COMMUNICATIONS TECHNOLOGY

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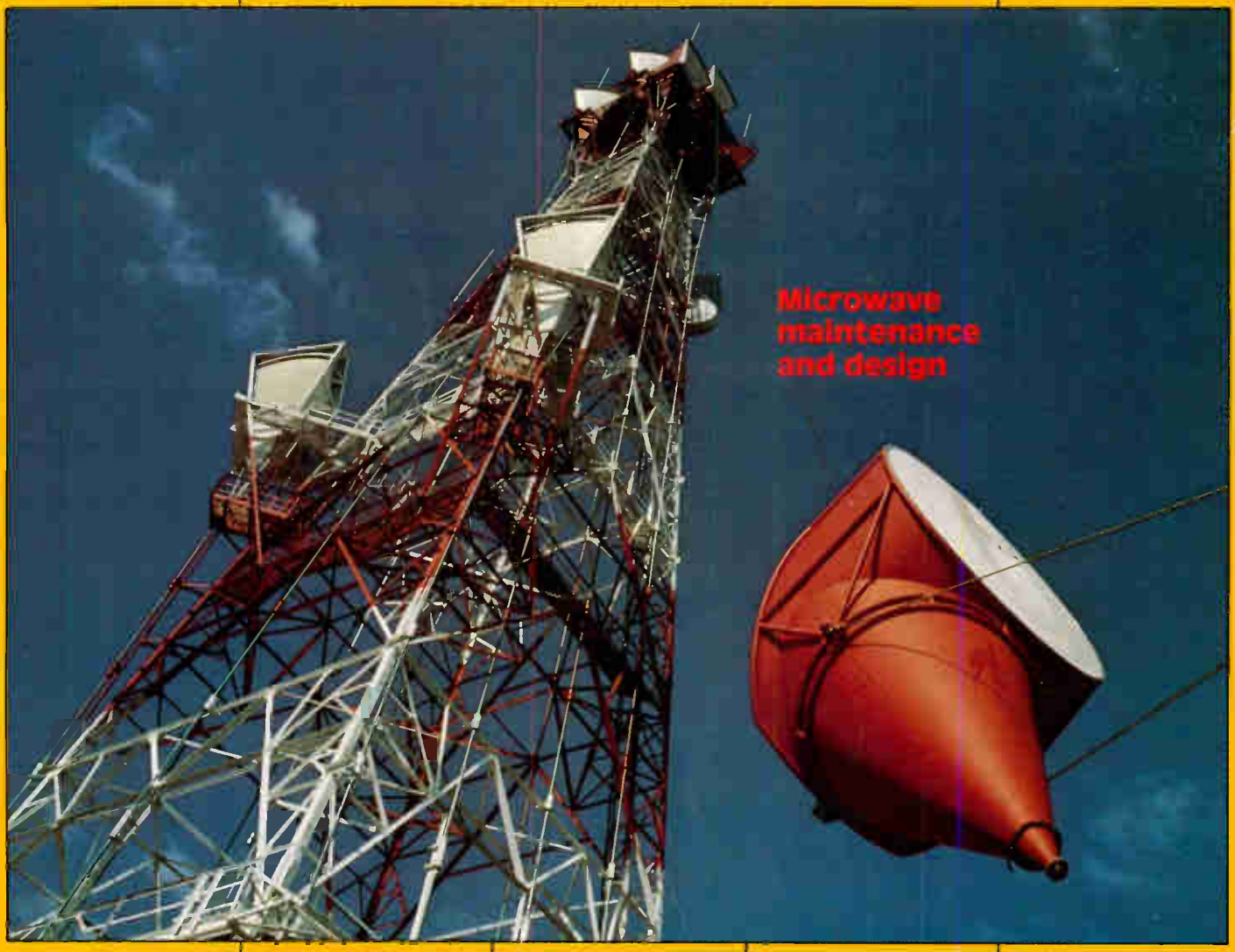
Official trade journal of the Society of Cable Television Engineers



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January 1989

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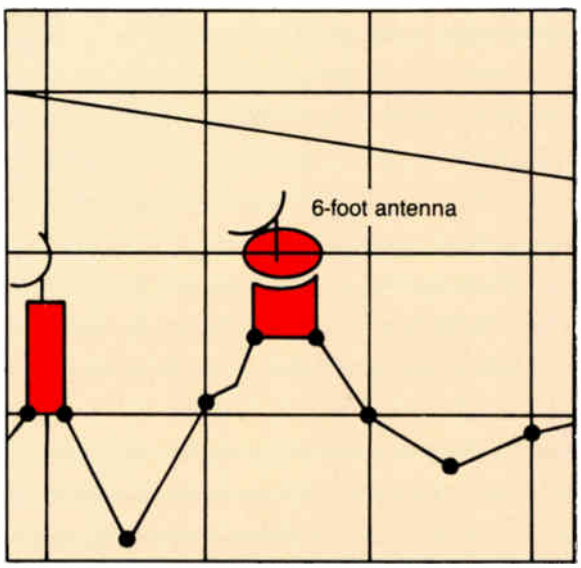

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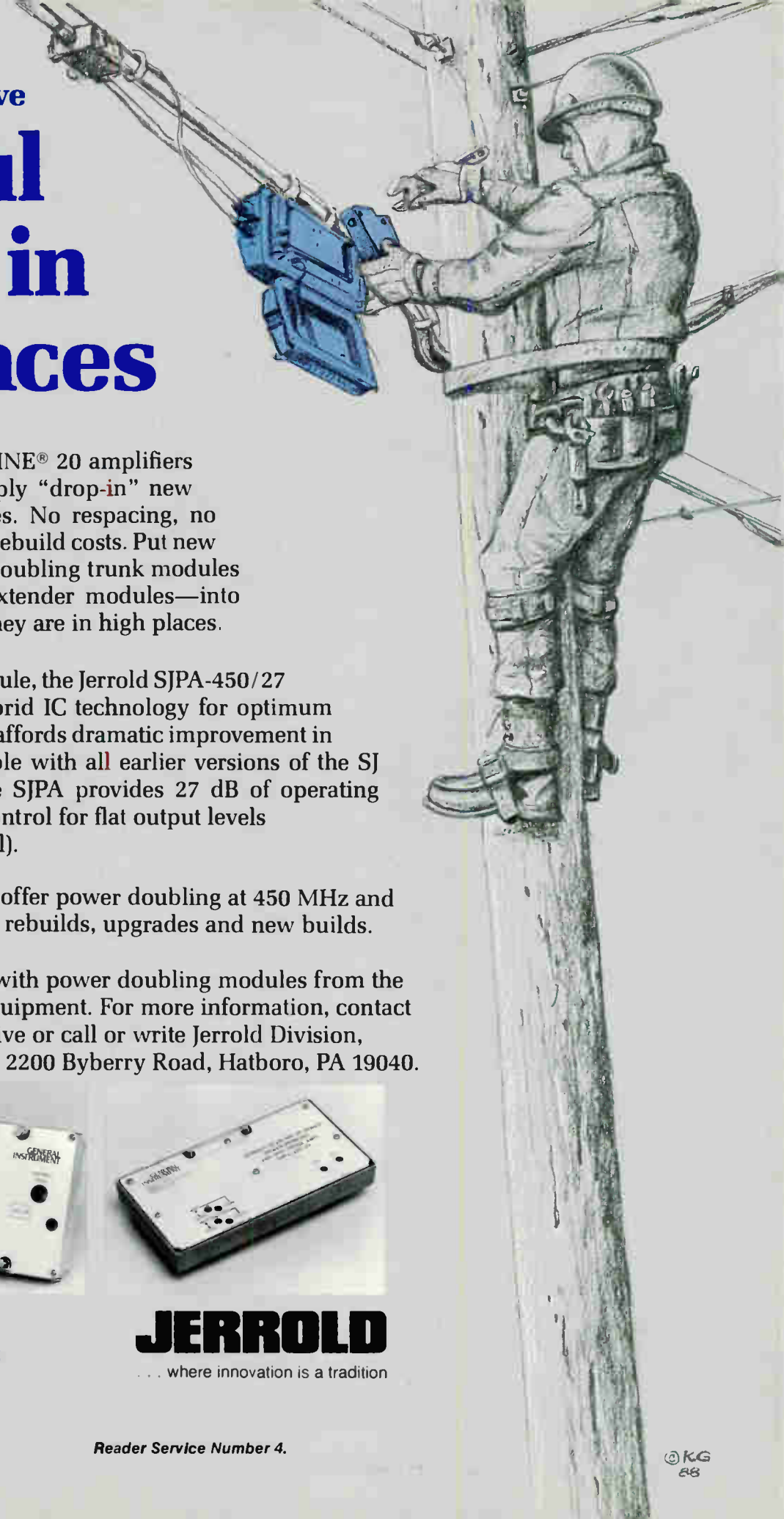

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Anecdotes from Anaheim

If the 60 mph Santa Ana winds didn't blow you away at last month's Western Show, the technical sessions, exhibit floor and other events came quite close. It was one of the most memorable Western Shows in years. But, for those of you who require the bottom-line figures, here they are: Attendance was estimated at 9,800, with 225 exhibitors occupying a floor area of 109,800 square feet. By the way, these were all increases from last year. However, there were no numbers on the amount of Epsom salts, liniment or aspirin substitutes consumed during the show.

In case you missed the show, here are some of the highlights:

- *The sound of pins dropping.* Things really started rolling Tuesday evening with the second annual CT Publications bowling party. Equipped with their CT hand towels, over 100 guests donned shoes, ate pizza, drank beer and competed for prizes. The Drop Shop's Lee Heller and CableTek Center Products' Tim Reilly won free advertorials in our sister publication *Installer/Technician* for overall best team performance. Rosemary Peterson of Professional Cable Contractors won a pair of "Robby" gloves and a pair of "Dexter" shoes (she was the highest female bowler). In addition, Russ Cohen of Cable Video Entertainment won the same as highest male bowler; he bowled 258, the best game. Jay Dorman of MPCS won a free advertorial for most unusual bowling style. We'd like to thank everyone for participating.
- *Getting technical.* There were six excellent seminars coordinated by the Society of Cable Television Engineers and the California Cable Television Association: "FCC update," with Bill Riker (SCTE) moderating; "Signal leakage," with Robert Dickinson (Dovetail Systems); "Fiber and cable: A view of possibilities," with Joe Van Loan (consultant); "Fiber transmission systems: Exploration of system architectures," with Jim Chiddix (ATC); "High definition—Moving toward reality" and "HDTV roundtable," with Ted Hartson (Post-Newsweek Cable); and "Consumer electronics interface report," with Walt Ciciora (ATC). Each seminar presented up-to-date information from a panel of respected members of the industry. Hats off to Pete Petrovich, Bill Riker and Dave Large for a job well done.
- *Happy birthday to you.* The Jerrold Division of General Instrument threw an unforgettable birthday bash for its 40th year in the CATV business. Hundreds of guests enjoyed the food, drink and entertainment, sharing the ballroom with thousands of balloons. Attendees were encouraged to bring along an old piece of equipment manufactured by Jerrold, with the oldest specimens receiving awards.
- *Exhibiting the latest.* As usual, the exhibit floor was packed with attendees trying to catch a glimpse at the equipment now available, as well as technology for the future. Jerrold put on a digital audio demonstration, Zenith demonstrated its NTSC-compatible HDTV system, Scientific-Atlanta unveiled off-premise addressability and fiber-optic products, Magnavox displayed new fiber-optic and status monitoring products, Corning put its fiber to the test, etc., etc. (For more information on some of the products introduced at the show, read "Product News" on page 110.)

Rikki Lee

During the Jerrold party at the Western Show, Frank Drendel of Comm/Scope announces a winner in "the oldest CATV product" contest as General Instrument executives Frank Hickey, George Safiol and Hal Krisbergh look on.

Just the facts, please

Let me clarify a couple of things that appeared in the November issue. In "News," page 13, we mentioned that The Drop Shop Ltd. had marked its 10-year anniversary with a move to a new facility in New Jersey and a quadruple in sales. It should have mentioned that the move occurred in February 1988; the quadrupling in sales occurred after only seven years in business.

Also, in the article "In-band vs. out-of-band addressability," Paul Harr of S-A wrote (page 20, third paragraph from the bottom), "If the subscriber orders a PPV event, the out-of-band system will send the PPV load to the converter only once." However, he was speaking only in relation to the S-A system, not in general.

Happy new year, birthday

It's 1989, and we're 5 years old! Each month we'll be spotlighting our staff members and telling you what we'll be planning for the future. Take a look at our ad on page 114, let us know what you think. We're growing and doing many new things, because we're dedicated to the cable TV industry and we're working for you!

Rikki T. Lee

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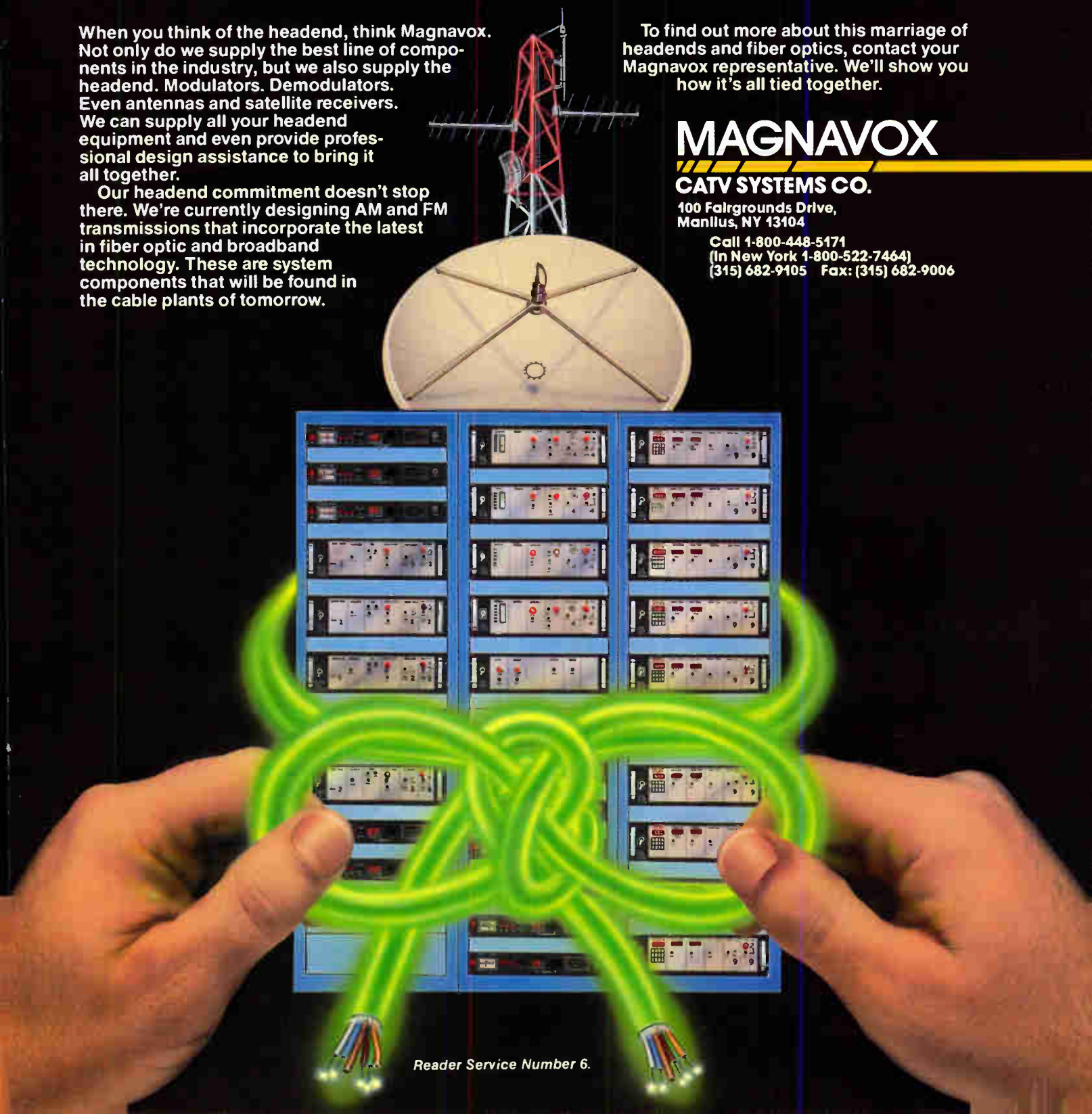

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COMMUNICATIONS TECHNOLOGY

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Cable Labs drive declared successful

BOSTON—Founding members of Cable Television Laboratories Inc., the industry's research and development consortium, now represent systems serving more than 75 percent of all cable subscribers in the United States. Results of the successful recruitment drive were announced at Cable Labs' first membership meeting held here last November.

The membership also elected its board of directors at the meeting, which then named Dr. John Malone (Tele-Communications Inc.) as chairman. Also elected were James Doolittle (American Television and Communications Corp.) as treasurer and Brian Roberts (Comcast) as secretary. The board's officers, plus Joseph Gans Sr. (Cable TV Co.), John Rakoske (Continental Cablevision) and Richard Roberts (Tele-Cable Corp.) were named to the board's executive committee; Dr. Richard Green, Cable Labs president and CEO serves on the committee in an ex-officio capacity.

Other members of the board of directors include Robert Brooks (Cencom Cable Associates), Dr. Walt Ciciora (ATC), William Eckberg (Meyer Broadcasting Co.), John Goddard (Viacom Cablevision), Henry Harris (Metro-Vision) and Ted Hartson (Post-Newsweek Cable). Also members on the board are Bradley Johnson (Warner Cable Communications), Marvin Jones (United Artists Cablesystems), James Mooney (NCTA), Dan Pike (Prime Cable), James Robbins (Cox Cable Communications) and Larry Wangberg (Times Mirror Cable TV).

Cable Labs is a for-profit membership corporation that provides information about technical developments of interest to the cable industry, plans and funds research and development projects and transfers relevant technology to its member companies and industry suppliers.

Rikki Lee

Ron George (right) of Viacom Cablevision displays a plaque given by the SCTE at the Western Show, while Pete Petrovich of Petrovich & Associates looks on.

Western Show notes

- A new insurance benefits program will be available to members of the Society of Cable Television Engineers through the Smith-Sternau Organization. By participating in a group trust program, the SCTE will be able to offer reduced rates to interested members. Also, the Society awarded Viacom Cablevision of San Francisco two plaques—one for its support in videotaping technical sessions and one for Plant Manager Ron George's support. In addition, the SCTE announced that Cable-Tec Expo '89 will be held June 15-18 at the Orange County Convention Center in Orlando, Fla., with Expo Evening at Sea World.
- Magnavox was selected to design and supply a two-way interactive system for Hiroshima Cablevision in Japan and signed a deal with Golden Channels Group in Israel to supply amplifiers, taps and line passives. As well, Magnavox is working with parent company N.V. Philips on research and development of laser transmitters and receivers. Also, the company signed Midwest CATV of Charleston, W. Va., as its new distributor.
- Oak Communications named BradPTS as its authorized U.S. service center for its Sigma line of addressable converters. BradPTS plans to add a Sigma repair center in Southern California by mid-year.
- Compusen is offering a computer-linked network for cable system operators that allows them to buy and sell merchandise, review vendor offerings, communicate with each other, search out and order needed parts, list job opportunities and many other industry functions. Those who sign up for one year of service will receive the first month free and a communications terminal.
- Scientific-Atlanta is shipping 7,000 addressable set-top terminals and other equipment to C. Itoh, a major Japanese trading company. S-A also created two business units within its Broadband Communications Business Division. David Fellows is vice president and general manager of distribution, headend and earth station systems; Steve Nussrallah is vice president and general manager of subscriber systems.
- Times Fiber announced that its 25,000 square foot plant expansion program is under way to accommodate the increase in coaxial cable business.
- Wegener Communications is providing its SDM 2000 QPSK subcarrier digital audio transmission system to Home Box Office. This will allow the programmer to transmit selected HBO and Cinemax programming in Spanish beginning this month. Affiliates may then deliver the Spanish audio to consumers using the SAP channel of MTS stereo encoders.
- General Instrument's Jerrold Division and Ortel are participating in a joint program to develop high performance lasers for use in fiber-optic CATV distribution systems.
- Orchard Communications recently took over the multichannel fiber-optic video business and plant facilities of Pirelli Communication Systems. Orchard will support all of the products previously sold by Pirelli and pursue new product development.

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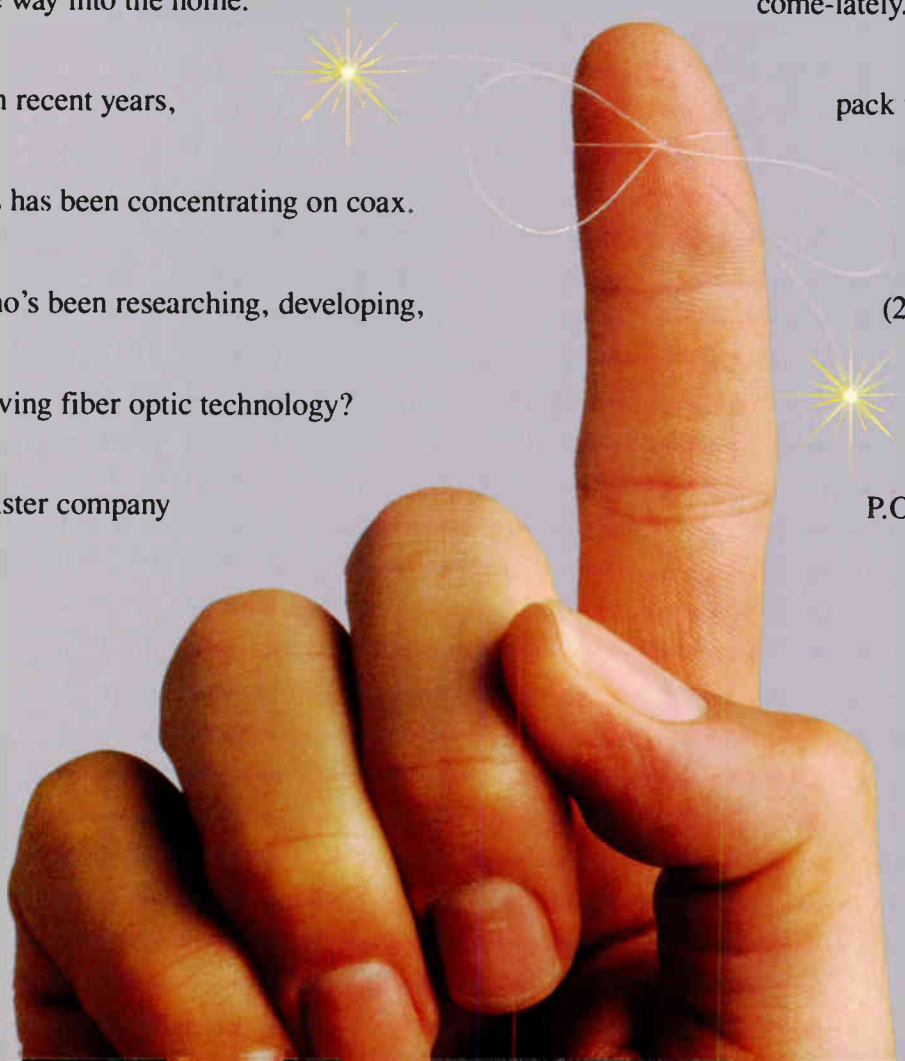

TFC

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See us at the Texas Show, Booth 415.
Reader Service Number 9.

The MBA "black hol

By Isaac S. Blonder
Chairman, Blonder-Tongue Laboratories Inc.

My *best friends* are masters of business administration (MBAs), who rank equally with lawyers in this dubious tribute to their profession. Lawyers, always faithful to the tenets of their oath, will labor unceasingly to win officialdom's approval of the deeds of their clients, regardless of their personal judgment of the criminal nature of the miscreants they represent.

Likewise, the MBA, having spent two long years paralleling the law schools' indoctrinations that freeze the mind and instincts into clonelike replicas of the breed, emerges from the cocoon uttering the same plaintive cry at the sight of every balance sheet, "What's the bottom line?!"

Never taught in the law or business schools, in my opinion, are the long-range consequences of their actions. Does the lawyer worry about the potential for further criminal acts from the criminal who is so cleverly defended against justice? Does the MBA, ever eager to show the maximum profit every quarter, have a fleeting moment of doubt when axing the R&D budget? Has anyone ever generated an R&D program that showed a profit each and every quarter? No way! Thus, your classically trained MBA, armed with a computer and a wary eye on the stockholder, makes certain that the "black hole" in the company will be exposed and banished from the balance sheets!

Impenetrable area

The physics definition of a black hole is the same as the one embraced by the MBA: an impenetrable area impossible to measure or understand that swallows everything within its reach (money) and spits out nothing useful. Equally reprehensible is the chief executive (guided by a "seeing eye" MBA) whose company has been coasting along for years without long-range planning (another form of R&D) when suddenly the industry is threatened with a new technology out of the blue. "Help," the executive moans to the MBA, "go buy up that fiber-optic competitor and save our skins." Does the mouse eat the cat? Not unless it turns into a very, very big rat!

