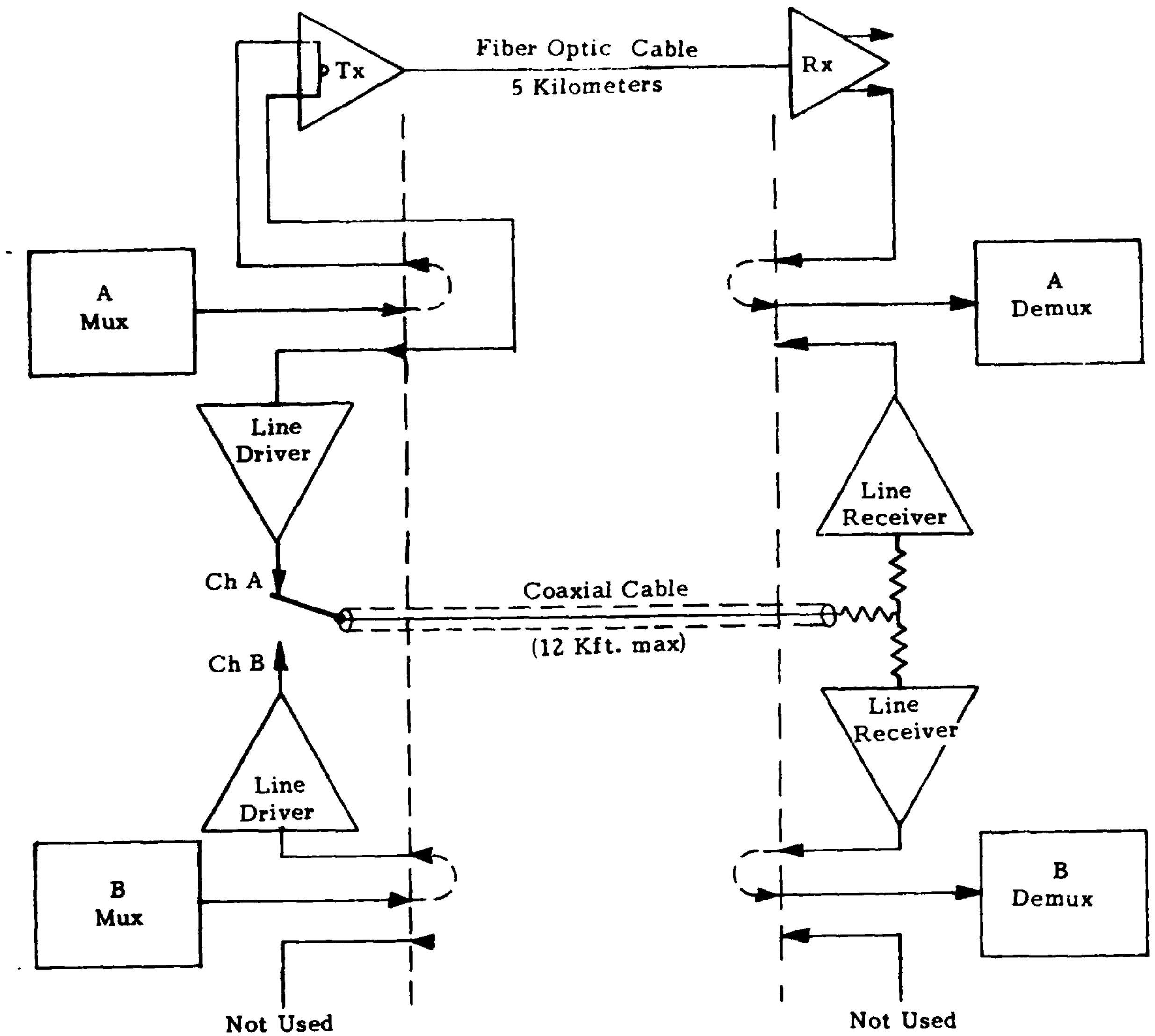


Figure B4. Modified Configuration Allowing Channel B Demux to Function as On Line Back Up

Appendix C

Jeweled Ferrule Connectors

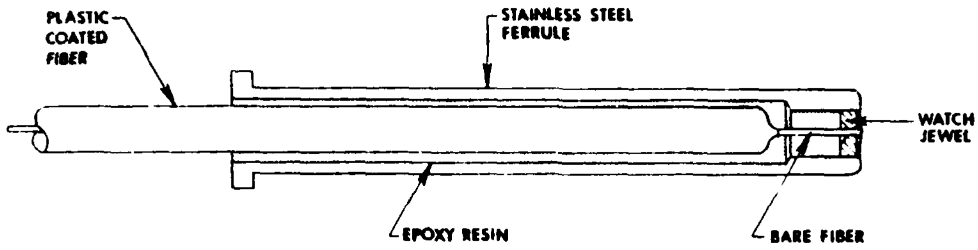
1. The ITT jeweled ferrule connector has design problems. The connector parts are the jewel, ferrule, spring, threaded sleeve and nut (See Figure C1). After these end connectors are installed on a fiber, two fibers can be connected by inserting the end connectors into a housing. The ferrule is inserted into a guide and the nut/sleeve is turned as a unit to thread into the housing. Several turns are required to seat the unit.

