INSTALLATION AND PERFORMANCE OF A FIBEROPTIC VIDEO SYSTEM AT VIACOM

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ABSTRACT

This paper describes the Fiberoptic Video System installed by Valtec Corporation at Viacom's Suffolk County Cablevision in Islip, Long Island, N.Y. The system is designed to carry a single studio quality video and audio signal over an 8800 foot long aerial fiberoptic cable. The design of the terminal equipment, and 3-fiber aerial cable is discussed. System performance is cited.

INTRODUCTION

A turnkey fiberoptic transmission system connecting the Local Program Origination Studio with the Head End was installed by Valtec Corporation at Viacom's Suffolk County Cable-Vision in Islip, Long Island.

The system was designed to transmit a single video and audio channel over a distance of 2.7 km(8800 feet) without the use of line amplifiers. The terminal equipment was installed in the working environment of a television studio at one end, and head end at the other. A three fiber aerial cable was installed by Viacom's installation crew under the supervision of technical personnel from Valtec. Although present system requirements called for only one fiber transmission, a three fiber cable was installed to facilitate future expansion of services offered by Viacom.

The optical fiber, aerial cable, and the terminal equipment including the Light Emitting Diode were designed and manufactured by Valtec Corporation. The cable and system installation took place in early December, 1978.

TERMINAL EQUIPMENT

The terminal equipment was designed to interface between the electrical signals and the fiberoptic cable. A block diagram of the terminal equipment arrangement is shown in Fig. 1. At the transmitter end, the baseband audio signal is modulated onto an RF carrier, and combined with the composite video signal. Together, these frequency division multiplexed signals are converted into equivalent light intensity modulated signals by the combination of the LED, and the driver circuit.

The light is coupled into the fiber pigtail which is connected to the fiberoptic cable via a demountable optical connector. At the receiver end, the light is coupled from the cable into a detector pigtail via an optical connector. The detected light levels are transformed into photocurrent which is amplified by the receiver circuit. The audio RF carrier is filtered from the received signal by the audio demodulator which converts the RF into the baseband audio.

VIDEO TRANSMITTER

A block diagram of the video transmitter is shown in Fig. 2a. The video and RF audio are summed by a transimpedance amplifier which feeds the predistortion circuit. The predistortion circuit was designed to compensate for the nonlinearities of the LED, and, therefore, improve the differential gain and phase distortions of the transmission system. The predistortion circuit feeds a voltage to current converter which in turn powers the Light Emitting Diode.

Valtec's own IRE-160F LED was employed in the transmitter circuit. The entire video transmitter circuit, including the LED and the optical connector, was assembled on a single plug-in type printed circuit board. The individual transmitter parameters are listed below.

Light power coupled into the fiber	26 μW
Modulation index	90%

Frequency response	1 Hz to 35 MHz
Differential gain	< 2%
Differential phase	< 2.5°
Power Supply	± 15V
Power Consumption	< 2.5 W
Input Impedance	75 Ω (DC to 35 MHz)
Input Signal Level	1-10 Vp-p

AUDIO MODULATOR

A unique modulation scheme was employed in the audio modulator circuit. This technique, labeled the period modulation scheme, nears the performance of an FM system, but retains the simplicity of AM. A block diagram of the audio modulator is shown in Fig. 2b.

The baseband audio, 600 Ω balanced or 5000 Ω unbalanced, feeds the input buffer and preemphasis filter. The signal then enters the low frequency period modulator which outputs a TTL signal whose period is proportional to the input voltage. This signal in turn AM modulates a crystal controlled RF carrier. The carrier, after passing through a band pass filter, feeds the video transmitter. Advantages of the modulation scheme employed here over conventional schemes are frequency stability, ability to transmit drift free dc information, and ability to transmit data from DC to 250 kb/sec. The modulator specifications are listed below.