It seems that our capitalistic economy is heavily infected by the black hole virus. Television technology and delivery is in the front rank of the victims of the MBA plague. American investors and scientists pioneered all electronic TV, financed by visionaries like David Sarnoff (no MBA he). After the birth of NTSC, how many dollars went into R&D by the TV broadcasters? How about zero? Perhaps one-tenth of 1 percent?

The TV manufacturer I worked for in New York City, as well as the other small companies I knew, supported product design, not R&D. The National Association of Broadcasters looked to R&D from their members who in turn looked to the few large manufacturers and the occasional impoverished inventor for the future designs. In the '60s when TV manufacturing left the country, American R&D was clothed in hand-me-downs by the MBAs. But other countries, whether by wisdom or tradition, supported large, true R&D facilities. Abroad, at least 5 percent of revenues went to R&D, apparently without a single MBA recommendation to cut loose the black hole. After the birth of television, 40 years have passed with useful but minor improvements in TV technology—satellite delivery, the exception, is a military triumph and not a civilian R&D achievement. Was the U.S. broadcaster happy with the resultant bottom line and no R&D budget? You bet!

"Everyone in television must wake up and treat R&D with the understanding and funds it needs to survive."

But the piper's tune is loud and clear: HDTV, we are now orphans of the storm! Suddenly the Federal Communications Commission emits a clarion call to the troops to save the existent TV body politic. What a ragged bunch of soldiers are able to answer the call! Our R&D labs have been slaughtered by the MBAs, our scientists turned into fast-food dispensers and the schools have catered to the computer revolution for which R&D money still nourishes the researchers.

As I have recommended in many of my previous columns, everyone in television must wake up and treat R&D with the understanding and funds it needs to survive. All entities in our world of television should devote no less than 5 percent of their gross income to research and development. This sum should remain inviolate except for intelligent managerial inspection of the R&D goals and staff. Never mind how many years will pass without proof that R&D contributed one dime to the bottom line, one miracle every blue moon is enough reason for its survival.

Although I am a firm believer in capitalism, the previously stated course of action seems to indicate a socialistic tinge to my rhetoric. Perhaps we need to add another facet to our society in order to restore the free enterprise stimulant. There has to be significant rewards to the inventors. Let the FCC judge the new technologies, pick a winner and then decree a royalty to be paid in equal parts to the inventors and the companies that employed them. Add on an appropriate level of tariffs on imports and America will once again look like a winner in TV design and manufacturing.

P.S. Hopefully my old friend, an emeritus professor of MBAs, will overlook this "black hole" view and remain my old friend.

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A simple look at AML preventive maintenance

By Dane Walker
Microwave Systems Engineer
Hughes Aircraft Co., Microwave Products Division

Preventive maintenance (PM) can be thought of as what occurs between installation and failure. In microwave systems Federal Communications Commission requirements (as set forth in Part 78 of the Rules and Regulations) must be considered in addition to what is thought to be "normal" PM. Any time we undertake a PM program, we must first define the depth of our program and frequency of checks. Far too many times very minor adjustments are made when not needed, only to find that the parts adjusted (e.g., potentiometers and capacitors) wear out before they need to. We can prevent this to a large degree by setting normal operating windows.

A microwave system breaks down into four major areas:

1) headend and equipment feeding the transmitters
2) transmitters
3) tower, waveguide and antenna systems
4) receivers

Each area has its own requirements and neglect in any area will affect the reliability and quality of the cable system and the satisfaction of the subscribers. In each area, the requirements are different but all affect what the subscriber sees.

The equipment to be discussed is manufactured by Hughes. (Other companies also manufacture AM 13 GHz microwave, but I have chosen the Hughes AML equipment since it represents by far the largest amount of this type of user-serviced equipment.) While all the stated levels are for AML (amplitude modulated link) microwave, much of the procedures are the same for all microwave equipment.

Headend and equipment feeding the transmitters—The AML requirements in this area are fairly clear: for the MTX- and STX-type transmitters, an input level of +39 to +41 dBmV with audio 17 dB below video and all spurious emission at least −60 dBc (dB below video level) and for the broadband equipment inputs to the transmitter between +24 and +31 dBmV again with audio at −17 dBc (see manual for specific broadband transmitter input requirements).

The flatness is very important in the broadband system as each dB difference on the input causes a corresponding dB change on the output. Being a broadband system there is no way to correct for discrepancies in one or two channels. The frequency must comply with FCC Part 76 (Ref. 76.612) and will affect the output frequency of the transmitters that must comply with Part 78 (Ref. 78.111). With the headend in proper order and all headend logs filled out we now can move to the transmitters.

Transmitters—The four types we will discuss will be the STX-141 and 141A high-power, MTX-132 medium-power, HPOLE-112 high-power broadband and OLE-111/111A low-power broadband transmitters. The output levels can run from +36 dBm for a single-channel STX-141A to −11 dBm for an OLE-111 loaded to 60 channels. A simple rule applies to all transmitters: the greater the number of channels the lower the output power. The proper output levels depend on transmitter type, number of channels, number of usable outputs and distortion requirements (broadband only).

The normal checks performed on the STX and MTX transmitters are: low voltage power supplies, master oscillator frequency, solid-state source tuning, klystron power supply voltage, current and klystron output for the MTX and transmitter output level. With the broadband transmitter (OLE-111 and HPOLE-112) normal checks are: AC voltage into the transmitter, +12 VDC, −20 VDC, calibration 2,870 ohms normal, temperature, crystal oscillator (XO) frequency, source phase lock, source alarm and output levels. All but output levels are checked from the TM5 test box.

In checking the STX, MTX and OLE transmitters, we first check the low voltage supplies. They must be within 0.5 volts of the absolute with ripple of less than 5 mV. With the OLE and HPOLE transmitters, the temperature must be checked because a change in temperature will change the XO frequency. For the STX and MTX transmitters, the master oscillator is checked for proper frequency.

In looking at the allowable drift, we first must assure that our headend is within specifications as per FCC 76.612; i.e., ±5 kHz. To meet the 0.0005 percent drift for the microwave, the master oscillator for the AML must be within ±370 Hz (for worst case). In a phase lock system the frequency out of the receiver will be the same as is fed to the transmitters. If the frequencies meet 76.612 then, in fact, the cable system will meet that regulation. In the case of a non-phase lock system we then see that the transmitter's XO and receiver's XO must be within 29 Hz of each other and the transmitter must be within ±370 Hz of its assigned frequency. It also should be noted this does not allow for any frequency drift at the headend site.

With the latest FCC rules, we see in all cases that the easiest way to comply is to phase lock the receivers to the transmitter. It is felt that if we keep the XO within ±180 Hz of its assigned frequency it will provide a better running system. Long-term studies have shown most oscillators will remain within ±50 Hz once properly set.

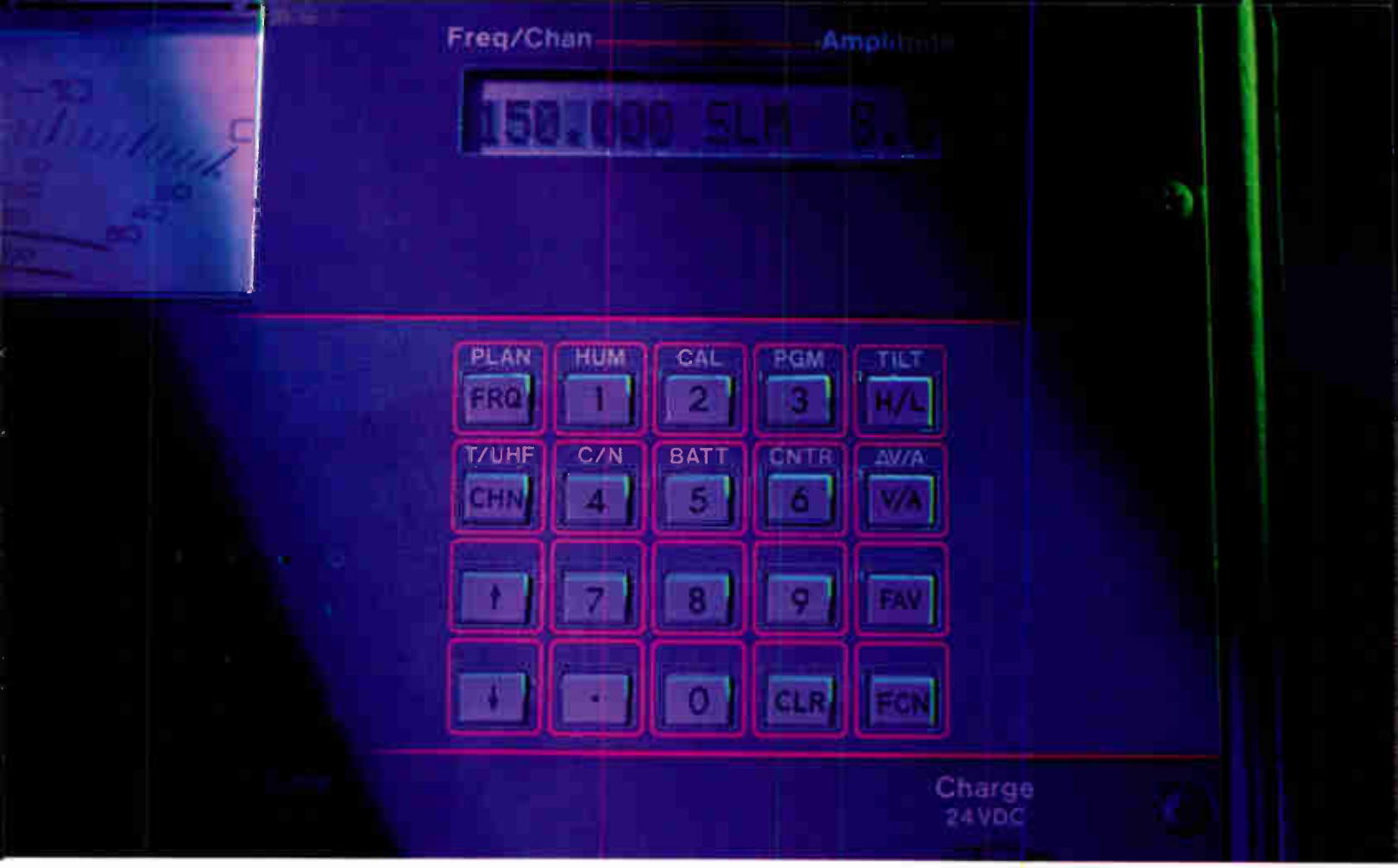
"Any time we undertake a PM program, we must first define the depth of our program and frequency of checks."

Solid-state sources

Next, check the solid-state sources. These units are normally set to the center of their range of 10 volts and will normally run from 5 to 15 volts before the alarm voltage becomes greater than 0.5 VDC. The alarm also is indicated by an LED on the front panel of the STX and MTX transmitters and by a source alarm voltage greater than 0.5 VDC on the TM5 of the OLE and HPOLE transmitters.

In the MTX and STX channelized transmitters, the klystron—while being the same basic tube—is tuned somewhat differently. In each case, check the high voltage (about 2.2 kV) and current (135 mA to 75 mA). When a tube is replaced, check the filament voltage (6.3 VDC ±0.1 volt). The current is the key to the tube's output. While some tubes work down to 60 mA, it has been found that when a tube gets down to about 75 mA it is time to replace it. The output of both tubes is set by changing their inputs. With the STX-141s and 141As, this input is the output of the upconverter. By logging the current draw of the tube, you will start to see a slight drop in current over time as this approaches 75 mA. The drop will become more pronounced, and this is the time to think about replacement.

In the case of the MTX transmitter, check to see that all klystrons are running at +45 dBm (30 watts) output level. The check is normally made at the cross-guide coupler on the klystron output. The normal coupler value is 45 dB but some may differ by up to ±1 dB. A second place to check is the input to an upconverter at the output flange of a magic tee. This level is +36 dBm when the klystron is running at +45 dBm. This would normally be checked with a calibrated 30 dB coupler and does require the system to be shut down when the coupler is installed and removed. Once this level is set you may now use it to calibrate the 45 dB coupler. From this point



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on there is no need to shut down the system to check klystron output levels on the MTX transmitter.

The output level of the klystron in the STX transmitter depends on its tuning and input level. With both the MTX and STX transmitters, normally once the system is set up by measuring the output with a power meter, we then calibrate the transmitter monitor. With these levels logged, we now have a way to check output levels using a field strength meter (FSM) without taking the system out of service.

With the OLE and HPOLE equipment, the factory provides a data sheet that calibrates the VHF monitor to a reference level of 0 dBm output. If the system is designed to run at −9 dBm, subtract 9 dB from the calibrated output VHF level. The reading is once again done using an FSM. Normal failures that may occur in the broadband equipment (if not spotted on the TM5) also may be found by checking the current draw of the GaAs FET amplifiers. The normal values are on the data sheet shipped with the equipment. Unlike the STX and MTX transmitters we do not normally check and log these current readings, since this would require the transmitter to be opened, the +12 VDC going to each amplifier to be broken and an ammeter inserted. This causes system downtime and reveals no useful information.

Again, all work performed must be entered in the transmitter logbook at the time the work is performed. In the old days (about 1968) a logbook was defined as a bound ledger with the numbered page filled out in blue or black ink. While many of the FCC engineers might feel this is going a bit "overboard," it does provide a document that will hold up in court.

In many cases during an FCC visit if you can show the engineer the calibration information in your logbook, you may find no need to take the system off-line to prove the output level. But remember that the engineer is within his rights to check the level out of the transmitter any way he pleases at the time he is on-site.

Tower, waveguide and antenna systems—What we have seen over the years is that this area is the most overlooked when it comes to PM. When properly done, this should be the least of your problems. The tower should be checked for proper guy tension; it also should be checked to see that it is plumb. Normally these checks are done in winter and spring, and usually by an experienced tower contractor.

Monitoring the waveguide pressurization is very important for two reasons. First, if there is leakage of dry air from the waveguide, it also will allow moist air to enter the guide. This will cause excess loss in the waveguide and cut down on system performance. Leakage also may be an indicator of a damaged piece of waveguide or bad connector, leading to poor frequency response. Normal waveguide pressure is 3 to 8 psi of dry air or dry nitrogen. The leak rate for the system should be less than 15 percent in 24 hours, conforming with RS-222D. Moisture in waveguide can be a couple of drops to many cups; in either case, it will lead to poor system performance if not dealt with.

Grounding of the waveguide may not stop all damage caused by a lightning strike but it will help to minimize the damage. Grounds should be checked for damage and to see that they are properly attached. All waveguide runs over 20 feet should be grounded at both ends; under 20 feet, ground just the equipment end.

Antenna realignment is normally performed after a tower has been replumbed and the guys retensioned. If we see a 3 dB loss in the no-AGC (automatic gain control) system level, it could be caused by antenna misalignment. With a 10-foot dish, we need only to twist the tower 0.3° to get a 3 dB loss. Even a 4-foot dish will lose 3 dB of gain with a tower twist of only 0.7°. All antennas and tower hardware should be checked at least once a year and after a very severe storm (e.g., hurricane).

The tower and antenna systems, while needing a person with very little electronics knowledge, can cause problems if not properly maintained, just as much as if the headend and transmitter had failed.

Receivers—The receivers used in an AML system can run from the very simple ILNCSRX-272 composite AGC 300 MHz indoor to the most complex OLNAEXR-285 phase lock pilot tone AGC low-noise (with LNA) VHF AGC 550 MHz receiver. In using the RM2, 2A and 6A receiver monitor (RM) test boxes we must remember that only the outdoor full-size receiver will show the temperature.

At the receive site many checks can be performed using either the RM2, 2A or 6A test boxes. By logging each reading we can see changes that occur over long periods of time. If we see changes in the AGC voltage, we may choose to look at the transmitter or antenna and waveguide. Changes in phase lock voltage may show a problem in either the transmitter XO or the cooling system in the receiver. Normal RM readings are as follows:

RM function	**Reading**
VAC 60 volts AC	6 VDC
30 volts AC	3 VDC
−20 VDC	−24 VDC ±0.5 V
+24 VDC	+24 VDC ±0.5 V
Error	4-14 VDC, nominal 8 VDC
High alarm	<0.5 VDC
Low alarm	<0.5 VDC
Source PLL	6-14 VDC, nominal 10 VDC
Source alarm	<0.5 VDC
Microwave AGC	0.5 to 8 VDC (depends on input level)
Calibration	2,870 ±30 Ω
Temperature	3 to 4.2 kΩ (nominal 3.606 Ω)

By far one of the most important measurements that can be made is the *no*-AGC output level of the receiver. This level will change with almost any problem you see and is directly linked with the fade margin and system reliability. By logging this and other levels, we can see trends in our system. These trends, if spotted early, can be cleared before causing an outage.

One misconception about fade margin comes from the thinking it is the same as the difference between the AGC and no-AGC levels of the receiver. In fact it is the difference between the no-AGC carrier-to-noise (C/N) and a 35 dB C/N. We don't lose our pictures at 35 dB C/N; it is just the point where it is felt the quality is objectionable.

A microwave system is no different than a cable system. We start with good quality signals and try to maintain that quality from start to finish. Along the way we perform some form of PM to keep it running at its optimum levels. One of the first questions asked is "how often." While some feel daily checks are needed, others prefer weekly or monthly checks. The FCC requires you to measure or log the master oscillator frequency annually and to comply with their standards all the time. You may choose to check your transmitter once a week and all receive sites once a month.

The following are a few simple rules to follow not only with microwave but with all your equipment:

1) In all cases use the factory manuals. If you can't find them, in most cases a phone call to the customer service department and sometimes a small charge will get you the manual you need.
2) Ask questions of your fellow workers; in many cases they will be very happy to help you. If you don't ask questions, no one will know you need help.
3) Consult with factory reps, over the phone or in person.
4) Attend training seminars. Many are offered throughout the year by the different manufacturers. Also, the Society of Cable Television Engineers has many sessions by satellite; the SCTE local chapters and meeting groups always have outstanding speakers. ■

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Maintaining FML microwave equipment

By Ron Hranac
Senior Staff Engineer, Jones Intercable Inc.

Maintaining FML (frequency modulated link) microwave equipment is not as complicated as it may first seem, although a basic understanding of frequency modulation and baseband signals is helpful. Because microwave radiation may be present during normal operation of the equipment, a knowledge of safe maintenance practices is mandatory. Also, a minimum amount of test equipment will be needed for proper operation and maintenance of transmitters and receivers. This article provides general maintenance guidelines for M/A-COM (formerly Microwave Associates) MA-12X and MA-12G radios, but it is highly recommended that individuals who maintain this kind of equipment attend manufacturers' training seminars when they are available. The following is a representative list of test equipment necessary for proper maintenance of 13 GHz FML radios:

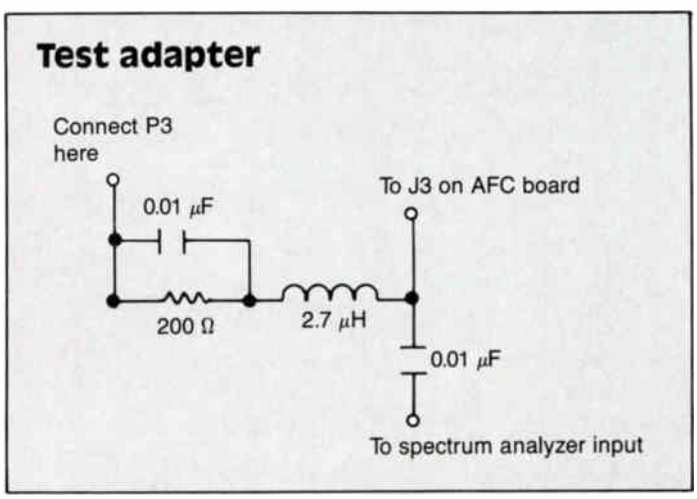
- Hewlett-Packard (HP) 435B power meter
- HP 8481A power sensor
- HP P281C waveguide to N adapter
- HP MP 292B waveguide adapter
- Hughes 102-594-01 20 dB crossguide coupler (for MA-12X transmitters)
- Hughes 102-594-02 30 dB crossguide coupler (for MA-12G transmitters)
- Texscan MDC-3 or MDC-5 microwave downconverter
- HP 8558B or 8590A spectrum analyzer digital multimeter
- HP 654A test oscillator
- HP 5342A microwave frequency counter (or equivalent)
- Video waveform monitor
- Regulated variable (0-12 V) DC power supply (for MA-12X series only)

The main parameters requiring attention when maintaining FML equipment include baseband input and output levels, equipment operating voltages, transmitter output power and deviation and frequency of operation. Once each year you should verify path alignment. The following procedures assume antennas are correctly aligned, polarization has been set and a line-of-sight condition exists between antennas.

MA-12X series

The M/A-COM MA-12X series of microwave radios is in the low-power (nominal +13 dBm transmitter output) category of single-channel FM video transmission equipment for 12.7 to 13.2 GHz CARS band short- or medium-haul links. Although the MA-12X transmitter is no longer manufactured by M/A-COM (MA-12X receivers are available), many units are still in the field providing reliable service.

The following maintenance procedures are for transmitters and receivers in good working condition; major repair and alignment is not covered here. Refer to the factory service manual or contact M/A-COM directly for repair and alignment procedures.



Monthly maintenance

1) Verify that the room temperature is normal.

2) Inspect the equipment for loose or corroded connections and hardware. Check the antennas, waveguide and support hardware for signs of damage and make sure the waveguide pressurization system is operating correctly.

3) Check transmitter baseband input levels and receiver baseband output levels to ensure that they are correct (nominal 1 volt peak-to-peak for video signals and within manufacturer's specifications for subcarriers or other baseband signals). Record all readings in your transmitter/receiver logbook.

4) Measure AFC voltages at the test points on the rear of each radio; record the readings in your transmitter/receiver logbook.

5) Make sure there are no burned out indicator bulbs or faulty alarm circuits. Record any repairs you make in your transmitter/receiver logbook.

6) Look at the picture quality on each channel.

Annual maintenance and proof-of-performance

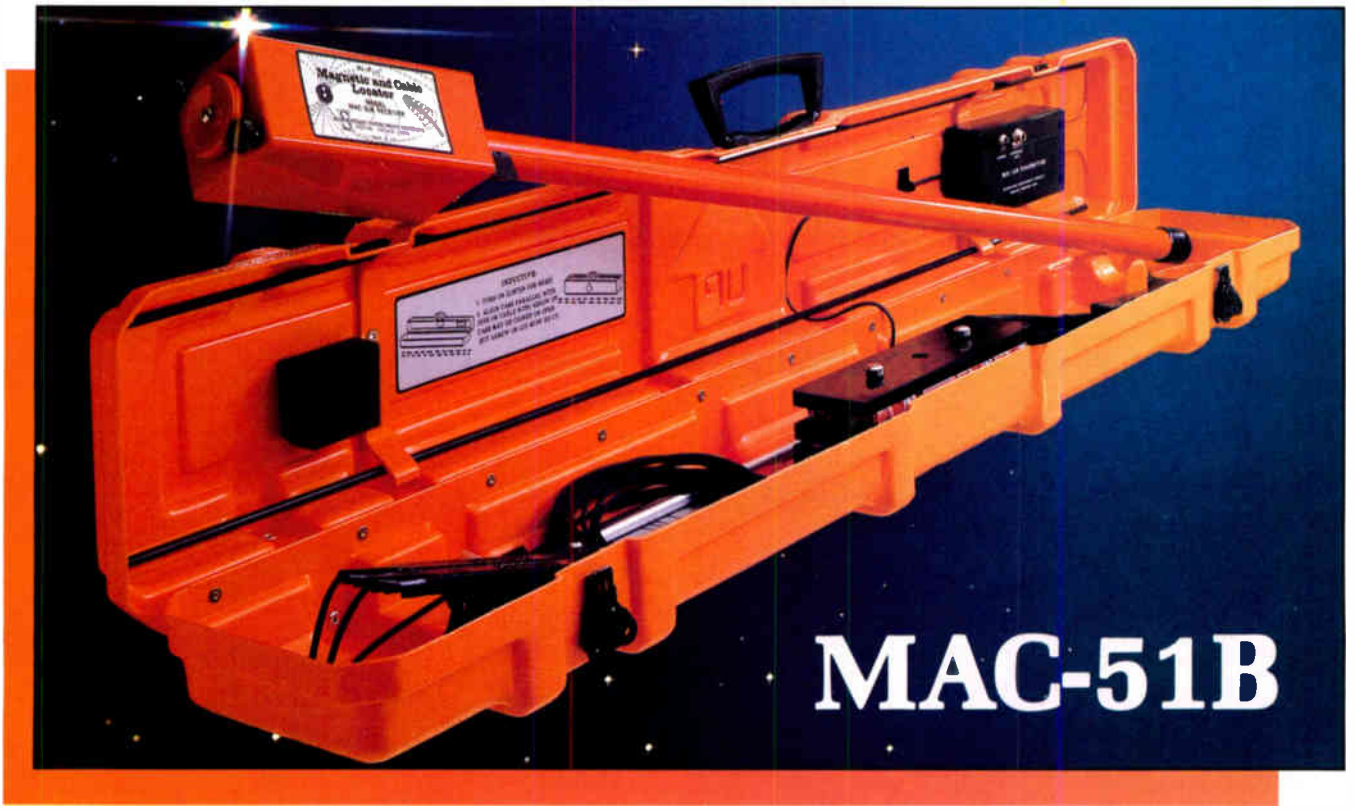
1) Perform procedures described under "Monthly maintenance."

