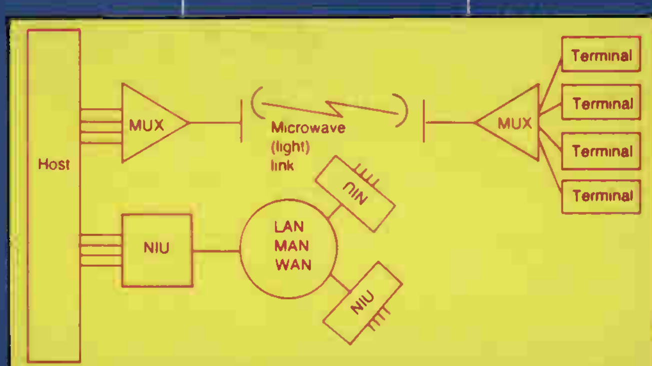
COMMUNICATIONS TECHNOLOGY

Official trade journal of the Society of Cable Television Engineers

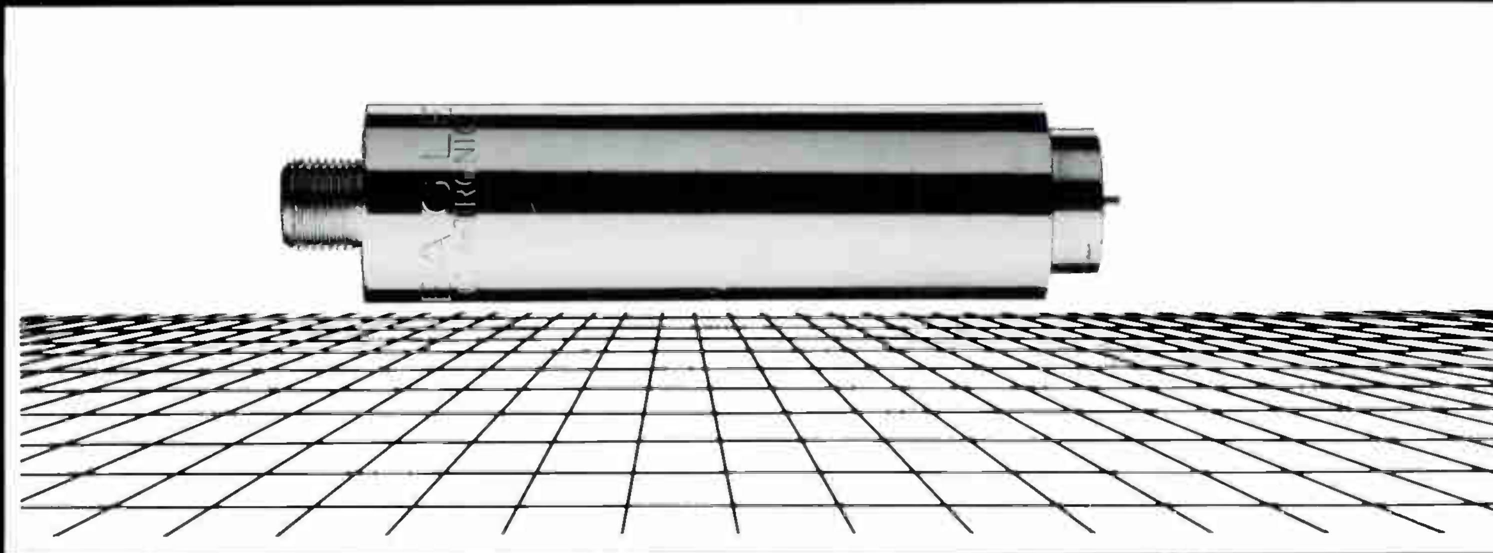
Signal leakage: A bane to shared frequencies



November 1985

RF data transmission

TRAPS VS. DESCRAMBLERS



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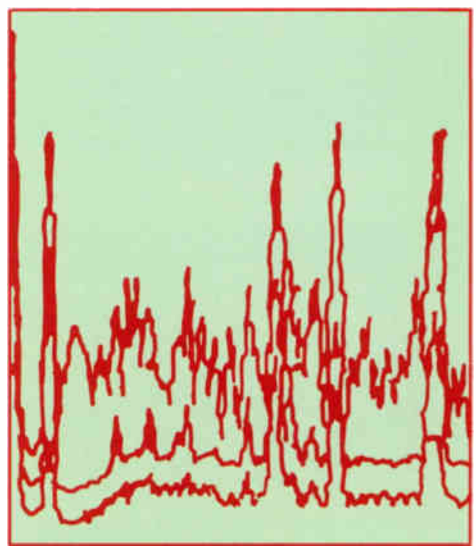

Bruce Catter

Features

Cover
Hubert Gentry's photograph of technician checking for leakage courtesy of ComSonics; jet preparing to land by Rob Stuehrk.

Communications Technology™ (ISSN 0884-2272) is published monthly by Communications Technology Publications Corp., 12200 E. Briarwood Ave., Suite 250, Englewood, Colo. 80112—or—P.O. Box 3208, Englewood, Colo. 80155, (303) 792-0023. November 1985, Volume 2, Number 9. Office of publication is 12200 E. Briarwood, Suite 250, Englewood, Colo. 80112. Second-class postage paid at Englewood, Colo. POSTMASTER: Please send address changes to Communications Technology, Box 3208, Englewood, Colo. 80155.

Remember... it was only yesterday when offering a PPV event in one-way cable systems usually meant mass confusion. Too many telephone operators to pay, but not enough to handle the last minute phone calls. In solving this problem, Jerrold drew on experience that dates back to 1956. That year, a two-channel device was developed and demonstrated at the Jerrold plant in Philadelphia. Known as the PBPB "program-by-program billing," it attracted much interest—and visitors—from all over the world. Although the PBPB was too far ahead of its time to be a financial success, it was one of cable's earliest demonstrations that pay-per-view technology was quite feasible.

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GENERAL INSTRUMENT

Why don't we listen?

I know. I've been on a soapbox about signal leakage ever since we started publishing *Communications Technology*. The advent of deregulated signal leakage requirements will soon enable cable system operators to control their own destinies, which is what the FCC would prefer to see happen. So, you'd assume that operators would pay attention to their systems. Never assume!

One case in point is Sonic Cable TV in Grove City, Calif. In 1982 the FCC issued an initial notice of apparent liability to that cable operator. The result of this situation is that Sonic was fined $6,000 for failure to correct harmful interference as well as for signal leakage in excess of the rules.

I don't mean to single out Sonic Cable as one of the few systems exceeding signal leakage levels—most of the others just haven't been caught. But, why don't we listen?

New glossary of terms

One of our good friends, Ralph Haimowitz, director of engineering for American Cablesystems of Florida, sent us his definitions of cable terms that I'm sure we can all relate to. The following is derived from Haimowitz's experience in the cable industry and is titled, "A glossary of cable terms—Field version."

"Over the years there have been several different printings of cable television terminology with definitions designed to improve our communications with each other throughout the industry. I have observed, with keen interest, that the field definitions to some of this terminology is vastly different from the printed glossaries. Therefore, in an attempt to ensure greater understanding throughout the cable industry, I have provided the following update for inclusion in the glossary of cable terms.

"*Automatic gain control (AGC)*—A technician with a diddle stick.

"*Converter*—An individual who changed job positions from one career area to another, i.e., from business office representative to installer or from service technician to telemarketing.

"*Distribution system*—The method by which rumors are instantly spread throughout any cable company.

"*Equalization*—When every employee knows what every other employee earns and wants the same amount.

"*Flat loss*—What the cable company pays out in overtime pay.

"*Group delay*—The extended coffee break that occurs every morning when employees are supposed to be on the job.

"*House drop material*—Those small bits and pieces of debris left on the subscribers floors and carpets after installation or service calls.

"*Hum*—The phrase used by technicians when they are evaluating a reception problem just described by the subscriber.

"*Pole attachment*—The reaction that occurs upon having a gaff break out of the wood.

"*Subscriber*—A cable customer. This word is the derivative of three common words: A) *sub*, meaning lower than or inferior to, particularly about how good or bad his cable reception is; B) *scrib*, from the word scribe, one who writes, especially checks to pay cable bills; and C) *er*, from the word err; to make a mistake or be wrong, particularly with regard to complaints about picture quality.

"*Distortion*—An explanation given to the subscriber about his reception problems.

"*Common carrier*—The technician who overstocks his truck and then drives around the system all day providing parts for those technicians who fail to replace their truck stock.

"*Active*—What employees must appear to be in the presence of a supervisor.

"*Picture blanking*—The phenomenon that occurs to the subscriber's TV set when the installer cuts through the new house drop he installed while he is burying it with his shovel.

"*Combining network*—Two or more service technicians who gather together at the same spot to solve a simple cable problem.

"*Block tilt*—What may happen if all of the on duty technicians form a combining network.

"*Frequency response*—The number of times a technician is dispatched to the same location to troubleshoot and repair the same problem.

"*Universal baffa*—Incorrect spelling of the second word often confuses the issue and leads to misunderstandings. The proper term is "universal baffle" and describes what happens when a technician is unsure of which fittings and connectors are supposed to go together.

"*System noise*—The loud, harsh sounds emanating from supervisors when things don't go right.

"*Terminator*—A supervisor who has been forced beyond the limits of his patience.

"*Performance standards*—Undefined in the cable industry."

Toni G. Barnett

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BPA membership applied for November 1984.

Western Show preview

LOS ANGELES—The California Cable Television Association announced that 163 firms have committed to purchasing more than 80 percent of the available exhibit space at the 17th Annual Western Cable Television Show and Convention, to be held December 4-6 at the Anaheim Convention Center.

The Society of Cable Television Engineers is coordinating the six technical sessions for presentation at the Western Show. Subjects to be covered include: local area networks, pay-per-view, underground construction, customer service, FCC update and PacBell Bluebook changes.

In 1984, 217 companies participated in the exhibition portion of the show. Here is a preliminary schedule of sessions, exhibit hours and activities.

Tuesday, Dec. 3
Preconvention activities begin. Preregistrants may pick up their packets at the convention center from 3-6 p.m. Hospitality suites and entertainment begin tonight.

Wednesday, Dec. 4
8 a.m.—Registration opens
10 a.m.-6 p.m.—Exhibits open
1-2:30 p.m.—Welcome and keynote panel
2:45-4 p.m.—Breakout sessions
4-6 p.m.—Hosted cocktail party in exhibit hall

Thursday, Dec. 5
8 a.m.—Registration opens
8:30 a.m.-5 p.m.—All day technical sessions (Co-sponsored by the Society of Cable Television Engineers)
10 a.m.-6 p.m.—Exhibits open
8:30-9:45 a.m.—Breakout sessions
10-11:15 a.m.—Breakout sessions
11:15 a.m.-12:45 p.m.—Exclusive exhibit hours
12:45-2:15 p.m.—Luncheon
2:30-4 p.m.—Breakout sessions
4-6 p.m.—Exclusive exhibit hours; no-host cocktail party in exhibit hall

Friday, Dec. 6
8 a.m.—Registration opens
10 a.m.-3 p.m.—Exhibits open
8:30-9:45 a.m.—Breakout sessions
10-11:15 a.m.—Breakout sessions
11:15 a.m.-12:15 p.m.—Exclusive exhibit hours
12:15-1:30 p.m.—Luncheon
1:45-3:00 p.m.—Roundtable sessions
3-4:15 p.m.—General session
6-7 p.m.—Cocktails
7 p.m.—Annual banquet with entertainment and dance

British operator picks star-switched system

WALLINGFORD, Conn.—Times Fiber Communications Inc. and its British affiliate, Cabletime Ltd., announced the receipt of a major contract to supply a star-switched cable television distribution system to Windsor Television. Windsor holds one of 11 original pilot franchises awarded by the British government. The new system will be installed in the Langley and Wexham districts of Slough encompassing 7,000 homes as the first phase of a 100,000-home build.

The equipment contract received by Cabletime from Windsor Television is worth approximately $800,000. It specifies the use of Cabletime 16 switches, which form the basis of an advanced star-switched network capable of handling both data and entertainment.

Riser-Bond moves

AURORA, Neb.—Riser-Bond Instruments has announced an expansion and move to a new location in Aurora. Its new address is 505 16th St., Box 188, Aurora, Neb. 68818, (402) 694-5201. The move to the new location will enable the company to combine all its operations.

Sonic fined for leakage

WASHINGTON, D.C.—The Federal Communications Commission has denied Sonic Cable TV's request for reconsideration of a $6,000 forfeiture for violating FCC rules. Sonic has been cited for its failure to correct harmful interference, as well as for signal leakage in excess of the rules.

In seeking reconsideration, Sonic argued that the commission lacked statutory authority under then Section 503(b) of the Communications Act. Finding Sonic's contention unfounded, the commission stated that Congress had legislated the warning procedures in Section 503(b)(5) to protect those who might be unaware they were engaging in regulated activities.

Limited scrambling to commence by year end

NEW YORK—Showtime/The Movie Channel Inc. began shipping M/A-COM scrambling decoders to its affiliates in September. All Showtime and TMC affiliates who have registered their headends with Showtime/TMC should expect to receive their equipment by December, and limited scrambling, for the purpose of testing, will begin by year's end.

At the present time, it is anticipated that the East Coast feeds will be the first to be tested.

Anixter reports sales and earnings

SKOKIE, Ill.—Anixter Bros. Inc. reported record quarter sales and net earnings. Net earnings increased 14 percent to a record $5,781,000 or 32 cents a share, from $5,068,000 or 28 cents a share, a year earlier. Sales rose 4 percent to a record $170,606,000 from $164,689,000.

Net earnings for the full fiscal year increased 17 percent to $17,456,000, or 95 cents a share, from $14,937,000, or 82 cents a share, a year ago. Sales advanced 9 percent to a record $650,949,000 from $597,808,000.

New SCTE group, Cable-Tec Expo update

WEST CHESTER, Pa.—The Society of Cable Television Engineers announced the formation of a new (16th) meeting group. The West Texas Meeting Group will be headed up by Jim McCain and will hold its first meeting on the 13th of this month (see *The Interval* for more on this).

The SCTE Cable-Tec Expo, to be held June 12-15, 1986, has 16 firms signed up for exhibit space to date. These firms are: Augat Broadband Communications Group, *Communications Technology*, CWY Electronics, Eagle Comtronics Inc., FM Systems Inc., Lode Data Corp., M/A-COM MAC Inc., Magnavox CATV Systems, Quality RF Services, Reliable Electric, Reliable Electric Utility Products, RT/Katek Communications Group, Standard Communications Corp., Tele-Wire Supply Corp., Triple Crown Electronics and Wavetek.

The one-day Spring Engineering Conference and the expo will be held in Phoenix, Ariz. The SCTE is still accepting proposals for papers and technical programs to be presented at the conference and the expo. Proposals should be sent to Bill Riker, executive vice president, SCTE. For more information on Cable-Tec Expo '86, circle #1 on the reader service card.

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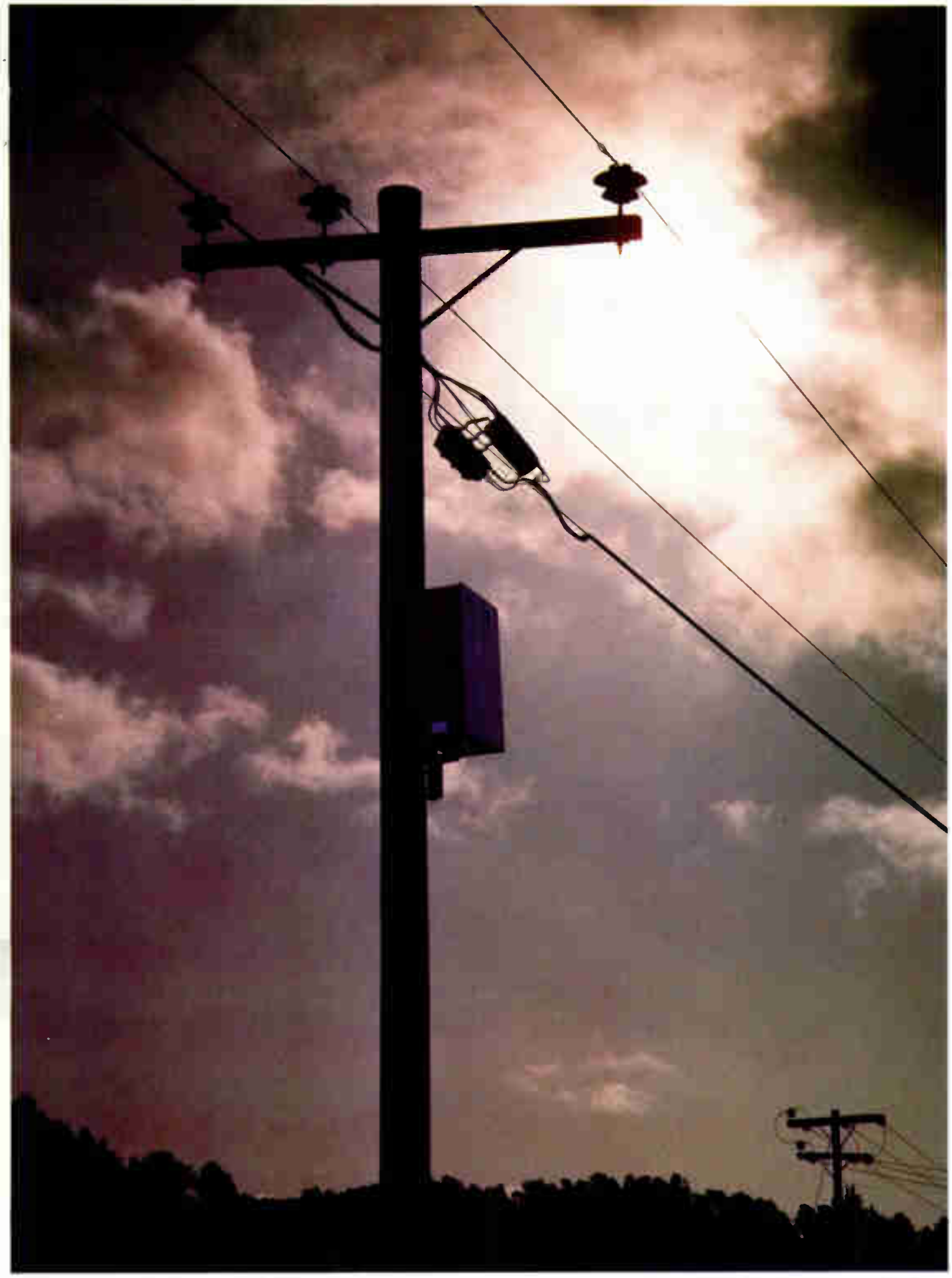

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For more information, and other technical data, write or call Bob Hasewinkle, Product Manager—Specialty, GNB Batteries Inc., P.O. Box 64140, St. Paul, MN 55164, 612/681-5000.

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Reader Service Number 9.

Scrambling, pay TV and survival

By Isaac Blonder
Chairman, Blonder-Tongue Laboratories Inc.

Modern dictionaries have now blessed the verb "to scramble" with its electronic label, e.g., "to make transmitted signals unintelligible in transit."

When the transmitted signal path is by radiation, it must be protected by scrambling. On the other hand, if the cable signal is transmitted by the switched star technology (a wideband clone of the telephone network), scrambling is superfluous since every program is transmitted singly over a secure line and recorded.

For the indefinite future, coaxial, broadband, tree and branch distribution to the subscriber will continue to be the delivery system for cable TV. Scrambling is the method of choice for adding pay programming to the traditional cable system.

It is now obvious that simplistic cable scrambling systems breed purveyors of pirate decoders, and discontent by the moral majority of subscribers who refuse to cheat, but resent the cable operators' inability to control the freeloaders. Let us review some historical events in pay TV, drawing from each what should be a universal lesson in the merchandising art of promotion and sales.