Input impedance	600/5000 Ω
Input signal level for 100% modulation	4 Vp-p
RF carrier	15 MHz
Carrier amplitude	15 db below color subcarrier
Preemphasis time constant	75 μsec
Frequency deviation	150 KHz total
Power consumption	< 2.5 W
Power supplies	± 15 V

VIDEO RECEIVER

A block diagram of the receiver circuit is shown in Fig. 3a. The light emerging from the optical cable is guided into the PIN photodetector via a fiber pigtail which interfaces with the cable through an optical connector. A Field Effect Transistor(FET) preamplifier is used in order to maximize the signal to noise ratio of the video signal. The AGC amplifier keys on the horizontal sync pulses, and provides a constant RS-170 compatible video output. The signal from the AGC amplifier flows to the line driver, and the dc restoration circuit which clamps the blanking level at OV dc. Receiver parameters are listed below.

Signal to noise ratio at 0.8 μW light signal power	52.4 db CCIR weighted
Frequency response	3 dB at 7 Hz and 18 MHz
Dynamic range	10 dB optical 20 dB electrical
Power supplies	+ 15 - 15

AUDIO DEMODULATOR

The RF carrier is filtered from the receiver output by the band pass filter as shown in Fig. 3b. The signal is envelope detected, and fed into the period demodulator circuit which yields a baseband audio signal at the output. The deemphasis and output buffering are accomplished in the last circuit stage. The demodulator performance is given below.

Audio frequency response	20 Hz to 18 KHz
Signal to noise ratio at 100% modulation	50 dB, 18 KHz bandwidth
T.H.D.	< 0.1%
Output Signal	4 Vp-p at 100% modulation
Output Impedence	600 Ω or 5000 Ω
Power Supplies	± 15V

The system components(the video transmitter, the audio modulator, video receiver, and the audio demodulator) were manufactured on individual printed circuit cards, and mounted in a 19" rack mountable chassis with individual power supply modules.

THE CABLE

The Viacom system required that the 2.7 km cable be aerial, with exposure to the elements, and temperature extremes of from -40°C to +65°C. The cable had to have an end-to-end loss, including splices and connectors, of less than 17 dB in order to meet the system requirement for the signal to noise ratio. A loose tube cable design was chosen for this application. In this design, each fiber was put into a polypropylene 2.5 mm O.D. tube. Contra-helical layers of Kevlar® were overlayed to act as strengthening members. A thin color coded jacket of urathane formed the final extrusion on each of these sub-members of the cable. Each sub-member exhibited a short gauge length strength of 270 kg (600 lbs.).

The three km lengths of sub-channels were stranded and bound with polypropylene tape; with Mylar® wrapped over them to form a heat barrier. During stranding, the 3 km length of cable was cut in half to facilitate handling. An additional contra-helically laid Kevlar® belt with a urathane jacket was applied to each of the 1.5 km lengths of cable forming an O.D. of 12.4 mm(.50").

To assure the moisture resistance of the cable, a corrugated steel belt was applied around the cable. The steel belt was then jacketed with a 1.25 mm(.050") polyethylene jacket. The final cable weight was 223 kg/km(492 lbs.).

Installation of the first length of cable took place in early December of 1978. The installation started at the head end. The first pull section to a pole on Willson Blvd. was 200' long. At that point, the cable negotiated an 80° bend, and continued over cable blocks down Willson Blvd. The cable was pulled by attaching the cable through a short pulling line to the bucket of a service truck. Reasonable effort was made to maintain the pulling axis close to the messenger during the pulling operation. Frequent stops were made during pulling to thread the cable through numerous trees that dotted the roadside, and for routing the cable to the field side of many of the poles. The first section pulled was 1.25 km(4100') long. It took nearly a day to complete, and an additional day to lash. The second length of cable was installed in the same manner with the starting point at the studio on Brightside Avenue, and the cable pulled down Willson Blvd. to meet the end of the first cable.

It should be noted that the installation crew had no prior training on the installation of fiber cable, and as a result, treated this cable as a conventional coaxial cable.

Splicing was accomplished in less than favorable weather with temperatures in the teens, and 20 to 30 MPH winds. Despite the fact that a heated bucket was provided for the Valtec engineer who spliced the cable, the conditions for splicing small 5 mil fibers were barely adequate due to the wind and cold. Nevertheless, all splices were successful on the first attempt.