2) *Transmitter frequency:* Turn all the transmitters off by unplugging the AC power cord from each one. Disconnect the antenna waveguide from the top of the circulator chain and install a 20 dB crossguide coupler. Terminate the through port of the coupler and connect a microwave frequency counter (with the appropriate waveguide to cable adapter) to the tap port of the coupler. Measure the frequency of each transmitter one at a time (all other transmitters must be off). Make sure the frequency counter has warmed up for at least one hour prior to making any measurements and allow each transmitter to warm up again a few minutes prior to measuring its frequency. Each transmitter should be within 0.005 percent of its assigned frequency; if not, it will be necessary to readjust output frequency.

Field adjustment of the transmitter frequency is not recommended, but if you cannot justify the downtime to send the transmitter to M/A-COM for alignment, use the following procedure: Remove the top and side covers of the transmitter for access to internal components. Disconnect the lead from E3 of the automatic frequency control (AFC) board, and attach an external +7.5 VDC to the lead. Allow the transmitter to operate for 30 minutes. Tune the transmitter frequency to the correct frequency by adjusting the "Gunn" tuning slug on the transmitter RF assembly (caution: the Gunn VCO is closest to the isolator at the rear of the transmitter; make sure you do not adjust the "X50 mult" tuning slug by mistake).

For the next step, you will need to fabricate a test adapter (see accompanying figure): Place a 0.01 μF (microfarad) capacitor and 200 ohm resistor in parallel; connect a 2.7 μH (microhenry) choke in series with the parallel circuit and a 0.01 μF capacitor in series with the choke. Attach the output of the series 0.01 of capacitor to the input of a spectrum analyzer.

Disconnect the AFC input (P3 from RF mixer) from J3 on the AFC board and connect P3 to the input of the parallel circuit. Attach the junction of the series 0.01 μF capacitor and choke to the AFC input (J3) on the AFC board. Set the spectrum analyzer to 50 MHz. Adjust the "X50 mult" tuning slug and peaking capacitor to obtain a 50 MHz signal greater than −30 dBm (+19 dBmV) on the analyzer. Then adjust L1, L2, C11 and C13 on the "osc/X2 mult" board to reduce spurious signals (sidebands) to a minimum. During this process maintain a 50 MHz signal and a level of −30 dBm (+19 dBmV) or greater on the spectrum analyzer (verify the 50 MHz frequency with a counter). Disconnect the test adapter and reconnect P3 to J3. Disconnect the external +7.5 VDC and reconnect the AFC lead. Allow the transmitter to operate for a few minutes and confirm the transmitter frequency and AFC voltage (6 to 9 VDC). Carefully adjust the



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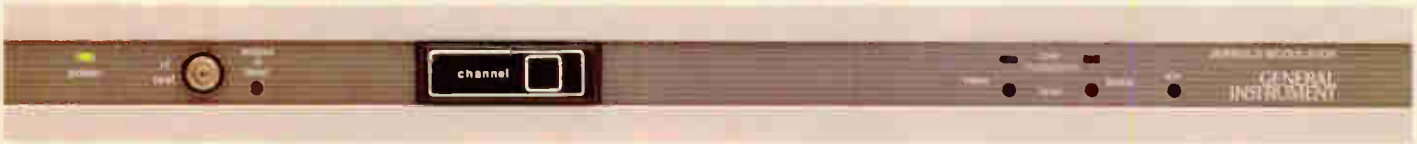
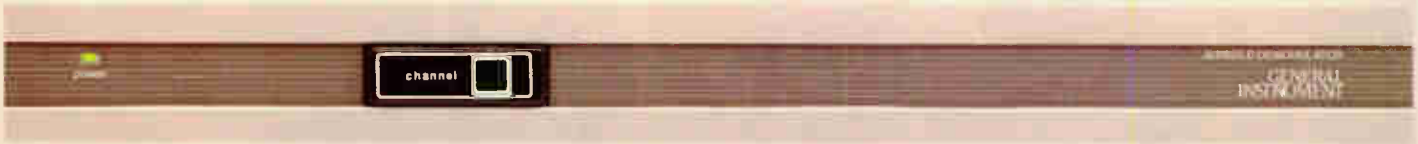


S450M
Frequency Agile Modulator

- *Frequency Agile from 50 to 450 MHz*
- *Front Panel Controls*
- *60 dBmV Output*
- *BTSC Stereo Compatible*



S890D
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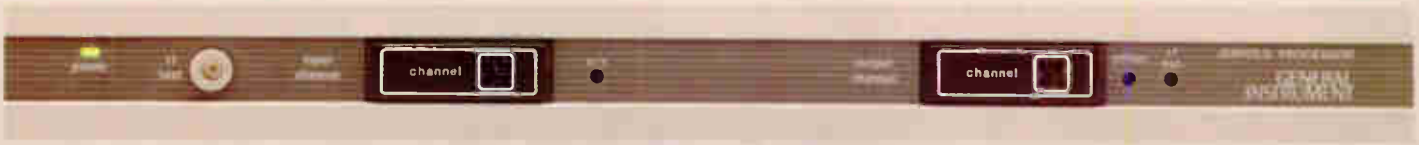

S450P
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- *450 MHz Output Capability*
- *Front Panel Controls*
- *60 dBmV Output*

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GENERAL INSTRUMENT

All components are FCC compliant.

Annual maintenance and proof-of-performance

1) Perform procedures described under "Monthly maintenance."

2) *Transmitter frequency:* Turn all the transmitters off by unplugging the DC power cable from each one. Disconnect the antenna waveguide from the top of the circulator chain and install a 30 dB crossguide coupler. Terminate the through port of the coupler and connect a microwave frequency counter (with the appropriate waveguide to cable adapter) to the tap port of the coupler. Measure the frequency of each transmitter one at a time (all other transmitters must be off). Make sure the frequency counter has warmed up for at least one hour prior to making any measurements and allow each transmitter to warm up a few minutes prior to measuring its frequency. Each transmitter should be within 0.005 percent of its assigned frequency; if not, it will be necessary to readjust output frequency.

Because of various revisions to the AFC circuitry in MA-12G transmitters over the years, it is recommended that you refer to the service manual or contact M/A-COM directly for the appropriate frequency adjustment procedure. Record all adjustments and measurements in your transmitter/receiver logbook.

3) *Receiver frequency:* Do not adjust a receiver's frequency until its companion transmitter's frequency has been verified as being correct. Disconnect P1 from J1 (IF network input), and, using appropriate adapters, connect P1 to a frequency counter. The counter should read within ±500 kHz of 70 MHz; if it does not, it will be necessary to adjust the receiver frequency. To do this, insert a 5/32 Allen wrench into the Gunn local oscillator tuner access plug and rotate it counterclockwise to increase frequency or clockwise to decrease frequency, so that the receiver IF is within ±200 kHz of 70 MHz. Reconnect P1 to J1 and record all measurements and adjustments in your transmitter/receiver logbook. (Note: If the 70 MHz signal on P1 is not of sufficient level to drive your frequency counter, it will be necessary to open the IF network and access a higher amplitude IF signal at J10, the output of the equalizer board.)

4) *Transmitter deviation:* Connect the 75 ohm output of the HP 654A test oscillator to a frequency counter and adjust the oscillator's output to 2.33 MHz. With the oscillator connected to a waveform monitor or oscilloscope (terminated in 75 ohms), adjust the oscillator output amplitude to 1 volt peak-to-peak (same as measuring video). Remove the transmitter's video input and replace it with the 2.33 MHz test oscillator signal. Connect the microwave downconverter and spectrum analyzer to the 30 dB crossguide coupler that was installed for transmitter frequency measurement. Tune to the transmitter's output frequency; with the analyzer controls set to 10 dB/vertical division, 300 kHz resolution bandwidth and 2 MHz/horizontal division, adjust the "baseband gain" control on the baseband amplifier card (located inside the transmitter on the left side) for the first carrier null on the spectrum analyzer. Deviation is now set to manufacturer's specifications. Disconnect your test equipment from the transmitter. Verify that the input video signal level is 1 volt peak-to-peak and reconnect it to the transmitter. Record all measurements and adjustments in your transmitter logbook.

5) After transmitter deviation has been adjusted, readjust each transmitter's companion receiver video output to 1 volt peak-to-peak.

6) *Transmitter output power:* Connect a calibrated power meter to the 30 dB crossguide coupler that was installed for transmitter frequency measurement. Read and record the power meter reading (remember to add the power meter reading to the loss of the coupler to determine actual output). When measuring power in this manner, only the transmitter being measured should be turned on. Do each transmitter one at a time. Since there is no power output adjustment, record the readings in your transmitter logbook. If any of the transmitters are 3 dB below manufacturer's spec, it will be necessary to have the transmitter sent to M/A-COM for repair.

When power measurements are complete, remove the crossguide coupler (all transmitters must be off when you do this) and reconnect the antenna waveguide. Turn the transmitters back on, ensure that video leads have been reconnected, check transmitter voltages and input levels and make sure that no alarm conditions exist.

7) Look at the picture quality on each channel and make sure you have recorded all measurements, readings and adjustments in your transmitter/receiver logbook.

Microwave and satellite subcarriers

By Frank McClatchie
President, FM Systems Inc.

In the early days subcarriers were called "diplexers," alluding to their main function at that time to place a second channel (TV audio) onto the same baseband as the television signal for TV studio-to-transmitter (STL) microwave links. After a while, two or more channels were multiplexed onto STL systems, so the term "subcarriers" came into prominence. The term is now applied to a host of multiplexing processes that are carried in the frequency band above video, typically ranging from 4.5-10 MHz. In fact, some channels have discarded the video and carry only subcarriers.

A given type of subcarrier may be operated over both satellite and microwave, but these two transmission facilities differ in some important characteristics. A subcarrier designed for one may not operate as well on the other. The microwave facility is characterized as having an excellent carrier-to-noise (C/N) under normal conditions, only dropping to threshold a very small percentage of time. A satellite channel is just above threshold all the time. This causes the choice of design factors relating to signal-to-noise (S/N) to be more crucial in satellite systems. Conversely, since the satellite is a one repeater system —while microwave systems may extend up to 50 or more links for one channel—in microwave subcarriers the design factors that reduce the impact of differential phase, differential gain and envelope delay predominate in importance. Subcarriers are not all born equal.

Wideband: In general these subcarriers deviate from ±75 to ±500 kHz and carry uncompanded program audio, FM stereo multiplex, BTSC multiplex, 12 channels of frequency multiplexed voice grade audio or wideband data (up to 100 kilobits or even more). This type of subcarrier accounts for most of the satellite TV audio channels and most of the microwave subcarriers. The high deviation ratio enables these channels to provide good S/N, even on satellite facilities (typically about 70 dB). The wideband occupancy restricts the number of subcarrier channels that may be carried. Up to four such subcarriers have been carried on terrestrial microwave and usually no more than two are carried on satellite transponders.

The 15 kHz program audio type of wide deviation subcarriers is what started the subcarrier business. Although still widely used it is falling out of favor as operators discover that 15 kHz program audio can be transmitted on compandored narrowband channels that allow eight or more channels to be transmitted over the same microwave or satellite facility. Wideband subcarriers retain their usefulness when transmitting baseband multiplexed signals such as FM stereo multiplex, BTSC multiplex, wideband data and multichannel frequency division multiplex (FDM) voice grade channels.

Narrowband: Narrowband audio subcarriers usually deviate ±25 to ±50 kHz and carry compandored program audio. Companding of some sort is necessary because the narrow deviation results in a low deviation ratio and thus poor basic S/N. Companding improves this S/N to 65-90 dB. The ±25 kHz deviation subcarrier is usually limited to transmitting 7.5 kHz audio, while ±50 kHz deviation transmits 15 kHz program audio. Uncompanded narrowband carriers also can carry AFSK, FSK, BPSK or QPSK data.

The most common narrowband satellite facilities use a sliding pre-/de-emphasis system developed by Wegener. At high volumes, the channel frequency response is flat. As the program audio level is reduced, a de-emphasis network time constant is progressively increased at the receiving end. Since the transmitting modulator is pre-emphasizing with the same dynamically controlled time constant, the overall frequency response should remain constant. The result is that at low modulation levels, the high frequency response of the receiver is greatly reduced, thus reducing the level of received noise accordingly. A consideration of this system is that the pre-emphasis at the transmitting end must be in step with the receiving de-emphasis network, or the frequency response will no longer be flat. Any difference in level at the receiver vs. the transmitter will cause changes in the frequency response. This system is in widespread use as a standard for stereo audio delivery to TV stations and also for radio programs and other audio services.

Various other types of compandors are in use in satellite and terrestrial microwave facilities in order to overcome the fundamentally poor S/N of narrowband subcarriers. Most of these systems are proprietary and are usually available from only one company. These systems consist of one- or two-band compandors with either 2:1 or 3:1 compression ratio. The crossover frequency of the more common two-band systems will vary according to manufacturer, as will the companding ratio and attack/release time ratio. With such variation in operating parameters, the subcarrier receiving equipment should match the transmitting system to get best performance.

Narrowband channels also are used to transmit FSK data. At least 19.2 kb can be transmitted on the ±50 kHz deviation type of narrowband system and at least 9.6 kb can be transmitted on the ±25 kHz deviation subcarrier systems.

Each of the two bandwidths of narrowband deviation subcarrier systems is assigned to a specific frequency (see accompanying table).

"The wideband occupancy restricts the number of subcarrier channels that may be carried."

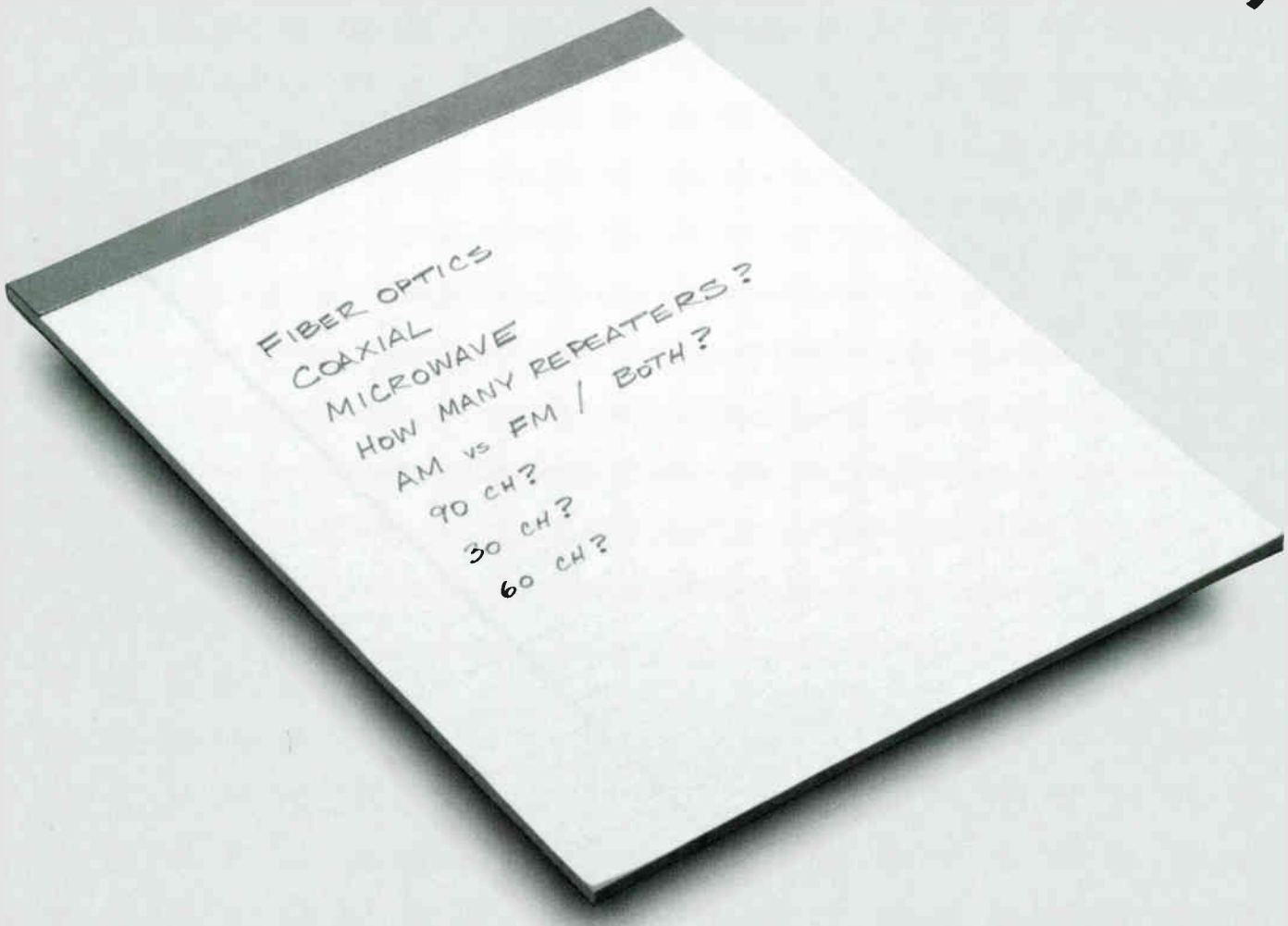
Note that the first subcarrier frequency is 4.5 MHz and is assigned to Ch. 25. This is because 4.5 MHz is the 25th harmonic of the 180 kHz frequency interval. All other frequency assignments will be the whole number multiples of the 180 kHz frequency spacing. These channels will be deviated ±50 kHz and be capable of passing a 15 kHz baseband audio signal. Since most 4.5 MHz subcarriers are for TV audio, deviation on this particular channel is ±25 kHz and contains no compandoring. The lowest frequency commonly used is 5.4 MHz. If this frequency is not used, the two ±25 kHz channels (5.355 and 5.445 MHz) may be used. In each case, either the 180 kHz spacing channel may be assigned or the two 90 kHz spacing channels may be operated, but never any combination of the two within one frequency interval.

Delta modulation systems

Some systems use one of the versions of delta modulation developed by Dolby. The audio signals are sampled at a very high rate, then the difference between the current sample and the previous sample is determined by subtraction. This difference is encoded into a bit stream along with step size encoding and sliding de-emphasis. This is referred to as "adaptive delta modulation" (ADM). This bit stream is usually modulated onto a carrier by the quadrature phase shift keying (QPSK) modulation system. (HBO will be using ADM to transmit its Spanish language audio service.)

Various countries are currently experimenting with the Dolby Adaptive Delta Modulation system. Wegener is developing an audio delivery system using ADM for West Germany's post and telecommunications agency. In the United States, a 12-channel system (being designed by FM Systems for the Digital Radio Corp.) can carry any combination of data and stereo or monaural program audio signals. Each data channel can carry 512 kb and each program channel can carry either two 15 kHz audio channels or one 15 kHz stereo channel. The bandwidth of this system is 6 MHz (to the −60 dB points) so transmission is possible on any facility intended for video, such as direct broadcast satellite (DBS), multipoint distribution systems (MDS), and inter-

KNOWING WHERE YOU WANT TO GO,



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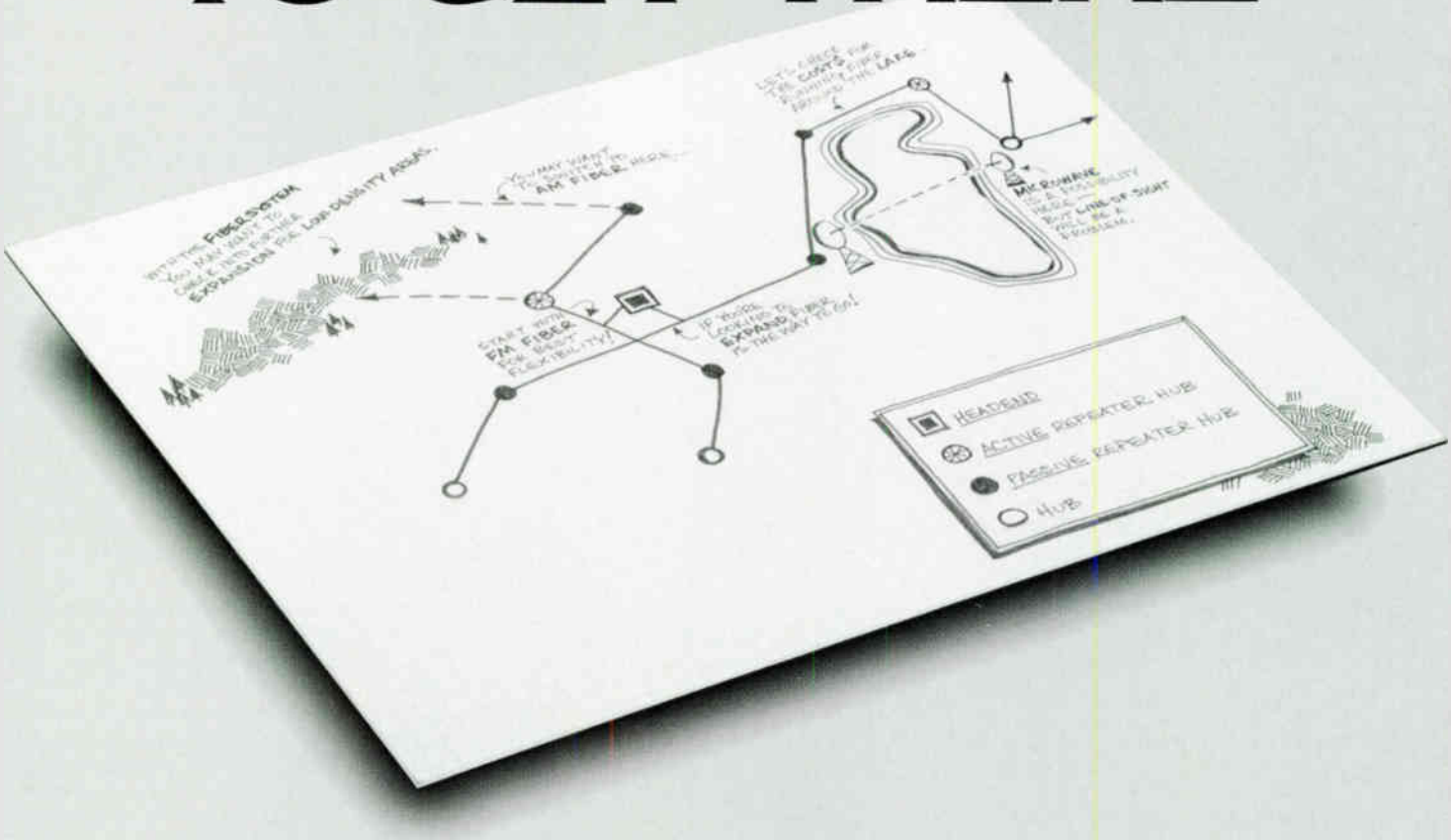

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Reader Service Number 20.

Narrowband frequency assignment chart

Low band			High band		
180 kHz spacing	Carrier frequency	90 kHz spacing	180 kHz spacing	Carrier frequency	90 kHz spacing
	4.455	25 A		7.335	41 A
25*	4.500		41	7.380	
	4.545	25 B		7.435	41 B
	4.635	26 A		7.515	42 A
26	4.680		42	7.560	
	4.725	26 B		7.605	42 B
	4.815	27 A		7.695	43 A
27	4.860		43	7.740	
	4.905	27 B		7.785	43 B
	4.995	28 A		7.875	44 A
28	5.040		44	7.920	
	5.085	28 B		7.965	44 B
	5.175	29 A		8.055	45 A
29	5.220		45	8.100	
	5.265	29 B		8.145	45 B
	5.355	30 A		8.235	46 A
30	5.400		46	8.280	
	5.445	30 B		8.325	46 B
	5.535	31 A		8.415	47 A
31	5.580		47	8.460	
	5.625	31 B		8.505	47 B
	5.715	32 A		8.595	48 A
32	5.760		48	8.640	
	5.805	32 B		8.685	48 B
	5.895	33 A		8.775	49 A
33	5.940		49	8.820	
	5.985	33 B		8.865	49 B
	6.075	34 A		8.955	50 A
34	6.120		50	9.000	
	6.165	34 B		9.045	50 B
	6.255	35 A		9.135	51 A
35	6.300		51	9.180	
	6.345	35 B		9.225	51 B
	6.435	36 A		9.315	52 A
36	6.480		52	9.360	
	6.525	36 B		9.405	52 B
	6.615	37 A		9.495	53 A
37**	6.660		53	9.540	
	6.705	37 B		9.585	53 B
	6.795	38 A		9.675	54 A
38**	6.840		54	9.720	
	6.885	38 B		9.765	54 B
	6.975	39 A		9.855	55 A
39†	7.020		55	9.900	
	7.065	39 B		9.945	55 B
	7.155	40 A			
40†	7.200				
	7.245	40 B			

* TV audio
** Do not use with standard 6.8 subcarrier
† 2x color burst

Note: 45 kHz spacing also is used for 3.5 kHz baseband audio channels and some data circuits.

stitial television channels (ITC). Dolby Adaptive Delta Modulation occupies a fraction of the bandwidth required for digital modulation processes, so three to five times as many channels can be transmitted in the same bandwidth.