The evolution of pay TV

1000 B.C. (?)—Greek theatre. Pay at the entrance, no refunds, no complaints! Show business was born with the box office mystique and it will never vanish. The closer a pay TV system resembles the traditional theatre, the easier it is to negotiate a deal with the performers.

1929—Eugene McDonald, founder of Zenith Radio, declared, "Television programs should be sponsored by the viewer not the advertiser," and he committed his firm to develop pay TV with the largest budget of all. McDonald deserved the title, "father of pay TV."

1938—Scophony (founded by Sol Sagall), on two occasions in London, presented large screen TV shows in movie theatres. Pay TV was born!

1949—International Telemeter (Paramount Pictures; Barney Balaban, president) conducted a well-financed (and staffed) effort to develop pay TV systems for cable. Balaban's oft declared principle was to place a coin box in the home, simulating the traditional box office principle of "pay cash before you view." Telemeter built a cable system in Palm Springs, Calif., in 1953, featuring first-run movies. Success was immediate and soon the local theatres threatened the operation with antitrust lawsuits, compelling a shutdown due to the absence of first-run movies.

1950—Skiatron tests its Subscriber Vision pay TV for 10 days over WOR-TV, New York.

1951—Zenith experimented with various versions of its pay TV system, PhoneVision, in Chicago. At first, only the picture was scrambled, but sound scramble was soon added when it was discovered how enjoyable was the audio itself.

1957—Bartlesville (Okla.) Cable (Henry Griffing, owner) experimented with a $9.50 flat rate for two movie channels. Response was disappointing even with a rate reduction to $4.95. The announced cause for cancellation of the project was the excessive cost of the leased cable facilities from Southwestern Bell.

1960-65—Etobicoke (Ontario, Canada) was the pay TV cable test bed. Since the United States was so litigious, the entrepreneurs welcomed the Canadian opportunities to measure public responses to all the facets of cable pay TV. Many of the cable TV pioneers appeared at this Canadian scene: Etobicoke system operator Famous Players (55 percent owned by Paramount), Skiatron, Matty Fox, Rediffusion, Tim Cross, Ed Jermain, Gene Fitzgibbons, Bill Rubinstein and Ken Easton. An orchestrated public outcry against the idea that Canadians were subsidizing American interests in an unwanted arena—pay TV—finally caused the shutdown.

Also, since Famous Players did not have a CATV franchise for Etobicoke, and it was painfully clear that pay TV could not carry itself, the long-term future was failure.

1962-64—Subscription TV Inc., a $22 million cable pay TV venture by Matty Fox in San Francisco and Los Angeles, featured the Dodgers and Giants, who had moved to the West Coast to enjoy the pay TV windfall. A vigorous and effective anti-pay TV campaign by the National Association of Theatre Owners bled STV Inc. into bankruptcy and coincidentally blocked all forms of pay TV for another 10 years.

1962-69—With the blessings of the Federal Communications Commission, Zenith and RKO spent about $70 million (in Hartford, Conn.) gathering the statistics, derived from an operating over-the-air pay TV station, which became the basis for the FCC fourth report and order of Dec. 21, 1968, establishing subscription television (STV).

1975—HBO began delivery of pay TV by satellite to cable headends. Thus commenced the modern era of cable growth fueled by quality movies and exclusive sports events.

'Other TV delivery systems...are potent competitors to cable and will have access to the same programs'

1977—Wometco-owned WBTB-TV, Newark/N.Y.C., opened the first STV station in the United States. The public welcomed STV and it was only the growth of cable with its multiple pay channels that caused the demise of STV.

History teaches us...

A complete record of pay TV happenings is beyond the scope of this article, so I will summarize the lessons learned to date.

1) Secure scrambling is an absolute requirement.

2) To be profitable against competitors new and old, cable must offer a full cornucopia of video treats.

3) Pay-per-view has a future, but when?

4) Other TV delivery systems—TVRO, VCR, DBS, telco—are potent competitors to cable and will have access to the same programs.

5) The highly publicized revenue streams —security, banking, teletext, FM music, data communications, etc.—are dry gulches so far and likely to stay that way.

6) Is each feature offered by the more elaborate pay TV schemes cost effective? As an example, would the subscriber pay extra for parental control? The answer is usually "No."

Cable is not a franchised monopoly without competitors. Efficiency through a selective offering of programs and spartan technology is the means for survival.


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Deregulation and the leakage rules

By Chris Papas
CATV Specialist, FCC

Will cable systems deteriorate without specific signal leakage rules or will systems voluntarily clean up their act without Big Brother looking over their shoulder? The answer to these questions will depend as much on management philosophy as it will on system use.

Many cable operators are firm believers in preventive maintenance and keeping their system in good operating condition. Unfortunately, there are still a few around that will do repairs only after subscriber complaints come in. Signal ingress and signal leakage each cause their own unique problems to the operator. Signal ingress can degrade the picture quality of a subscriber's set and wreak havoc with signals carried on the cable. Signal leakage can cause a multitude of interference problems to off-air services.

The leakage rules, which were recently modified, provide only minimum requirements that the cable operator should meet. Operators that are providing new or expanded services are finding that they must develop a tighter monitoring program for signal leakage than is required by the Federal Communications Commission.

Best possible service

The new technologies coming into use in cable systems will force some operators to keep their system tight. Ask any chief tech who has had his system converted from a one-way to a two-way plant. He will tell you that any leakage out of the plant is nowhere near the problems caused by ingress into the plant on the upstream frequencies. With the advent of new uses of the cable plant such as security systems and data networks, reliability has become very important. Imagine what would happen to a 10 MBPS data signal covering a few MHz when an interfering carrier suddenly appears due to ingress. The error rate goes up, the reliability goes down and the complaints go up.

Since the cable industry has grown beyond thinking that subscribers are a bottomless pit, the concern has now shifted to how to keep what we have. Many systems have spent and will be spending a great deal of effort keeping up their cable plant to provide the subscriber with the best possible service. Service is the only item cable systems have to sell, it is the end product. Without good service the customer will be dissatisfied and disconnect thereby making the proverbial bottom line shrink.

Not all cable systems have received the message. A few system operators think preventive maintenance is an incurable disease and signal leakage monitoring is to be discussed only in hushed tones, hoping it will go away. One system manager didn't believe he had a leakage problem until he was shown his premium channel on a battery operated TV, while we were standing in the road near a large apartment complex. That demonstration was very convincing. After all, how can you sell service to people that are already getting it for free. (Note the direct effect on the bottom line here.)

'With the advent of new uses of the cable plant such as security systems and data networks, reliability has become very important'

FCC's position

Where does the FCC stand in all this? Looking back over rule makings that have come out in the last several years, the cable systems have received mixed reviews. In the rule making petition RM 4040 in which the American Radio Relay League (ARRL) petitioned the FCC to remove channels E and K from all cable systems, the commission stated:

> "The commission finds no justification in the record to preclude frequencies from CATV system operation. It is clearly the responsibility of the CATV system operator to solve such interference problems pursuant rule Sections 76.613(b), and 76.605. A continuous and vigilant maintenance program is required in order to minimize CATV interferences."
>
> "The commission strongly urges CATV system operators to implement sufficient measures to minimize signal leakage as specified in Section 76.605 and to resolve all interference problems in accordance with Section 76.613. In the absence of a diligent effort on the part of CATV operators, the commission will have no choice but to enforce the rules and levy fines for violations."

In Docket 21006, where the commission proposed the CLI, they stated:

> "Based on the record at this time, we are unable to conclude that cable operators can be relied upon to maintain their systems sufficiently free from signal leakage as not to create risks of harmful interference in the aeronautical radio frequency bands. Many have not adequately complied with either signal leakage standards or monitoring requirements."

In the final release of this docket where the FCC implemented the CLI, frequency offset and quarterly monitor requirements, it stated:

> "We considered allowing cable usage of non-emergency aeronautical radio frequencies without frequency offsets, cumulative leakage index (CLI) requirements or quarterly monitoring obligations. These rules are necessary, however, to ensure that cable systems do not cause harmful interference to aeronautical radio services. The uniform offsets, although temporary, are necessary under current conditions, whereas, the CLI as well as the monitoring obligations are long-term tools for minimizing CATV signal leakage in the aeronautical bands."

Doing our job

Quite a bit of furor was raised over the implementation of the cumulative leakage index. It may be a pain to use but the truth is, if cable systems were doing their job properly in controlling the leakage problems, then there wouldn't be leaks to cumulate.

The news for cable operators is not 100 percent bad though. In the recently proposed technical deregulation docket (85-38), the commission proposed to raise the leakage limit since it felt the limits may be too strict. This would not give open season for leakage since the harmful interference standards would apply but would apply a more lenient standard to the leakage limits in non-interference situations.

The commission is presently in a deregulatory mood but it is unable to go any further due to the poor performance of the cable systems. Any deregulation of the signal leakage in the future will be highly dependent on the performance of the cable operators with the rules in existence.

Some operators may tighten up their systems because it's good business, some will tighten up their systems because they have to in order to run the new technology signals, and a few may or may not care. The ball is in the cable systems court.

The views expressed are those of the author and do not necessarily reflect the views of the Federal Communications Commission.

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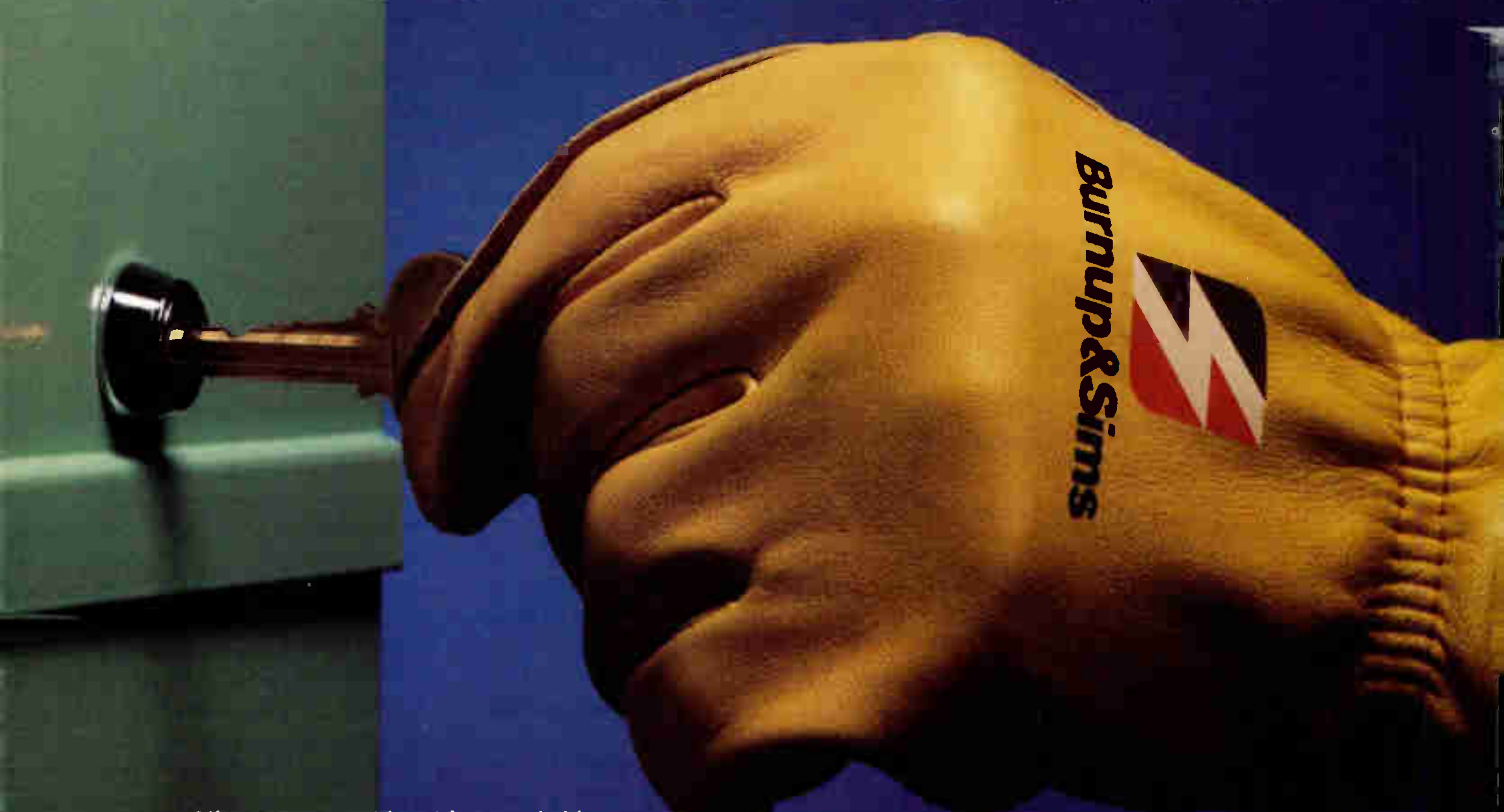

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Reader Service Number 12.

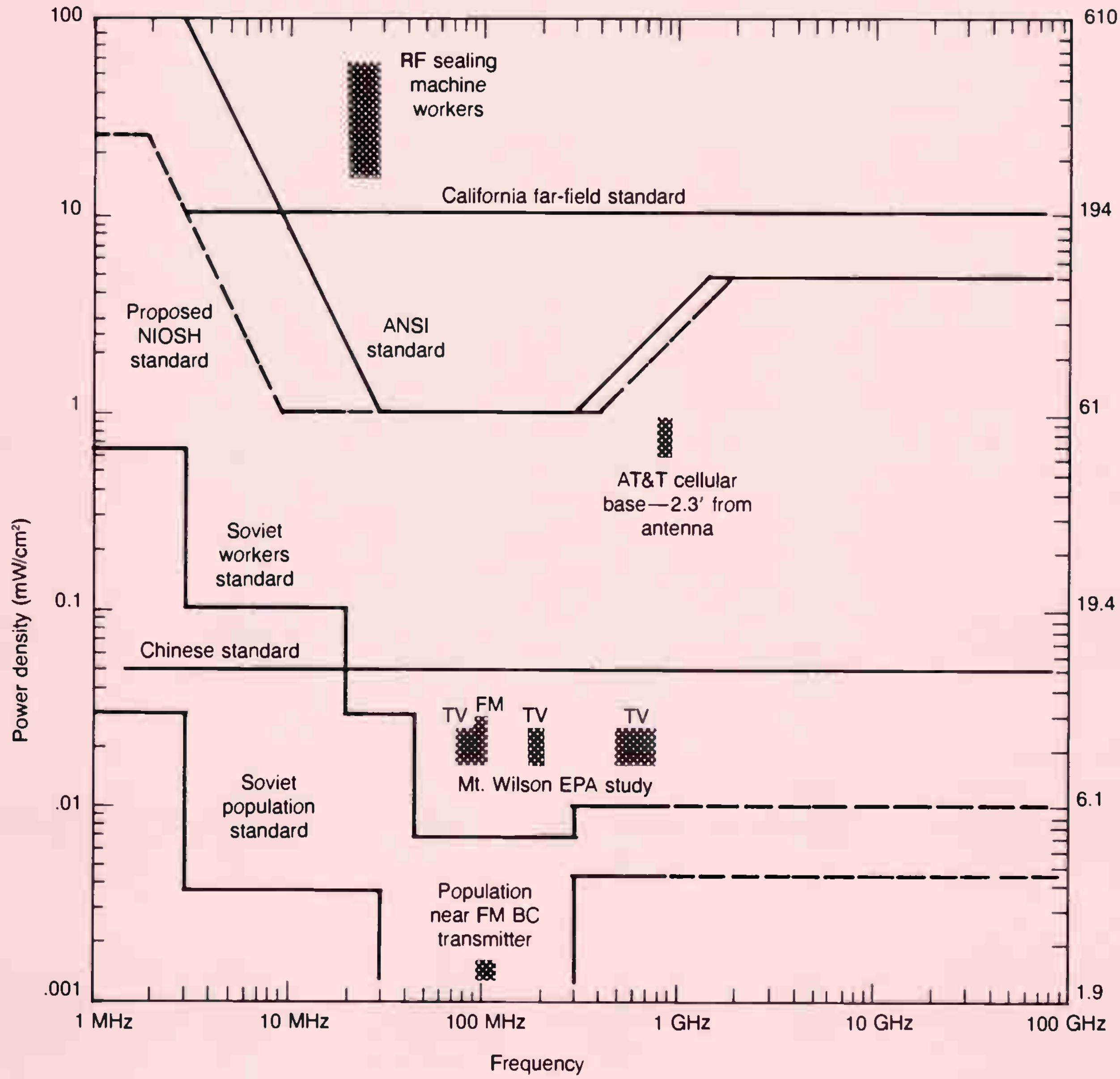
Complying with new leakage rules

This article focuses on Docket 21006, which is an amendment to Part 76 of the Federal Communications Commission's rules to add frequency channeling requirements and restrictions, and to require monitoring for signal leakage from cable television systems. The docket has been around the commission for a long time and has gone through many changes in order to reach the point where it was finally issued. It speaks of the problems of signal leakage in cable television plants, especially in the aeronautical frequencies.

By Ray Rohrer
Northwest Regional Engineering Manager, Group W Cable

In the early years of cable television, we all knew we had a closed-loop system, we could use any frequencies we chose, it wouldn't bother anyone else, and they wouldn't bother us. Even though we had some problems with amateur radio operators, we were certain we had a closed-loop system. Then came the Harrisburg incident. All of a sudden the Federal Aviation Administration told the FCC that it wanted the cable television industry to be prohibited from using any of the aeronautical frequencies for transporting services on cable systems. This generated a lot of activity throughout the industry, the FAA and the FCC. A lot of studies were made. Finally, after the first report and order, the commission chartered an Advisory Committee on Cable Signal Leakage to provide advice and conduct a

Figure 1: Radiation standards



study. On this committee were representatives of the FAA, the National Cable Television Association, the National Telecommunications and Information Administration, the cable television industry and private aviation interests, as well as the commission.

In November 1979, this committee issued its final report to the commission. After several different notices of proposed rule making by the commission, the second report and order was finally issued in November 1984. This second report and order generated a great deal of concem, and there were seven petitions filed for reconsideration of the report and order. The commission did consider all these petitions; it rejected some, agreed with some, and finally issued its memorandum of opinion and order on July 1, 1985, which terminated the proceedings in Docket 21006.

One thing has been changed that you will probably not see written comments on, but I believe is an important change for our industry. The rules previously talked about *radiation* from a cable television system. In this opinion and order, the current rules talk about basic signal *leakage* criteria. I think this is a very important point, and we need to get this vocabulary change set in our minds and use "leakage" or "ingress/egress," not "radiation." We do not want to have an association in people's minds between the likes of Three Mile Island or X-rays and leakage from cable systems. I think the importance of this vocabulary change was emphasized some time ago by an article headlined "Signal leakage spooks subs," which stated:

'The theory of the CLI was that with all the leaks combined you . . . would have one great big leak at some location over the cable system'

"Cable subscribers became concerned last week when they received letters from Cable TV notifying them that crews would be checking in that area for radiation leaks from the company's cables. The general manager said the company has been bombarded with calls from subscribers who took that to mean that cable was emitting dangerous radiation. One lady said her child had been sick for a couple of weeks and the doctors did not know what was causing it. She was sure it was radiation from cable TV."

Since the rules governing cable TV egress are way below the bottom of the radiation standards scale (Figure 1), which starts at 1.9 volts per meter[1], I suggest we also refer to emissions from cable TV systems as leakage not radiation.

Uniform frequency offset requirements

The uniform frequency offset requirement is a positive for our industry because if we did have a catastrophic leak we should still not interfere with aeronautical, navigation or communications. There have been some comments that the offsets and tolerances were not sufficient to prevent problems, but the commission agreed with the NCTA, and the FAA agreed, that the offsets were sufficient since the FAA would probably not be splitting its channels for some time to come.