A conventional cast iron telephone splice case was used. Half of the case was clamped to the messenger. To the lower edge, an aluminum base was bolted to form a platform on which to work. The front lip of this platform was rested on the edge of the bucket for support. The platform accommodated the microscope, splices, epoxy, and other tools required to perform the splice. The splicing was accomplished using Thomas & Betts armored splices. This splice requires that the cable be prepared by removing the outer jacket of the cable sub-members, and cutting the Kevlar® to length(as well as the polypropylene tube). The fibers are then cleaved and inserted into the V groove splice, and aligned under a microscope. A heater in the microscope base shrinks tubing around the fibers, and holds them in place. The Kevlar® is crimped to the splice, and clear epoxy is inserted through a viewing port to act as an optical coupling agent, and to bond the fibers to the splice. Shrink tubing is put over the entire assembly, and the splice becomes an integral part of the sub cable. After splicing was completed, the splice case was closed, and sealed with sealing tape. The fiber and cable parameters are listed below.

Cable length	2.7 km(8800')
Weight	492 lbs/km (223 kg)
Strength	> 400 lbs (gauge length - 1/2 km)
Temperature performance	< 1 dB/km -50°C to +85°C
Number of fibers	3
Fiber attenuation including splice and two connectors	13 dB(2.7 km length)
Fiber bandwidth	> 200 MHZ-km

SUMMARY

A turnkey high quality video transmission system was successfully installed in a working CATV environment. The system currently carries a single video and audio channel over a distance of 8800' without the use of line amplifiers. With the advent of higher opto-electronic technology, the system capacity can be expanded to at least 30 TV channels.

The authors wish to thank their colleagues at Valtec Corporation who have been involved in manufacturing and installion of all system components.

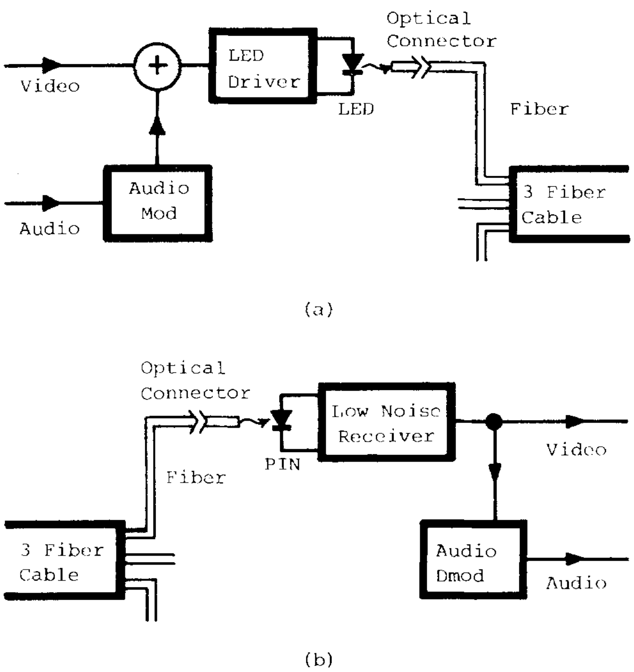

Fig. 1. Fiber optic interface circuits. (a) Studio. (b) Head end.

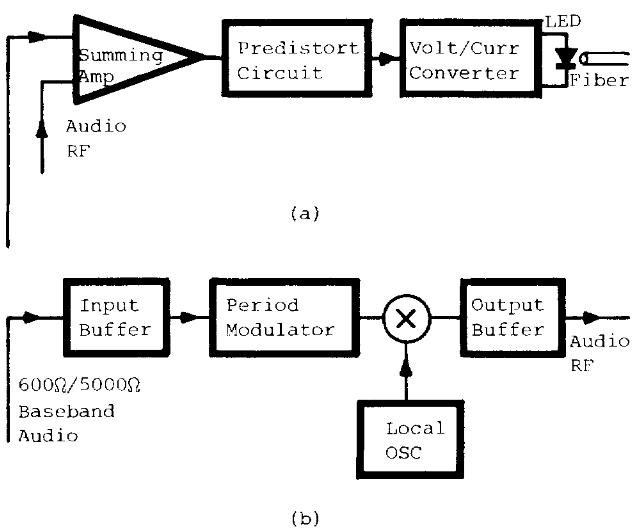

Fig. 2. (a) Video transmitter. (b) Audio Modulator.