This system requires very little more spectrum than FM stereo multiplex. The latter requires 4.8 MHz to transmit 12 channels, with energy right to the band edges. The 12-channel delta modulation system requires 6 MHz but is 60 dB down at the band edge. Another advantage is that delta modulation can operate at 13 dB C/N while FM stereo requires a much higher C/N. Also delta modulation can deliver 80 dB S/N, while FM multiplex rarely exceeds 65 dB. Widespread use of delta modulation is still in the future, but this system has much to recommend it and will be worth watching.

Single channel per carrier

A discussion of subcarriers would be incomplete without mention of single channel per carrier (SCPC) systems. These channels differ from subcarriers in one crucial respect, but otherwise subcarriers and SCPC have much in common. The subcarrier is characterized by first adding it to the TV signal at baseband, then frequency modulating this composite onto one carrier. SCPC frequency-modulates video, audio and other signals onto separate carriers, then adds them together to form the composite signal.

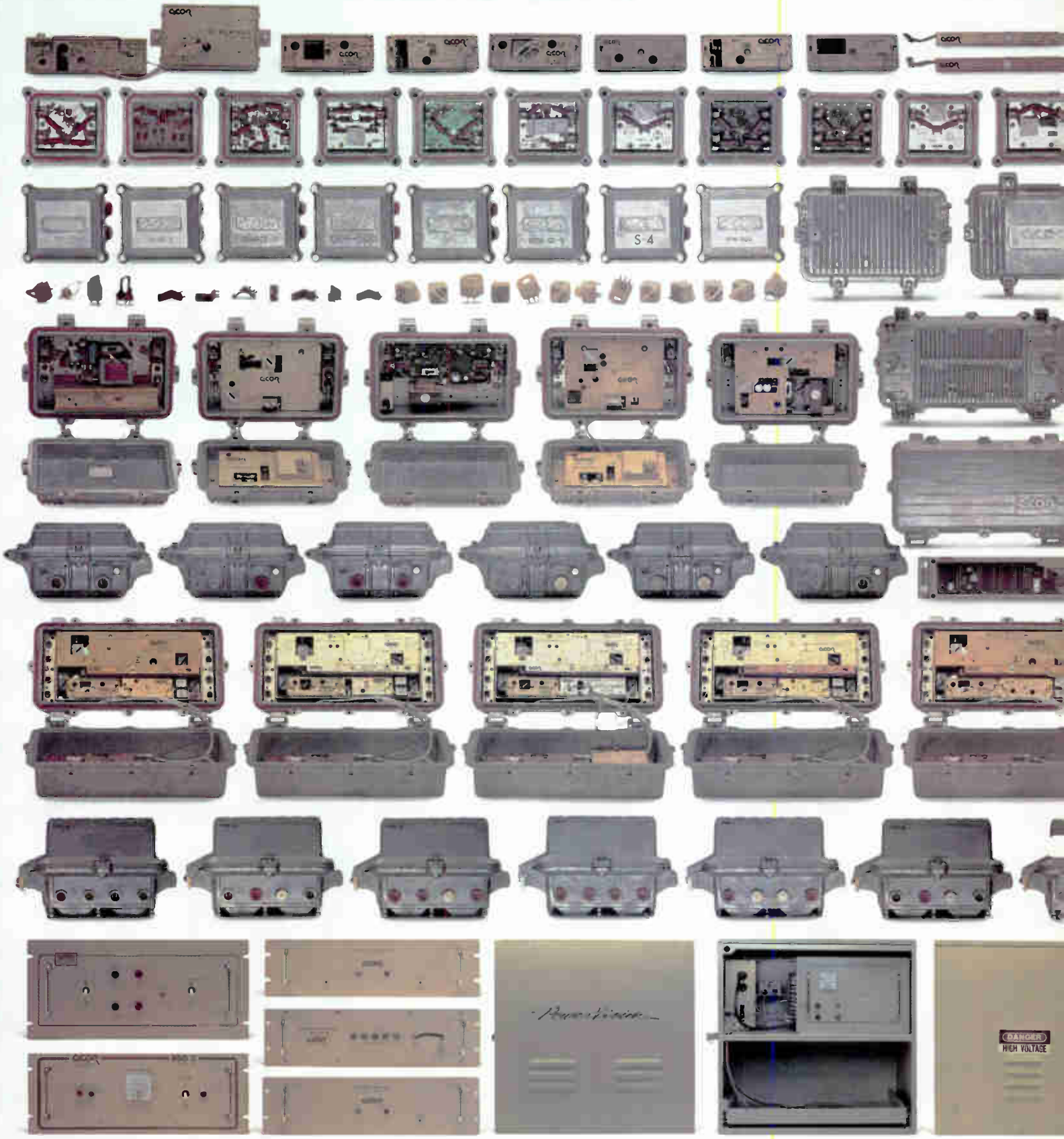
This difference in sequence between addition and modulation results in some very interesting consequences. Subcarriers and any video signal must be combined at one physical location as a composite baseband signal. At that point all signals are modulated on one carrier. So subcarriers must be uplinked to the satellite from a single location. SCPC carriers are added together after modulation, so each carrier may originate from different geographic locations. This geographic freedom enables much more flexible communications systems to be built. SCPC is a multiple origination system while a subcarrier is a single geographic source system.

The main design differences between subcarriers and SCPC are that SCPC channels usually operate in the IF (intermediate frequency) band between 52-88 MHz and the modulators may require a frequency dispersion signal. Also, the receiver usually must contain a threshold extension system of some sort. SCPC is used almost exclusively in satellite systems.

The SCPC receiver must be able to operate at the lowest possible carrier level so that small antennas may be used. This then requires some sort of threshold extension circuitry, usually a phase lock loop detector or tracking filter. Most threshold extension circuits will allow good reception with signals 3-5 dB weaker than possible with standard discriminators.

Another variation of SCPC can be used to transmit up to 10 FM stereo channels over the 4 MHz MDS channel (2,156-2,160 MHz). This transmission system is already in operation in the United States.

This article was presented at a Spring 1987 meeting of the Society of Motion Picture and Television Engineers in Montreal. It was updated for publication.



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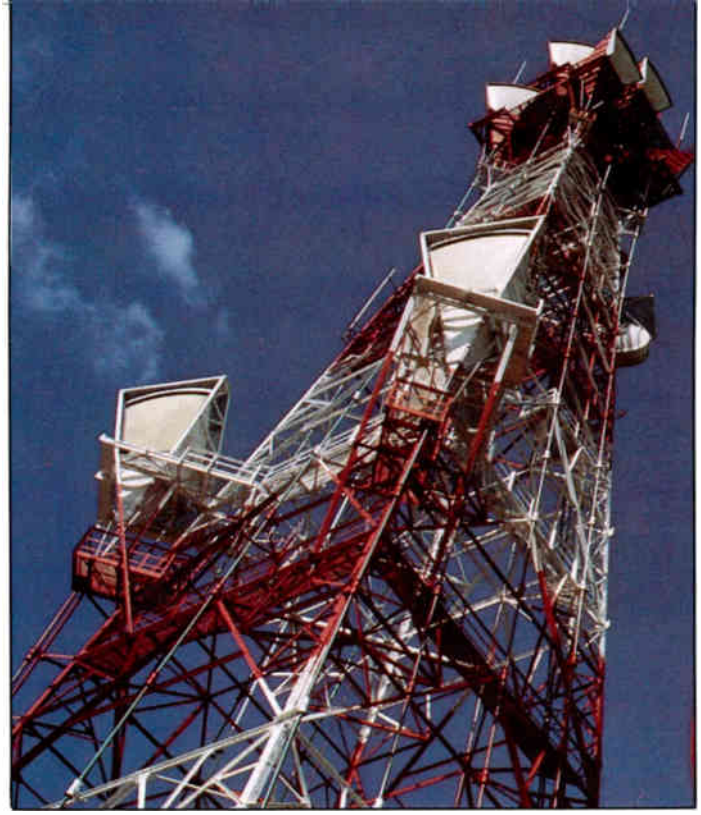
Reader Service Number 21.

How to successfully modify your tower

By Donald W. Rose, P.E.
President, Rose Engineering

As we approach the 1990s, it is evident that the cable TV industry will continue to expand dramatically into the 21st century. To meet the growing and changing demands of this industry, tower owners need to be prepared for modifications to their towers.

Tower modification is not as simple as some owners may think; you cannot just add an antenna to take care of increased transmission requirements without considering the additional structural loads. On a microwave tower, for example, increased wind forces can cause enough twist and sway in the tower to temporarily disrupt line-of-sight communications. Overstresses in individual tower components or in the foundations are very likely if the structural effects are ignored. Tower collapse or foundation failure is the final possibility if strengthening for additional loads is not done.



Peter Russell Clemens

Added loads

Towers attract antennas. Requests to add equipment come both from the owner's own transmission planners and from other companies and agencies. A typical tower will need modifications for an extra one to six antennas that were not in the original plan.

Wind pressure on tower members and antennas is, by an order of magnitude, the primary structural load on telecommunication towers. For example, a large horn antenna weighing 2 kips (1 kip = 1 kilopound = 1,000 pounds) or more with its mounting frame may experience a wind force of 3 to 5 kips or more, depending on the required design wind speed, antenna height and tower exposure.

Since the wind force vector is nominally horizontal, it induces a wind reaction in the foundation and tower legs that is magnified by the ratio of the antenna elevation to the leg separation at the base. If the antenna is 200 feet above grade and the leg separation is 40 feet diagonally at the base, the induced wind reaction is 200/40 or 5 times the wind force on the antenna—or 15 to 25 kips or more. This is many times the 2 kip gravity load that, unlike the wind force, is carried to the base without amplification.

While a large added antenna obviously suggests the need for strengthening, it should be borne in mind that a much smaller added load can overstress a critical member or connection. Everything hinges on the size and nature of the tower, its components and the method of transferring the added load into the tower.

When preparing to modify a tower, the prudent owner should be aware of present and future needs, and especially the history and current condition of the tower to be modified. A checklist of eight key elements in the tower modification design process, plus a checklist of seven major categories of information needed before serious modification design can commence, are listed in the accompanying sidebar.

Define the scope

Crystal balls can give vague or incorrect views into the future, but a reasonable forecast of transmission requirements at a microwave station can result in reduced tower modification costs. If future paths and antenna sizes can be reliably predicted, include their loads in the current modification project (or in the initial construction of a new tower). Overbuilding now for planned expansion vs. extra modification costs in the future is a question of engineering economics. In the simplest form, you need to compare the present values of the current overbuilding and the discounted future incremental cost of modifications. Overbuilding is indicated if its present value is less.

Aside from provisions for the future, engineers must realize it is critical to the efficiency of the design process to define the scope of work as precisely and completely as possible. This definition will provide critical pieces of information essential to the modification. The more clearly the scope is laid out, the easier it is to determine and control the final cost and timing of the project. Your in-house or outside consulting engineers may have prepared preliminary modification budgets. If the scope is changed or is incomplete, these initial cost studies and alternatives may be useless and misleading.

In order to complete any tower project on time, it is crucially important for the owner to obtain FAA and FCC and local approvals. A modification may require a vertical tower extension, for example, that could call for protracted public hearings at the local level. It is not unusual for an owner to present the case to three or more groups, such as a planning board, an architectural review board and a zoning board. The most common questions voiced by the public are: 1) Will the tower fall down?, 2) Will TV reception be affected? and 3) Is microwave radiation harmful? The owner or legal counsel should prepare to respond to public concerns and have credible professional witnesses to support the case.

The first thing any owner should check is the approved overall height of the tower. In some cases future growth has been planned for in the original or even in previous modification designs of the tower. A lot of community relations problems and/or the necessity to obtain new approvals may be avoided by a little research into the parameters of the previous approval. It sometimes happens that the scope of modifications is large enough that a second tower or a replacement tower may be economical. The decision to modify the existing tower or build a new one will in many instances be governed by local codes or the outcome of public hearings.

Just because a tower is already on the site, the owner doesn't have *carte blanche* to destroy an existing tower and replace it with a new one. A new tower, even one no taller than the original tower, means new approval (which may not be granted). In other instances, the lack of real estate necessary to build a new tower will prompt a modification.

Modification projects are most successful when the complete history of the tower, building and site are known. Key documents need to be available. This information for the original construction and each previous modification includes the tower type and height, date built, designer, design drawings and specifications, foundation drawings and specifications, soil reports and foundation recommendations, fabricator and erector and the as-built revisions of the shop drawings.

The design drawings and specifications are important since they usually provide the primary dimensions and criteria used to design the tower and its foundation. In cases where foundation strengthening or new footings are needed, the site plan and building drawings will help to avoid conflicts with building footings, oil tanks, septic systems, gas, water and electric lines, easements and property lines. As-built revisions to the shop drawings are very valuable but very rare. These revisions should be made upon the completion of each construction project, but all too often the field notes don't get back to the designer and the revised drawings aren't made.

In one instance, an existing microwave tower was originally built rotated

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★ VHF input signals can be any modulation, such as VSBAM, FM, or Digital, and may be NTSC, PAL, or HDTV video!

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Reader Service Number 22.

Tower modification checklists

Background information needed:

1) Defined scope of modification, including answers to:
   - Antennas: size, make and model number of each one.
   - Azimuths and centerline heights.
   - Type of waveguide or coaxial cable.
   - Radio entrance to building—new or existing opening?
   - Is access walkway or ladder to antennas needed?
   - Is ice protection of antennas and waveguide needed?
   - Temporary service for work on existing antennas?
   - Special design needs, beyond local building codes.
2) Site plan locating tower, building, foundations, anchors and property lines. This should show a true north arrow and the orientation of tower to true north.
3) FCC sketch or plot plan showing antenna manufacturers and models, azimuths and centerlines above ground or base plate.
4) Design drawings, specifications and as-built shop drawings of the original tower and all modifications. Identify the designer, fabricator and erector.
5) Details of appurtenances, including mobile antennas, tower lighting and ice canopies.
6) Soils reports, foundation design drawings and specifications.
7) Tower inspection and construction reports.

Key elements in the design process:

1) Gather information. Search data bases and drawing archives for missing items. Field visits may be needed.
2) Locate new antennas to:
   - clear all obstructions on tower
   - minimize structural impact on tower and foundation
   - facilitate waveguide design and installation
3) Determine governing building code design critiera.
4) Structural analysis:
   - perform for critical wind velocities on tower and all new and existing antennas
   - check for member and connection overstresses
   - check safety factors of foundation piers and anchors
   - determine if antenna twist and sway values (i.e., wind induced deflections) will exceed antenna transmission requirements.
5) Design tower and foundation strengthening as needed:
   - to eliminate overstresses
   - to reduce excessive twist and sway
   - re-evaluation of soil properties may result in either reduced or eliminated foundation strengthening
6) Prepare design drawings and specifications:
   - use of existing tower's shop details will reduce field work and erection time
   - antenna mounts, tower extensions and reinforcements, waveguide support structures and foundation work
   - coordinate with site drawings to avoid subsurface conflicts (i.e., with building footings, oil tanks, utility conduits, easements and property lines)
7) Prepare waveguide layouts and material ordering lists.
8) Coordinate construction bidding, check shop drawings and provide field services as required.

90° from the designed orientation. No one realized it until a snag was hit in the erection of modifications over 20 years later. Walkways, designed as a part of the modification work, were conceived to be in the wrong place because no as-built drawings existed. Everyone working on the modification project assumed the correctness of the existing drawings. The owner had to pay the extra costs of field corrections.

Foundations are critical

Engineers should be aware that foundation information is critical in attempting to modify a tower. Without foundation drawings and soils reports, it may not be possible to determine the strength of a tower's foundations and anchors.

The gross dimensions of spread footings—the most common type of foundation—may be established by excavation, but you cannot tell what is *inside* the concrete. The embedded length of the anchor bolts or details of anchor plates will still be a mystery and the reinforcing steel is totally hidden. These details need to be known in order to calculate structural capacities. In the case of piles or other types of piers and caissons, it may not be possible to establish even the gross dimensions if the drawings are missing.

Typically, only about 20 percent of all tower modifications require foundation reinforcement. But if the information is lacking to determine the foundation's bearing and pullout capacities in a modification project, a prudent engineer will need to assume worst case values to account for the unknown. Expensive foundation strengthening may be the consequence of missing information.

When full information does exist, but there is an indicated need for foundation strengthening, a new evaluation of the soil properties is advisable. This evaluation should be done by a geotechnical engineer highly knowledgeable about towers. This experience is necessary because tower foundations are unusual; they have large "uplift" loads unlike most common building foundations. A re-evaluation may cost about $5,000 but can save the owner $20,000 to $100,000 in foundation work. In recent years, many studies and full-size tests have led to the acknowledgement of additional capacity in existing foundations.

The process of tower modification is detailed, involved and time-consuming. If everything runs on schedule with just nominal problems to iron out, the modification from design through completion can take anywhere from three to six months. You must anticipate adding another three months should major problems develop. Still more time may be needed if there is a dearth of information on the existing tower. In this case, you should engage a tower consultant as early as you can to take advantage of specialized knowledge and archival information that may include similar towers.

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Reader Service Number 24.

Microwave design for intercept paths

By Jack Sanders
Director of Engineering and Technology, American Television & Communications Corp.

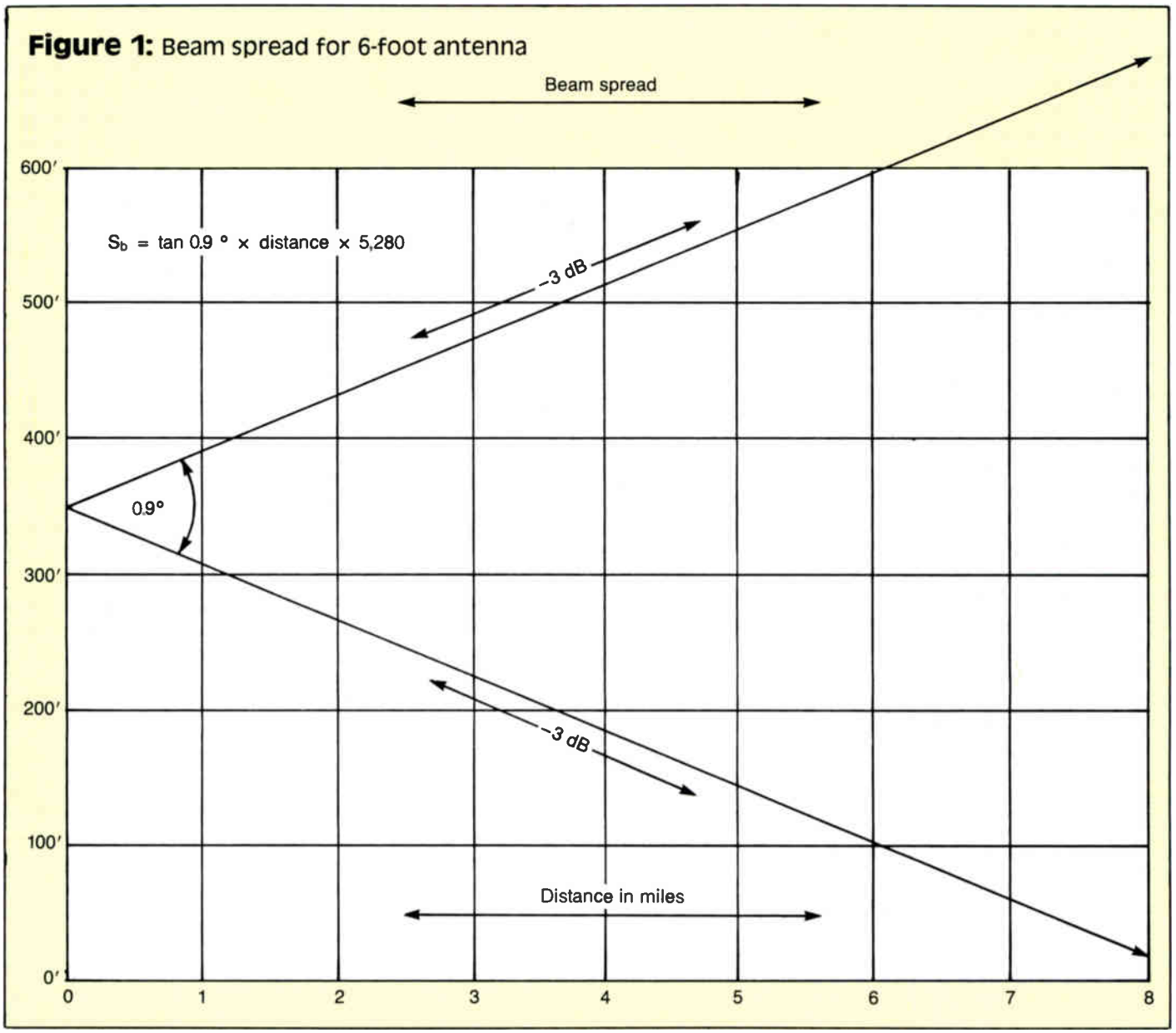
The cable industry operates several intracity microwave systems that serve multihub receiving locations. These systems typically have one central transmitter location that is power split in several directions to feed the various receiving hubs. Occasionally, a situation occurs that provides an opportunity to design an "intercept" receive station to allow one to feed pockets of new developments more efficiently. The typical intercept consists of a microwave receive station located "in-line" along an existing path. The intercept could be located near the center of a rather long path or an "overshoot" some distance beyond the receive site of an existing short path.

The intercept approach has several advantages both from cost considerations and in some cases system technical performance. The intercept eliminates the requirement for an additional transmit antenna system and therefore reduces costs. It does not create additional loading on the transmit tower structure, which could prevent a major rework. In certain situations, it also allows one to activate a new path without creating the need for an additional power split, which would normally reduce the available power by 3 dB. Frequency coordination for the intercept receive site would not necessarily be required since typically no change in the transmit technical parameters would occur. However, licensing with the Federal Communications Commission is recommended in order to acquire future interference protection for the intercept site. It is best to check with your FCC attorney to verify whether or not licensing and coordination is required.

In some cases, the area one needs to serve creates a path angle separation problem with an existing adjacent path. For FM systems, where the individual transmitters are not phase locked, the minimum separation angle is approximately 5 to 20 degrees, depending on the size and quality of the antenna systems. For AM systems (such as the Hughes amplitude-modulated link) the discrete path separation angles can operate down to about 2°. This is due to the unique feature that uses phase-locked carrier frequencies and the fact that each path is typically carrying the same channel program modulation. For path separation angles of less than 2°, one should consider the intercept approach.

Choosing a site for an intercept is much more critical than the conventional method, since options are limited to specific areas along the "azimuth line" formed by the existing path. The actual amount of real estate one has to work with is a function of the *distance* from the transmit site and

Figure 1: Beam spread for 6-foot antenna



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the *beamwidth* of its antenna pattern. The greater the distance, the more the beam tends to spread.

Antenna beamwidth: The specification for the beamwidth of a given antenna is stated in degrees between its half-power points; i.e., −3 dB on each side of the center of the main lobe. For any given antenna the beamwidth is in general a function of the antenna's diameter. Therefore, the larger the diameter the higher its gain and more narrow its beamwidth at the 3 dB half-power points. Typical antennas ranging in size from 4- to 10-feet in diameter will produce beamwidths on the order of 1.4° to 0.6° respectively.

Given the beamwidth of the antenna and the distance to the proposed intercept point, the amount of beam spreading can be calculated as follows:

$$S_b = D_p \times \tan B \quad (1)$$

where:
S_b = beam spread in feet
D_p = path distance in feet
B = beamwidth in degrees

Example: Let's calculate the amount of beam spreading over a distance of five miles using a 4-foot antenna with a beamwidth of 1.4°. First, convert path miles to feet: 5 × 5,280 = 26,400 feet. S_b = 26,400 × tan 1.4° = 645 feet, or ±322 feet from the center of the beam to the −3 dB points. Now, perform the same calculations using a 10-foot antenna with a beamwidth of 0.6°. S_b = 26,400 × tan 0.6° = 276 feet. Therefore, antennas with diameters of 4 and 10 feet will produce a beam spread of 640 and 276 feet respectively. Note also that doubling the distance will double the beam spread and increase the path loss by 6 dB. Figure 1 is a graph that calibrates the beam spread in feet and the distance in miles for a 6-foot antenna with a 3 dB beamwidth of 0.9°. The equation for the path loss is as follows:

$$L_s = 96.6 + 20\log D + 20\log F \quad (2)$$

where:
L_s = space loss in dB
D = distance in miles
F = frequency in GHz

Note that 20log 2 = 6.02 dB, which confirms our 6 dB per double rule.