Basically what this rule says is in the communications frequencies we will offset by 12.5 kHz because the assignments in the communications band (Table 1) are at every 25 kHz; so, if we offset by 12.5, we will be half way between any assigned frequency. Besides the offset, we have to maintain a frequency tolerance of ±5 kHz. And, in the aeronautical radionavigation band (Table 2), we have to be offset by 25 kHz, with a tolerance of ±5 kHz. (Twenty-five kHz here because the navigational frequencies are assigned in 50 kHz increments.) Navigational offsets actually only affect Channels A-2 and A-1 and Channel FF. This would seem to create some problems for HRC frequencies; however, the commission has determined that if the master oscillator is offset with a frequency of 6.0003 MHz and holds a tolerance of ±1 Hz that this would

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maintain enough separation to not create problems. There is no change in the emergency radio frequencies (Table 3). The special offsets remain and 121.5 MHz needs to be offset by 100 kHz; 156.8 and 243.0 need to be offset by 50 kHz. These, of course, affect Channels A, G and N. None of these with the standard offsets create any problem with the actual offset required on the emergency radio frequency.

So, the uniform frequency offset is a positive in that it gives a little added protection; however, it does create some problems for us in the industry. If you have looked at the technical specifications for your headend equipment you will notice that the best frequency tolerance specification we have had is ±8 kHz, with some as great as ±18 kHz.

Major manufacturers have come out with upgrades for their modulators to maintain the required ±5 kHz tolerance by the substitution of a crystal that is more precise. In many cases, however, this also requires an improvement in the climate control of your headend because the crystal tolerance is temperature dependent. We need to look at our climate control systems to be sure the necessary heating and cooling requirements are met. As far as processors are concerned, unless you are operating "on channel" or a phase lock processor, it is probably unlikely that you can maintain the tolerances required to stay within ±5 kHz. Generally, the current recommendation for off-air processed signals is either to put those channels on something other than the aeronautical bands, or go to a demod, remod, so you can have the stability on the modulator. This could become a significant expenditure for any system that has a number of processed signals, or older type modulators that cannot be upgraded to the required frequency tolerances on the aeronautical frequencies. Frequency checks will have to be made more often than the once a year.

Table 1: Uniform frequency offset requirements in the communications band

Frequencies in band:

118-136 MHz
225-328.6 MHz
335.4-400 MHz

Channels subject to 12.5 kHz offset (±5 kHz)

		Standard	**+12.5 kHz**	
14	A	121.250	121.2625	
15	B	127.250	127.2625	
16	C	133.250	133.2625	
25	L	229.250	229.2625	+5 229.2675 −5 229.2575
thru				
41	EE	325.250	325.2625	
43	GG	337.250	337.2625	
thru				
53	QQ	397.250	397.2625	+5 397.2675 −5 397.2575

HRC master oscillator 6.0003 MHz with a stability of ±1 Hz

Basic signal leakage criteria

The commission concluded that systems must show compliance with the basic signal leakage performance standards and that this is a prerequisite to operating in the aeronautical radio band. Cable systems must use either a ground-based or an air-based measurement to indicate compliance with the cumulative leakage index (CLI). The CLI has created a lot of controversy and comment for reconsideration. To perform either the aerial or ground-based measurement is quite a significant undertaking. The theory of the CLI was that with all the leaks combined you would have a cumulative effect and, consequently, would have one great big leak at some location over the cable system.

Studies were made by the Advisory Committee on this leakage index with some fly-over tests with a number of systems and also ground-based measurements. The two were correlated to develop a cumulative leakage index limit in both cases. It was determined that the fly-over would be at 450 meters and that you could not have a cumulative leakage level greater than 10 microvolts per meter. If you had 10 μV/m, or less, at 450 meters then you were in compliance. The fly-over creates somewhat of a problem in many areas where dozens of cable systems are interspersed with each other. If you do a fly-over and discover you do not meet the criteria, how do you determine which cable system is causing the problem, or is it an accumulation of all the cable systems?

The ground-based measurement requires that you cover at least 75 percent of your plant and that at least the areas that are susceptible to higher levels of leakage need to be in that 75 percent. The coverage has to be made as described in Section 76-609(h), or by means of another device that is calibrated in a realistic fashion against such dipole and field intensity. Section 76-609 measurements (h.3) reads as follows:

> "The resonant half-wave dipole antenna shall be placed three meters from and positioned directly below the system components and at three meters above ground. Where such placement results in a separation of less than three meters between the center of the dipole antenna and the system component, or less than three meters between the dipole and ground level, the dipole shall be repositioned to provide a separation of three meters from the system components at a height of three meters or more above ground."

So, the rules are very specific about how the measurements are to be made. After the measurements are made and recorded, it then requires some rather significant calculations to determine whether or not you are in compliance with the CLI of 64. We'll do a scenario of two systems—a smaller system with 200 miles of plant and a larger system with 1,200 miles of plant (Table 4). If we assume an average of one leak per mile, and we have to cover 75 percent of each plant, that means the small system will have 150 miles covered and the larger system will have 900 miles covered. Likewise, the smaller system will have 150 leaks and the larger system will have 900 leaks. Let's assume two-thirds of those leaks will be at 50 μV/m, 23 percent of them will be at 100 μV/m, 8 percent at 150 μV/m and 2 percent at 200 μV/m. If we sum the squares of each of the leaks and multiply the sum by the ratio of plant miles divided by the plant miles driven, and then convert that to dB by taking 10 times the log of that, we end up with a CLI of 61.19 for the small system. If we do the same thing for the large system that has 900 leaks then we'd have 600 at 50 μV/m, 210 at 100 μV/m, 72 at 150 μV/m and 18 at 200 μV/m; we sum the squares of each one of those leaks, multiply it by the ratio of the plant miles divided by the plant miles driven, and then convert it to dB by taking 10 times the log, we get a 68.98 CLI, which exceeds the FCC's CLI limit of 64. The larger system with the same leaks, in relation to the smaller system, is not in compliance. The larger system would need to reduce its leaks to one in four miles. By doing so, even

with the same ratio of leakage levels, a CLI of 63 would be achieved and the system would then be in compliance (Table 5).

We have spent quite a lot of time concentrating on the CLI, which may seem like somewhat of a waste, seeing how it has been postponed for five years and the annual CLI will not be required until July 1, 1990. However, I think we need to know exactly what the CLI involves and how important it is to prove to the commission that the CLI will not be required. *If*, in this five-year grace period, we maintain our systems and keep the leakage level to the barest minimum we possibly can, we will have convinced the FCC that the CLI testing is, in fact, not needed. If we do not maintain our systems and keep the leakage levels to the barest minimum, we will be required to do an annual CLI.

Table 2: Uniform frequency offset requirements in the aeronautical radionavigation band

Frequencies in band

108-118 MHz
328.6-335.4 MHz

Channels subject to 25 kHz offset ±5 kHz

Channel		Standard	Offset	
60	A-2	109.250	109.275	+5 109.280 −5 109.270
61	A-1	115.250	115.275	+5 115.280 −5 109.270
42	FF	331.250	331.275	+5 332.280 −5 332.270

Monitoring requirements

In the second report and order there were monitoring requirements requiring that the cable television system cover all portions of the system at least once every three months for signal leakage monitoring. This monitoring would be adequate to detect cable leakage of 20 μV/m at three meters. There were many comments objecting to the requirements of the CLI once a year and then monitoring every three months throughout the year as being more duplication than what is needed and with the offsets this would be superfluous. The commission did reconsider this and made a few important editorial changes in the language in 76-614 changing the regular monitoring from *covering all portions of the system* at least once every three months to *substantially covering the plant every three months*. Also in the comments the FCC stated specifically "*such monitoring can be done by service personnel while conducting service calls, installations, etc*. The only extra effort on the part of the cable operators comes when leaks are found and must be repaired."

If we have all of our vehicles equipped with monitoring receivers that we know have the sensitivity to detect 20 μV/m at three meters; if we provide logs for all of the vehicles and we log and repair the leaks as they are found, then we will be in compliance with the quarterly monitoring requirement. In order to be certain that we are able to detect 20 μV/m at three meters, we will have to have a routine calibration procedure for all of the monitoring receivers we are using in the field. This can be accomplished by establishing a calibrated leak, probably in the vicinity of the parking lot where trucks come on a daily basis, with the leak being established at 20 μV/m at three meters, then paint a line in the parking lot at a distance equivalent to the distance to the back yard easements of the average distance that vehicles will be driving from the cable. If the vehicle receiver does not break squelch at that point, it is not sensitive enough to detect 20 μV/m at three meters for the backyard easements.

Grandfathering was established as of Nov. 30, 1984, and states that any frequencies you are presently authorized to carry in the aeronautical bands will be grandfathered for five years. Grandfathering refers both to frequencies and system size. Frequencies that have been authorized to operate at greater than 10^{-5} watts, but have not been activated, may be activated anytime within the next five years without any prior notification. Any new frequency to be added that has not had prior authorization from the FCC that will be operated at greater than 10^{-4} watts must meet the offset requirements, tolerance and have authorization from the FCC prior to initiating that frequency. The commission will allow all existing aeronautical frequencies that have been approved to continue to operate for the five years, along with new frequencies that do meet the offset requirements. However, should a conflict arise, that is, the FAA assigns a new frequency that develops a conflict on the frequencies that you are using, you would be required to either go to the precise frequency offset of the new rules, request a waiver to continue using that frequency, or reduce power to less than 10^{-4} watts. If you do change to the precise offset, the remainder of the frequencies that are authorized can continue to be used.

The authorization and use of any new frequency, of course, will invoke all the requirements of the new rules for that particular frequency, which would include the offset requirements, the tolerance, the quarterly monitoring and annual reporting. The commission also decided that it would consider expanding your service radii with the existing frequencies. If the system wishes to expand their radius, it can request authorization from the FCC for the frequencies that will be used. If the commission finds that there are no conflicts in the extended service area, it will authorize the use of the grandfathered frequencies in the extended service area. One note about the service area that each system should check very carefully: when frequencies were requested from the FCC, the system radius was stated in miles to the north, south, east and west from the coordinates given. The commission, when they authorized the frequencies from those coordinates, established a system radius. This, hopefully, was the radius from the longest distance from the coordinates. However, in some instances they strictly took the miles to the north and used that as the system radius. If that was the longest

Table 3: Offsets for emergency radio frequencies

Frequency	Offset required
121.5 MHz	100 kHz
156.8 MHz	50 kHz
243.0 MHz	50 kHz

Channel	Frequency	Actual offset
14 A	121.2625	237.5 kHz
20 G	157.2625	462.5 kHz
27 N	241.2625	1.7375 MHz

mileage, you are okay. If however, it was not the longest mileage your system may now be out of compliance with the system radius.

Cable signal threshold power levels

Under the old rules the aeronautical restrictions applied from 10^{-5} peak watts, which required the notification/authorization prior to the use of any frequencies. The second report and order reduced that to 10^{-4} watts in a 25 kHz bandwidth. In the reconsideration, this was changed to 10^{-4} watts average power, rather than peak power. Specificially, the new rules state: "10^{-4} watts with an average power level across a 25 kHz bandwidth in an 160 microsecond period."

The 10^{-4}, or 38.75 dBmV, was necessary in order for the precise frequency offsets to work. At 38.75 dBmV the sound carriers are no longer a consideration. A very important point is, with the 25 kHz bandwidth in a 160 microsecond period, we can now legally operate our sweeps. While the peak power is above the threshold, the average power would be significantly below that. Another very important point is the measurement of the power levels for notification purposes on the coaxial distribution system as opposed to the internal levels in the amplifier, headend equipment, etc. Therefore, the amplitude of the signals in the bridger unit itself is not the trigger, but the actual levels of the signal going into the coaxial line. In other words, if there is a four-way distribution, you gain 7 dB on the threshold requirements.

Notification requirements

As cable operators, we need to notify the commission annually of all signals carried and before we use any frequencies in the aeronautical band that are going to operate at greater than 10^{-4} watts. Notifications are very specific. They are:

1) Legal name and local address of the cable television operator.

2) The names and FCC identifiers of the system communities affected.

3) The names and telephone numbers of local officials who are responsible for compliance of Section 76.610 through 76.616 of the rules.

4) Carrier and subcarrier frequencies and tolerances, types of modulation and the maximum average power levels of all carriers and subcarriers occurring at any location in the cable distribution system.

5) The geographical coordinates of a point near the center of the cable system, together with the distances in kilometers from the designated point to the most remote point in the cable plant, existing or planned, which defines a circle enclosing the entire cable plant.

6) A description of the routine monitoring procedures to be used.

7) Results of the CLI and how the CLI was derived—by ground-based measurements or air space measurements—and methods used to calibrate the measuring equipment.

Item 7 needs to be provided to the commission prior to July 1, 1990, and each calendar year thereafter.

Table 4: Cumulative leakage index calculations

Federal CLI limit = 10 log I oo ≤ 64

Two systems each with one leak per mile

Small system: 200 miles plant—75 percent monitored = 150 miles
Large system: 1,200 miles plant—75 percent monitored = 900 miles

66.67 percent leaks at 50 μV/m
23.3 percent leaks at 100 μV/m
8 percent leaks at 150 μV/m
2 percent leaks at 200 μV/m

Small system:	150 leaks	100 @ 50 μV/m
		35 @ 100 μV/m
		12 @ 150 μV/m
		3 @ 200 μV/m

CLI = 10 log (990000 x 1.33) = 61.19

Large system:	900 leaks	600 @ 50 μV/m
		210 @ 100 μV/m
		72 @ 150 μV/m
		18 @ 200 μV/m

CLI = 10 log (5940000 x 1.33) = 68.98

Table 5: Large system with one leak per four miles

1,200 mile plant—75 percent monitored = 900 miles

66.67 percent leaks at 50 μV/m
23.3 percent leaks at 100 μV/m
8 percent leaks at 150 μV/m
2 percent leaks at 200 μV/m

225 leaks
150 @ 50 μV/m
52 @ 100 μV/m
18 @ 150 μV/m
5 @ 200 μV/m

CLI = 10 log (1500000 x 1.33) = 63

Leakage limits

Section 76.605(a)(12) of the rules limits signal leakage to 20 μV/m in the frequencies of 54 to 216 MHz. The second report lists 50 μV/m for doing a ground-based CLI, while 100 μV/m was suggested in the Advisory Committee's final report. Computers are allowed from 30 to 70 μV/m (depending upon the operational frequency) at 30 meters and TV sets are allowed from 150 to 500 microvolts per meter (also depending upon the frequency used). There is a wide variation in leakage limits, and the commission is considering this in a special rulemaking, Docket 85-38.

All indications are that the leakage limits should be raised significantly and that significantly higher leakage levels could be allowed and still not affect the air space or navigational or communications bands, especially with the offsets. The commission is cognizant of other considerations such as those of the American Radio Relay League (ARRL), which would like to see the limits actually reduced because they do operate in a close proximity to the cable services. But, with the new docket, the comission may very possibly raise the limits for leakage while maintaining, or expanding, the harmful interference as designated in 76.613.

If the commission raises the limits to 50 μV/m, this would seem as if it's doing the cable industry a favor, however, in order to have the finest quality transmission of our signals, we must control signal leakage, keeping it at the lowest level possible. If we control our leakage, we will be able to provide a better quality of picture and have fewer service calls, as many of the causes for service calls are found prior to affecting the customer through signal leakage programs. And after all, providing the best quality pictures without interruptions to customers should be our primary goal. ■

Reference

'Charles McMorrow, *Communications News*.

Data communications and ingress

By Thomas J. Jordan
RF Consultant, Allied Data Communications Group Inc

With the widespread use of broadband in local area networks and the expected move of CATV into providing data communications services, system engineers must familiarize themselves with the behavior of data carriers on coaxial cable. No longer can we visually observe interference of a signal with only a television set. The occurrence and severity of signal interference can be minimized by judicious frequency planning and an agressive network certification and maintenance plan.

Among the many types of radio frequency interference, signal ingress can be a particular problem on a data network. Typical ingress signals are off-the-air broadcast, citizens band, amateur radio, and sky-wave reception of foreign broadcasts. While it may only be annoying in video transmission, unwanted signals entering the cable network can cause serious impairment of data transmission.

The advantage of working with video transmissions is that when interference occurs, the symptom is readily observable and an immediate diagnosis can be made. For example, "snow" seen in a picture is easily attributable to excessive noise in the channel bandwidth in relation to the video carrier level. It follows that a check will be made of the carrier level and the noise level. The fault may take time to isolate, although the diagnosis has been made quickly. A similar argument can be made for video transmission impairments such as co-channel interference and other common distortions of which the effects are "visually" observable.

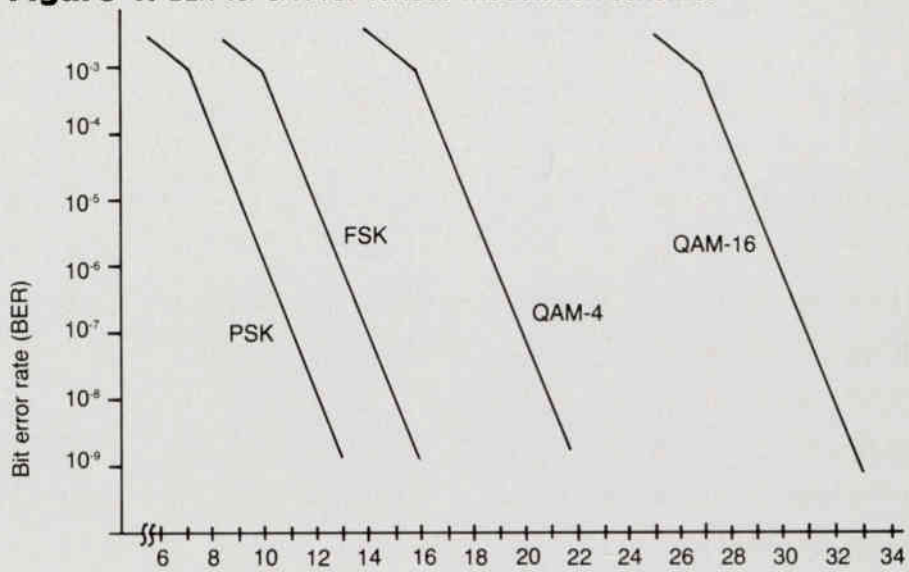
In working with RF data communications an unsatisfactory transmission can only be observed indirectly as data errors, intermittent operation of a data link, or by inordinately high retransmissions of the data. The diagnosis of the cause is not readily evident and a step-by-step examination of the possible causes can be expected before one is isolated. Knowing the behavior of data carriers on a broadband system and how they are affected by interference can make this troubleshooting much easier.

Performance

The quality of a data link is expressed by the bit error rate (BER). This is the maximum number of data bit errors in relation to the total number of bits received. RF modem manufacturers specify the expected BER as a function of the system carrier-to-noise ratio (C/N). This does not necessarily mean that the modem will not work with a C/N worse than that specified. Indeed, it simply means that there will be more bit errors expected over the link.