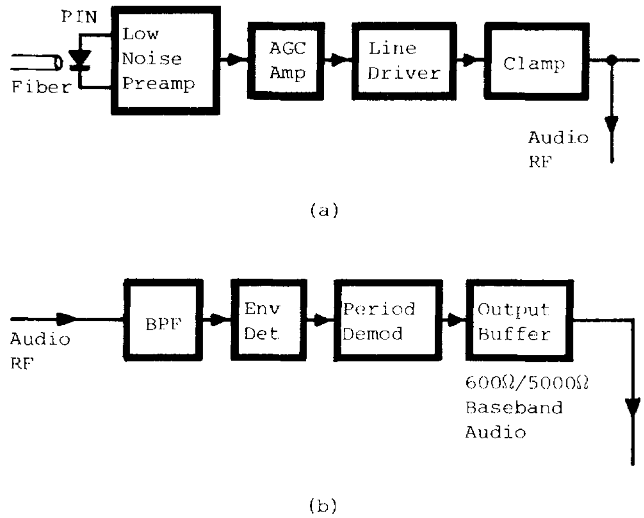

Fig. 3. (a) Video receiver. (b) Audio Demodulator.

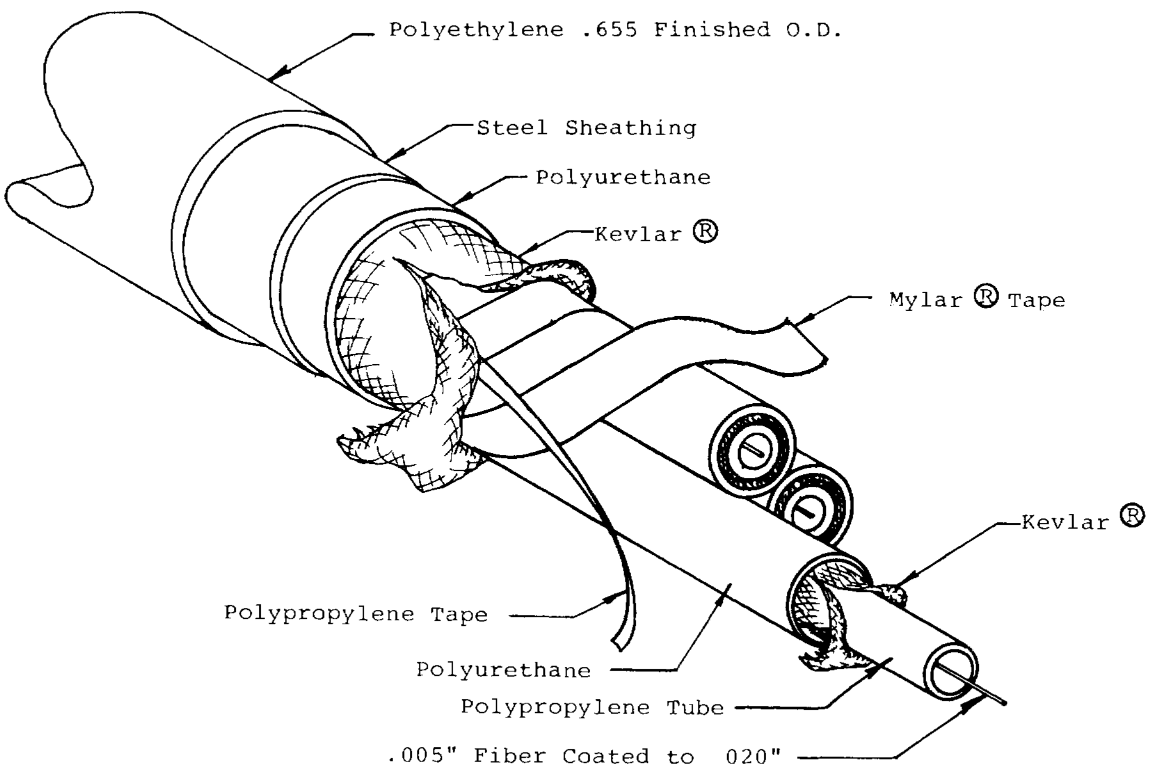

Fig. 4. Cross sectional view of the three fiber cable.