Locating the azimuth line: The existing path should be rechecked, with particular attention given to confirming the exact coordinates. If there is any doubt concerning the exact location of the existing transmit and receive sites, then a professional survey should be performed. However, in most cases, with a little care, one can locate the sites on a 7½-minute topographic map.

Measuring distance vs. coordinates: One second of latitude is equal to 101.3 feet and is for all practical purposes linear between the equator and the poles. One second of longitude measures 101.2 feet at the equator and converges to zero at the poles. Therefore, one must correct the longitude conversion by using a factor derived from the cosine of the latitude intersection. Example: One second of longitude and latitude 40° is: 101.2 feet × the cosine of 40° = 77.5 feet/second. Note also there is a convenient distance scale on the 7½-minute topographic maps that can be used to calibrate an engineering rule using the 20 division per inch scale. Once the sites have been accurately located on the topographic map and the coordinates known, the distance and azimuth can be calculated using conventional computer programs.

For relatively short paths, one can carefully match and tape the maps together then, using a long straight edge, connect the two ends together to form the path azimuth line.

One also could consider using visual sighting techniques such as a mirror flash or a small tethered balloon. These efforts must be well-coordinated using radio communications at all locations. When using the visual approach one does not need to be as precise with the actual coordinates since these errors would be factored out when the sites are physically in-line.

The RF energy beam from the transmit antenna spread linearly, forming an expanding radius around its center. Therefore, one must examine

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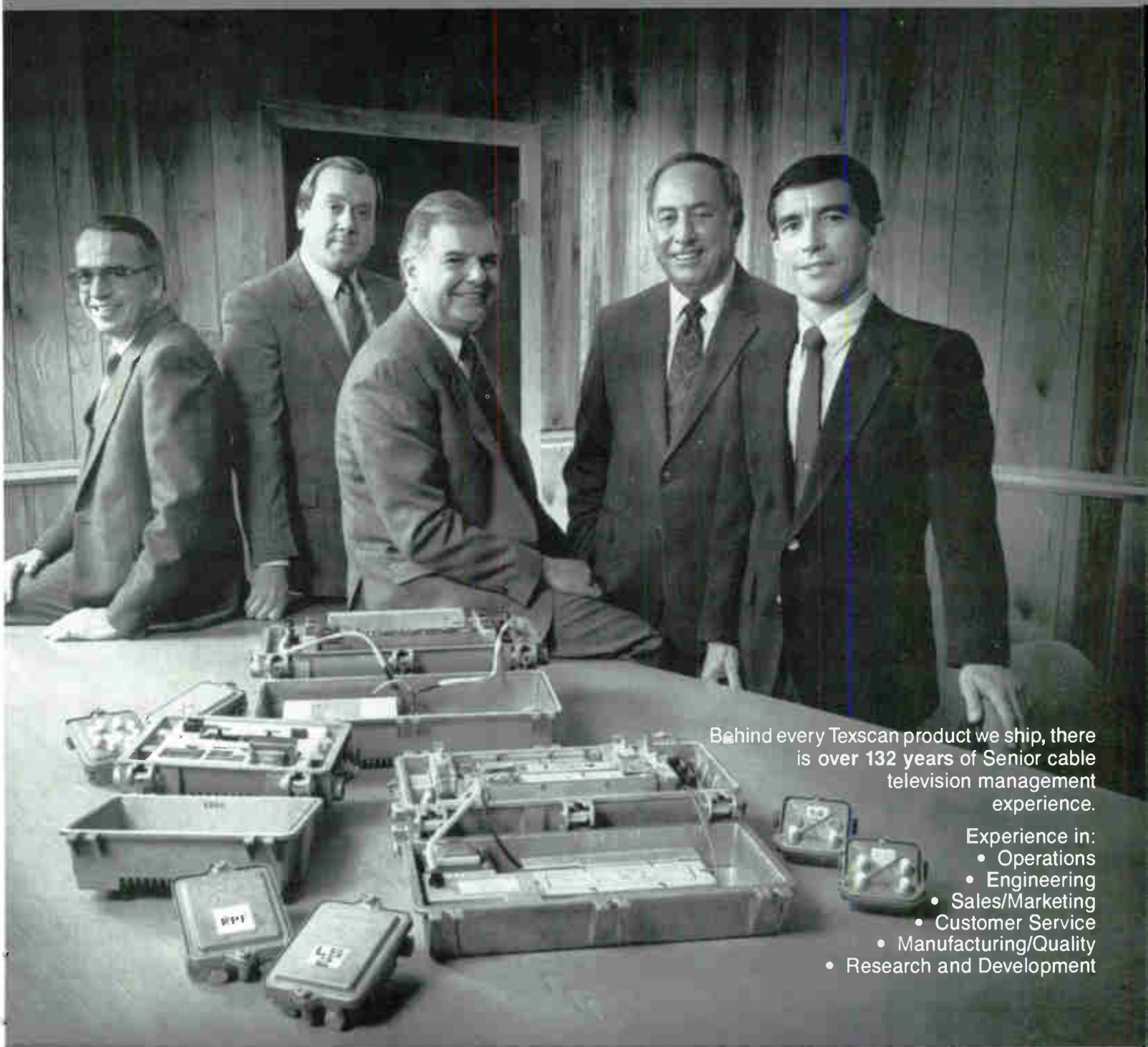

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Microwave path performance calculations

Radio: Hughes STX-141 Freq: 12.925 GHz
Standard receiver: NF = 10 dB

	Receive #1	Transmit		Receive #2	Receive #3	Transmit
Antenna height (ft.)	75	280	280	55	90	280
Antenna size (ft.)	4	6	6	6	8	6
Antenna gain (dB)	41.5	45.1	45.1	45.1	47.6	45.1
Elliptical waveguide (ft.) EW-127 A	50	25	25	60	20	25
Circular waveguide (ft.) WC-109	—	270	270	—	80	270
Elliptical waveguide loss (dB) 3.5/100′	1.75	0.9	0.9	2.1	0.7	0.9
Circular waveguide loss (dB) 1.2/100′ + 0.3 dB	—	3.5	3.5	—	1.3	3.5
Circulator/power splitter loss (dB) typical system		10	10			10
Radome loss (dB)	1.5	1.7	1.7	1.7	1.8	1.7
Path length (miles)	6		9		16	
Space loss (dB) = 96.6 + 20log D + 20log F	134.4		137.9		142.9	
Safety factor (dB) Misc. loss: 2 dB + intercept alignment	5.0		4.5		2.0	
Total losses (dB)	158.75		162.30		164.80	
Total gains (dB)	86.80		90.20		92.70	
Net path loss (dB)	72.15		72.10		72.10	
Transmitter output power (dBm) (2 watts)	33.0		33.0		33.0	
Normal received carrier (dBm) (RCL)	−39.15		−39.1		−39.1	
Carrier required for 33 dB S/N (dBm) (−98 + 33)	−65.0		−65.0		−65.0	
Fade margin (dB)	25.8		25.9		25.9	
AGC margin (dB) Refer to −45 dBm RCL	5.8		5.9		5.9	

both the horizontal (side-to-side) and vertical (up or down) parameters. For all practical consideration, the vertical spread is the same as the horizontal. Therefore, the previous equation is valid for both planes.

The transmit antenna tilt

Typically, the transmit antenna will operate very near zero degrees tilt relative to the true horizontal plane. However, if the transmit site is located on a nearby mountain or a very tall building, the tilt angle must be considered, especially if the antenna elevations between the transmit site and the intercept are considerably different. The beam tilt can be calculated as follows:

$$T_b = \tan^{-1}\left[\frac{\Delta \text{ elv.}}{D_p}\right] \quad (3)$$

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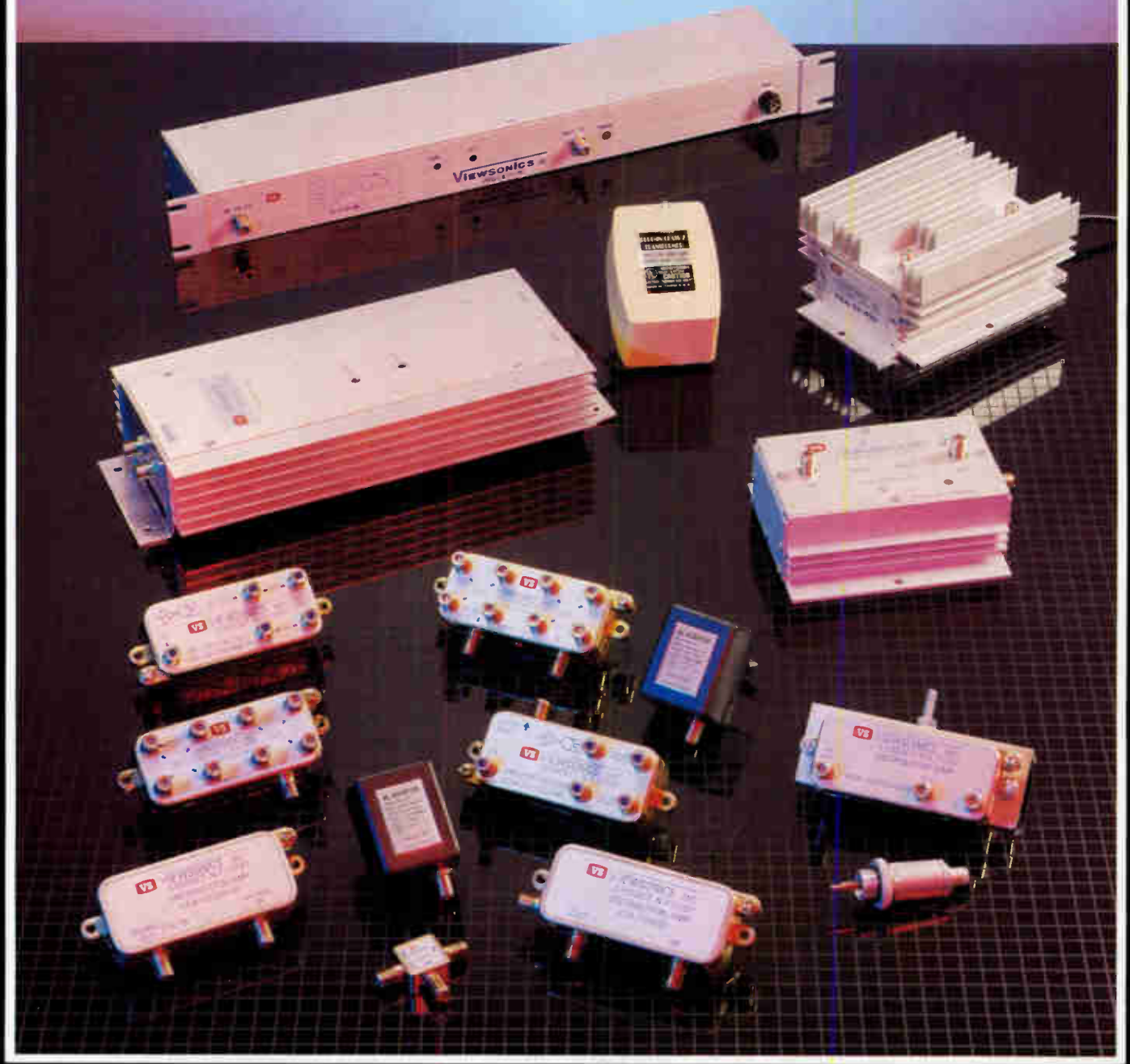

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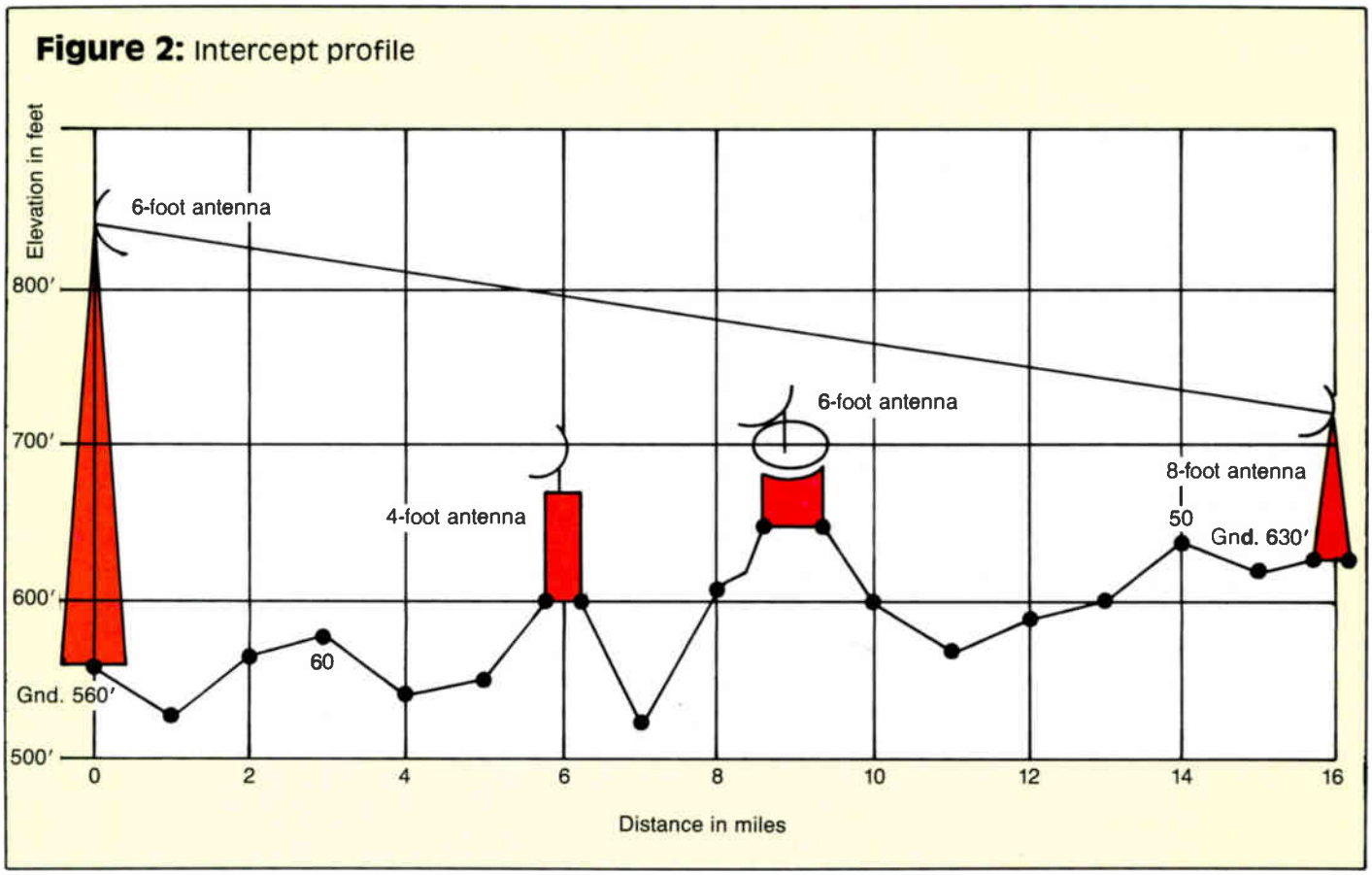
Figure 2: Intercept profile



where:

T_b = beam tilt in degrees
Δ elv. = difference in antenna elevations in feet
D_p = path distance in feet

Example: If a five-mile path has a Δ elv. of 300 feet, then:

$$T_b = \tan^{-1}\left[\frac{300}{26{,}400}\right] = \pm 0.65°$$

These calculations should be performed for both the intercept site and the original receive site. By comparing the tilt requirements for both, one can determine the amount of expected loss in both the horizontal and vertical planes.

The Earth bulge factor

When using a flat graph profile, remember that the Earth is a sphere and therefore exhibits a curved surface between any two points. The flat graph profile must be corrected in order to compensate for the true Earth bulge effect. The Earth bulge factor can be calculated using the following equation:

$$\text{Ht.} = \frac{d_1 d_2}{1.5\ K} \qquad (4)$$

where:

Ht. = height in feet
d_1 = distance from one end of the microwave path to a given "obstruction point"
d_2 = distance from "obstruction point" to other end of microwave path
K = equivalent Earth radius factor

Figure 2 is a profile of a 16-mile path that illustrates two potential intercept locations: #1, a 70-foot office building at the six-mile point and #2, a water storage tank out nine miles.

Intercept #1: The 6-foot transmit antenna has a beamwidth of 0.9°. Therefore, the beam spread to the six-mile point will be approximately 500 feet; or 250 feet from center of the main lobe. Assuming the office building is within approximately 175 feet plus or minus the center azimuth line, we would only lose about 2 dB in the horizontal plane. Calculating the vertical requirements, after allowing approximately 25 feet for Earth bulge, places the top of the building less than 100 feet under the center of the main beam. Therefore, this path should operate using standard calculations less 3 dB.

Intercept #2: This intercept will utilize a 50-foot water storage tank at the nine-mile point. The beam spread from the same 6-foot antenna will be approximately 750 feet, or about 375 feet plus or minus the center azimuth line. Assuming the tank is within approximately 300 feet (about one block), the horizontal loss is approximately 2.5 dB. Correcting for Earth bulge, the tank is approximately 20 feet under path center line, well within the main lobe. Therefore, this path should come in at about 2.5 dB from standard calculations. The accompanying table is a path analysis comparing the calculated performance of each of the three receivers.

Worth considering

While intercept paths are obviously not possible for many situations, they are worth considering, especially where reconfiguration of existing trunk cable is being planned. The intercept approach can in many cases reduce costs, eliminate additional splitting losses and reduce the potential for overload on the transmit tower structure.

Note that when designing the intercept paths we have deliberately stayed within the 3 dB beamwidth spreading zone. This design approach is not necessarily mandatory, especially for short paths that have less space loss. However, when one is aligned to the −3 dB points of the transmit antenna pattern, the physical stability of the antenna could be a potential problem, since a very small amount of twist could drop the signal down from the steep portion of the power curve by several dB.

As the table illustrates, the intercept can be designed to operate as well or even better than the initial path. It is in many cases a free signal that has already been paid for.

From Headend to Drop

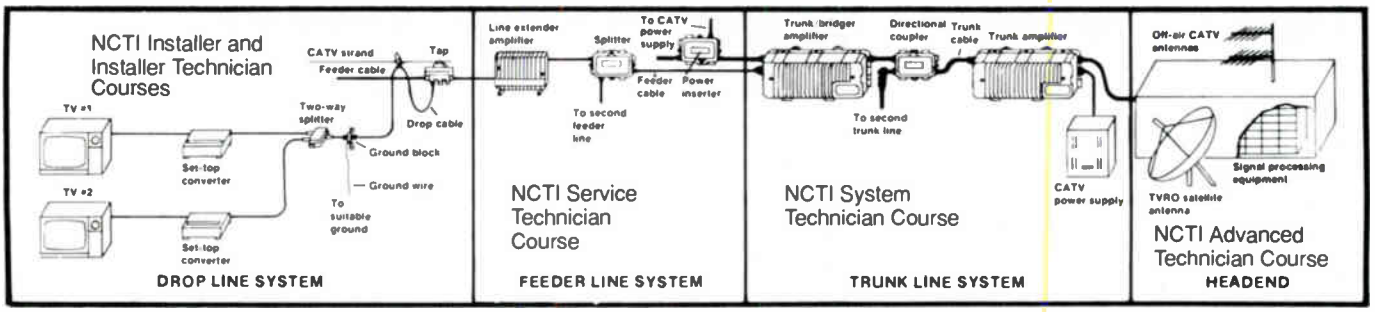


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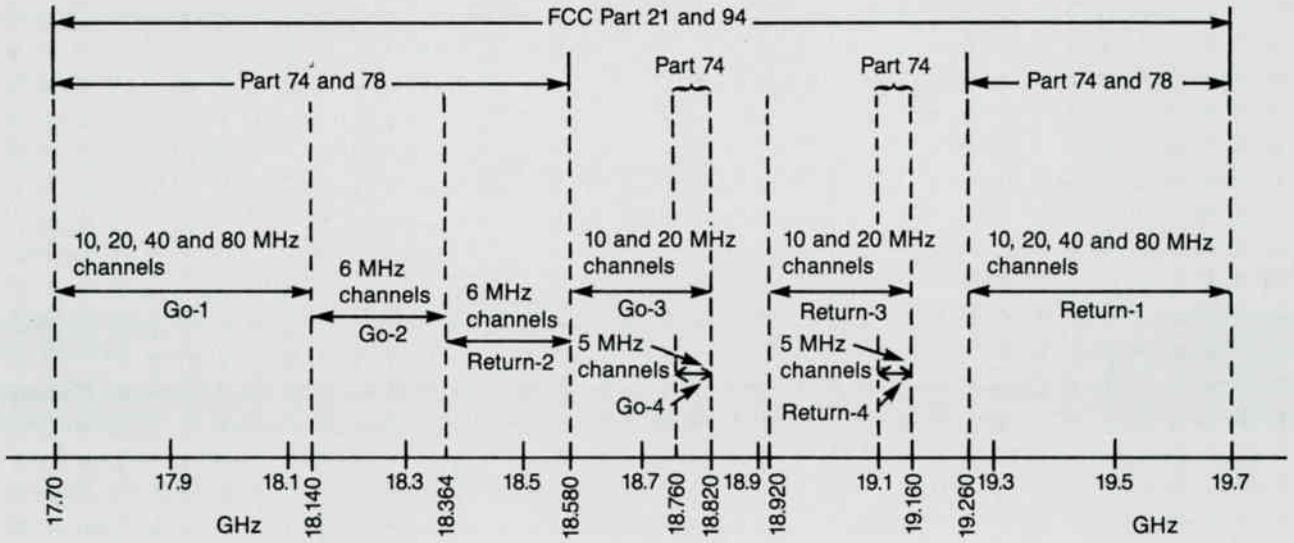
Figure 1: Frequency usage (17.7-19.7 GHz)



Source: *IEE Conference Report on Radio Wave Propagation*, October 1968.

The move to higher frequency bands

By Ernest M. Hickin
Staff Consultant, M/A-COM MAC

International agreement on the broad allocation of the radio frequency spectrum to various services is achieved at World Administrative Radio Conferences (WARC) held roughly every 10 years. The meetings are organized by the International Telecommunications Union (ITU) founded in 1867 and now a U.N. agency. In 1939 frequencies up to 1 GHz were allocated, in 1949 up to 10 GHz and in 1959 up to 40 GHz. The agreements are set out in the Radio Regulations and recognized by just about every country in the world.

Sometimes, the agreements follow the usage, as was the case with television (45 GHz was in use in 1936) and with centimetric radar (3 and 9 GHz in the 1939-49 period). The Bell System was already using the 10.7-11.7 GHz band in 1959; this influenced the allocation of the 10.7-13.25 GHz band to the "fixed and mobile" service, the ITU category covering point-to-point microwave.

But in 1959 not only the 10.7-13.25 GHz, but also the 17.7-19.7 (Figure 1), 21.2-23.6 and 36-40 GHz bands were added to the Radio Regulations. Thus the 18 and 23 GHz bands have been available for worldwide exploitation for nearly 30 years. It is reasonable to ask why it took until the late '70s for 18 GHz digital radios to come on the market and the '80s before video systems were available (23 GHz in 1982, 18 GHz in 1986). Probable reasons can be summarized under the headings of need, economics and technology.

"By using a bipolar feed up to eight video channels can share a common antenna in either the 18 or 23 GHz bands."

Need: The exploitation of the 10.7-13.25 GHz band released a thousand megahertz of bandwidth to users such as broadcasters and cable TV systems. This was more than all previously available bands combined. Thus the pressing need for more spectrum in these markets did not arise for many years.

Economics: Conventional fixed links with antennas, waveguide, pressurization, etc., for the shorter paths dictated by rain attenuation in most locations would not cost any less at 18 or 23 GHz than at 2, 6 or 13 GHz. Thus the cost per mile would rise with frequency, making microwave less competitive with cable systems.

Technology: In 1959 efficient sources of microwave energy were not readily available. The development of Gunn diodes and the relaxed frequency tolerances permitted by the Federal Communications Commission had a dramatic effect. General Electric introduced the AM Gemlink around 1980, followed closely by the M/A-COM FM system. The latter, by exploiting

(Continued on page 64)

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(Continued from page 44)

the wideband required to handle the looser tolerance, achieved higher signal-to-noise ratios and set the pace with several thousand links in use by 1985. Almost all subsequent entries to the market have used this method of modulation.

The impact of these systems, with antenna-mounted RF heads, permitting links costing as little as 25 percent of conventional 13 GHz equipment, cannot be exaggerated. New users came flocking in, users who would never have dreamt of using microwaves before that time. In addition to the security market (the initial target), dealers who could install—and more importantly maintain—systems were offering them to banks, businesses and industrial complexes. As a result of a M/A-COM petition the 23 GHz band was opened for video entertainment operators who quickly realized that quality transmission was available and became major users.