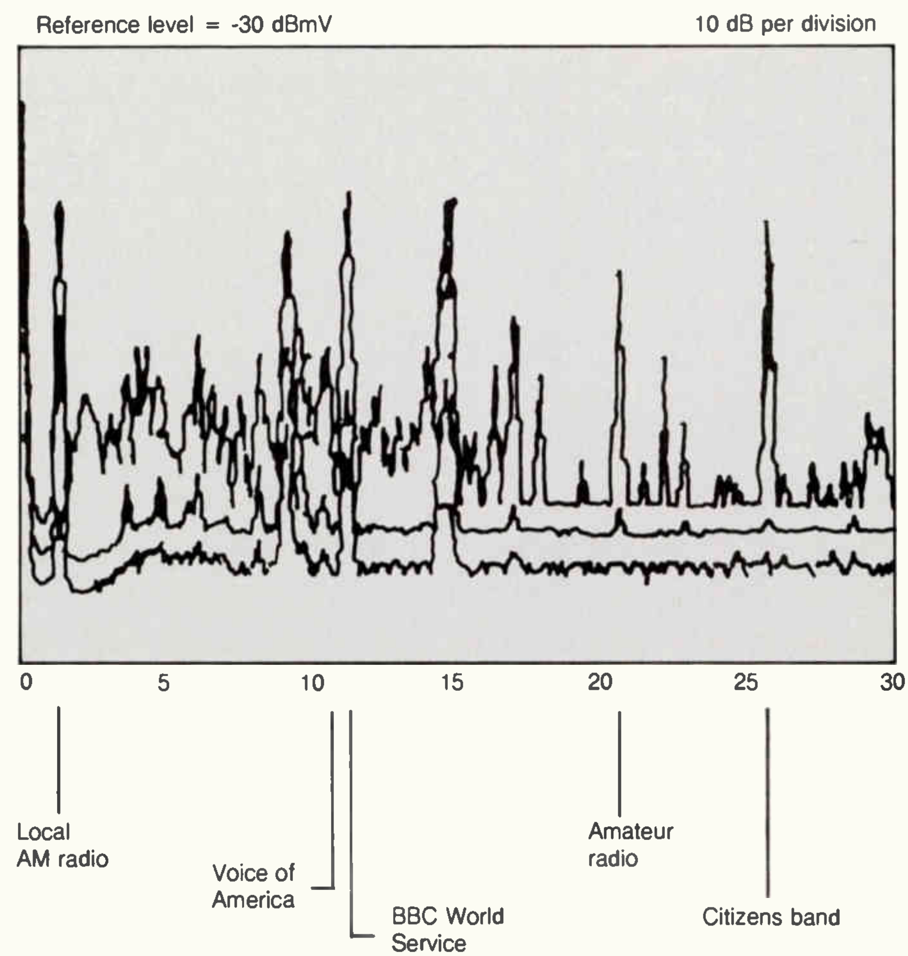
Typical performance characteristics for four types of modulation schemes are shown in Figure 1. Note that the higher level schemes require a better system C/N for the same BER specification. Also, higher data rates using the

Figure 1: BER vs. C/N for various modulation schemes



(Note: The performance also depends upon data rate.)

Figure 2: Example of signal ingress levels measured at the headend



Portrait Of Madame A.F. Aude And Her Two Daughters, 1899 — Mary Cassatt same modulation format as a lower data rate would require a higher C/N.

While the BER vs. C/N specification is not the only performance parameter of an RF data link, it is perhaps the most important. It is imperative, therefore, that a system engineer pay particular attention to not only the noise generated in the system but also to interference levels due to signal ingress in the frequency band of data carriers.

Unless properly implemented, data carriers can be subject to extreme interference from extraneous signals that might only slightly impair the quality of a picture carrier. Data carriers are narrowband signals, there may be as many as 60 carriers in a 6 MHz video channel bandwidth. These carriers will be derated from the video carrier level to conserve the total power in the bandwidth. It is typical to set data carrier levels below the normal video carrier level using the equation of 10 log N, where N equals the number of data channels in a 6 MHz bandwidth. Thus, the data carrier level will be closer to any extraneous signals on the system than the video carrier levels.

The ratio of the carrier to the noise is important in the link performance as is the absolute level of the noise or interference. Signal ingress that is of sufficient level may be within the sensitivity range of the detection circuits of the modem receiver. This results in the modem "thinking" that a data carrier is present and it attempts to receive the signal ingress as incoming data. Such phantom data transmissions are often interpreted incorrectly as a carrier-to-noise problem.

In understanding the effect that extraneous signals have on a data carrier, it is important to become familiar with those frequencies where signal ingress can occur. Typically, the frequencies at which data carrier performance is affected are the same ones at which CATV picture or audio quality is impaired. A look at a frequency allocation chart of the broadband coaxial spectrum will provide the clues.

Traditional thinking tells us that signal ingress will typically exhibit itself in the sub-VHF band below 30 MHz. The shortwave, ham and, notably, the citizens band services in this area of the spectrum can wreak havoc on coaxial cable systems. The severity of interference of course depends upon the proximity of the transmitter to the system, the transmitter power and the amount of signal leaking onto the cable. Figure 2 shows an example of reverse path signal ingress levels measured at the headend of a sub-split network.

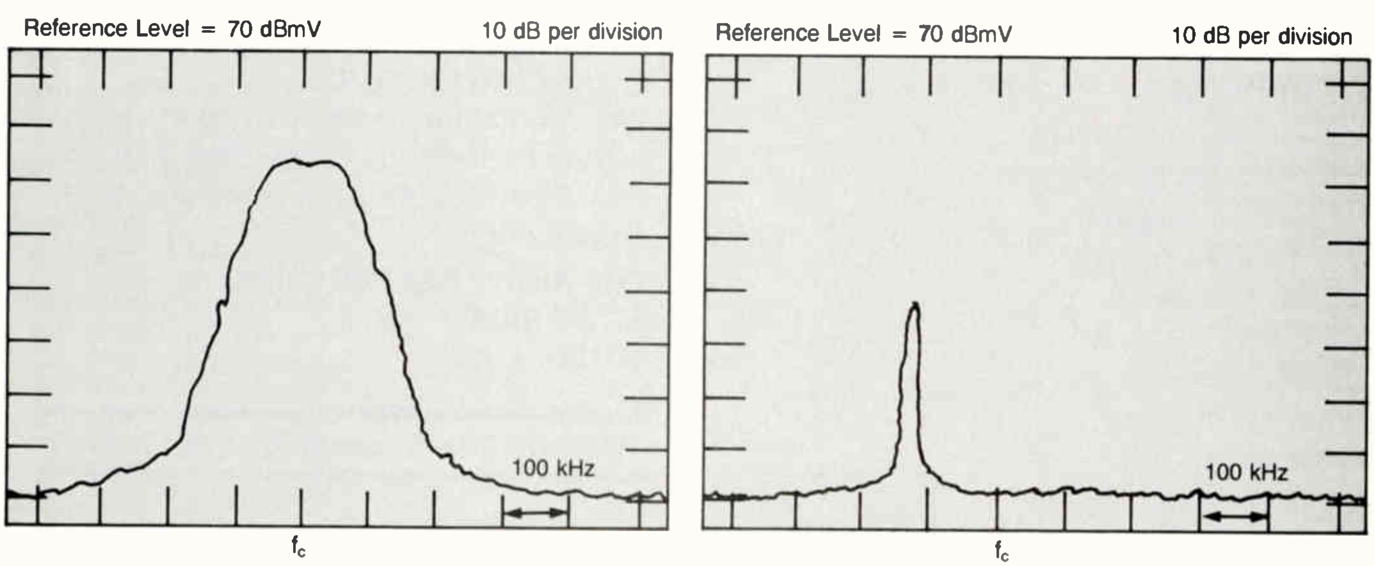
Unlike entertainment systems, broadband data networks will be of the mid- or high-split variety. This means that VHF television Channels 2-6 fall within the reverse bandpass of the system. If one of these channels has a strong off-air transmitter in the vicinity of the cable network there may be significant ingress of the off-air signal onto the system. These undesired off-air carriers cannot be identified by simple observation of a "ghost" in a television picture. It will, though, impair data transfer by causing bit errors.

Determining the cause of signal ingress and eliminating it can be a tedious process. Unlike an entertainment system where most transmission is one-way, data signals will operate in both the forward and reverse frequency spectra of a network. That is, to send information from one location to another the signal is first sent upstream to the headend and there it is changed in frequency for rebroadcast on the forward path of the system. This frequency conversion can actually disguise the true frequency at which the interference is introduced into the system. An explanation of this is in order.

Most translation is performed on a 6 MHz channel bandwidth. The signals in the incoming reverse path (data carriers as well as all noise) are frequency converted and amplified to another 6 MHz channel in the forward path.

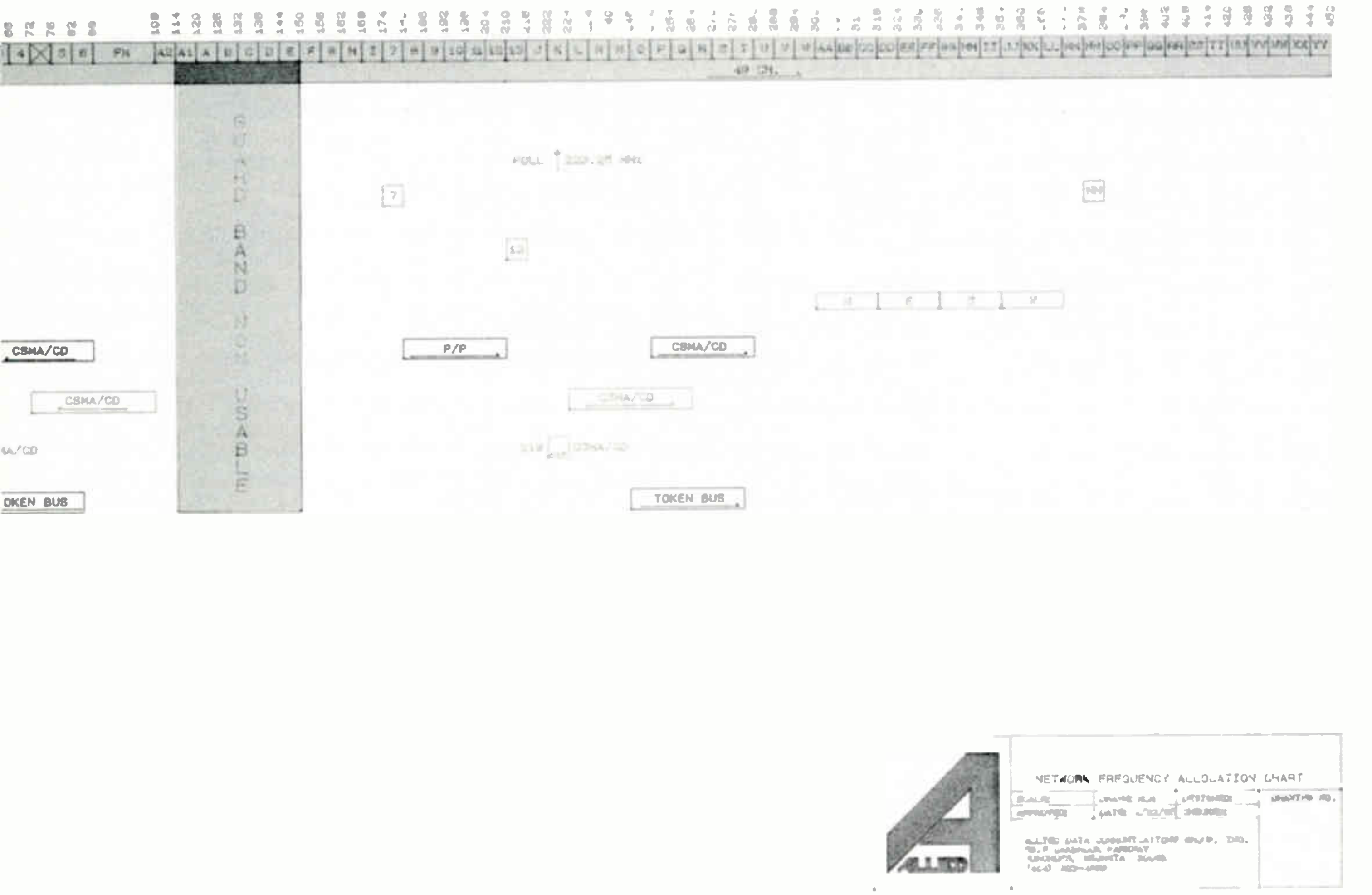
Figure 4: Network frequency

Figure 3: A masked interfering carrier



Modem transmit signal with interfering carrier on left skirt. **Interfering carrier only with modem carrier off.**

allocation chart illustrating the potential services to be implemented



Examining the forward cable spectrum for ingress may reveal the presence of a number of extraneous carriers. These signals may be generated at the forward frequency, but more likely, they are simply the translated result of reverse path ingress signals. This difficulty in troubleshooting is generally due to limitations of the test equipment. Because of the amplification of the translator, these signals that appear to be sitting in the noise floor of the reverse path are making themselves known in the forward bandpass.

A form of ingress interference not typically observed with video signals is a behavior that might be called masking. This occurs with a high data rate carrier that occupies more than a couple of hundred kilohertz of bandwidth. The modulation of the carrier actually hides, or masks, an interfering carrier located within the modulation bandwidth. An example of this is shown in Figure 3. A casual observation with a spectrum analyzer would not immediately reveal the interfering signal. Since most modulated data signals are symmetrical about the carrier frequency, an experienced engineer might observe the blemish on one skirt of the wave form. To isolate the interfering carrier would require that the data transmitter be turned off leaving only the extraneous signal.

Prevention

Much of the ingress interference with RF data transmission is similar to that found with traditional video transmission. The effects are simply more subtle and difficult to diagnose. Before implementing a broadband data communication link, it is wise to plan a deliberate allocation of the cable frequencies. Figure 4 shows one way of allocating the system frequencies. Note that in this system the four lowest reverse channels, where much of the ingress can occur, has been allocated to video teleconferencing rather than data. Since they are operating with higher carrier levels the video channels will be more immune to the interference.

While most vendors' modems operate at only one frequency some can operate anywhere the operator desires. These frequency agile modems allow the data carrier frequency to be selected so as to avoid areas where ingress interference is significant. In addition, they can fill in the gaps around fixed frequency services. This type of planning limits the potential for ingress to affect link performance. Of course, some services must operate at specific channel frequencies. This is the case, for example, with IEEE 802.4 networks. The operating channels are fixed at specific frequencies and do not offer the luxury of frequency agility. Therefore other precautions must be taken for implementing these networks.

Separate from frequency allocation planning, the physical integrity of the cable plant is the most important factor in controlling signal ingress. While this is especially true in outside plant, it is relevant to intra-building distribution as well. Some of the major reasons for failure of a system's shielding integrity are described in the following paragraphs.

Drop cables typically account for the majority of the cable installed in any broadband system. By design they do not provide the protection that solid aluminum sheath hardline cables do. In a one-way entertainment system

'Unless properly implemented, data carriers can be subject to extreme interference from extraneous signals that might only slightly impair the quality of a picture carrier'

this limited isolation to signal ingress/egress generally is not a significant factor. In data networks, though, high isolation drop cable having a broad coverage of 98 percent is deemed necessary for efficient signal transmission. Also, to limit the potential for signal ingress the length of each drop cable should be as short as practical.

Trunk and distribution cables provide extremely high isolation to signal ingress since the outer conductor is a solid aluminum sheath. Points where signal ingress can occur are the connectors, which couple the cable to active or passive components. It is imperative that the manufacturer's recommended installation practices are followed closely to form a tight electrical connection between the cable and all components. Pin-type connectors are recommended to provide improved performance over temperature variations and with system aging. At regularly scheduled time intervals a check should be made to verify the integrity of all connections.

Trunk, distribution or drop connections are the primary failure points of shielding integrity. This can be due to either poor workmanship or the use of poor quality connectors, or both. Improperly fitted connectors will, over time, expose the network to signal ingress and egress. Connectors with integral sleeves will maintain good, long-term shielding efficiency. F-type connectors should have a long ferrule and integral crimp ring to minimize the potential for signal ingress.

It is interesting to note that reverse path ingress through a connector at the reverse input port of an amplifier will be worse than if it occurred at the connector at the reverse output port. In its transmission to the headend the signal will first be amplified by the reverse amplifier and thus, be higher in level than the signal entering through the reverse output connector. Neither situation, though, is acceptable.

Determining the location where signal ingress is occuring can rapidly consume a technician's time. An easier method for identifying points of signal ingress is by checking for RF signal egress. Often, the places where network signals are leaking from the cable are the same places where extraneous signals are entering the system.

Radiated emissions are something that all broadband network operators must be concerned with. The FCC has established limits for the amount of allowable emissions that can occur in a system. Using a cable Sniffer or tuned dipole will identify quite accurately the connector or cable that is leaking excessive amounts of network signals. Measures taken to reduce the amount of signal leakage will likely minimize signal ingress as well. Periodic testing for signal leakage is required by the FCC to guarantee that a broadband network is within the acceptable parameters.

Many other practices that are taken for granted in an entertainment system can mean the difference between satisfied data network customers and a money losing experiment. This includes the proper seating and tightening of amplifier and passive device housings, the termination of unused tap ports and wall outlets, and proper equipment grounding.

The effects signal ingress can have on data transmissions are subtle and difficult to isolate to a specific cause. Adherence to the technical standards expected in the industry can result in the "tight" system desired and necessary for efficient data communications networks. Coupled with the proper planning and a knowledgeable technical staff, these measures will ensure the satisfactory implementation of broadband data services.

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Reader Service Number 22.

The 'how to' of CLI, our experiences

By R. J. Davidson
Division Engineer, United Artists Cablesystems

The situation: We had 900 miles of CATV plant built between 1969 and 1972, which currently serves 50,000 subscribers. Sniffers are operational in all field technician vehicles. The beginning cumulative leak index (CLI) was averaging 75 throughout the system. Requests for repair of radio frequency interference (RFI) leaks were averaging 35 locations per day, and it was apparent that this system would not be able to comply with FCC Docket 21006.

Seeking a solution

Corporate policy at UA requires that all measurable leaks must be used when calculating the CLI, as opposed to the FCC's method, which requires the use of only those leaks 50 µV/m and above. The difference in the resulting corporate CLI is slightly more critical and ensures system compliance with Docket 21006.

We are desirous of attaining compliance in the shortest period of time, at the least total cost and in such a manner that we would be able to continue to comply with 21006 during the years that followed. Our efforts resulted in three methods of resolving the RFI problems before we established our current procedures.

We initially undertook the analysis of a small isolated area, to determine the true workload that was ahead of us. The results of this evaluation of two miles of plant, which had 50 drops, were:

Results	Number of drops	Percentages
Illegal tampering	1	2
Drop replaced	2	4
Bad F-connector in home	2	4
Bad F-connector at ground block	11	22
Bad F-connector at tap	17	34
Loose F-connector	9	18
No work required	8	16

From this data we formed method I. We concluded that 90 percent (d, e, f and g) of the RFI could be eliminated if we: installed a new integral sleeved F-connector, hex crimped at the tap and ground block of each active drop; wrench tightened each new F-connector; cleaned and wrench tightened all tap spigot F-terminators; checked each completed job for any remaining RFI with a Sniffer or equivalent; and wrote up any additional leaks for system technician follow-up. Since this seemed to be a rather straightforward, we chose to subcontract the task.

The workload of verifying subcontractor invoicing and tracking areas completed or missed, not to mention the continued failure of the upgraded areas to attain a reliably reduced CLI, caused us to reevaluate our decision.

After considering all aspects of the first method it became obvious that it would be just as viable (and potentially produce higher quality workmanship) to establish and equip our own RFI team. This team would start at a point (hub or headend), pick a trunk, and proceed through the system, performing whatever task was required to eliminate the leaks. Very accurate field data was accumulated on this effort. Here is a summary:

Total poles passed	3,054
Total poles reworked	738
Total time required to rework (minutes)	11,548
Average quantity of poles cleared/day	57.6
Average quantity of poles reworked/day	13.9
Percent of poles requiring work	24.2
Average time to rework a pole (min.)	15.6
Number of days worked	53
Elapsed calendar days	128
Average cost per mile, total	$218
Material	$57
Labor and vehicle (2 man crew)	$161
Average miles completed/day worked	1.44
Average miles completed/calendar day	0.6
Once through the system completion date	March '89
Percent of work requiring a tech	26.8
Percent of work requiring an installer	73.2

'We were desirous of attaining compliance ... at the least total cost and ... be able to continue to comply with 21006 during the years that followed'

We established a 10-mile test area, which we drove weekly to determine a MTBF (mean time between failure). The first drive through found 49 measurable leaks (see Table 1). The leaks above 20 µV/m were repaired. The second drive through found 26 measurable leaks (see Table 2), again all above 20 µV/m were repaired. The third drive through found 23 measurable leaks (see Table 3), and the fourth found 19 (see Table 4).

After reviewing the results of the second method, we became rudely aware of several facts: that we would not get through the system even *once*, until March 1989; that the cost per mile was extremely high; and that it appeared that we had to go through the system a minimum of two times and possibly three times before the leaks were controlled at or near 20 µV/m. We therefore developed the following

(Continued on page 53.)

