Application of Fiber Optics in CATV Distribution Systems

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INTRODUCTION

There is little doubt that the age of the "wired city" has arrived: CATV trunk and distribution cables are being installed at an ever-increasing rate to provide TV programs as well as security service and other interactive capabilities.

However, as an industry expands into high-rise buildings, the coaxial system becomes more vulnerable to unauthorized taps which escape cable audits. Furthermore, the coaxial system is a potential source of RF ingress and egress.[1] The unanswered question is "Does the high-rise building wired with coax form a large multi-element antenna?"

Fortunately, there is an alternative technical method of TV distribution within a high-rise building.

With the advent of inexpensive fiber optic connectors, large core fiber optic cable, and reliable GaAlAs light emitting diodes (LEDs), a fiber optics distribution network is a reality.

A fiber optic network eliminates unauthorized taps, has virtual freedom from RFI ingress and egress and lends itself to cosmetic installation.

Particularly well-suited to the high-rise building, the fiber optic distribution system is relatively free from electrical codes, meets fire safety standards, eliminates ground loops and reduces the risk to CATV operator.

This paper will review some of the advantages available with the Mini-Hub distribution network for CATV high-rise buildings and compare it to perceived problems expected in coaxial high-rise distribution networks.

FIBER OPTICS IN CATV

Not a new topic, the military and telephone industry have long recognized the advantage of fiber optics to their specialized fields. The advantages of fiber optics over standard coax are overwhelming:

- o Lower attenuation - longer runs, fewer repeaters.
- o Wider bandwidths - system updating and expansion.
- o Freedom from RFI/EMI - no egress or ingress of interferance.
- o Security - no unauthorized taps.
- o Electrical isolation - no sheath currents or ground loops.
- o Safety code - no electrical code, meets fire codes.

The Japanese have demonstrated the viability of fiber optics in their "wired city" project. The Hi OVIS interactive television experiment in Higashi-Ikoma District in Nara Prefecture[2] is an example of the application of fiber optics to a CATV-type distribution environment.

Currently Ma Bell is exploring the use of fiber optics in CATV distribution networks. They have already gained much experience in the use, reliability, and cost effectiveness of the fiber optic technology and seem to be proceding to utilize it where they can.

Several new developments in fiber optic cables and connectors[3] (Reference Dr. Pinnow's paper titled "Optical Fiber Cables and Connectors for Mini'Hub" in this abstract) have

provided the catalyst to make fiber optic high-rise networks for CATV reality.

- The connector is easy to install; it requires no polishing or long cure cycle epoxy solutions; it has low light loss (≪2 dB) and is inexpensive.
- The fiber optic cable is fabricated in either a drop (two-fiber oval element) or a multi-fiber configuration (many fibers bundled in a tube). Also, it is cost effective. These fibers have large core, low attenuation, and wide bandwidth.

  The small size cables provide neat installation appearance and the light weight of the cable reduces installation labor.

- A new light emitting diode (LED) is now available. It is constructed as a surface emitting GaAlAs diode packed to focus its high output power into a 200 um fiber core. An inexpensive device, it meets stringent reliability testing and meets its wide bandwidth and low distortion specifications.

These components associated with a unique approach to a Star Network have evolved the best means of distributing CATV signals within a high-rise building.

THE FIBER OPTIC DISTRIBUTION NETWORK

Usually one thinks of a CATV distribution network as a trunk line with directional couplers and splitters providing the signal splitting to feeders and ultimate subscribers. These directional couplers, however, do not have a cost effective counterpart in the fiber optics system. Therefore, the computer, industrial control and other industries have resorted to other means of signal distribution in their communication networks.

The most popular distribution system being applied today is a "Star Network."

The CPU communicates with a remote terminal over a duplex (two-fiber) fiber optic cable system. Like a traffic cop, the CPU can direct that communication from the first terminal to another terminal. Each terminal has the ability

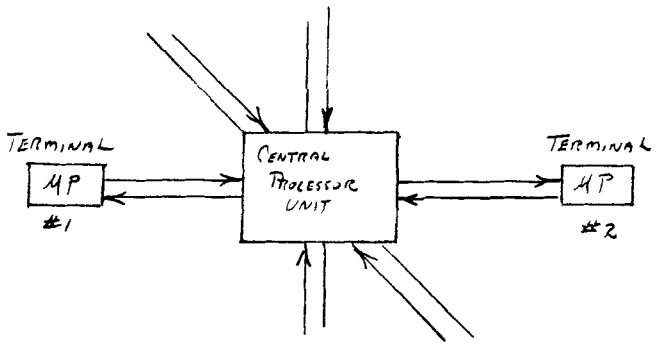

Figure 1.
Star Network

to communicate only with the CPU or with any other terminal through the CPU depending on how the system architecture is designed.