Figure 2a: Cumulative distribution of loss at 18 GHz (March 1964-February 1965)

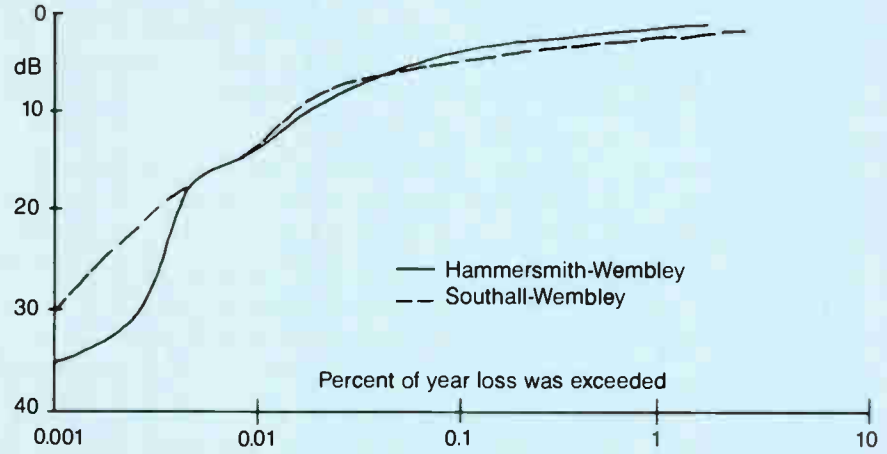


Figure 2b: Cumulative distribution of loss at 18 GHz (March 1965-February 1966)

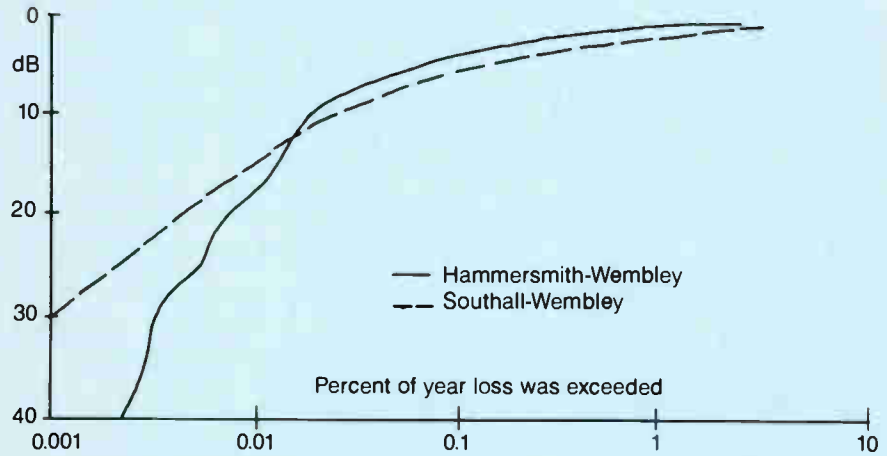
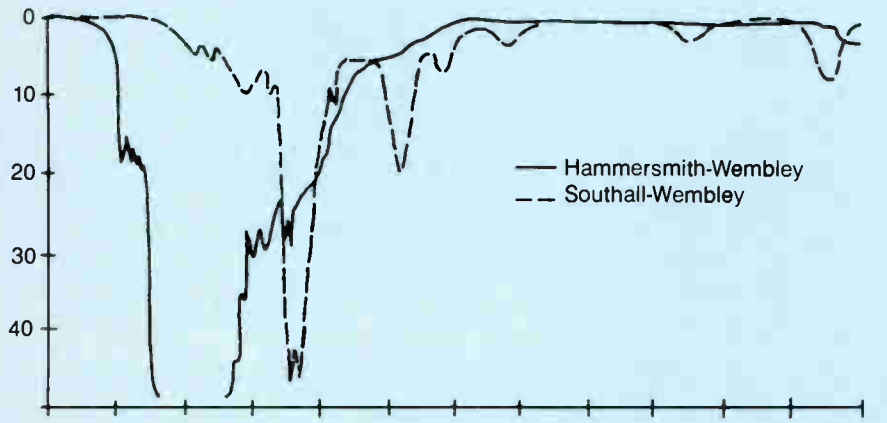


Figure 2c: Fading July 20, 1965



The late exploitation of these bands did not mean that no thought was being given to the crucial effects of rainfall. In a 1968 paper I described a five-year study of rainfall effects; Figure 2 shows how two five-mile paths behaved. A good fade margin was maintained for over 99.999 percent of a year (less than five minutes outage on either path in one year), and only a severe thunderstorm caused a significant outage of 12 minutes on one of the two paths in the next year. This early study is borne out by recent experience, namely that steady general rain is less likely to interrupt a link than local storms. Also, 18 GHz suffers somewhat less than 23 GHz, with seven- and five-mile paths respectively showing the same outage time.

Under Part 94 of the FCC Rules it is necessary to go through a coordination procedure in the 18 GHz band. The established frequency coordination organizations can undertake this task and will provide a worst-case answer. This is because they are usually given approximations to the terminal coordinates and cannot assume other than co-location.

In a recent case a video user wanted a link with a 2-foot receiving antenna on a bearing of 340°, nominally co-located with a digital antenna facing 190°. The discrimination of a 2-foot antenna would not be adequate to protect the video receiver against co-channel interference from the digital link. However, given more information, it turned out that the situation was very different. The 2-foot requirement came from the need to point through a narrow window in a multistory building and a larger antenna would have achieved nothing, while the digital link terminated on the roof two floors above. In a situation like this the building will provide the shielding that would have come from a larger antenna in other circumstances. If walls do not provide enough attenuation then aluminum foil can be fixed beneath the wall covering or paint. Thus local siting as well as frequency coordination is important.

By using a bipolar feed up to eight video channels can share a common antenna in either the 18 or 23 GHz bands. However, at present this is only permitted under Parts 21 and 74 at 18 GHz and under Part 21 at 23 GHz. Part 94 limits the user to a maximum of four channels on a given route or from a given site. A petition for rule-making (RM-6014) has been filed with the FCC to remove this restriction in the 18 GHz band for private operations. This band was originally allocated to cable operators and others displaced, or threatened with displacement, from the 12 GHz bands to make room for the direct broadcast satellite service.

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4) The forms as published in *Communications Technology* are to be used for entries or may be copied as required.

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Reader Service Number 34.

Wireless or wired cable: Comparable technologies?

By George Harter
Systems Engineering Manager
General Electric Co., Comband Products Operation

As the cost of building a cable system continues to increase, operators continue to search for alternative technologies to deliver equivalent or better performance at lower costs. One alternative operators now have is to supply programming over a microwave multichannel multipoint distribution service (MMDS) and reduce the amount of cable plant. New FCC regulations have allotted sufficient frequency spectrum in the 2.5 to 2.7 GHz range to give operators the ability to offer an attractive number of channels.

Eliminating the need for a cable plant certainly proves MMDS to be less costly, but can the performance of an MMDS system meet or exceed cable system performance? The answer is *yes*. MMDS performance can meet and even exceed cable in fundamental performance areas like received signal level, carrier-to-noise ratio and non-linear distortion products. Also, current equipment available to MMDS systems can provide many of the technical advances found in cable such as addressability, scrambling and stereo broadcasts. Combining comparable features and improved performance can make MMDS a successful complement to an existing cable system or a very competitive alternative.

Performance

MMDS received signal level: To begin, let us define a typical MMDS and cable system as shown in Figure 1. The MMDS system in this example will utilize an omnidirectional transmitting antenna mounted 500 feet above ground level. For simplicity we will assume a constant receiving antenna height of 20 feet and a flat Earth, realizing the farthest practical receive site distance will be limited to approximately 40 miles by the radio horizon. The detailed characteristics of the transmit and receive site equipment are listed in Table 1.

The received signal level can be calculated from the formula

$$P_R = P_T - L + G_T - L_P + G_R + G_B \quad (1)$$

where:

P_R = received signal power at downconverter output (dBm)
P_T = transmitter power (dBm)
L = transmit site losses due to channel combining and waveguide losses (dB)
G_T = transmit antenna gain (dBi)
L_P = free space path attenuation (dB)
G_R = receive antenna gain (dBi)
G_B = block downconverter gain (dB)

Typically, transmitter output powers will range between 10 and 100 watts. For this comparison, the transmitter output power will be 10 watts (+40 dBm).

Losses between the transmitter and transmitting antenna depend upon the length and type of waveguide being used, whether adjacent channels are being transmitted and the number of transmitting antennas available. Non-adjacent channels can be combined with passive waveguide combiners and incur only 1-2 dB of loss plus the waveguide run losses. However, if adjacent channels are being transmitted and only one transmitting antenna is available, a minimum loss of 3 dB plus the loss of the waveguide run must be incurred in order to combine the microwave channels. Utilizing more than one transmitting antenna to transmit adjacent channels will eliminate the hybrid combining problem. For this comparison, waveguide and combining losses will be assumed to be 3 dB.

A variety of transmitting antenna patterns and gains are available. Standard omnidirectional antennas either horizontally or vertically polarized can be obtained with gains from 10 to 17 dBi. Various cardioid patterns can be obtained with gains as high as 24 dBi. For this comparison, a typical omnidirectional antenna with 13 dBi gain was chosen.

Free space path loss can be calculated from the equation:

$$L_P = 96.6 + 20\log f + 20\log d \quad (2)$$

where:
f is in gigahertz (GHz) and d is in miles.

The frequencies available for multipoint systems are 2.150-2.162 and 2.5-2.686 GHz. For this comparison a median frequency of 2.6 GHz will be used.

The receive site consists of a receive antenna and a block downconverter to convert the microwave channels in the cable mid-band or superband frequency range. The receive antennas typically have gains in the range of 18 to 30 dBi. A variety of block downconverters exist with gains ranging from 20 to 40 dB and noise figures from 2 to 5 dB. For this comparison, a receive antenna gain of 21 dBi, a block downconverter gain of 20 dB and a downconverter noise figure of 5 dB will be used.

The calculated received signal levels are shown in Table 1 for distances of 0.5 to 50 miles from the transmit site. The perturbations in level from 0.5 to 1.5 miles out are caused by the elevational pattern characteristics of the transmitting antenna as shown in Figure 2.

MMDS noise performance: The carrier-to-noise (C/N) ratio at a given receive site can be obtained by comparing the received carrier level calculated in Table 1 to the noise level present at each receive site. The noise level at each site will remain fixed assuming the same receiving antenna and block downconverter are used. →

Figure 1: MMDS and cable system architecture

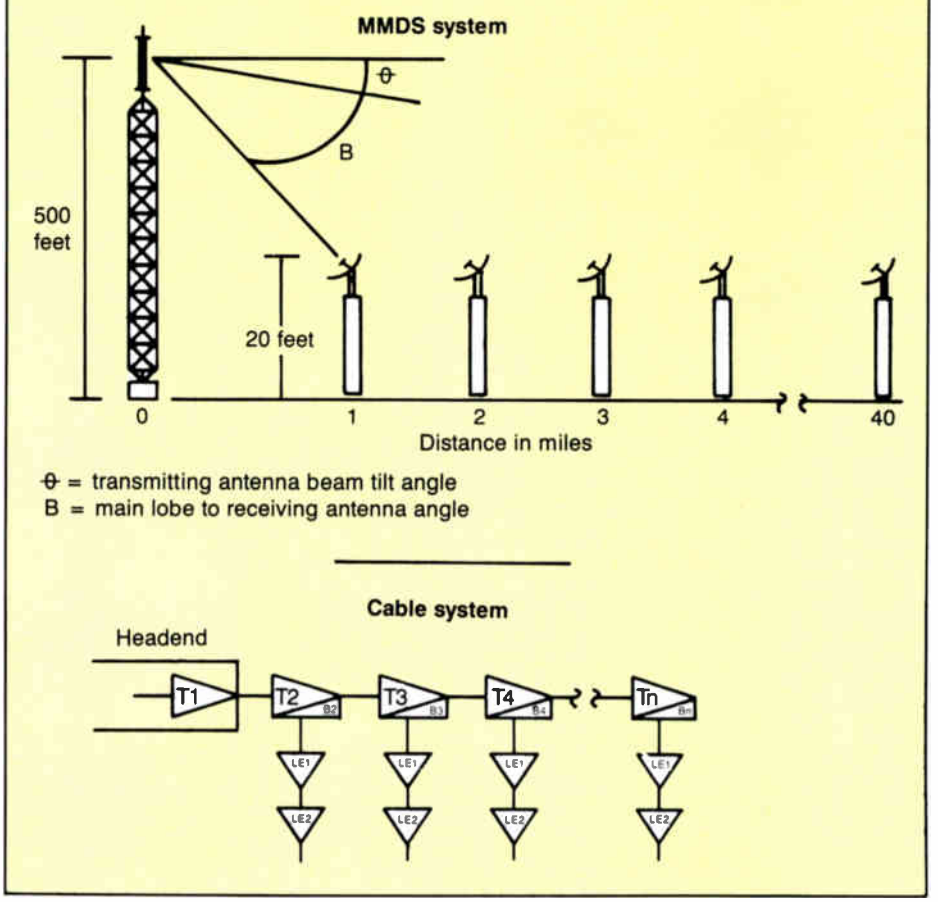

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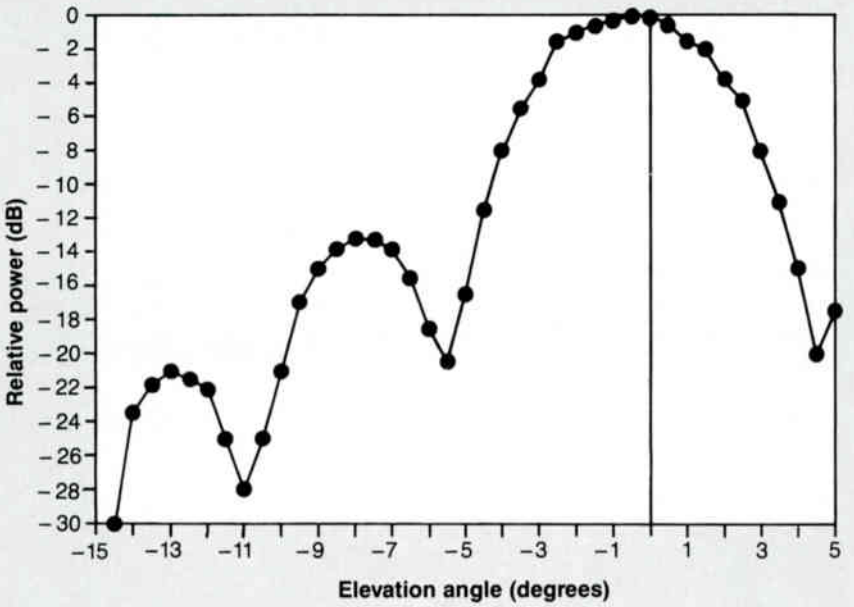
Figure 2: Transmitting antenna elevational characteristics



Therefore, the noise level at each receive site can be calculated from

$$N_R = kBT_EG_P \quad (3)$$

where:
N_R = noise power at downconverter output (dBm)
k = Boltzmann's constant (1.38×10^{-23} Joules/° Kelvin)
B = bandwidth (4×10^6 Hz)
T_E = effective noise temperature of receiving system
G_P = block downconverter gain (power ratio)

With the receiving antenna and block downconverter characteristics shown in Table 1, the effective noise temperature of the receiving system is approximately 780°K and the noise level at the output of the block downconverter from Equation 3 is −83.7 dBm. Table 1 shows the resulting C/N for the various receive sites in the MMDS system.

Cable system noise performance

The cable system design consists of a series of feedforward trunk amplifiers with a generous 2,600 feet of separation. Each trunk amp breaks off into feeder legs consisting of a bridger amplifier and two line extenders. The performance levels at the output of this second line extender will be compared with the MMDS performance levels at the block downconverter output. The amplifier characteristics are listed in Table 2.

The C/N ratio can be calculated for the trunk, bridger and line extender systems independently using

$$C/N = P_R - G_A - NF - 10\log N + N_O \quad (4)$$

where:
P_R = received signal level (dBmV)
G_A = amplifier gain (dB)
NF = amplifier noise figure (dB)
N = number of amplifiers
N_O = system thermal noise level, −59.1 dBmV for a 4 MHz bandwidth

and then combined using

$$C/N = -10\log [10^{(.1\ C/N_T)} + 10^{(.1\ C/N_B)} + 10^{(.1\ C/N_E)}] \quad (5)$$

where:
C/N_T = C/N for the trunk cascade (dB)
C/N_B = C/N for the bridger amplifier (dB)
C/N_E = C/N for the line extender cascade (dB)

The C/N was calculated for distances out to 40 miles (80 trunk amplifiers) and the results are shown in Table 2.

Figure 3 is a comparison of the C/N performance of the cable and MMDS systems. The results show that even at 10 watts of output power, MMDS performance can rival cable performance out to distances of at least 23 miles (47 trunk amplifiers).

Table 1: MMDS system characteristics used in analysis

Distance (miles)	Path loss (dB)	Rx level (dBm)	C/N (dB)	Tx/Rx antenna angle (degrees)	Elevation pattern attenuation (dB)
0.5	98.88	−28.88	54.56	−9.80484	−21
0.75	102.40	−26.90	56.54	−6.41122	−15.5
1	104.90	−30.40	53.04	−4.69442	−16.5
1.5	108.42	−21.22	62.22	−2.96822	−3.8
2	110.92	−21.42	62.02	−2.10256	−1.5
3	114.44	−23.94	59.50	−1.23570	−0.5
4	116.94	−26.19	57.25	−0.80195	−0.25
5	118.88	−28.13	55.31	−0.54162	−0.25
6	120.46	−29.46	53.98	−0.36805	0
7	121.80	−30.80	52.64	−0.24405	0
8	122.96	−31.96	51.48	−0.15106	0
9	123.98	−32.98	50.46	−0.07872	0
10	124.90	−33.90	49.54	−0.02085	0
15	128.42	−37.42	46.02	0.152757	0
20	130.92	−39.92	43.52	0.239566	0
25	132.86	−41.86	41.58	0.291652	0
30	134.44	−43.44	40.00	0.326376	0
35	135.78	−44.78	38.66	0.351180	0
40	136.94	−45.94	37.50	0.369782	0
45	137.96	−46.96	36.48	0.384251	0
50	138.88	−47.88	35.56	0.395825	0

Frequency (GHz) =	2.6
Transmitting power (watts) =	10
Combining losses (dB) =	3
Transmitting antenna gain (dBi) =	13
Receiving antenna gain (dBi) =	21
BDC gain (dB) =	20
Receiving antenna temperature (° Kelvin) =	150
BDC noise figure (dB) =	5
Transmitting antenna height (feet) =	500
Transmitting antenna tilt (degrees) =	0.5
Typical receiving antenna height (feet) =	20
BDC noise factor =	3.16
BDC noise temperature =	670.16
System noise temperature =	820.16
Noise power BDC output =	−8.34E+01

BDC—block downconverter

Now, the results shown in Figure 3 describe the ideal situation where the C/N is only limited by the signal level received at each receive site. For systems of two to 16 channels in size the level of performance is quite practical. However, when the number of channels increases to beyond 16, the downconverter dynamic range will typically limit the maximum allowable received signal level and thus will be the controlling factor for C/N. The received signal level must be chosen to balance between C/N and non-linear distortion performance. This is especially true for clear line-of-sight receive sites out to distances of 20 to 25 miles.

Figure 3: 10 watt MMDS vs. cable C/N performance

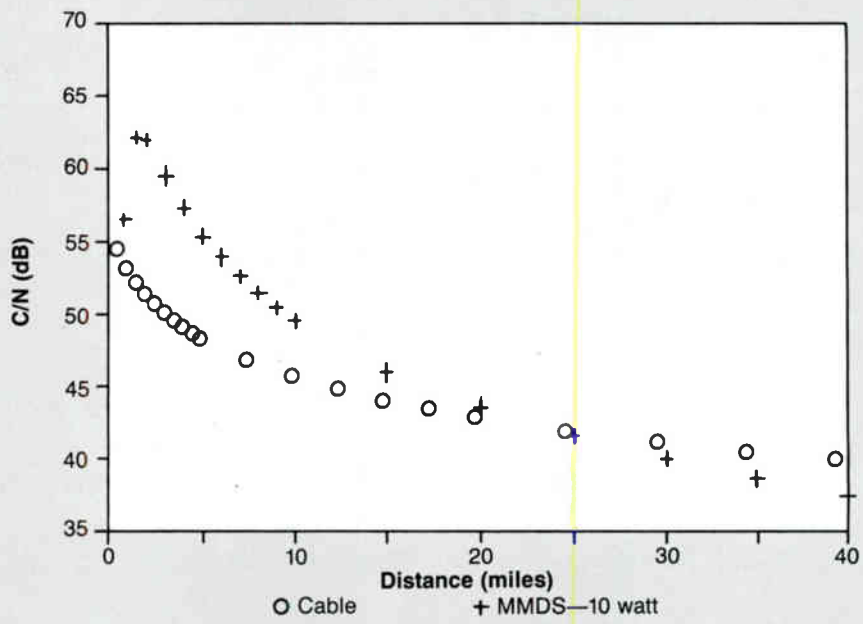


Table 2: Cable system characteristics used in analysis

Trunk amplifier	Distance (miles)	C/N at trunk amp. output	C/N at line ext. output
1	0.49	59.10	54.49
2	0.98	56.09	53.20
3	1.48	54.33	52.20
4	1.97	53.08	51.40
5	2.46	52.11	50.72
6	2.95	51.32	50.13
7	3.45	50.65	49.61
8	3.94	50.07	49.15
9	4.43	49.56	48.73
10	4.92	49.10	48.35
15	7.39	47.34	46.82
20	9.85	46.09	45.70
25	12.31	45.12	44.80
30	14.77	44.33	44.06
35	17.23	43.66	43.43
40	19.70	43.08	42.88
50	24.62	42.11	41.95
60	29.55	41.32	41.18
70	34.47	40.65	40.53
80	39.39	40.07	39.97

Trunk amplifier	
Gain =	26.00
NF =	10.00
C/N =	59.1
Bridger amplifier	
Gain =	31.00
NF =	9.50
C/N =	59.60
Line extender	
Gain =	30.00
NF =	8.00
C/N =	62.1

Non-linear distortion

As previously mentioned, the downconverter dynamic range will typically be the controlling factor for the system non-linear distortion performance. The architecture of the MMDS transmitting system is optimized for minimum distortion generation. An individual transmitter is used for each channel and channels are combined through the use of passive waveguide combiners. Cross-modulation and intermodulation numbers of −60 dB are very typical at the output of the transmitting antenna(s). Therefore, the downconverter is the only active element in the system handling the combined power of all channels. Because of this, the downconverter input level must be kept within the manufacturer's specified dynamic range to ensure intermodulation and cross-modulation performance on the order of −55 to −60 dB as delivered to the subscriber. Obviously, this adjustment of received signal level will ultimately affect the C/N ratio.

Cable systems have a much more severe problem with non-linear distortion because of the number of active devices handling all of the video channels. Cross-modulation, intermodulation and composite triple beat worsen through every amplifier. The major contributor to non-linear distortion products in a cable system are the feeder lines containing the bridger amplifiers and line extenders. These amplifiers typically have 20 to 30 dB worse distortion figures than the trunk amplifiers. Because the cable system model used in this comparison contains only two line extenders and one bridger amplifier per trunk amplifier, the cross-modulation calculations result in excellent performance. However, unlike MMDS, distortion products increase as the cable system grows.

MMDS limitations

As described before, MMDS can have significant performance advantages over cable. However, there are limitations placed on MMDS because it is an over-the-air technology. Because of the transmission frequencies (2.1 to 2.7 GHz), MMDS is essentially a line-of-sight technology. Receive sites with totally or partially obstructed views of the transmitting antenna may have tremendous variations in received signal strength. Receive sites surrounded by foliage may experience large signal level fluctuations as the seasons change. It is essential to ensure clear line-of-sight between transmit and receive sites in order to obtain consistent performance at all times.

However, these problems with terrain and obstructions can be managed. There are signal strength contour studies available that will predict the amount of loss an MMDS operator can expect from terrain. By combining these studies with intuitive reasoning regarding other structures in the propagation area and foliage, an MMDS operator can predict the coverage area very accurately.

Not only can MMDS offer performance advantages over cable but also increased system reliability. Since there is no closed distribution system and no large cable plant to maintain, the only equipment reliability concerns exist at the transmit site and the subscriber's home. Also, the current design trend for MMDS transmitting equipment is away from tube technology and toward solid-state devices. Solid-state technology is more reliable and less power-consuming.

The receive site antenna and downconverter are designed to reside on the subscriber's roof and provide excellent reliability in a variety of weather conditions. However, the potential weak link in the receive site installation can be the interconnections from the downconverter to the antenna and into the subscriber's home. Care must be taken to ensure all connections are sealed and weather tight. The ingress of moisture

into these interconnections can have considerable impact on received signal quality.

Other significant MMDS advantages include the speed at which a system can be built. Once transmit site construction begins, it is not unusual to be ready to install subscribers in a one-to three-month time frame anywhere in the potential coverage area. This is significantly better than the typical cable start-up times. Also, there is significantly less up-front cash needed to start a system as the major cost comes from subscriber equipment, not transmission equipment or plant.