Table 1

Hub	Test area
Date	9/16/85
Total hub mileage	39.7
Miles driven	10.3
Number of RFI leaks written	39
Percent of hub sampled	7.2
Number of readings made	49
Maximum radiation level	329
Average radiation level	49.92
Minimum radiation level	12
Readings per mile	4.757
RFI leaks per mile	3.786
Number of leaks ≤20 µV/m	10
Number of leaks from 21-29 µV/m	17
Number of leaks from 30-42 µV/m	6
Number of leaks from 43-59 µV/m	7
Number of leaks from 60-83 µV/m	2
Number of leaks from 84-117 µV/m	4
Number of leaks >118 µV/m	3
Cumulative leak index	65.91

Table 2

Hub	Test area
Date	9/23/85
Total hub mileage	39.7
Miles driven	10.3
Number of RFI leaks written	5
Percent of hub sampled	7.2
Number of readings made	26
Maximum radiation level	83
Average radiation level	18.39
Minimum radiation level	5
Readings per mile	2.524
RFI leaks per mile	0.485
Number of leaks ≤20 µV/m	21
Number of leaks from 21-29 µV/m	2
Number of leaks from 30-42 µV/m	0
Number of leaks from 43-59 µV/m	2
Number of leaks from 60-83 µV/m	1
Number of leaks from 84-117 µV/m	0
Number of leaks >118 µV/m	0
Cumulative leak index	48.2

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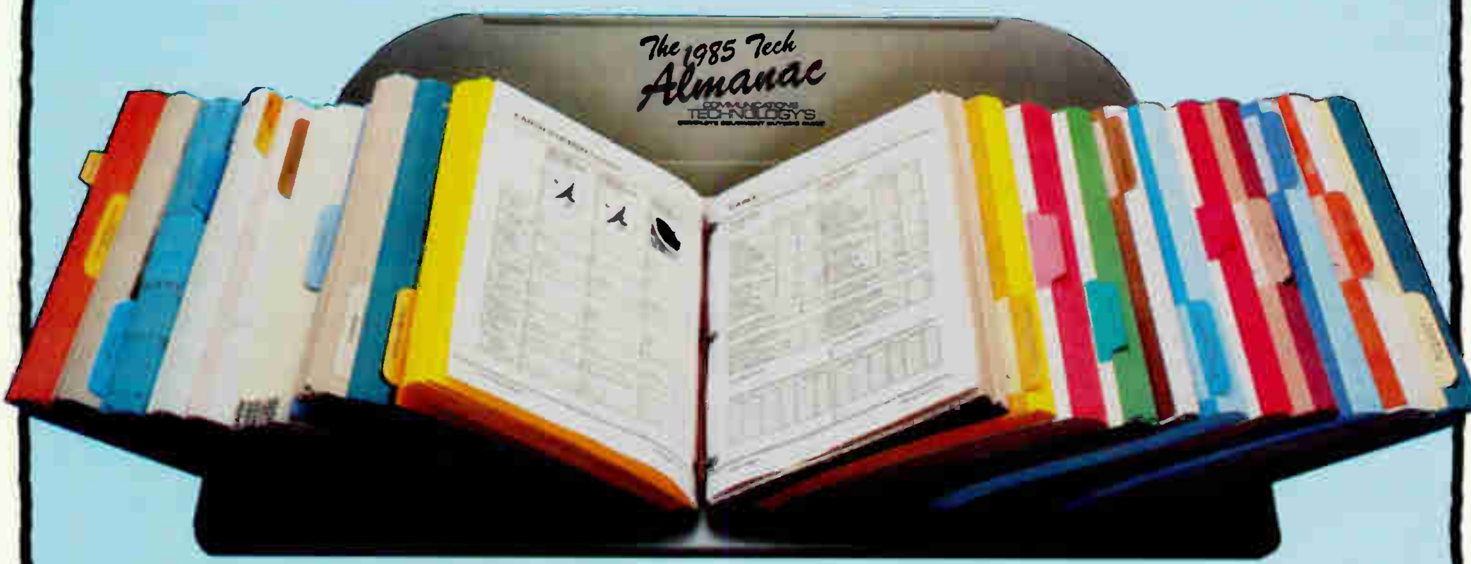

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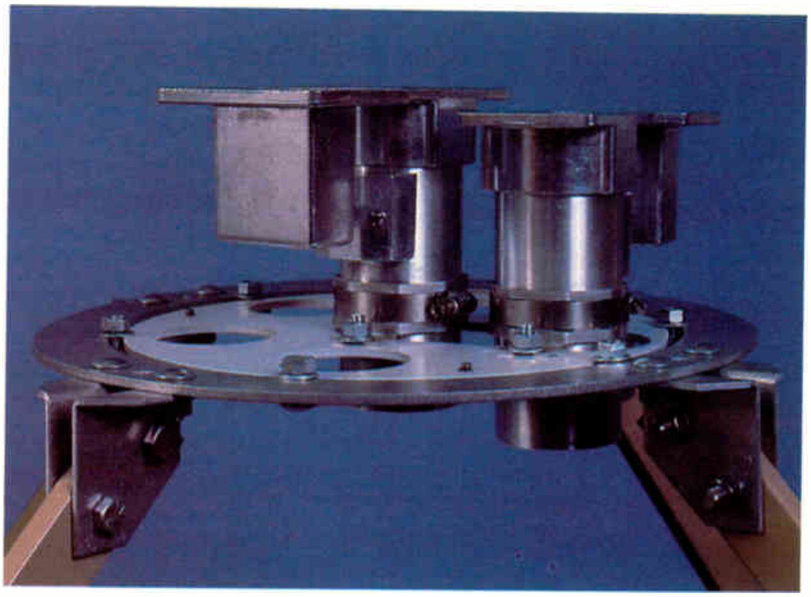

TYPICAL INSTALLATIONS

Scientific Atlanta	4.6m
Scientific Atlanta	3.65m
Scientific Atlanta	3.2m
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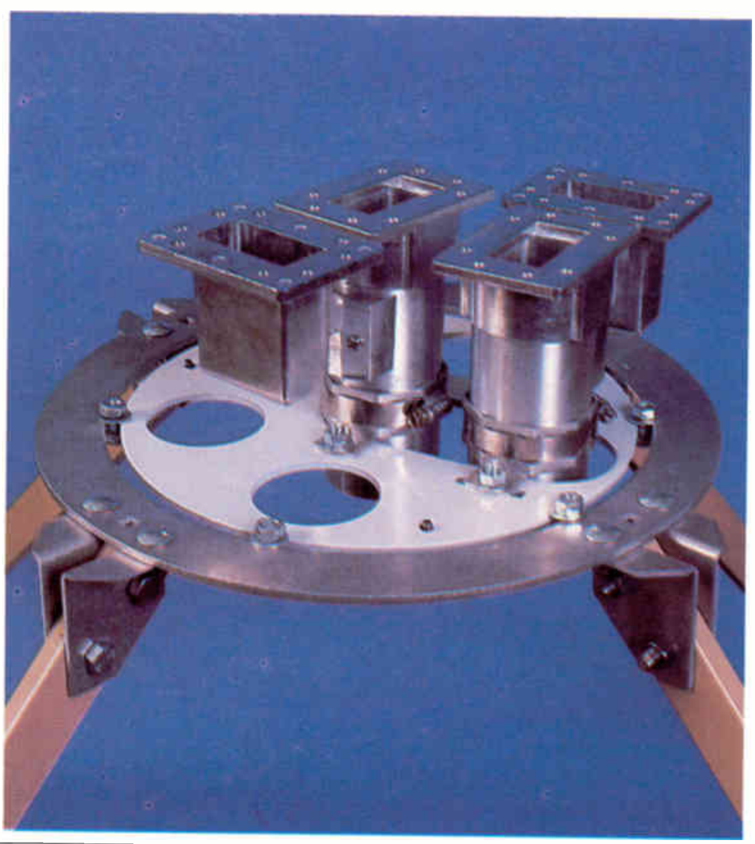
(and many more)



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Reader Service Number 25.

(Continued from page 36.)

procedure (method III), which we implemented in October 1985:

Current Procedure

Utilize a test setup as shown in Figure 1. This set-up will detect all leaks and focus the repair effort on those leaks greater than 83 μV/m. The field procedure is:

1) Select the calibrate mode (CAL) on the Sniffer. Adjust the gain control to center the meter indication at the CAL mark on the dial.

2) Position the vehicle under a calibrated 20 μV/m leak. Set the Sniffer to the normal mode (NORM), A/B switch(es) in the A position(s). The meter indication should be at the CAL mark on the dial. If the indication is greater or less than the CAL mark, verify the indication with the system engineer.

3) After calibration leave the A/B switch(es) in the A position(s) and begin patrolling the system over a predetermined route, at a speed of approximately 20 mph but not faster than 25 mph. When a full scale leak is detected, stop the vehicle and maximize the leak level indication by alternately moving the vehicle backward and forward.

4) Switch the A/B switch(es) to B; if the needle is in the green, switch back to the A position(s) and continue patrolling. If the needle indicates yellow or higher, locate the leak and repair.

5) After repairing the leak, resume patrolling as indicated.

Table 3

Hub	Test area
Date	9/30/85
Total hub mileage	39.7
Miles driven	10.3
Number of RFI leaks written	6
Percent of hub sampled	7.2
Number of readings made	23
Maximum radiation level	59
Average radiation level	16.35
Minimum radiation level	5
Readings per mile	2.233
RFI leaks per mile	0.583
Number of leaks ≤20 μV/m	17
Number of leaks from 21-29 μV/m	5
Number of leaks from 30-42 μV/m	0
Number of leaks from 43-59 μV/m	1
Number of leaks from 60-83 μV/m	0
Number of leaks from 84-117 μV/m	0
Number of leaks >118 μV/m	0
Cumulative leak index	47.47

Table 4

Hub	Test area
Date	10/07/85
Total hub mileage	39.7
Miles driven	10.3
Number of RFI leaks written	2
Percent of hub sampled	7.2
Number of readings made	19
Maximum radiation level	23
Average radiation level	13.42
Minimum radiation level	5
Readings per mile	1.9
RFI leaks per mile	0.2
Number of leaks ≤20 μV/m	17
Number of leaks from 21-29 μV/m	2
Number of leaks from 30-42 μV/m	0
Number of leaks from 43-59 μV/m	0
Number of leaks from 60-83 μV/m	0
Number of leaks from 84-117 μV/m	0
Number of leaks >118 μV/m	0
Cumulative leak index	45.2

Data indicates that this procedure should locate an average of one leak per plant mile. If we assume an average repair time of 30 minutes per leak, the average productive patrol


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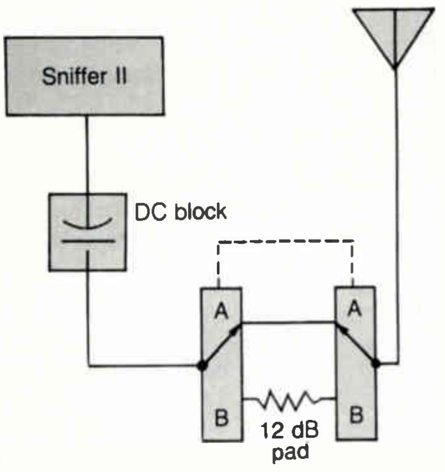
Reader Service Number 27.

Figure 1: Test setup



speed will be 1.8 mph. Depending on the productive manhours accomplished in each work day, the completed plant mileage should be between seven and 10 plant miles per work day (average 8.5 miles). The remaining 790 miles of initial system evaluation and repair could therefore be completed by *March 1, 1986*.

However, RFI leaks detected by other system technicians cannot be ignored, therefore if four work days in each week are utilized as described above, and the remaining work day of each week is devoted to RFI leaks, both tasks can be accomplished. A word of caution, if RFI leaks start piling up, do not succumb to the logical solution of devoting more RFI crew time to them. This would only compound your problems and delay the primary task of systematic system repair.

Having started this procedure on Oct. 5, we should be able to expect that during the next two quarters, the remaining 790 miles of plant will have all leaks greater than 83 μV/m repaired. During the second and third quarters of calendar year (CY) 1986, we should reduce the attenuation in the B position of the test rig to 9 dB (59 μV/m), and repeat the procedure covering the entire plant again. Historical data suggests that during this period we should detect and repair about three leaks every four miles. Therefore, by Oct. 1, 1986, all system leaks above 59 μV/m should have been found and repaired.

During the fourth quarter of CY 1986 and the first quarter of CY 1987, we should reduce the attenuation in the B position of the test rig to 6 dB (42μV/m). We then will repeat the procedure, covering the entire plant again. This time, data suggests that the quantity of leaks found will be about the same as the previous two quarters. During the second and third quarters of CY 1987, we should reduce the attentuation in the B position of the test rig to 3 dB (29 μV/m), and repeat the procedure, covering the entire plant again. Data suggests that the quantity of leaks found will be about the same as the previous two quarters.

Hereafter all of the attenuation should be removed from the test rig and semi-annually, or more often if required, repeat the procedure, covering the entire plant each time.

The bottom line

(A) Labor		
Tech average: $18,000 + 40 percent/ 240 days	=	$105
(B) Vehicle		
Bucket: $30,000/5 years/ 240 days	=	$ 25
Tools: $9,600/5 years/ 240 days	=	$ 8
Vehicle expense: $280 per month/ 20 days	=	$ 14
(C) Total labor and vehicle	=	$152
(D) Material		
per pole (average cost to-date)	=	$ 6
Total for 8.5 poles	=	$ 51
(E) Total cost per day	=	$203
Cost per mile (at 8.5 miles per day)	=	$ 23.88

Method III will allow us to comply with the FCC CLI of 64, not later than October 1986. In addition, it will allow us to enjoy a system CLI of 54 or less by October 1987. The cost savings of method III over method II is anticipated to be over $100,000 on the entire project. Continued semi-annual compliance with these procedures should maintain the system at or below the requirements of the FCC's Docket 21006.

Data communications and CATV

In this four-part series the how-to's of RF data communications will be presented, with both theory and applications discussed. This first article will present an overview of data communications to provide a background against which we can judge the economy, versatility and, therefore, the competitiveness of a broadband cable-based approach to data transfer.

By Terry A. Stanard
Executive Vice President

And Richard J. McKeon
Director of Data Products, Dumbauld & Associates

Now is the time to start employing the thousands of miles of CATV cables whose capacity is vastly under used. Today a broad range of technology is available that will allow us to economically and competitively implement high-speed point-to-point data communications or local area networking on institutional or subscriber CATV networks. Cable operators looking for new ways to generate revenue from existing cable plants should investigate broadband data communications. The marketplace is seeking an alternative to telephone for data communications, and CATV can take advantage of this and provide the alternative.

Data communications is simply the process of moving information from one place to another. That is it! The basic idea or definition of data communications is very simple. It's only when we start getting involved in the details of how a communications system is implemented that it gets a bit involved. And even then, the individual pieces are relatively simple and easy to understand. It's just that there are a lot of those little pieces to keep in mind!

Figure 1: ASCII code chart

Numeric Cross Reference of ASCII Codes

DEC	ASCII	BINARY	DEC	ASCII	BINARY	DEC	ASCII	BINARY
0	NULL	0000000	43	+	0101011	86	V (uc)	1010110
1	SOH	0000001	44	,	0101100	87	W (uc)	1010111
2	STX	0000010	45	-	0101101	88	X (uc)	1011000
3	ETX	0000011	46	.	0101110	89	Y (uc)	1011001
4	EOT	0000100	47	/	0101111	90	Z (uc)	1011010
5	ENQ	0000101	48	0	0110000	91	[	1011011
6	ACK	0000110	49	1	0110001	92	\	1011100
7	BEL	0000111	50	2	0110010	93	]	1011101
8	BS	0001000	51	3	0110011	94	^	1011110
9	HT	0001001	52	4	0110100	95	_	1011111
10	LF	0001010	53	5	0110101	96	`	1100000
11	VT	0001011	54	6	0110110	97	a (lc)	1100001
12	FF	0001100	55	7	0110111	98	b (lc)	1100010
13	CR	0001101	56	8	0111000	99	c (lc)	1100011
14	SO	0001110	57	9	0111001	100	d (lc)	1100100
15	SI	0001111	58	:	0111010	101	e (lc)	1100101
16	DLE	0010000	59	;	0111011	102	f (lc)	1100110
17	DC1	0010001	60	<	0111100	103	g (lc)	1100111
18	DC2	0010010	61	=	0111101	104	h (lc)	1101000
19	DC3	0010011	62	>	0111110	105	i (lc)	1101001
20	DC4	0010100	63	?	0111111	106	j (lc)	1101010
21	NAK	0010101	64	@	1000000	107	k (lc)	1101011
22	SYN	0010110	65	A (uc)	1000001	108	l (lc)	1101100
23	ETB	0010111	66	B (uc)	1000010	109	m (lc)	1101101
24	CAN	0011000	67	C (uc)	1000011	110	n (lc)	1101110
25	EM	0011001	68	D (uc)	1000100	111	o (lc)	1101111
26	SUB	0011010	69	E (uc)	1000101	112	p (lc)	1110000
27	ESC	0011011	70	F (uc)	1000110	113	q (lc)	1110001
28	FS	0011100	71	G (uc)	1000111	114	r (lc)	1110010
29	GS	0011101	72	H (uc)	1001000	115	s (lc)	1110011
30	RS	0011110	73	I (uc)	1001001	116	t (lc)	1110100
31	US	0011111	74	J (uc)	1001010	117	u (lc)	1110101
32	space	0100000	75	K (uc)	1001011	118	v (lc)	1110110
33	!	0100001	76	L (uc)	1001100	119	w (lc)	1110111
34	"	0100010	77	M (uc)	1001101	120	x (lc)	1111000
35	#	0100011	78	N (uc)	1001110	121	y (lc)	1111001
36	$	0100100	79	O (uc)	1001111	122	z (lc)	1111010
37	%	0100101	80	P (uc)	1010000	123	{	1111011
38	&	0100110	81	Q (uc)	1010001	124	|	1111100
39	'	0100111	82	R (uc)	1010010	125	}	1111101
40	(	0101000	83	S (uc)	1010011	126	~	1111110
41	)	0101001	84	T (uc)	1010100	127	DEL	1111111
42	*	0101010	85	U (uc)	1010101			
DEC	ASCII	BINARY	DEC	ASCII	BINARY	DEC	ASCII	BINARY

General concepts and terms

- *Bits and character codes:* The information or "data" that we are going to move from one place to another is usually just the letters of the alphabet, numbers and special symbols that are found on the keyboard of a typewriter or computer terminal. These characters are encoded into binary digits or "bits" as ones and zeros so that they can be sent electronically. If the information is voice, telemetry or analog control signals, it can still be digitized and sent as a string of bits just like data.

So that the receiving end will understand the data sent to it, a few standard character codes are used. These character codes are nothing more than an agreed upon meaning for each combination of ones and zeros. The American Standard Code for Information Interchange (ASCII) shown in Figure 1 is a seven-bit or seven-level code. Using seven bits provides 128 different characters. The Extended Binary Coded Decimal Interchange Code (EBCDIC) is an eight-bit code, and the Baudot Code uses five bits per character.

- *Parallel and serial data transfer:* As shown in Figure 2A, if we could connect two machines together with a multi-wire cable so that the information about each bit could be carried by a separate wire, we could set up the appropriate pattern of ones and zeros to represent a given character, and send a "strobe" signal to tell the receiving machine to sample it. This is called parallel data transfer because all of the bits of a given character are transferred at once in parallel when the strobe signal is issued. This technique is very commonly used to send information from a host computer to an attached parallel printer.