Today this same "Star Network" architecture is available for use in CATV applications. Like the Star Network, the Mini-Hub distribution, designed by Times Fiber Communications, Inc., employs a Central Distribution Unit (CDU) and two-way fiber optics communications to each subscriber as well as with the central operator's office.

Reference an article titled "Mini-Hub Addressable Distribution Systems for High-Rise Application" by M.F. Mesiya and others in this abstract.④

A modular system, the Mini-Hub distribution network consists of a Central Distribution Unit housed in a locked metal cabinet. (Figure 2.)

It includes a fiber optic network of dual fiber cable to each subscriber location. (Figure 3.)

Figure 2.
The Mini-Hub Central Cabinet

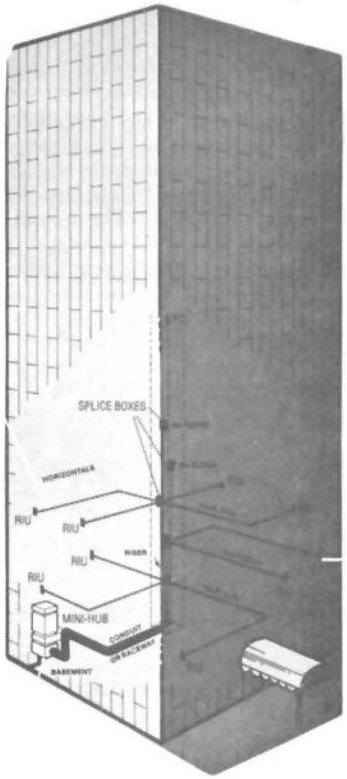

Figure 3.
High-Rise Distribution Network

These fiber cables include bundles of fiber riser cables located in air ducts, elevator shafts, or other installation locations requiring asthetic appearance. Splice boxes are used to distribute these bundled fibers to drop or horizontal single subscriber cables.

The fiber cable is terminated at the Residential Interface Unit (RIU) where the optical energy is converted to normal electrical RF and digital components.

Figure 4.
Wall-Mounted Residental Interface Unit

The RIU is a wall-mounted resilient plastic housing with conventional "F: connector outputs for TV (Channel 3 or 4) and FM signals.

A conventional telephone cord connects the RIU to the subscriber set-top Keypad. The Keypad is used by the subscriber to communicate to the CDU. He not only selects his channels with the Keypad, but also interacts with the CATV central office via interactive communications through the CDU.

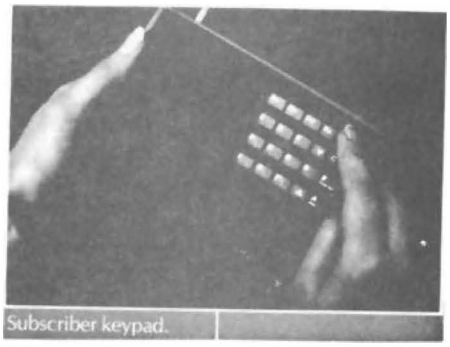

Figure 5.
Subscriber Keypad

The Mini-Hub system fiber optic network eliminates any problem with RFI ingress and egress. Besides, it is virtually impossible to tap the cable and steal basic tiered signals.

The most expensive item within the subscriber home is the $20 Keypad. This provides additional advantage to the system operator--reduced theft of expensive converters.

The two-way modular, interactive distribution network may be expanded to include many additional services with no subscriber access problem. See Figure 6 for system expansion.