Bells and whistles

Transmission and reception equipment currently available to MMDS operators offers many of the cable system operational features and more. Signal security, addressability, stereo compatibility and spectrum space for ancillary data services are all available in MMDS.

From a security standpoint, both audio and video scrambling techniques are available. Current techniques consist of video inversion, sync suppression, bandwidth compression and combinations of these.

Addressability is performed through the use of in-band data transmission. Current techniques involve transmission in either the video or audio paths. Along with addressability come features like pay-per-view capability, flexible tiering and combining of programming, channel mapping and increased deterrents to pirating of signals and converters.

Since most MMDS equipment is designed to handle the additional audio bandwidth for BTSC stereo, the system is stereo transparent from the beginning. With the addition of stereo encoders at the transmitter site and decoders in the home, subscribers can enjoy excellent quality stereo sound.

A well-designed and well-managed MMDS system can exceed cable system performance in the fundamental areas that significantly impact subscriber satisfaction. Through careful and detailed system design, MMDS can achieve an excellent reputation as a high quality and high performance broadcast service. Also, since MMDS operators do not have an expensive distribution system to maintain, more attention can be paid to customer service and satisfaction. However, it is important for an MMDS operator to understand the technical capabilities and limitations of the system. With this understanding, an MMDS operator can build a successful and profitable business.

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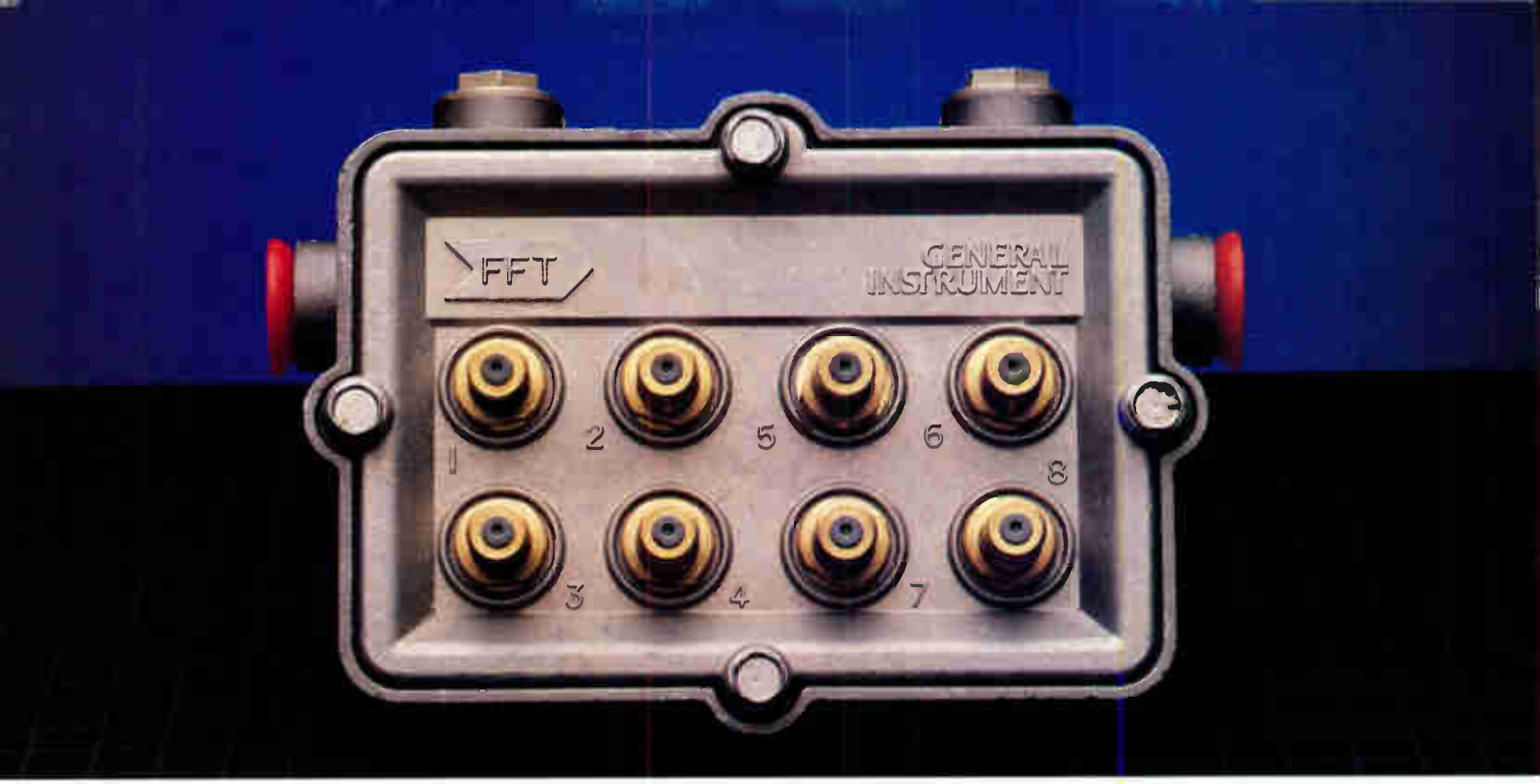

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Reader Service Number 37.

Competing technologies for conventional CATV

By Dave Wachob
Director of Advanced Technology, Jerrold Division/General Instrument Corp.

The conventional cable TV market represents an area of business familiar to most of us in terms of the method of distribution, achievable performance, technologies involved, cost of providing services and signal security. What may not be so familiar is how some of today's (and tomorrow's) competing technologies compare with the performance established during 30 years of CATV operation. With this point of reference in mind, this article will analyze two such competing technologies.

DBS, *direct broadcast satellite*, receives signals directly from the satellite via either C- or Ku-band. Of the two, C-band (2 GHz) is presently more common, although Ku-band (12 GHz) holds the most promise for the future. The majority of premium services offered are scrambled using VideoCipher technology and thus require a descrambler as part of the microwave satellite receiver station. Although some initial cases of signal piracy have been reported, these have been somewhat eliminated using a variety of legal, hardware and software measures.

Program services are available in the clear or scrambled, a la carte or bundled. Service costs vary, depending on the quantity and tiering selected. The potential channel offerings can exceed cable TV, particularly if a steerable dish is employed.

Cost/performance tradeoff decisions are particularly relevant for DBS, especially in relation to cable, where most operating hardware is provided by the system. DBS costs can vary from the $500 do-it-yourselfer to more than $2,000, with additional costs incurred for descrambling premium satellite services. Although there are no distance limitations from the satellite to the receiver per se, dish size has a major impact on system performance. In addition, the receiver dish angle relative to the satellite position also contributes to the achievable performance.

MMDS, *multichannel multipoint distribution service*, offers an alternative to the conventional satellite receiver, although 2 GHz satellite frequencies are still used to transmit the signal. Here, the distinction is that the signals are transmitted from a fixed terrestrial microwave transmitter at a site in the area to be served. As a result, one of the performance limitations for this technique is that subscribers must be geographically located near the MMDS transmitter—typically within 25 miles—for reasonable reception. In addition, physical obstructions between the transmitter and receiver (trees, buildings, ground elevations, etc.) also must be considered in MMDS.

MMDS cost benefits

By not requiring the receiver performance associated with satellite reception, MMDS offers certain cost benefits over DBS. In addition to smaller antenna/dish size, no antenna steering is required because only a signal transmitter site is involved. Channel capacity for MMDS is limited, relative to DBS and conventional cable TV, with a maximum channel capacity of 30. This service limitation is also a cost advantage because of the hardware reduction in possible tuning range.

In general, all MMDS channels are scrambled to maintain overall system security. Scrambling techniques similar to conventional cable TV are employed, with little theft-of-service detected to date. This may change in the future, however, if MMDS usage becomes more widespread, offering additional incentives for piracy. (It should be noted, however, that MDS suffered extremely from theft.)

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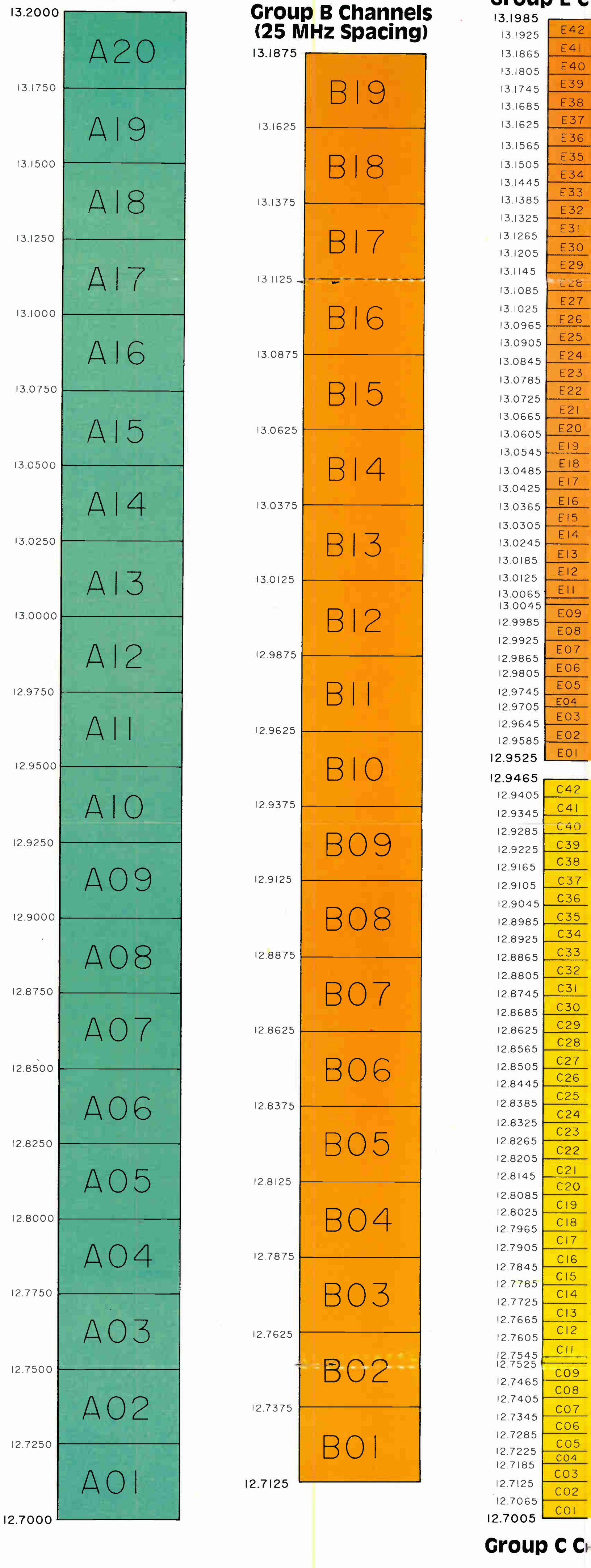

Compiled by Ron Hranac, Jones Intercable Inc.

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E10 (FM4)

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FMI
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PT
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C10 (FM4)

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Group F Channels

13.1985	F32	M
13.1925	F31	L
13.1865	F30	K
13.1805	F29	J
13.1745	F28	13
13.1685	F27	12
13.1625	F26	11
13.1565	F25	10
13.1505	F24	9
13.1445	F23	8
13.1385	F22	7
13.1325	F21	I
13.1265	F20	H
13.1205	F19	G
13.1145	F18	F
13.1085	F17	E
13.1025	F16	D
13.0965	F15	C
13.0905	F14	B
13.0845	F13	A
13.0785	F12	AUX
13.0725	F11	AUX
13.0665		
13.0645		
13.0585	F09	FM3
13.0525	F08	FM2
13.0465	F07	FMI
13.0405	F06	6
13.0345	F05	5
13.0305	F04	PT
13.0245	F03	4
13.0185	F02	3
13.0125	F01	2

F10 (FM4)

Group D Channels

13.0057	D42	W
12.9997	D41	V
12.9937	D40	U
12.9877	D39	T
12.9817	D38	S
12.9757	D37	R
12.9697	D36	Q
12.9637	D35	P
12.9577	D34	O
12.9517	D33	N
12.9457	D32	M
12.9397	D31	L
12.9337	D30	K
12.9277	D29	J
12.9217	D28	13
12.9157	D27	12
12.9097	D26	11
12.9037	D25	10
12.8977	D24	9
12.8917	D23	8
12.8857	D22	7
12.8797	D21	I
12.8737	D20	H
12.8677	D19	G
12.8617	D18	F
12.8557	D17	E
12.8497	D16	D
12.8437	D15	C
12.8377	D14	B
12.8317	D13	A
12.8257	D12	AUX
12.8197	D11	AUX
12.8137		
12.8117	D09	FM3
12.8057	D08	FM2
12.7997	D07	FMI
12.7937	D06	6
12.7877	D05	5
12.7817	D04	PT
12.7777	D03	4
12.7717	D02	3
12.7657	D01	2
12.7597		

D10 (FM4)

Group K Channels (12.5 MHz Spacing)

13.2000	K40
13.1875	K39
13.1750	K38
13.1625	K37
13.1500	K36
13.1375	K35
13.1250	K34
13.1125	K33
13.1000	K32
13.0875	K31
13.0750	K30
13.0625	K29
13.0500	K28
13.0375	K27
13.0250	K26
13.0125	K25
13.0000	K24
12.9875	K23
12.9750	K22
12.9625	K21
12.9500	K20
12.9375	K19
12.9250	K18
12.9125	K17
12.9000	K16
12.8875	K15
12.8750	K14
12.8625	K13
12.8500	K12
12.8375	K11
12.8250	K10
12.8125	K09
12.8000	K08
12.7875	K07
12.7750	K06
12.7625	K05
12.7500	K04
12.7375	K03
12.7250	K02
12.7125	K01
12.7000	

Pull-out Wall Chart

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Small systems—The last frontier

This is the first in a series of articles prepared to help the small system operator or entrepreneur avoid some basic (and perhaps fatal) mistakes. This installment begins a discussion on the basic problems of smaller CATV operations. Upcoming articles will deal with the cable plant and transmission system itself, the headend and signal acquisition problems, and a discussion on the day-to-day operation of smaller systems.

By Bill Grant
President, GWG Associates

And Lee Haefele
President, Haefele TV

Although a great deal of industry attention has been directed at the continuing penetration of cable service into population-dense urban areas and cities, there is also a persistent level of interest and activity in constructing smaller independent CATV systems. For those of us who participated in the earliest evolution of CATV, it brings back many memories. Such an effort may seem to be a simple project for people with previous CATV experience—but make no mistake about it, this isn't a game for amateurs.

It's easy for people working in larger systems to simply dismiss the small operation as "kid stuff," but if a small system is to be economically viable it requires a very sound understanding of the business, both technically and economically. Although the capital requirements are smaller, so is the revenue base presented by a smaller number of potential subscribers. The margin for errors in judgment or system design are very small indeed. On the other hand, smaller systems present entrepreneurial opportunities that haven't been readily available for many years, and again the old-timers will feel a twinge of nostalgia.

What are we really looking at here and just how could such opportunities be addressed logically? Is it really simply a case of using home receiver satellite units and stringing a bunch of line extenders in cascade? We don't believe this is so.

Unique small system problems

First and foremost of problems is the fact that a smaller system cannot afford to compromise the quality of the product it offers for sale, that is, the TV pictures it presents to the subscribers. In a larger system perhaps the operator can survive on lower penetration of the market, at least for some period of time until marketing efforts improve that performance, because 30 or 40 percent of, say, 20,000 subscribers is still a substantial sustaining cash flow.

The smaller system enjoys no such privilege. Usually it is operating on a distinctly limited amount of capital. It is essential that the system reach and sustain significant levels of penetration quickly. Furthermore, there is no reason to expect small community subscribers to be less critical of the quality of service either, so the small operator must establish a reputation of quality service at the outset. Initial subscribers who disconnect for any reason may be very difficult to recover at a later date.

A second reason for designing and constructing well should be obvious. Given a distinctly limited subscriber count and thus a limited supporting revenue base, the smaller operator cannot afford either manpower or sophistication in long-term maintenance. It is necessary not only to construct a system inexpensively but also to see that the operation of the system be as trouble-free as possible. By "trouble-free" we mean not only that the system remain in service but the quality of the signals transported be maintained at the highest level possible, with an absolute minimum of day-to-day attention.

The reader may well say, "So what? Exactly the same criteria applies in the larger, more sophisticated urban systems, doesn't it?" Of course it does, but given the cash flow that the larger operation presents, such installations can provide and support a sophisticated technical staff. Supervision and problems can be more rapidly identified and more effectively rectified. The smaller system cannot afford and probably won't get the same "babysitting" care on an hourly basis.

The point is that the small system operator must design and build the system with meticulous attention to low maintenance. Transmission quality cannot be compromised either, since there will not be continuous service monitoring and repair capabilities at hand. Is this possible?

Hardware and equipment

If we review the system hardware currently available, including headend signal acquisition equipment, the prognosis is most promising. Today's equipment, certainly when compared with the earlier tube and discrete transistor units, has a history of trouble-free, reliable operation over the long term. The very design of some units that provides for plug-in card or module replacements as a troubleshooting operate facilitates the maintenance of systems with less stringent requirements for either sophisticated test equipment and procedures or even a high degree of technical skills. This is most encouraging for the smaller operator who can ill-afford either luxury.

Beyond the question of operational reliability, present-day units lend themselves well to simpler maintenance programs also. It is difficult to conceive, for example, a modern CATV amplifier of any type that would, in the course of extended but normal operation, suddenly produce a significantly higher level of intermodulation distortion or would evidence a drastically different noise figure. Anything is possible, of course, but it is highly improbable that today's equipment would do this without evidencing some drastic change in transmission levels within the system.

Fortunately, monitoring signal levels is the easiest maintenance procedure to perform and the test equipment required is also the most common, least expensive and simplest to use. Then a practical maintenance program for the smaller system might really focus on signal level testing alone. More complex tests such as sweeping or spectrum analysis can be eliminated entirely or limited to infrequent periodic applications.

Another example of practicality in a maintenance program is the use of Sniffer- or Cuckoo-type RF leakage detection systems as trouble locating devices. These are relatively inexpensive units; with just a little training, they can be effectively used to diagnose and locate a number of cable system faults such as defective connectors, unterminated cable ends, open cable sheaths, etc.

System design alternatives

If the logic is sound that equipment irregularities will most probably introduce signal level variations, then we could even design the transmission system to minimize the impact of any such variations. This might be achieved by providing a higher degree of system self-regulation; that is, by using automatic gain control (AGC) and automatic slope control (ASC) units more frequently. Let us examine this point objectively.

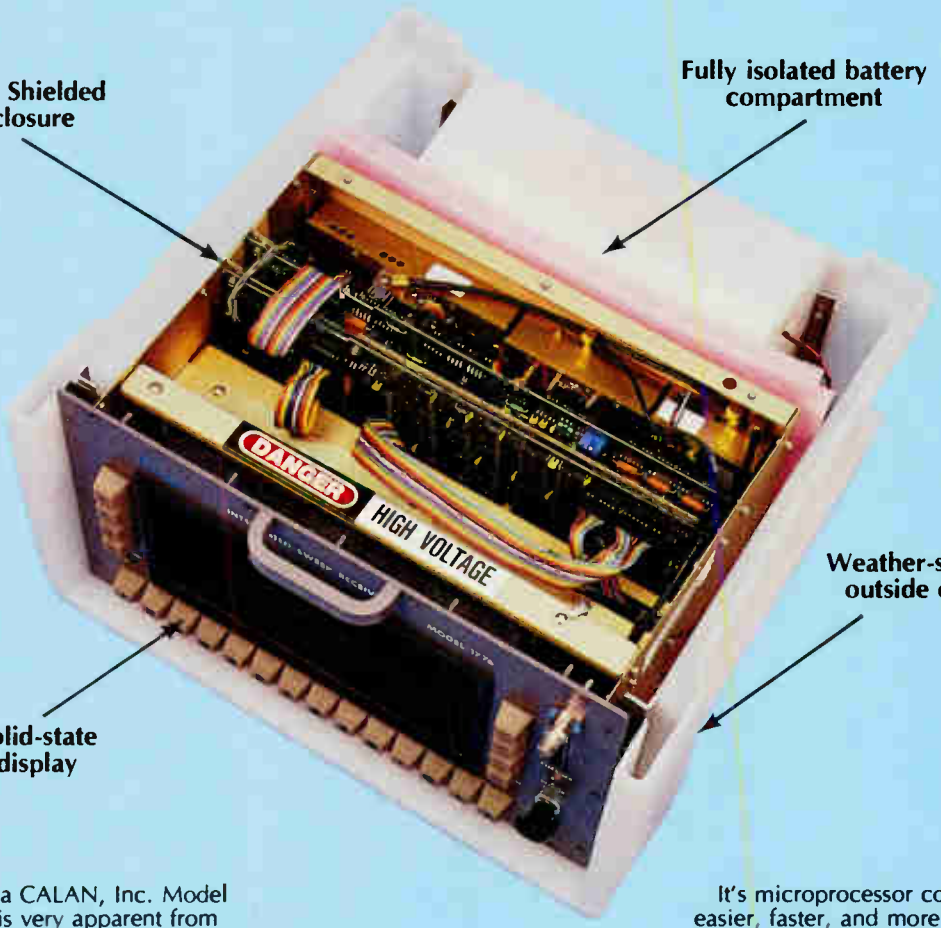
In the earlier CATV systems self-regulation in the form of AGC and ASC was recognized as a necessary evil but the use of such units was held to a minimum. Such units did introduce some degree of electronic sophistication and thus some concern about reliability. Of course, they cost more and each such unit introduces the very real possibility of improper adjustment.

The system design engineer calculates the cable lengths in the system, considers the temperature variations that the plant will be exposed to and determines how much and how frequently self-regulation capability has to be introduced into the system. Although this process is technically sound and may have been done correctly, the long-term beneficial corrective effect becomes dependent upon the AGC or ASC units being adjusted and maintained in the field so as to actually produce the corrective range that the equipment system designers had provided.

It is possible—indeed, it may even be probable—that over the course of time and given a number of equipment replacements or readjustments by a number of different people, the regulating units do not actually provide the corrective action of which they are capable. Some years back we questioned a number of senior technical people in the industry as to how many AGC or ASC units in all the coaxial plant in operation in the nation they would expect to find improperly adjusted. The response was that they expected well over 50 percent would not be adjusted correctly. (What do you think the figure might be?)

Then we may well have many systems where self-regulation has been well-engineered and adequately provided but where the system is actually operating out of specifications some of the

The Inside Story on Reliability



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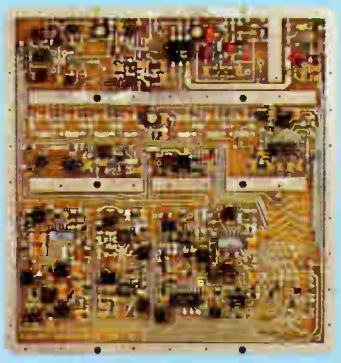

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time, particularly under conditions of drastic thermal change or stress. Note that if a higher level or density of self-regulation had been provided initially rather than simply that that was technically adequate, then signal level variations due to improper regulation adjustment might have been self-corrected in the next regulating unit. Performance at the end-of-system might not have been compromised.

Although there are sound reasons for using a relatively high level of self-regulation in smaller systems as we have pointed out, we don't want to overemphasize this point. There are many smaller systems operating where auto-regulation is more strictly limited. Indeed, there is a school of thought that says AGC only—no ASC at all—is required until the amplifier cascade exceeds perhaps six units or so, even in aerial plant.

There is some precedent for using fewer units in systems. Consider a trunk/feeder system where AGC was installed at every third amplifier location. It is now possible for some subscribers to be fed signal from the last AGC unit through two unregulated manual trunk amplifiers and then through an additional two unregulated line extender units. This condition would not be unusual in many systems and they do function adequately, presumably.

What we wanted to accomplish here was to help the reader understand the function and use of auto-regulation, not to arbitrarily impose some strict rule. For the smaller system we are not advocating more regulation because the present level generally used was necessarily inadequate. However, we are suggesting that using more regulation might significantly reduce maintenance requirements without adversely affecting the long-term transmission quality of the system. The reader may or may not agree that this objective justifies some increase in plant construction costs. But if a high priority of the small system operator is reduced maintenance cost and protection of transmission quality, then it seems logical that a high level of system self-regulation in the longer, extended cable runs at least would be most beneficial.

It's not enough to build the plant inexpensively. What we want is a system that is extremely "rugged," that is, relatively unaffected by signal level changes regardless of whether such changes are temperature-induced or the result of improper or minimal maintenance programs. We want a system that accepts and corrects for all changes and thus maintains a high quality of transmission for long periods of time with an absolute minimum of attention.

Even if automatic units cost more than manual amplifiers, since there is not a lot of cable plant involved in most small systems and since we do not have to put automatic units at every location, the overall cost penalty may be acceptable. We are obliged to cut costs aggressively in these efforts but cutting all the corners may not be the wisest choice in every case. After all, you build a system once, but you live with it for a long time.

Keep in mind that some suppliers of equipment that might be considered suitable for small systems only offer single pilot regulating units, which precludes any ASC at all, unless other equipment types are introduced into the inventory. ■

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Part II: CLI revisited

This is the second of two parts. Part I, which appeared in the July 1988 issue, contained an overview of the cumulative leakage index (CLI) test. Part II addresses the management side of CLI.