The method of parallel data transfer works very well if we can connect the communicating devices together with a multi-wire cable, but if the printer is located across town or across the country we do not have such a cable available. When sending information over long distances whether by the telephone network, microwave, satellite, fiber or broadband cable, we need to take each character and serialize it so that we can send the individual bits one at a time in some predetermined order. Figure 2B shows how a universal asynchronous receiver transmitter (UART) can be placed in front of each machine to do the necessary conversion. The UART on the sending end takes the parallel data when it is strobed, and sends the character out one bit at a time in serial fashion. The corresponding UART at the receiving end collects the individual serial bits and presents them in parallel fashion along with a strobe to the printer. In this way communication can take place on a single wire. For clarity communication has been shown in only one direction, but each UART has both a transmitter and a receiver section.

• *Asynchronous and synchronous communication:* Asyncronous communication is very simple, but not very efficient. It is simple in that the receiving machine does not need to be synchronized or phase locked onto the incoming bit stream, there is no protocol required, and no special block mode transmission takes place. In the asynchronous mode, you simply strike a key on a terminal keyboard and the character is immediately sent. Characters can be sent in a steady stream back-to-back or with random periods of time between them. Very precise and sophisticated clocking circuitry is not required so asynchronous communication can be relatively inexpensive. But the price is paid in overhead, which makes asynchronous data transfer very inefficient.

As shown in Figure 3A, we have to let the receiving UART know that the next character is coming by preceding each character with a start bit. Also, because there can be a random period of time between characters, we have to wait at least one bit's worth of time between characters so that the receiving UART can start looking for the next character. This bit's worth of time between characters is called a stop bit. If we also carry a parity bit along with each character to do some rudimentary error checking, the overhead for ASCII code is 30 percent because there are three extra bits required to send seven bits worth of data. This means that the maximum efficiency achievable is 70 percent. If you are paying a lot of money for computer time or high-speed lines, you start to think about more efficient communication.

If we could eliminate the start, stop and parity bits and just send straight data, our efficiency would be 100 percent. Of course, we can not get rid of all overhead, but as shown in Figure 3B, we can do a lot better than the 70 percent efficiency of asynchronous communication. In this case the clock at the receiving end is synchronized or phase locked onto the incoming data and the information is sent many characters at a time in a block with a specific format or protocol for each block. What is shown in Figure 3B is not bits, but whole characters. The receiving USART (universal synchronous asynchronous receiver transmitter) is synchronized bitwise by its clocking circuitry and it is a programmable device so it can be told to look for a special sync character to synchronize itself.

Depending on the specific protocol used, the header can be one or several characters. It is not part of the message, but can contain such information as the address within the network where this message is to go, the address of the sender, the block sequence number that identifies which block it is in case it has to be retransmitted, and control information for the receiving terminal. In any given protocol, it is known by both sender and receiver what information lies in the header. The start of text (STX) and the end of text (ETX) characters bracket the message, and the block check character (BCC) are used in error detection. The clocking circuitry and protocol involved with synchronous communication are somewhat more complex, but we pick up the ability to do error checking with selective retransmission, routing data packets within a network, and with five characters of overhead for a message of 95 characters, the efficiency is 95 percent.

• *Modes of communication:* One term that is frequently used (and misused) in data communications is "duplex." Figure 4 shows the three basic modes of communication. Simplex communication implies that the transmission is in one direction only. This type of one-way communication is illustrated by the receive only (RO) terminal or the radio in your home. You don't talk back to the radio announcer. Even if you do, it doesn't do much good because there is no channel provided for your side of the conversation.

Half-duplex communication takes place in both directions, but only in one direction at a time. Both ends must know who's turn it is to talk, and the line must be turned around when it is time to exchange talk and listen roles. Half-duplex communication has the advantage of allowing the sender to use the entire bandwidth of the channel. This becomes important when dealing with a medium such as the voice frequency (VF) telephone network where the available bandwidth is only from about 300 Hz to 3,300 Hz. Conversation between two people should (but doesn't always) take the form of half-duplex communication. In

this case it is understood either by the context or by a pause that is in the other person's turn to speak. With machines the communication must be more precise, and they need to support the half-duplex flow control.

Duplex communication (often called full-duplex) allows for transmission in both directions simultaneously. In this case no line control is required, but a method must be used that allows the two communicating machines to share the medium.

Implementing communication systems

Now that we have defined a few of the basic terms of data communications, we will look at some specific implementations. Figure 5 gives an overview of the various ways a terminal can access a host computer. We will refer to this figure for the remainder of this discussion.

• *Direct connection:* The simplest and most direct way to establish a communication link between a terminal and host computer port is to plug one end of a cable into the back of the terminal and the other end into the host port. In this way the terminal is directly connected or hard wired to the computer. If all terminals could be located fairly close to the computer port to which they had access, this would be the only type of connection necessary.

The serial interface found on most terminal equipment today conforms to the Electronic Industries Association's (EIA) recommended standard 232C. (The RS-232C interface is described in a document available from the EIA Engineering Department, Standards Orders, 2001 Eye St. N.W., Washington, D.C. 20006. All of the EIA's available publications are described in its *Catalog of EIA & JEDEC Standards & Engineering Publications.* The basic document describing the RS-232C is called *Interface Between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange.* It consists of seven sections that include a description of the electrical and mechanical characteristics, the functions of assigned signals, standard interfaces, recommendations, explanatory notes and a glossary of terms. A companion document, EIA Bulletin No.9, entitled *Application Notes for EIA RS-232C*, also is available.)

This interface provides for connectivity over relatively short distances at moderate speeds. Recommended cable length is 50 feet, but it is common practice to use 150-foot cables made of inexpensive 22 gauge stranded wire at signal rates up to 9,600 BPS and still not experience problems. Many companies make "extended distance" cables that will allow signaling at 9,600 BPS over a distance of 500 feet.

The RS-232C has enjoyed widespread acceptance, and will continue for some time to be the most widely accepted binary serial interface, but the pressure is always toward extended range and higher data rates. This pressure will encourage the acceptance of the proposed RS-449. This standard will be more complex and more costly to implement, but does offer speed and distance advantages. When we refer to RS-449, we are really only talking about the functional and mechanical characteristics that are to be used with EIA RS-422 or RS-423. These two standards specify the electrical characteristics for balanced and unbalanced interfaces respectively.

An unbalanced interface, such as RS-232C or RS-423, uses a single wire for each interface signal, and a common return. The RS-422 balanced interface uses two wires per signal so that each signal has its own return path. A balanced or differential circuit is much less sensitive to noise.

Under the RS-422 specification, signal rates of 100 kBPS can be achieved at distances of up to 4,000 feet, and at shorter distances higher bit rates can be obtained. At 40 feet a signal rate of 10 MBPS can be used.

• *Current loop communication:* Many terminals provide a current loop interface as a standard feature or as an inexpensive option. Using this mode of communication, transmission rates of 9,600 BPS at distances of 2,000 feet can be achieved. The basic principle behind the speed and distance advantages of current loop signaling over voltage level signaling is that if you can force current through a closed loop, the current is the same everywhere. Unlike voltage, which will drop in value across a resistance and end up lower at the other end of a long wire, a current loop is like pumping water around a closed loop of water hose, it will be the same everywhere in the wire as long as there are no other branches for it to flow through.

This interface typically uses four wires to form two closed loops. They are called the receive loop and transmit loop as seen from the point of view of the terminal. The terminal transmits by interrupting current in the transmit

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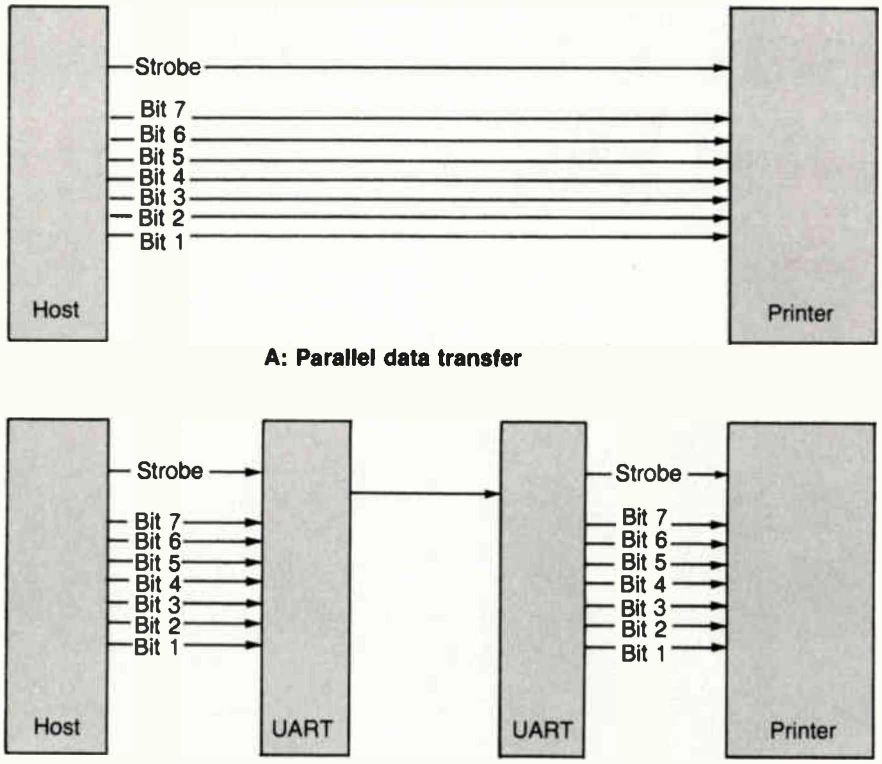
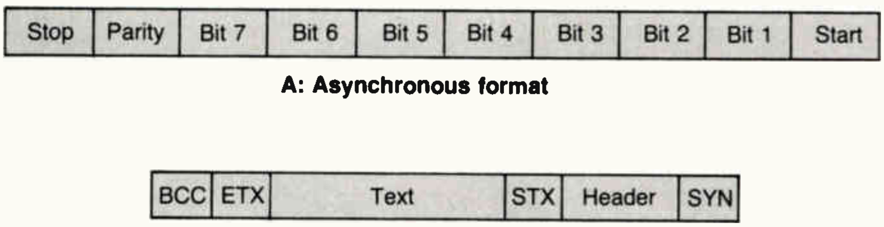
Figure 2: Data transfer methods



A: Parallel data transfer

B: Serial data transfer

Figure 3: Asynchronous vs. synchronous



A: Asynchronous format

B: Synchronous format

loop. To sense or control current in the loop, an LED/phototransistor pair is used. An added advantage of this optical coupling is the electrical isolation of both devices from the line. This adds a measure of protection from high-voltage levels, which might be induced on the line during electrical storms.

Terminals that support current loop communication generally use four pins of the EIA connector. Unlike the RS-232C interface, there is no standard pin assignment for the current loop functions. Manufacturers may even support current loop differently for different models in their product line.

- *Long metallic circuits:* If you have to communicate at distances of a few thousand feet to a few miles, you are exceeding the distance limitations of both RS-232C and current loop circuits. Any special equipment used to achieve long distance communication will always mean more expense, but for distances in this "short haul" range, you may not need to resort to modems just yet. Line drivers can condition a digital signal so that it can be sent reliably for distances of up to 10 miles over your own private wire or twisted pair wire supplied by the telephone company. Although line drivers are not technically modems because they do not modulate a carrier, they are often called short-haul modems, baseband modems, limited distance modems or local modems. These devices are usually significantly cheaper than modems, provide for higher data rates, and the circuits are less expensive than the comparable analog or digital leased lines.

Line drivers can cost anywhere from around 70 to a few hundred dollars. Before purchasing a pair of line drivers it is very important to ensure that they will meet the speed and distance requirements of your application. Price and performance can vary greatly. For any given line driver the signaling distance reduces as the speed is increased.

The circuit used with line drivers must be a "DC continuous" path. This means that it is simply a pair of wires from one end to the other. No amplifiers, transformers, fiber-optic or microwave links can be included in the path. You should be able to short the wire pair at the far end, and measure its resistance with an ohmmeter. Typically you will measure about 220 ohms per mile for 26 gauge wire.

When purchased from the telephone company, this service is called local area data service (LADS), and is described in Bell Publication 43401. LADS circuits are only offered between points that both lie in the service area of a given central office (CO). When used on a LADS circuit, the line driver has some circuitry to prevent crosstalk between adjacent pairs and is called a local data set. Just because the point you want to reach is only across the street does not mean that it is in the same service area. The only way to determine if LADS service is available between any two given points is to call the telephone company. In rapidly growing cities where wire pairs are becoming scarce or are being multiplexed before they reach the local CO, this service is becoming less available. Where available, it can be a very economical way to do short-haul communication.

- *Analog leased lines:* If we need to communicate between two points that are separated by a distance great enough so that they do not lie within the same service area, then LADS will not be available. To communicate over long distances via the telephone network, we interface modems with either an analog 3002-type leased line or a dial-up circuit.

The telephone network was not designed to handle EIA voltage level signals or current loop signals, but rather analog signals in the voice frequency (VF) range from about 300 Hz to 3,300 Hz. Therefore, the digital information must be modulated on an analog carrier signal. Modulation can be accomplished by changing the amplitude (AM = amplitude modulation), the frequency (FSK = frequency shift keying), or the phase (PSK = phase shift keying) of the carrier. Today, sophisticated techniques of changing both the phase and amplitude of the carrier are being used. Using modern PSK and quadrature amplitude modulation (QAM) techniques, it is possible to encode more than one bit's worth of information in each "baud" or change of the signal element. Therefore, the bit rate can be greater than the baud rate. This means that the available bandwidth of the VF telephone network can be used more effectively. Today, because of efficient modulation techniques, manufacturers are producing 2,400 BPS modems that can be used in the full-duplex mode on a two-wire switched (dial-up) line.

• *Digital leased lines:* Digital lines are becoming a more common offering. The integrated services digital network (ISDN) may be a few years away, but the telephone company typically offers dataphone digital service (DDS) with full-duplex point-to-point and multipoint private lines at synchronous speeds of 2.4, 4.8, 9.6 and 56 kBPS. A 9,600 BPS DDS circuit is more costly than the comparable analog circuit but should provide a higher percentage up time with a lower bit error rate. On this type of circuit the signal remains in a digital form and is periodically regenerated instead of simply amplified. Whereas amplification of an analog signal also amplifies distortion and noise, regeneration extracts the information and recreates the digital signal so that it is just as clean as when it started.

Instead of using modems at each end of a digital line, a channel service unit (CSU) and data service unit (DSU) are used to interface to the line, condition the digital signal and interface to the customer equipment. Since the divestiture of telephone these two circuits are typically combined in a single DSU/CSU unit that looks like a modem.

Another digital offering that is becoming more available is digital carrier service (T1), which provides for signaling at 1.544 MBPS. Depending upon how you use it, this type of high-capacity channel can carry many individual subrate voice and data channels.

• *Multiplexing:* This is the process of combining signals from several different sources into a composite signal. This composite signal can be sent over a single channel, and then split off or demultiplexed at the other end. The whole process should be transparent so that each source thinks that it is connected directly to its destination, and is unaware of any other signals sharing the communication link. For terminals connected remotely to a host computer, this means that each terminal thinks it is connected directly to a port on the computer.

Figure 4: Communication modes

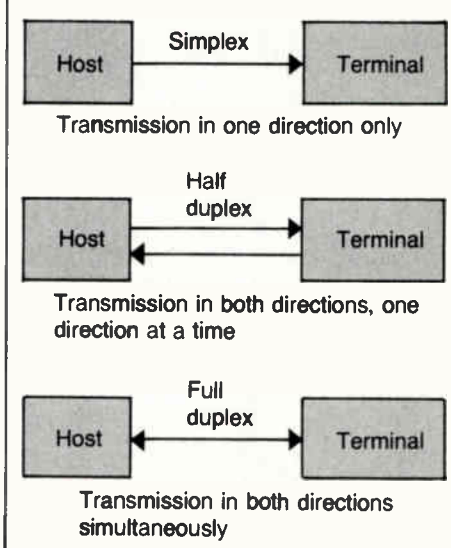
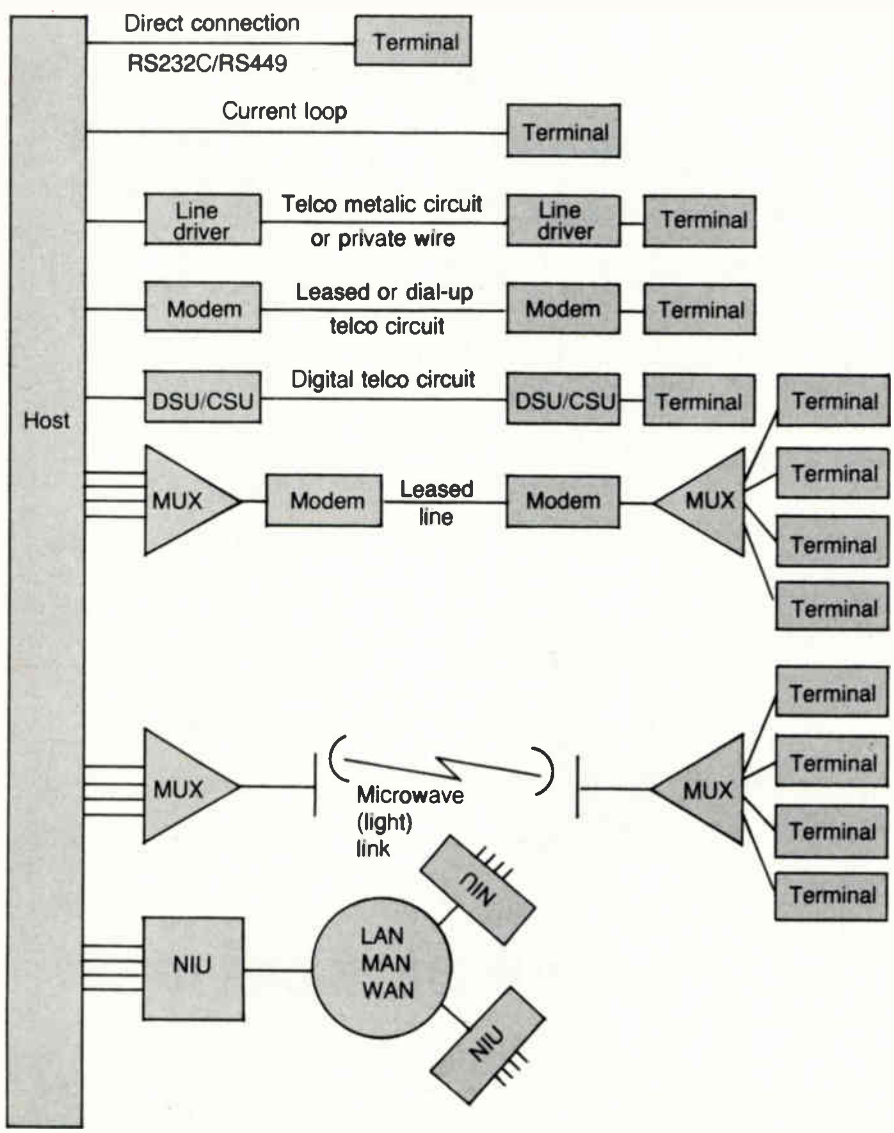


Figure 5: The physical connection



Connecting remote terminals via leased lines can become very costly as the number of terminals starts to grow. For anything more than a few terminals, it becomes economically feasible to reduce the number of modems and lines involved by multiplexing all of the individual signals on one high-speed line. Figure 5 illustrates how four terminals can access host ports using a single pair of modems on a single leased line. Depending on the application, that line and set of modems might not need to be as fast as one might initially think.

There are three methods of multiplexing in use today: frequency division multiplexing (FDM), time division multiplexing (TDM) and statistical multiplexing, which is sometimes called intelligent time division multiplexing (ITDM). As the discussion progresses, it will become apparent that each form of multiplexing has its economies and areas of application.

Frequency division multiplexing is the oldest multiplexing technique, and was quite satisfactory for voice frequency circuits when combining the signals from a limited number of slow-speed devices. It was the dominant technique when most terminals signaled at 110 or 300 BPS. A frequency division multiplexer divides up the available bandwidth into a number of subchannels, each subchannel carrying information separately. An FDM mux can be thought of as nothing more than a number of FSK modem pairs, each pair with its own set of transmit and receive frequencies, all of which are connected to the same line.