The Mini-Hub effectively eliminates set-top converters and all their associated problems as outlined below:

COMPARISON CHART OF EXCLUSIVE MINI-HUB SYSTEM FEATURES VS ORDINARY SET-TOP ADDRESSABLE CONVERTERS

Features	Ordinary Addressable Converters	Mini-Hub
- Modular Two-way Addressability	No	Yes
- Full Subscriber Access Verification	No	Yes
- Unlimited Program Tiering	No	Yes
- Total Control from Central Office	No	Yes
- Impulse Pay-Per-View	No	Yes
- Signal Leakage Immunity	No	Yes
- Compatible with Other Converters	No	Yes
- Remote Control of Basic Service	No	Yes
- Scrambled Channels Required	Yes	No
- Reprogramming After Power Loss	Yes	No
- Sheath Current Susceptibility	Yes	No
- Transient Surge Susceptibility	Yes	No
- Subscriber Access For Upgrading	Yes	No
- Equipment Theft Exposure	Yes	No
- Signal Theft Exposure	Yes	No

MINI-HUB MODEL	SERVICE AVAILABLE	SUBSCRIBER ACCESS
8100	Addressable Basic channel Tiered 54 levels Diagnostics FM channels Parental lock Cable A and B	One time RIU hook up
8200	Add Pay per view	No
8300	Interactive Store&Forward Impulse Pay Opinion polling Video shopping	No
8400	Interactive(Real time) Security Options Energy Managment	Add sensors
8500	Add Videotex	No

Figure 6
Mini-Hub Expansion Models

WHAT IS EXPECTED OF COAX?

Answering the question, "Are coaxial systems prone to radiation?" is very much dependent upon how these systems are installed; how they are maintained; and the type of components used to assure their continued integrity.

RADIO FREQUENCY INTERFERENCE

RFI is not a new problem to CATV operators. We have learned an expensive lesson in the past with RF carriers interfering with aircraft. Examples of these were[5]

- o Harrisburg, Pennsylvania
- o Oxnard, California
- o Hagerstown, Maryland
- o Wilmington, North Carolina
- o Flint, Michigan

Periodic testing and connector tightening are used to seek out and eliminate the RFI problem within CATV trunk and feeder systems. Performing these tasks is likely to be more complex in the high-rise building.

THE ANTENNA EFFECTS

The Antenna Effects have been reported by amateur radio operators for some time.[6] They interfere with coaxial systems just as readily as with rabbit ears.

The latest issue (March 1982) of QST presents an interesting observation. It suggests that a coaxial cable forms a counterpoise antenna when routed in proximity to AC power wiring. The argument when extended to a multi-floor building could present a serious problem to the CATV operator, if valid.

LONGITUDINAL SHEATH CURRENTS

Longitudinal sheath currents have been accepted as a necessary evil in CATV trunk and feeder cables.[6] Normally thought of as a 60 Hz problem, it is not unreasonable to expect higher frequency transient noise to appear to some extent through the 400 MHz spectrum. Obviously the larger level interference signals favor the lower RF spectrum.

One can model the coaxial system for LSC within the high-rise building and show an argument for the same type of condition prevalent in the trunk and feeder lines.

CONCLUSION

A fiber optic Mini-Hub system is an alternative to a high-rise distribution network of coaxial cable.

We have briefly described the advantages of fiber optics and described it as a mature technology.

It, unlike coaxial systems, provides much flexibility and presents a lower risk to the system operator.

The Mini-Hub is an electronic distribution system with fiber optic network. It is compatible with other converter systems and provides complete subscriber control and diagnostics capabilities from the central office location.

These advantages:

- o Eliminates unauthorized cable taps.
- o Prevents loss of expensive converter.
- o Freedom from RFI egress and ingress.
- o Permits expanded services without access problems.

and others offer the CATV operator peace of mind.

Reference

1 "Doughnuts for the Tennessee Valley Indians," John a Wick WIHIR, QST, March 1982.

2 "Hi-OVIS Project Interim Report," Hardware/Software Experiments, July 1978-March 1979, Shigern Watanabe.

3 "Optical Fiber Cables and Connectors for Mini-Hub," D. Pinnow and R. Strait, Jr., Times Fiber Communications, Inc., Wallingford, CT.

4 "Mini-Hub Addressable Distribution System for High-Rise Application," M.F. Mesiya, G.E. Miller, and D.A. Pinnow, Times Fiber Communications, Inc., Wallingford, CT.

5 "New Services Vs the FAA: A Problem in Need of a Solution," Nicholas E. Worth, Telecasting Corporation, Norfolk, VA.

6 "Longitudinal Sheath Currents in CATV Systems," J.C. Herman and Jacob Shekel, 24th Annual NCTA Convention, April 13-17, 1975.

7 Physics, Part II, David Hallidav and Robert Resnick, John Wiley & Sons, Inc., New York, April 1967.