2. A problem occurs as the spring compresses between cap and ferrule. The ferrule starts rotating with the cap. This caused the fiber to twist and in some cases the fiber makes several tight loops as the connection is made. The strain on the fiber and fiber loops are undesirable.

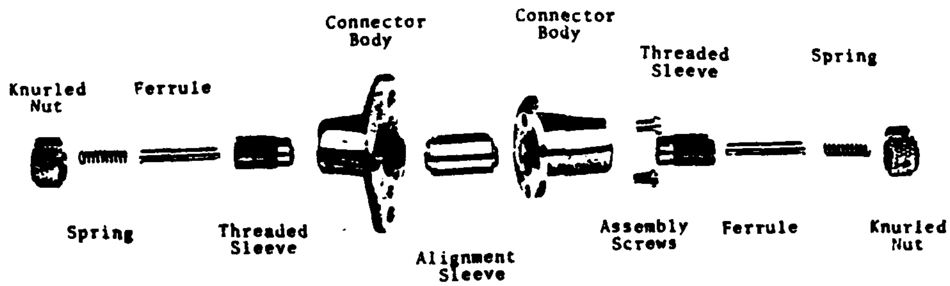
3. Another problem occurs as the connector is removed from the housing. At times the cap screws off the sleeve without rotating the sleeve. The sleeve must then be grasped with fingertips and unscrewed. This can be very difficult depending on accessibility. Now as the ferrule is extracted one has to maintain a grasp on the sleeve which is free to slip off the end of the ferrule. Should this occur over other equipment the metal sleeve could cause a short circuit. At the least, the cap screwing off the sleeve is an unnecessary inconvenience.

4. Early in our system test, we lost signal and power over the green fiber. A failure in one of the connectors was suspected. To continue the test we substituted the spare fiber (orange). Later we lost the signal over the blue fiber. The receiver activity light was OFF. Power meter indicated acceptable power from the blue fiber. The local transmitter was looped through a 30 dB attenuator into the receiver. Activity light was ON and signal looked good. Again the blue fiber was connected. As the ferrule was inserted the activity light came ON, but as the ferrule was seated, the light went OFF. Was the power to light the activity light coming from the cladding? If so, as the ferrule was seated the core of the receiver fiber could not longer "see" the cladding light. The power meter sees both core and cladding light. The blue fiber power was measured through a buffered fiber which only passes core light. Almost no power was being injected into the core. Cleaning and polishing the connector had no affect on the indications other than a slight improvement in the power. The connector was replaced on the blue fiber and signal was restored. The connector was also replaced on the green fiber and verified serviceable.

5. Approximately two months into the test, the signal over the orange fiber became weak and noisy. The receiver activity light indicated sufficient power and a power meter showed -34 dBm, well within the receiver input range. Loopback and fiber swaps verified the orange fiber was bad. On a chance, the connector at the radar end was replaced and the signal was restored.



Jeweled Ferrule Cross Section



Exploded Connector

Figure C1. Jeweled Ferrule Connector

Appendix D

Maintenance/Testing

1. This prototype FO system is to be operated for one year. Any malfunction/failure during that time is to be reported to the project engineer. The project engineer will perform any adjustment or maintenance required.

2. Periodic testing will be accomplished, every three months, to ascertain the capability of the system to sustain "as accepted" peformance. The equipment and link will be subjected to the following test;

a. Video Modulator Modules:

(1) Carrier Center Frequency.

(2) Carrier Output Level.

b. Optical Transmitter Modules:

(1) Optical power Output.

(2) Modulation Depth.

(3) Laser Drive Current.

c. Optical Receiver Modules:

(1) Input Activity Indicator.

(2) Optical Sensitivity.

d. Video Demodulation Modules:

(1) Output Level and Gain Control.

e. Power Supplies:

(1) Voltage Levels.

f. Optical Link:

(1) Attenuation, Each Fiber.

3. Periodic testing will require the FO system be out of service. During that time the coax remoting system will be placed in full service. Tests 2.a-e will be accomplished in the 1842 EEG Technical Applications Laboratory.

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