Higher speed communication requires more bandwidth per channel, and on VF circuits there is only a limited amount of bandwidth available, so FDM is not used today on voice frequency leased lines. If there were plenty of bandwidth available, FDM would be a simple and cost-effective way of having many conversations taking place simultaneously on the same channel. This is in fact the case when the transmission medium is private wire or

broadband coaxial cable. Twisted pair wires offer a few megahertz of bandwidth, and coaxial cable can provide a few hundred megahertz. Therefore FDM is still very much used for local communications involving distances of up to several miles.

Time division multiplexers allow each of the attached devices to use the entire bandwidth of the medium, but each must take its turn. The available time is divided up with each attached device given an equal share of time. This type of multiplexer could be thought of as a rotary switch which is turned to the next position at set intervals, attaching one port at a time to the line. The multiplexer at the other end of the line is switching at the same speed, so that there are a number of individual point-to-point connections being made one after the other. Naturally, TDMs are not simply rotary switches. The switching is done electronically, and it all happens very quickly so that the multiplexing appears transparent to the user. The major drawback of TDM is that a block of time is allotted to each port during each cycle whether the attached device is active or not. Much greater efficiency could be had if we could allocate time dynamically based on need, as is the case with statistical multiplexing.

Statistical multiplexing is a form of time division multiplexing. Being microprocessor-based, a "stat mux" can add some nice features like error checking and automatic retransmission, dynamic allocation of time so there is no waiting around for a channel that has nothing to send, speed and handshaking conversion, prioritizing channels, and the ability to obtain statistical information as to link performance and loading.

Because the attached terminals rarely send a steady stream of data, and the mux is capable of temporarily buffering characters during peak traffic, the speed of transmission on the link between multiplexers needs only to be fast enough to handle the average throughput. If the application is primarily interactive, with operators entering data from a keyboard, the throughput will be very low compared to the available speed. The terminal might be set to communicate at 1,200 BPS, but nobody can type at 120 characters per second. If someone could it would not be for too many seconds.

Most statistical multiplexers are very flexible and can accommodate a wide variety of attached devices. Individual channels can be set up for various speeds and word configurations along with various methods of handshaking and flow control. Modern statistical multiplexers can even perform intelligent interfacing for incompatible devices and some limited degree of protocol conversion. Also, the operating statistics and diagnostics available from a stat mux can reduce multi-vendor finger pointing, help you make decisions about utilization, and predict problem areas. For example, a day-to-day monitoring of retransmissions could help detect a deteriorating line before it drops out altogether. This same data on retransmissions might be just the evidence you need for the provider of the line to take your complaint seriously or save you from being billed for a "false service call." Also, using the available traffic statistics, you might be able to delay new equipment purchases through more effective traffic (people) management.

- *High-capacity point-to-point links:* For this type of data link, many customers are turning to microwave and optical transmission through the air. Optical and short-haul microwave transmission equipment cost about the same to implement. Microwave radios can supply a reliable link for multiple T1 circuits or video transmission at distances up to 20 or 30 miles, but do require FCC licensing. When compared to leased T1 services, the typical payback for this form of bypass technology is less than two years. If the current popularity of 23 GHz microwave communication continues, the "uncrowded K-band" won't be uncrowded for long. Optical links do not require licensing but do not have the range or reliability of microwave links.

Summary

In this article we have presented a broad overview of data communication. Throughout the rest of this series, we will rely on the concepts and applications discussed here to examine the feasibility and economy of implementing data communication networks on CATV systems.

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Reader Service Number 38.

Stereo TV cable kit

A stereo capable cable kit has been introduced by LRC Electronics for cable TV subscribers. The blister-packed kit contains jumper cables of RG-59 cable (foil braid, foil braid construction) designed for high RF shielding. Each jumper incorporates LRC's one-piece "F" connector made of cadmium-plated brass, with a hex crimp for RFI integrity. The kit also contains an FM splitter. The splitter is a two-stage filter in which one side passes the full frequency spectrum, enhancing the signal to the TV. The other side is designed to pass the frequency from 88 to 108 MHz and attenuates the rest of the spectrum. The splitter is constructed of die cast zinc with epoxy sealed edges. Custom lengths, AB switches and VCR hookups are available on request. The standard kit includes a 12-foot jumper, a 1-foot jumper, a matching transformer and an FM splitter.

For more details, contact LRC Electronics, 901 South Ave., Horseheads, N.Y. 14845, (607) 739-3844.

VCR converter option

The Jerrold Division of General Instrument announced an addressable converter option that permits time-controlled VCR recording of multiple cable programs. In addition, the option enables automatic turn-on and shut-off of a TV set or light using an auxiliary time-controlled outlet. This Jerrold VCR option allows subscribers to program the Starcom® VI addressable converter to turn on and tune to designated channels for VCR recording at preset dates and times. The converter is programmed by pressing the time controlled programming (TCP) button on the Jerrold IR remote control unit and entering the programming parameters.

The VCR-compatible converter gives subscribers a number of unattended recording options in addition to the capability for attended program recording on a daily basis. It allows unattended recording of up to four different events over a 31-day period. Or, if subscribers want to record favorite programs every day, the VCR converter option allows unattended recording of up to four programs on a daily basis.

Subscribers may enter, review and edit their programming parameters and change programming information in a matter of seconds. The time-controlled programming function can be used for morning wake-up and late night TV shut-off. If a light is plugged into the converter's auxiliary outlet, the TCP function can be used to turn it on and off.

The timing clock parameters in the Starcom IV VCR-compatible converter are resident in the data stream of the Jerrold AH-4 addressable control computer, requiring no action by the cable operator.

For more information, contact Jerrold Division, General Instrument Corp., 2200 Byberry Rd., Hatboro, Pa. 19040, (215) 674-4800.

Satellite antenna

M/A-COM Cable Home Group recently introduced a new satellite antenna as part of its complete satellite receiver system. The 3.7-meter earth station antenna has a T-bar mount and petals that are interchangeable in the field. It is light-weight and features integral indexing tabs for positive self-alignment. The feed can be rotated through 360 degrees of polarization from the rear of the antenna.

For more information, contact M/A-COM Cable Home Group, P.O. Box 1729, Hickory, N.C. 28603, (800) 438-3331; in North Carolina, (800) 222-6808.

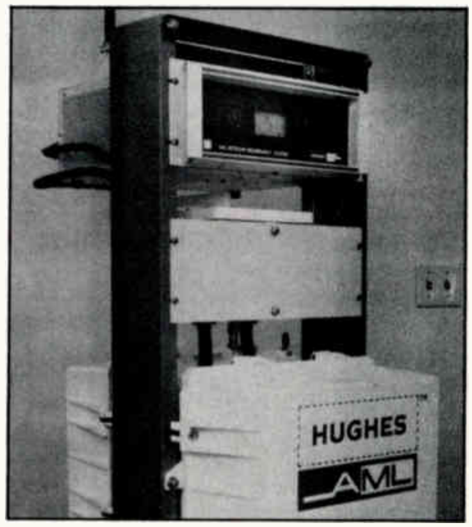
Options now standard

Wavetek now includes as standard on its system analyzers and system sweep models, some of its most popular options. System analyzer Models 1880 and 1881 offer a heavy duty power supply/charger. The power supply/charger will charge the 1880 and 1881 battery pack in eight hours and allows operations directly from a 110/220 VAC line. It also permits reliable operations when the battery is low.

Wavetek also now provides as standard a notch filter pair and a battery back-up with the Model 1855B CATV microprocessor-controlled sweep transmitter. The notch filters function as selective blanking controls, which notch out specific frequencies to eliminate AGC movement while sweeping. These notches are individually field adjustable. The battery back-up holds sweep parameters in memory in the event of a power interruption.

The Model 1865B CATV microprocessor-controlled, portable, battery-operated sweep receiver now includes memory expansion and a heavy duty power supply/charger. The memory expansion incorporates three features. An averager function permits instantaneous display of gain changes. The stacker function stores up to seven separate reference traces in non-volatile memory, backed up by a five-year lithium battery. And the normalizer function (A-B) subtracts a previously stored reference trace from the current trace and displays the difference between the two on a 2 dB per division display. The supply/charger will charge the 1865B battery pack in eight hours and also allows operations directly from a 110/220 VAC line.

For more information, contact Wavetek Indiana, 5808 Churchman, P.O. Box 190, Beech Grove, Ind. 46107, (800) 622-5155; in Indiana, (317) 788-5965.



Receiver redundancy

A new receiver redundancy subsystem, designed to protect CATV system operators and subscribers against total system outages, has been introduced by Hughes Aircraft Co.'s microwave products division. The subsystem, Model RRS-20B, continuously monitors the performance of two Hughes AML receivers and automatically selects the superior output signal to feed the cable system. In the event of a failure of any one of the monitored characteristics on the primary receiver, the control unit will automatically switch to the hot standby receiver. The unit also provides switching to an optional signal source, such as off-the-air or local origination signals, if both receivers or the transmitter should become inoperative.

The redundancy subsystem consists of a control unit and an optional waveguide switch unit, which is required only for a certain type of redundancy. The control unit, in addition to automatic sensing and switching, provides mode selection, status indicators, alarms and an analog metering circuit. The latter measures AML receiver (on-line and standby) operating parameters.

For further information, contact Hughes Microwave Communications Products, P.O. Box 2940, Torrance, Calif. 90509, (213) 517-6233.

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Autobite is a cost-effective automatic built-in test equipment system that reduces preventive maintenance costs, leads to better system performance, and frees technical personnel from repetitive tasks.

The Autobite system was specifically developed for CATV testing—to help you catch problems before they become serious. It automatically dials remote signal level meters and scans up to 70 channels (140 carriers).

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Autobite prints out complete test reports, or just the values that are out of tolerance. You can also select high-resolution graphics printout in either spectrum or normalized format with auto-ranged frequency and amplitude.

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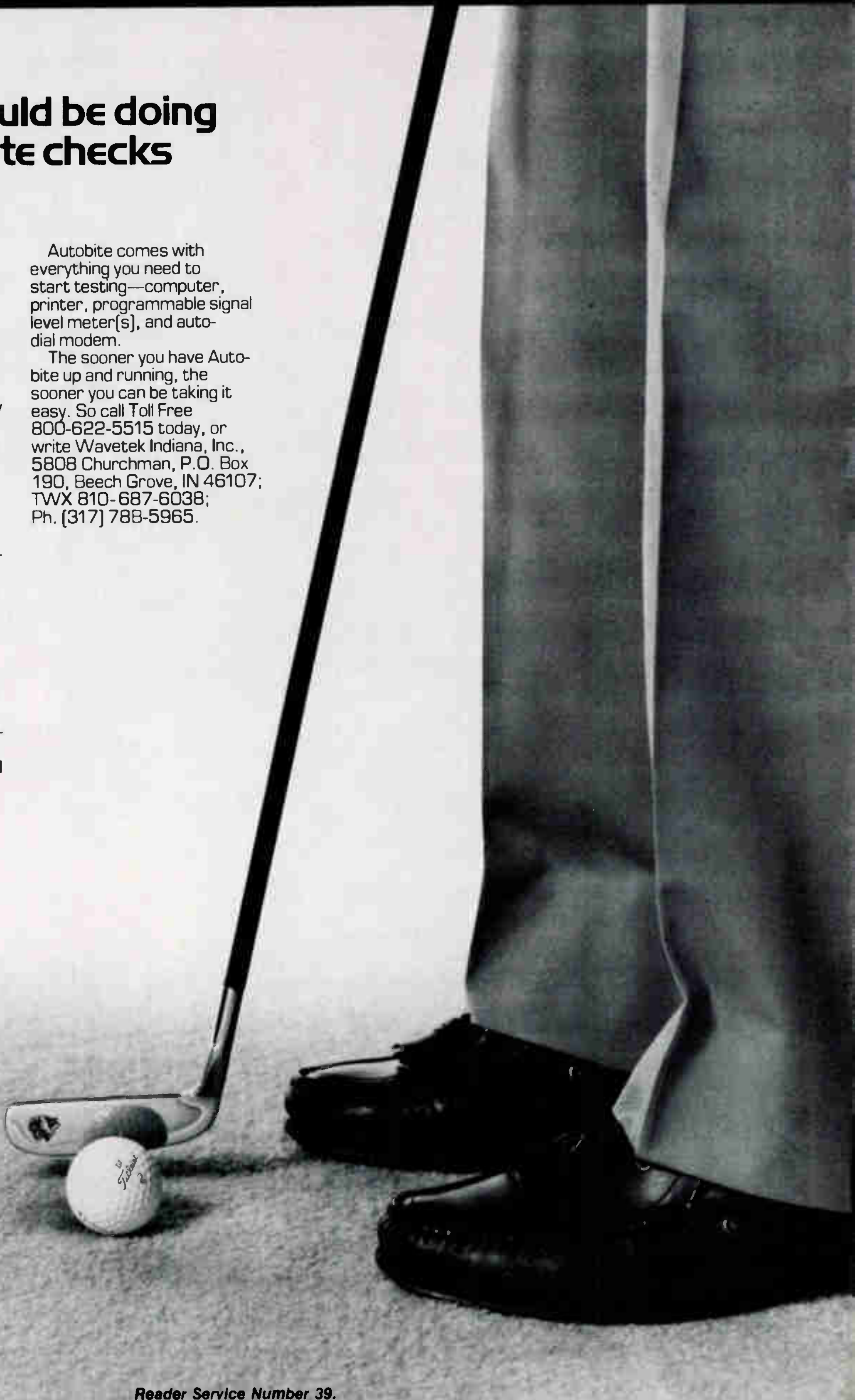

Reader Service Number 39.

Reader Service Number 40.

FCC Chairman **Mark Fowler** has been named acting chairman of the Administrative Conference of the United States, and chairman of the Council of Independent Regulatory Agencies (CIRA).

The conference is an independent federal agency whose mission is to advise the president and the Congress on administrative procedures. The CIRA was created by the council members to increase the effectiveness and responsiveness of the major independent regulatory agencies in doing the public's business.

CIRA's monthly meetings are designed to allow the chairmen to share common problems and successful solutions achieved at the various agencies. Contact: 1919 M St., N.W., Washington, D.C. 20554, (202) 632-7260.

Tele-Engineering Corp.'s Product Division has announced the appointment of **Jack Keith** to the position of technical service representative. Prior to joining Tele-Engineering, he was involved in the production of commercial insertion equipment, and was a technician for Continental Cablevision's Cable Advertising Inc. subsidiary. Contact: 12 Humbert St., North Providence, R.I. 02911, (800) 832-8353 or (617) 877-6494.

Goldman

Sadelco Inc. announced that **Gerald Goldman** has joined the company as vice president, marketing. His experience in RF distribution systems dates back to 1956 with RCA. He also was the manager of engineering for Teleprompter. Later he was with the Sylvania Commercial Electronics Division and GTE International where he was manager of product development/applications engineering.

For six years, Goldman was the Northeast regional sales manager at Texscan and during the past year, he was general manager, Telecommunications Division, Tele-Wire Supply Corp. He is a senior member of SCTE and a past member of SMPTE. Contact: 75 W. Forest Ave., Englewood, N.J. 07631, (201) 569-3323.

Dan Jones has recently been named as marketing manager, Western region, by **Cable America Corp.** Jones joined the MSO from Comprehensive Cable Enterprises Inc.

Helen Burk has recently been named as manager for Cable Arkansas Corp., a subsidiary of Cable America. Burk has been promoted from the position of office manager.

Stephen O'Connell has recently been named as financial manager by Cable America Corp. O'Connell joins Cable America from Microwave Systems Engineering where he served as business manager. Contact: 4350 E. Camelback Rd., Phoenix, Ariz. 85018, (602) 952-0471.

Tau-tron Inc. has named **Don Lancaster** as regional sales engineer. Lancaster was most recently employed by Pacific Bell and has a varied background in analog and digital engineering. Contact: 10 Lyberty Way, Westford, Mass. 01886, (617) 692-5100 or (800) Tau-tron.

Bostick

Johnson

Berry

Emily Bostick has been named executive vice president and director of sales and marketing at **Microwave Filter Co. Inc.** Earlier she served as vice president of sales and marketing for 10 years. Bostick has worked at MFC since its inception in 1967. In addition, she is corporate secretary and a member of the executive committee of the board of directors.

William Johnson has been named vice president, director of engineering at Microwave Filter. Johnson joined MFC in 1980 and was named chief engineer in 1983. Prior to working at MFC, he was employed with Syracuse Electronics Corp. and WMHR-FM Radio.

Alice Berry has been promoted to vice president, director of employee development at MFC. Previously her title was employees' advocate. Prior to joining the firm in 1982, she managed the Syracuse Provident Mutual Group and Pension office. Contact: 6743 Kinne St., Syracuse, N.Y. 13057, (315) 437-3953.

Establishing a PM program

This article is the first of a two-part series on the development of an effective preventive maintenance program.

By Ron Hranac
Corporate Engineer, Jones Intercable Inc

How many time have you heard the comments, ". . . we don't have time . . . ," ". . . can't afford . . . ," or ". . . lack the personnel . . ." when it comes to implementing a preventive maintenance program in your system? Yet daily operations continue. Handling service calls, responding to customer complaints, fixing outages; a workload that never seems to stop growing.

Preventive maintenance, coping with natural aging and deterioration of a cable system, is intended to prevent problems before they occur. Corrective maintenance, on the other hand, is taking care of problems after they occur.

Corrective maintenance is a way of life in many systems. Unfortunately, it's also an expensive way to do business. According to a recent *HP Journal* article, maintenance costs exceed $200 billion; this figure is increasing at the alarming rate of 12 percent per year! In facilities without structured preventive maintenance programs, emergencies account for 50 to 90 percent of maintenance work, and unorganized lubrication and service work account for the rest.

Cable television is certainly only a small contributor to these numbers. Nonetheless, the lack of a good PM program in a cable system does impact operating costs.

How much?

One way to get an idea of what maintenance is costing your system is to track service call percentages. The number of service calls in a given month divided by the average number of subscribers during that same month, all multiplied by 100, will yield a monthly service call percentage. For example, if a 10,000 subscriber system has 500 service calls this month, then its service call percentage is 5 percent ($500 \div 10{,}000 \times 100 = 5\%$).

Individual service calls have been estimated to average from $25 to $45 each to complete, depending upon the complexity of system operation. This includes answering the telephone, writing up the service order, computer processing time (when applicable), dispatching/routing, rolling a truck, driving time, troubleshooting the problem, materials used and other related overhead.

Being conservative and using the $25 per service call figure results in a monthly maintenance expense of $12,500 for our hypothetical 10,000 subscriber system. And this is only demand maintenance! If we could reduce the service call percentage in that imaginary system by 25%—from 5 percent to 3.75 percent—annual maintenance costs would decrease $37,500. A good preventative maintenance program will allow us to do just that!

Goals

Part of establishing an effective PM program includes setting goals. Determining the desired results beforehand will make it easier to design and implement a program that is tailored to a system's specific needs. Goals will vary from system to system, but here is a good place to start:

- Decrease the number of service calls performed. Reducing the number of service calls will impact the bottom line directly. Monitoring service call percentages also will allow you to determine the overall effectiveness of your preventive maintenance program.
- Reduce maintenance expenses. Getting out of the corrective maintenance mode will mean less time spent putting out fires. This also translates into greater savings.
- Decrease the incidence of system outages. A good preventive maintenance program will help you detect problems early, before they become visible to the subscriber.
- Improve and maintain picture quality. We don't sell decibels to our customers; they're paying for good pictures.
- Increase subscriber satisfaction. Improved subscriber retention is one result of this goal. Keeping service interruptions to a minimum and picture quality at its best promotes good will and a better bottom line.
- Protect the cable company's investment. As an employee of your company, you have an obligation to protect that company's investment in the cable system and the community it serves.

Putting it together

Preventive maintenance in any cable system can be broken down into four areas: electronic, mechanical, education and documentation. Developing a successful PM program requires careful consideration of each area as it applies to a system's needs.

Electronic

Electronic preventive maintenance involves more than just sweep alignment of your system. The objective is optimum performance of the entire plant. This requires a well-stocked service vehicle, accurate and regularly calibrated test equipment and previously aligned and tested replacement components.

- System sweeping—A regular schedule that includes sweep alignment of the trunk and feeder portions of the distribution system will ensure optimum flatness and operation within desired performance specifications.

'A good preventive maintenance program will help you detect problems early, before they become visible to the subscriber'

- Signal leakage/CLI—While sometimes considered part of mechanical maintenance, minimizing signal leakage will improve system flatness and make sweep alignment easier. It also will keep the FCC off your back!
- Headend/microwave adjustment—The pictures will never get any better than they are here. This equipment should be maintained as transparent as possible to the signals you're sending out into the system.
- FCC proof-of-performance—Include this in your PM program; and who says you only need to do it once per year? The results will provide an excellent reference point to monitor gradual deterioration of system performance.
- Power supplies—Regardless of whether you use standby power or not, all power supplies need maintenance. Just keeping track of voltage and current can tip you off to potential problems. Of course, don't forget about the maintenance demands of standby power supplies.
- Bench testing and QC—Cable, passives and actives need to be checked before they're installed in your system. Establishing a good quality control program will help avoid future problems.

Mechanical

Mechanical preventive maintenance keeps the entire system in top physical condition. Look for things that aren't right, and establish good communications with your construction people so problems that can't be repaired on the spot can be scheduled later.

- Hardware tightness—When was the last

(Continued on page 81.)

This is what your next signal level meter should look like

That is, if you're looking for a high-quality 600 MHz signal level meter for under $1200

Accuracy. Ease of use. Advanced features. Lasting value. Interested? You should be. Because these features, which you'd expect only from a high-priced signal level meter, are now available for much less. Presenting the Spectrum 700—Texscan's newest signal level meter.

Accuracy

Your system depends on it and the Spectrum 700 promises it. With ±0.75 dB (at ±68° f) over the entire range of 5 to 600 MHz. Dependable accuracy is maintained over the entire operating temperature range of 0° to +130° f—eliminating any need for recalibration. But that's only half of it. Accuracy is also important when it comes to taking level readings. That's why we've equipped the Spectrum 700 with a large easy-to-read meter.

Ease of Use

Besides the easy-to-read meter, and elimination of a recalibration function, the Spectrum 700 features a replaceable input connector. Each Spectrum 700 is supplied with a protective carrying bag, making transport easy and safe. The Spectrum 700's low profile means you can work with the meter right up front. Rather than off to the side.

Advanced Features

The Spectrum 700's most advanced feature is its 5 to 600 MHz accurate level measurement capability. In addition to signal level measurement, the meter measures hum. It has a built-in charger and an internal battery which provides five solid hours of operation between charges. And should you leave it on, Spectrum 700 lets you know with a "beep" every five minutes.

Lasting Value

Spectrum 700 has been designed to satisfy your measurement needs today and anticipate tomorrow's. It stands up against the environment with its waterproof carrying bag and waterproof mylar speaker. And withstands shock with its durable metal casing, protective rubber-ended handles, and padded bag. Durability under all of these conditions means longer life—and that's lasting value. Best of all, it's affordable. Which means you can afford to keep more around.

If you still aren't convinced—give us a call. Or better yet, request a demonstration. And see why Spectrum 700 should be your next signal level meter.

Spectrum 700

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Reader Service Number 46.

DI-TECH'S COMSERT 1000

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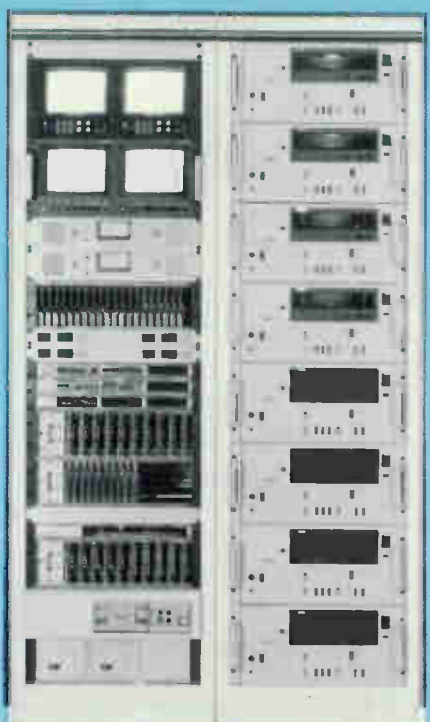
Comsert is user friendly, flexible, expandable, affordable and puts a whole new world of programming at your command.

The Comsert 1000 can locate any spot on any tape on any VCR! Our video detectors and tally circuits will accurately verify that the spot has been played!

The Comsert 1000 also features: ■ Random Access—The system can assign any VCR or groups of VCR's to any single program or multiple program sources. ■ User defined preroll time for each program source. ■ Insert commercials on more than 10 program sources, that is: USA, ESPN, CNN, MTV, etc. ■ Ability to control more than 30 VCR machines. ■ Commercials can be inserted into the schedule up to 15 minutes before air time. ■ Complete VCR status, that is, cued, running, played, etc. ■ Future programming well beyond a one year period. ■ 10, 15, 30, 60, 90 second spots, or any other lengths, can be programmed to run on an individual basis or linked



together on multiple machines. You are not limited to 1 or 2 minute blocks of time. ■ V.I. switching. ■ System capacity is over 10,000 commercials per week. ■ System can be supplied with optional time base correctors and audio compression units. ■ Multi-user capability. Up to 3 terminals can be added to the system. ■ Simple to use editing system with continuous prompting for inserting the required codes for each spot. ■ Complete open avail listings for each program source. ■ Variable window for cue tones. ■ Stereo Audio.

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Reader Service Number 47.
See us at the Western Show Booths 876-879.

(Continued from page 77.)

time you took a wrench to the hardware holding your system in the air? You might be surprised to find out how much it has loosened over time. It won't take long to snug everything up and keep it that way if everyone takes an extra minute to make this part of the job while doing installs, disconnects and service calls.

- Shrink boot inspection—Checking for proper waterproofing and fixing problems when they're found will help keep the H_2O where it belongs: outside!
- Kinked cable—Take care of this before it becomes cracked cable.
- Broken lashing wire—Fix it as soon as it's discovered, lest you find your aerial plant on the ground.
- Correct span sag—Improper sag can cause broken lashing wire, cracks in expansion loops, cable suckouts, damaged connectors and more. When possible, try to maintain at least 2 percent span sag.
- Corrosion control—If your system is in a coastal environment or is a victim of industrial pollutants, it's very important that proper measures be taken to reduce the effects of corrosion. This includes not only the cable plant, but towers, antennas, locks on pedestals and anything else that may be affected.
- Clearance infractions—You'll get along much better with local utilities if efforts are made to keep these problems to a minimum. A safer work environment also will result.
- Bonding/grounding integrity—Periodic visual inspection and measurements with an earth resistance tester also promote a safe work environment, in addition to reducing system problems related to poor grounding.
- Tap port terminations—Terminating unused ports will not only reduce signal leakage, but also improve return loss. This is especially important in systems with active two-way. The use of locking terminators will help discourage theft of service.

Education

Attitude is a major factor in a successful PM program. Positive attitudes can be enhanced by additional training. Understanding why a preventive maintenance program is necessary and what it will accomplish is one side of the story; training also shows that an employer cares about his people. The net result of education is better quality work. A properly trained staff will mean fewer call backs to correct mistakes.

- In-house training seminars—Regularly scheduled training sessions are a necessary part of the technical operation of any cable system. Encourage each member of your staff to occasionally teach a favorite subject to the rest of the crew. Include safety-related materials at least once a month; don't forget the basics, too often we take them for granted. Installer training programs, for example, will help ensure trouble-free drops.
- Industry seminars—One of the biggest morale boosters is attending an industry seminar. When the attendees return to the system, have them share what they learned with the rest of the crew.
- Correspondence courses—Encourage participation in job-related correspondence courses. Be sure to monitor progress, and develop incentives to complete the courses.
- Formal education—Don't overlook community colleges and vocational schools. They provide an excellent opportunity to study subjects that will broaden job skills.
- On-the-job training—One of the best places to get an education in cable television is right in the system. Each individual's needs should be determined and training schedules developed to accommodate those needs. On-the-job training can be as simple as additional pole climbing experience, or as complex as learning to measure visual depth of modulation with a spectrum analyzer.

Documentation

The most important part of an effective PM program is documentation. Without it, preventive maintenance will not work.

- As-built maps—How up to date are your system maps? Accurate maps will make system maintenance much easier.
- System operating parameters—Signal levels at amplifier inputs and outputs, slope, gain, bandwidth, AC and DC voltages, frequency response photographs and temperature are all candidates for entry into a logbook. Information stickers inside amplifier housings will aid troubleshooting.
- Form development—A preventive maintenance report form will allow you to track the progress of your program and keep your supervisors informed of its effectiveness. Quality control inspection forms will document the testing of equipment before it is installed in the field; training forms can be used to monitor education progress; they also can be added to each individual's personnel file (this is useful at review time).
- Timeline—One of the easiest ways to schedule the various parts of a PM program and track them simultaneously is with a timeline. It allows for quick referral at a glance.

Getting it underway

If you don't have the funds to hire extra staff to accommodate a preventive maintenance program, consider rewriting the job descriptions of existing personnel to include portions of the program as an integral part of their daily tasks. In most cases, the resultant decrease in service calls will allow you to reassign one or two technicians to full-time preventive maintenance.

As you consider the development of a preventive maintenance program, it becomes clear that there is no such thing as a generic version that will work in every situation. These suggestions are intended to be used as guidelines to help you develop a program that will satisfy the specific needs of your system.

Next month we'll look at a PM program that was established in one of Jones Intercable's West Coast systems. Although originally developed as a pilot program, the results were impressive enough to justify adapting it for implementation in other systems.

3's A Winner

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Entertaining more than 32 million cable homes, Superstation WTBS is in a class by itself.

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Director of Programming
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Director of Corporate Services
Continental Cablevision, Inc.

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Jerrold Fischer
Manager
King Videocable, Inc.

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Reader Service Number 49.

CALENDAR

November

Nov. 11-13: Magnavox CATV training seminar, Greensboro, N.C. Contact Laurie Mancini, (800) 448-5171; in New York, (800) 522-7464.

Nov. 11-15: M/A-COM MAC training seminar, Burlington, Mass. Contact Carolyn Calorio, (617) 272-3100.

Nov. 12-14: C-COR Electronics technical training seminar, Holiday Inn North, Marietta, Ga. Contact Deb Cree, (814) 238-2461, or (800) 233-2267.

Nov. 12-14: Texscan Instruments training program, Indianapolis. Contact Ron Adamson or Brenda Gentry, (317) 545-4196.

Nov. 12-14: Jerrold technical seminar, Atlanta. Contact Beth Schaefer, (215) 674-4800.

Nov. 13: SCTE West Texas Meeting Group seminar on signal leakage and the CLI, Holiday Inn, Big Spring, Texas. Contact Jim McCain, (915) 267-3821.

Nov. 14: Microwave Filter Co.'s seminar on terrestrial interference, East Syracuse, N.Y. Contact Bonnie Whipple, (800) 448-1666; in New York, Hawaii, Alaska and Canada, (315) 437-3953.

Nov. 19: SCTE Florida Meeting Group's seminar on feedforward and power doubling, Lakeland, Fla. Contact Dick Kirn, (813) 924-8541.

December

Dec. 4-6: California Cable Television Association's annual convention, the Western Show, Anaheim (Calif.) Convention Center. Contact (415) 428-2225.

Planning ahead

March 15-18: National Cable Television Association annual convention, Dallas.

May 13-15: Canadian Cable Television Association annual convention and cablexpo, Vancouver.

June 12-15: Society of Cable Television Engineers', Cable-Tec Expo '86, Phoenix (Ariz.) Convention Center.

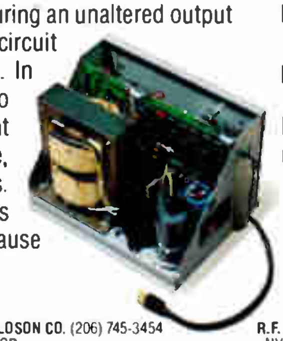
AD INDEX

We Gave Standby Power A Good Name

Unlike some other choices, Alpha maintains the Good Name of Standby Power by offering a reliable and failsafe approach—as we have right from the start. We call it the **"single ferro transformer"** concept.

This design concept leaves the ferroresonant transformer always connected to your Cable plant, regardless of power failures or other disturbances, and does away with the need for a second transformer.

The battery driven inverter takes over from the downed line in the **primary** winding of the transformer, ensuring an unaltered output voltage and waveform. Overload and short-circuit handling characteristics remain unchanged. In addition this **same** transformer is used to charge the batteries, providing a **high** current recharge of the batteries after a power failure, a feature lacking in most competitive designs.



This concept needs fewer components which translates into **higher reliability**. Because the inverter cannot be activated, even with the line relay contact "stuck", this concept also gave us the fail-safe feature that helped us to obtain both **UL** and **CSA** approvals. And that gives a good product a good name.

Of course, there are more reasons for Alpha's leadership and good name in Standby Power. Features such as **Temperature Compensated Charging** matched to the battery type and **Automatic Selftest** and **Equalizing**, to name just two.

Alpha was the **first** to offer **Remote Status Monitoring** for it's power supplies on a stand-alone basis.

And now Alpha has introduced two new State-of-the-Art Standby Power product lines. The **FT** series, a fast transfer type for critical loads up to 500VA, and the **APCG** series for true UPS performance up to 1500VA at Standby prices. Our ongoing efforts to give you the best engineered products will continue to give Standby Power a good name...**ALPHA.**

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Reader Service Number 51.

The smart house

By Robert A. Luff
Senior Vice President, Engineering
United Artists Cablesystems Corp.

The National Association of Home Builders Research Foundation Inc. (NAHB/RF) is enlisting over 20 of America's largest and most technically competent electrical and electronic products firms (GE, Westinghouse, Square D, Honeywell and Dupont, to name a few) to redesign the home electrical system. Today's house wiring, wallplates, switches, receptacles and sockets have changed very little in over 40 years. Even more driving, however, is the amount of other single-purpose communications and control wiring and installation labor in a typical house—door bells, heat and air-conditioning thermostats and controls, extension telephones, programmable or timer-controlled lights, security wiring, stereo speakers, intercoms and, of course, CATV coax.

As a result of this single-purpose system wiring, we can add the inconvenience of not being able to easily move the input or output devices (such as thermostats or speaker locations) when desired later; and not being able to later add, upgrade or enhance the use of other important but limited function and inaccessible wires. As well, we are unable to really zoom the technology of the end devices because of the present restricted ability of only simple interconnecting wires and the always less than satisfactory aesthetic result of post-wiring a beautiful home.

Wouldn't it be wonderful if there was an integrated power and unified communications network extending throughout the entire home with the ability to tie all home electrical and consumer electronics products together. Not only would such a technology eliminate the need for separate wiring for each system that needs to carry information from one location to another within the home, but it also would provide convenient all-purpose consumer telecommunications and control ports in every room. It would also promote the further development of advanced smart appliances with more useful consumer features, greater energy efficiency and higher safety. All future enhancements or new communications or control services would be "plug-in" capable anywhere in the house. This is a smart house.

Cable's opportunity

The smart house concept will have a significant impact on the future of the 1.5 million new homes built in the United States every year. There is a tremendous opportunity for the cable industry—operators and manufacturers—if we put our heads together. The cable industry can be far more than just one end user of an integrated home communications bus—it could be *the* bus. And, it could automatically connect the home bus with the outside world including networking home buses. CATV manufacturers and operators could advance these NAHB/RF concepts to a staggering future potential for the cable industry.

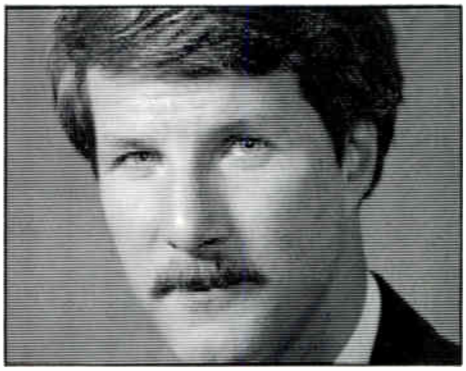
What single residential distribution technology alternative is better than coax? It is inexpensive, proven, reasonably easy to work with, and I estimate there is 1.3 million miles of 75 ohm coax drop cable already in use nationally—189,000 miles (enough to go to the moon) of it already in between the walls of U.S. homes! Competitors of the coax cable technology for the chosen smart house all important bus corridor are fiber optics, twisted pair, carrier current on house wiring, RS-232 type ribbon cable, infrared, or some integratable combination. But, can any of these handle 78 channels of simultaneous TV programming with plenty of sub-split bi-directional capacity for interhouse thermostat control, intercoms, audio system speakers, telephone extensions, and house security the way good old inexpensive 75 ohm drop cable can?

To the cable industry the trick will be the modest task of solving how to ring door bells and connect telephones, intercoms, security and fire alarm sensors by coax cable. Does anyone not believe we can do this? Does anyone not believe home owners would be supportive of more present and future use and convenience of their CATV coax house wiring? Does anyone not believe that CATV wires moving closer to home stereos, computers, alarms, thermostats, water heaters, refrigerators, dryers, and telephone extensions would result in opening revolutionary new long-term revenue opportunities as well as increasing our mainstay basic and pay lift? Does anyone not believe CATV could easily and naturally move into a smart house pre-wire and post-wire ancillary business?

Therein lies CATV's great opportunity to not only further extend our technology and cables deeper into our customer's walls, but into their everyday (non-television) lives and eventually their wallets for non-TV services. Even more importantly, however, is cable's ability to seize the home bus corridor opportunity and ensure our greater long-term influence and diversified revenue potential of the future continuing explosion and convergence of nearly every traditional electronic product and service toward the home and a greater dependence of interconnection and networking to get it there.

How big is the smart concept?

The opportunity doesn't stop with the smart house. Have you ever peeked above your office dropped ceiling? What a maze of control and communications wiring. Expensive single-system wiring and conduit could be eliminated by the integrated smart house concept in smart office complexes, smart high rises, smart city government buildings.



'CATV manufacturers and operators could advance these . . . concepts to a staggering future potential for the cable industry'

Given the right economic conditions it is easy to see how the smart concept could revolutionize end communications wiring and the final delivery form of all telecommunications and control signals into and out of the majority of U.S. homes and businesses—an issue of prime importance to the CATV industry.

Can we do it?

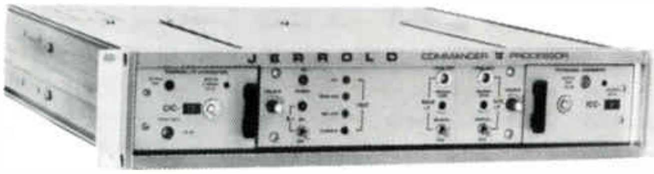
It use to be only Ma Bell and CATV fighting over the potential spoils of communication wires in the home. As these new uses and means to concentrate multiple uses on communication wires in the walls develop, lots of others with their own pet technologies and revenue ambitions also will be looking at the opportunities and trend that this year's 1.5 million new homes may provide.

There is no doubt that there will be fierce competition for the surviving smart bus technology standard. With all due respect, hopefully it will not be decided by the National Association of Home Builders. Regardless, a fractionalized CATV industry of independent and multiple system operators, programmers and manufacturers pulling and shoving against one another will be ineffective against more unified technological thrusts.

To succeed, the cable industry must rally behind its national associations to focus our disjointed individual efforts and effectively present and demonstrate that cable's unique technical capability makes it the *smart* choice.

Now In Stock At ANIXTER®

Jerrold COMMANDER® Headend Equipment



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