By Roy Ehman
Director of Engineering
And Pam King
Technical Training Coordinator, Jones Intercable Inc.

The clock is ticking away toward July 1, 1990. By now we have all seen and read many explanations of CLI and the deadline we have to meet. This is, therefore, a brief confirmatory overview for the sake of complete coverage, followed by updates on some of the progress one MSO (Jones Intercable) has made through its development.

What is cumulative leakage index?

CLI is a measurement technique for evaluating the combination of all the various big and small signal leaks of a cable system in the air space above it to ensure the safety of life and property in the air over a cable system. It was developed by the Advisory Committee on Signal Leakage and originally released in November 1979. The Federal Communications Commission in its Final Report and Order of Docket 21006 (July 1, 1985) mandated that all cable systems be sufficiently leak-free to meet the given parameters using the method by July 1990 or suffer the consequences of large fines and/or total or partial instant shutdown of the cable system. The FCC will accept successful ground- or air-based CLI submissions starting Jan. 1, 1990, a year from now.

In the ground-based method it is necessary to ride out 75 percent or more of the plant while measuring and recording the value of every leak over 50 μV/meter. A formula is then used to predict the integrated effect (or figure of merit) of all leaks big and small in the air space above the system. If that figure of merit number is over 64 the system fails. Important points to note are that leaks under 50 μV/m at the equivalent of 10 feet from the cable are not counted toward CLI (but leaks over 20 μV/m at 10 feet are in violation and must still be repaired). Note also that it is not sufficient to merely log the number of leaks over 50 μV/m. Each and every leak must actually be measured using close approximations to the proper procedures including use of a calibrated receiver and horizontally polarized dipole at the 10-foot equivalent. This is obviously labor-intensive and somewhat imprecise, but the results will be enough to give you a good idea of where you are.

Table 1

Number of leaks	kms from center	dB re 50 μV	μV/m	I	I_{3000}
1000	1.9	0.0	50	64.0	−7.0
250	1.9	6.0	100	64.0	−7.0
64	1.9	12.0	200	64.1	−6.9
16	1.9	18.1	400	64.1	−6.9
4	1.9	24.1	800	64.1	−6.9
1	1.9	30.1	1600	64.1	−6.9

Table 2

Number of leaks	kms from center	dB re 50 μV	μV/m	I	I_{3000}
50	1.9	6.0	100	57.0	−14.0
100	1.9	6.0	100	60.0	−11.0
100	1.9	12.0	200	66.0	−5.0

The other CLI method is by flying over the system in a grid pattern using a plane equipped with a suitable calibrated receiver, orthogonal dipole antennas, analog or digital data recorders, etc. If the 90th percentile of all the digital readings exceeds 10 μV/m the system fails. This is equivalent to a ground-based I_{∞} of 64 for small systems or I_{3000} of −7 for large systems.

Our first priority is to get our leakage under control, the second is to do ground-based CLI and third, possibly do a well-timed and managed flyover that will provide valuable correlation with our ground-based measurements. Since flyovers are expensive (somewhere around $5,000), they should be avoided by smaller systems that have sufficient confidence in their ground-based measurements. For larger systems with 500+ miles of plant it is more cost-effective to submit a flyover to the FCC once the system is confident from partial rideouts and extrapolation of the results that it has a good chance of passing. A failed flyover is not very valuable and may only tell you where the "hot spots" are, which you undoubtedly know already. Hint: Don't overlook tall buildings. You may have to go inside to the top or the (flat) roof. If you opt to go on a roof there must be two people and every safety precaution exercised.

Equipment and manpower requirements

First, budget for the necessary leak detection equipment and acquire it as soon as possible. Second, develop a plan. In order to meet CLI by July 1990 it is necessary for systems to sit down and develop a definitive action plan complete with intermediate goals to meet this deadline with sufficient margin to test and retest. (It usually takes two to three passes to get a leaky system into compliance.) Manpower and other resources must be *irrevocably* allocated. Example action plan goals might be expressed in terms of leaks per mile or better in levels such as no leaks over 150 μV/m by Jan. 1, 1989, no leaks over 100 μV/m by July 1, 1989, and no leaks over 50 μV/m by Dec. 31, 1989. Smaller systems that follow the equipment and procedural guidelines outlined here should be able to carry out satisfactory ground-based CLI measurements between January and June 1990 while the big systems rely on third-party flyovers. Think in terms of 40 minutes to repair a leak (or use another figure based upon your experience and personnel). Then multiply this by the number of leaks in the system plus some that will surface while you are fixing the first wave. Do you have the manpower and equipment to make it with a good safety margin?

In order to illustrate this, assume there are 1,000 miles of plant in which you have to perform a CLI. As an example, we will use a "moderately" leaky system with an average of 1.1 leaks per mile.

(1.1 leaks per mile × 1,000 miles × 40 minutes per leak)/60 minutes = 733.3 hours

In order to clean up this system within a three-week time frame, you will need at least six full-time people, complete with vehicles and equipment, working only on this task eight hours a day, five days a week. One full-time person will be required for at least 4½ months, assuming there are no new leaks. By using a similar approach, you will be able to present a strong argument for acquiring additional manpower and equipment.

Software as a management tool

When system personnel start to get serious regarding leakage control within the system, an effort is generally made to streamline the operation using whatever automation or computerization may be available. Typically the first step would be to enter "leaks found" into a simple Lotus 123 spreadsheet. This is a good first step as it enables clean, legible copy to be dumped

Figure 1: Signal leakage log

System name _____

Year _____ Freq. _____

Mo/Day	Tech	Location	Code	Distance	Level	Probable cause	Code	Tech	Mo/Day

to a printer and used as a work list. When the entries have been completed as "leaks repaired," the printed output makes an acceptable FCC log provided, of course, that these four fundamental FCC prerequisites are met:

- date leak was found
- location of leak found
- probable cause of the leak
- date leak repaired

It is not an FCC requirement for a valid leakage log to measure the level of the leaks found as many believe. But it is a good idea to do so even if it is only in terms of "little, medium or large" so that the cleanup can be prioritized (Figure 1). As we all now know, the big leaks will blow your cumulative leakage index away in a big hurry. For I_{∞} it is necessary to come up with a CLI figure of merit of 64 or less.

Tables 1 and 2 summarize how the bigger leaks consume your CLI allowance. Notice in Table 2 that doubling the number of leaks causes the CLI to deteriorate by three whereas doubling the size of the same number of leaks causes the CLI to degenerate by six!

For I_{3000} a distance from a center of 1.9 km has been used since at that distance I_{∞} and I_{3000} give equal results. At zero distance from the center, I_{3000} gives higher CLI; above 1.9 km it continually drops off to allow for large systems. For this reason, systems of approximately 500 miles and over should use I_{3000} or they would be unduly handicapped and might never make an I_{∞} of 64 or better. For these, a flyover would be a good alternative.

The next step in the evolution of leakage and CLI control software is to improve the spreadsheet approach by extending each line of leaks logged with the square of the leak level (in μV/m). At the bottom of the column it is then only necessary to sum these squares and take $10\log_{10}$ (sum of all the squared leaks) to get I_{∞}. This formula assumes you rode out 100 percent of the plant. For rideouts of less than 100 percent you introduce a simple factor and the basic formula becomes:

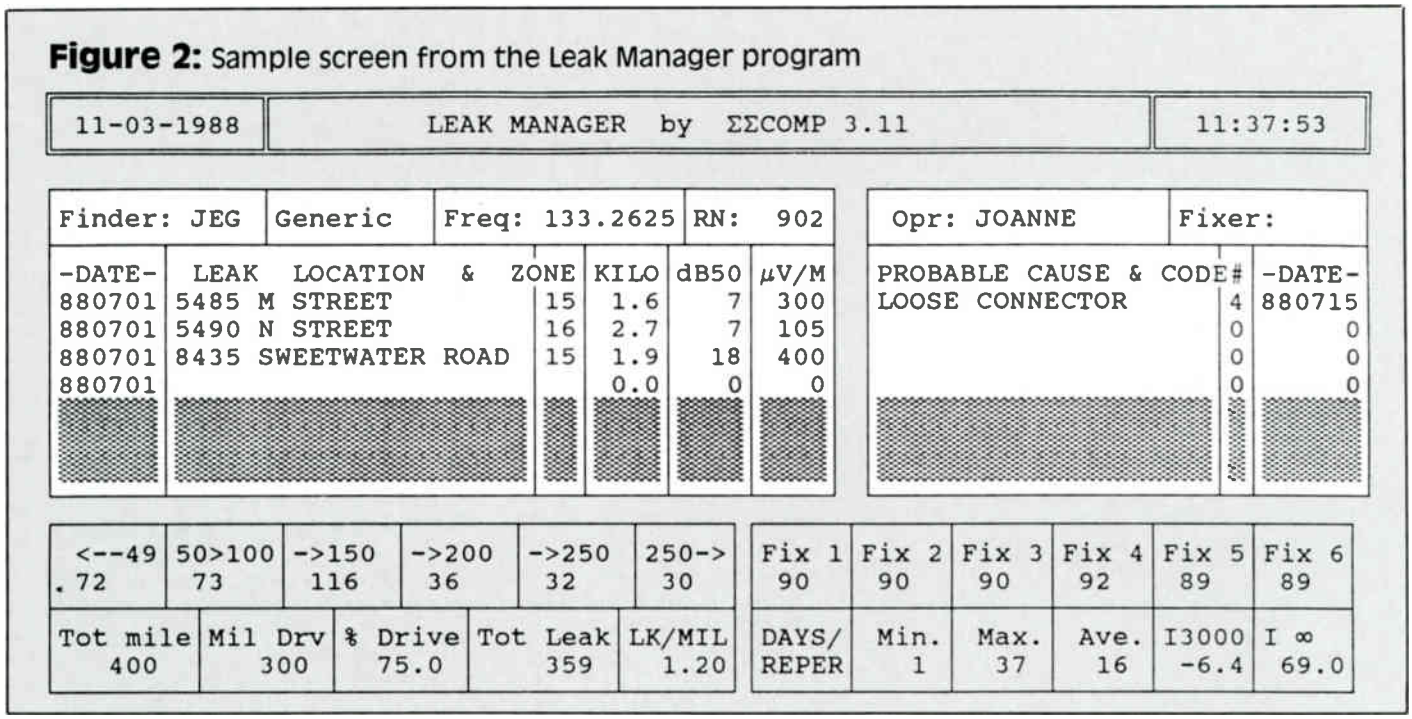
$I = 10\log_{10}$ (sum of the squares $\times$ T)

where:

T = total plant miles/miles driven

Further spreadsheet sophistication involves adding macro software that

Figure 2: Sample screen from the Leak Manager program



11-03-1988	LEAK MANAGER by ΣΣCOMP 3.11	11:37:53

Finder: JEG	Generic	Freq: 133.2625	RN: 902

Opr: JOANNE	Fixer:

-DATE-	LEAK LOCATION & ZONE	KILO	dB50	µV/M	PROBABLE CAUSE & CODE#	-DATE-
880701	5485 M STREET 15	1.6	7	300	LOOSE CONNECTOR 4	880715
880701	5490 N STREET 16	2.7	7	105	0	0
880701	8435 SWEETWATER ROAD 15	1.9	18	400	0	0
880701		0.0	0	0	0	0

<--49	50>100	->150	->200	->250	250->
. 72	73	116	36	32	30

Fix 1	Fix 2	Fix 3	Fix 4	Fix 5	Fix 6
90	90	90	92	89	89

Tot mile	Mil Drv	% Drive	Tot Leak	LK/MIL
400	300	75.0	359	1.20

DAYS/ REPER	Min.	Max.	Ave.	I3000	I ∞
	1	37	16	-6.4	69.0

will do things like print an FCC log, print work lists and sort leaks into categories.

As was mentioned in Part I, Jones has made available a Lotus 123 program, developed by Bruce Catter, at no charge. However, there are some minor drawbacks to using spreadsheets. You need to own Lotus 123 or similar, but worse is the high memory overhead demanded. To properly handle, say, 1,000 entries would probably require extended recognizable memory. Also, in order to avoid the occasional goof or tampering, the CLI spreadsheet would ideally need to be compiled.

With the foregoing in mind it is the next logical step to dispense with the spreadsheet and go straight for a specially written stand-alone compiled program in Basic or C or other modern powerful language. This opens up a new world of slick user-friendly programs with attractive and informative screens. With tools such as these the user progresses from basically only storing and regurgitating records to full management control. Leakage control and CLI measurements need to be managed. The software used needs to tell you how you are doing—preferably on-screen and in real-time.

The time and expertise required to write such programs is usually beyond the means of most systems. Luckily, a number of commercial products are now on the market to meet those needs. Here is a shopping list of features that you might want to look for if you are going to get into a full-fledged professional program that suits your system size and application.

- *It should be compact and not a "memory hog."*—With all the heavy overheads most of us now carry with terminate-and-stay-resident programs, larger operating systems and, in many cases, overheads due to being on a local area network (LAN) or other type of shared system, programs should be able to do a good job on 1,000 or more entries with 384K of free memory or less.
- *It should not require ownership of other programs.*—In other words, it is desirable (but not totally essential) that is be a one-shot, simple stand-alone program that is easy to transfer to your hard disc or multiple copies for multiple systems' right on floppies.
- *It should be versatile regarding input units.*—Many systems are in a state of transition and may currently be using one or more RD-1 dipoles with preamp and signal level meter with output in dBmV and perhaps a Vitek tracer or two with output in dB with respect to 20 µV/m, or better yet with an 8 dB pad in the antenna lead to give 50 µV/m center scale for CLI, and finally perhaps a Sniffer III with an output directly in µV/m. Your chosen program should be able to handle all of these on a direct entry basis, preferably with the ability for the user to change units "on the fly" without invalidating the entire data base. Who knows what units you may find yourself using when more equipment is purchased?
- *It should print out acceptable FCC logs and work lists.*—The latter should be available listed by highest leak first for reasons cited earlier. Another convenience feature is to have work lists available printed out by "zone" on separate sheets. This is a plus for big systems.
- *It should contain random access of leak records.*—You should be able to retrieve the particular leak you are looking for instantaneously by record number or address fragment as record numbers can change. A flag to inform you when a leak has previously been entered and/or repaired is a nice plus if available.
- *It should be fail safe.*—That is, you can't forget to "save" it to disc. Also, if you had a power bump, you would not lose a whole morning's work out of memory.
- *Management information* should preferably be available on a real-time on-screen basis, but printouts also will suffice. Having both available is best. Valuable items to look for are: leaks by size category; leaks by "fix" category; leaks per mile; I_{∞} and I_{3000}; audit trail (who made the entry); program activity report: who, when, what, how long; oldest leak date and location; and maximum, minimum and average days to repair. The latter is probably one of the finest supervisory facilities available. (In our systems, this facility has been made possible due to a suggestion from Bob Luff, group vice president of technology for Jones Intercable.) Figure 2 illustrates the main operation screen of one of the programs presently in use by Jones Intercable systems.

Thoughts on equipment selection

A Vitek tracer or equivalent is required for making actual field strength measurements as accurately as possible in connection with generating CLI figures. Other equipment can be used for routine vehicular monitoring, leak localization and leakage repair.

The measurement device you select must be truly peak reading, logarithmic with scale markings for 32 feet, 100 feet or other usable distances. The most outstanding features that place the major detection units in a class by themselves is that the meters are large, clearly marked in dB or µV/m, logarithmic and peak reading. No preamp with vague gain nor on-site arithmetic is required. Being logarithmic means that it covers a larger range of levels from a low of −20 dB below calibration to a high of +20 dB above. They should do so smoothly, with a well-damped meter movement. The recommended way to use the units calibrated with 20 µV/m at center scale for CLI work is to put an 8 dB in-line pad at the antenna input. Center scale will now be 50 µV/m, which is the pivotal point for CLI work. You can now read 20 dB above or below this value disregarding readings below 50 for CLI calculations but logging any between 20 and

50 for later repair. You also will be able to get a good handle on leaks up to 400 μV/m without any further switching or padding. Since the meters are peak reading as well as logarithmic, the variations due to changes in white levels in the picture carrier have a negligible effect on the displayed reading. Also due to the wide range, it has been possible to have meaningful markings on meters for monitoring at 32 feet and 100 feet from the plant, which, you will agree, is a necessary and frequent reality.

The preferred antenna orientation is a horizontal mount on a vehicle well away (24 to 36 inches) from the metal vehicle. This means the antenna is well-balanced with respect to ground but, even more importantly, it is spaced far enough away to eliminate the reflection effects that depend very critically on the exact spacing between the antenna and the reflector/director (vehicle metal roof) as with yagi elements. These factors are important if we are to simulate a true free-field horizontal dipole and have some degree of repeatability from vehicle to vehicle and system to system.

Some of the hand-held units at nominal cost are sufficiently sensitive to be used in vehicles for routine monitoring, as well as on the person. One unit has a high sensitivity of ±2 μV/m and is therefore suitable for wearing in a pocket or on the belt where it will pick up 20 μV/m in spite of reduced antenna Q and body shielding. You can actually "hear yourself" making or breaking connections either in the house or on a pole. In a vehicle with an outside antenna the unit is too sensitive and needs a 6 or 9 dB pad. The preferred frequency is Ch. C + 12.5 kHz = 133.2625 for standard headends. By equipping installers and service technicians with these units it is possible to hold them accountable if they walk away from a leaky situation.

Leakage semantics

The term "CLI" has recently become such a buzzword that is is frequently heard being used interchangeably or instead of the regular term of "leaks" or "leakage" or "leakage control." They are not exactly the same thing. CLI is a part of leakage control. One hears expressions like "how many miles of plant did you CLI today?" This is like saying, "How many amplifiers did you composite triple beat today?" First, cumulative leak index is not a verb. Second, the term "cumulative" embraces the entire plant or equivalent—not portions. Another typical misuse was observed in a contract that said that a contractor "must meet CLI" before final settlement will be made. Well, supposing he built 10 miles of new plant, he could have 25 leaks per mile of 100 μV/m each and still meet CLI over the 10 miles. (See Table 1, Data Line 2.) What the contract should have said was that "new plant must meet Part 76 before it will be accepted." New plant that does not meet Part 76 is defective and should not be accepted and certainly not put into service.

CLI is just one (albeit valuable) measurement technique in our toolbox and just one of the leakage parameters we must meet starting Jan. 1, 1990, and certainly no later than July 1990. We must, as always, still meet Part 76 in full at ground level. Since leaks tend to come back over time we can think of them as a moving target. With this in mind, the name of the game is leakage control.

Summary of new FCC rules

1) Cable systems must have copies of applicable FCC rules on hand at the system. (Part 17 for towers, if under Federal Aviation Administration regulations; Part 76 for CATV; Part 78 if CARS microwave is in use; and Parts 90 and 94 for private operational fixed microwave service, if used.)
2) All CATV systems carrying signals in aeronautical bands (108-137 MHz and 225-400 MHz) must comply with the new FCC rules by July 1, 1990. The FCC will accept successful CLIs starting Jan. 1, 1990.
3) If signals in the aeronautical bands are greater than +38.75 dBmV anywhere in the cable plant, systems must offset carrier frequencies (after proper filing with the FCC), comply with Part 76 (especially the CLI measurement), conduct routine leakage monitoring by substantially covering the entire plant on a quarterly basis and maintain proper leakage logs.

Will your system meet Part 76 in full between January and July 1990. about one year from now?

RF splitter test and measurement

This is the second installment of a two-part series on the RF splitter for CATV. Part I discussed splitter design considerations.

By Michael Holland
President, Pico Macom Inc.

This part will provide a brief review of basic methods and equipment for testing insertion loss, isolation, return loss (RL) and shielding. In that most engineers are familiar with the basic test methods, we will focus on the not so obvious "tricks" that ensure proper results.

Equipment

The basic test equipment includes a sweep generator with diode detector, a spectrum analyzer with tracking generator, a network analyzer and a return loss bridge used on the sweep generator and the spectrum analyzer. Knowing the limitations of each piece of equipment as well as proper cabling and termination are as important as the equipment itself in achieving proper, repeatable results.

Sweep generator limitations: A sweep generator is the most inexpensive way of testing passives but has the following limitations:

1) The input/output circuitry is poorly matched, which causes return loss errors due to connectors and cable variations.

2) Maximum isolation reading is 35-40 dB. The diode detector can only read down to +20 dB accurately. Therefore, with a signal generator output of 55 dB, a 35 dB isolation is the most that can be read accurately.

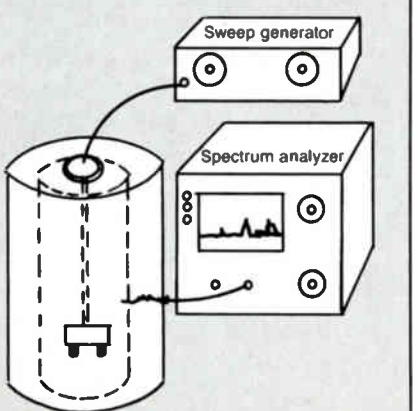
3) As the signal is amplitude-sensitive, the sweep rate limits the performance on narrow-band devices such as traps.

4) Scope reading can only be made by comparison methods in that the diode detectors response is not linear. The sweep generator is used almost exclusively in production of passives where only qualitative maximizing results are needed. Poor results are achieved with actives due to harmonics being included in the average signal detection.

Spectrum analyzer: The only disadvantage in using a spectrum analyzer is its lack of ability to compensate for cables and connectors. Also, insertion losses measurements in tenths of a dB are not usually detectable due to the large dynamic display range. (Return loss measurements require a separate bridge.)

Network analyzer: This is the most expensive and most accurate testing device for passives. It includes the ability to compensate for cables and connectors and can measure return loss directly without additional bridges.

Figure 1: Untuned chamber method for leakage test



Measurement errors

There are a few rules and procedures that should be followed in using any of the mentioned test equipment to provide repeatable results on the same or other equipment. It is customary for engineers in different locations to read 2-5 dB differences in return loss and isolation.

Termination: A splitter "mirrors" the return loss of the load with a degree of inefficiency. Testing a splitter with a 10 cent (25 dB RL) terminator vs. a $50 (50 dB RL) terminator makes a difference. It is not just the resistance of the terminator that makes a difference but the reactance across the entire frequency range. It is possible to reverse the same terminators on different ports of a splitter and have 2-5 dB change in return loss and isolation.

This is due to the reactance of the terminator being more inductive at some frequencies and with the splitter's more capacitive reactance resulting in resonances. Return loss measurements cannot usually be duplicated unless compensated, high RL terminators are used.

Connectors: Many times, adapters such as female-to-female barrels, male-to-male splices or BNC-to-F adapters having a maximum return loss of 20 dB are used with test equipment. This can act as the weak link in the chain when testing. If your return loss bridge has a female F connection and you are measuring a female ported splitter, don't be surprised when another lab using a high RL adapter reads an 8 dB better RL at 600 MHz.

Connector tightening: The seal between the center section of a male connector and female port *must* touch to provide proper RL readings.

"The present methods of testing a passive device for RF leakage are the most...inaccurate of all the test methods performed on splitters."

Usually only wrench tightening will ensure this connection produces repeatable measurements at high frequencies on staked-end port splitters.

No push-on connectors (or right-angle adapters): For precise measurements, a push-on connector is out of the question, Again, perform comparative tests to assure yourself that the use of these adapters at frequencies above 300 MHz dramatically alters return loss and isolation.

Cables: All test cables should have 60 percent minimum braid shielding; a quad type is preferred. Highly shielded flexible cables, using 90 percent braided copper, are available. Moreover, by using standard formulas for maximum allowable bend radius, splitting of the foil and deforming of the cable can be prevented. A rule of thumb: Use a minimum bend radius of approximately five times the cable diameter. Check cable catalogs for manufacturing specs.

A high degree of accuracy can be attained when performing inspections and comparison tests of competitive splitter models if you are aware of the limitations of your test equipment, cables and fixtures. Testing RF devices that operate above 500 MHz can be a virtual art. Use your understanding of the variables to put results into perspective.

Shielding test methods

The present methods of testing a passive device for RF leakage are the most misunderstood and inaccurate of all the test methods performed on splitters. In order to meet Federal Communications Commission RF leakage requirements, cable systems have been increasingly faced with the dilemma of how to set standards for individual passive components that meet overall system leakage levels. The FCC, which will specify only maximum system leakage, does not set standards for individual passive components, even though their connections and location significantly affect the ultimate leakage level. The main problems we face because of this are:

1) How to determine the minimum shielding requirement for a passive device that is *out* of a system, in order to know with certainty that it will not exceed maximum leakage levels when *in* the system.

2) How to measure the individual component in a test fixture in order to determine proper selections and acceptance standards.

At the risk of a system fine or channel shutdown by the FCC, cable systems usually set requirements conservatively, thus making the product cost substantially high. This primary shielding requirement often leads to the overlooking of other quality factors, such as return loss and isolation. Increasing quality while reducing cost can be achieved only by taking the guesswork out of the present methods.

Splitters' shielding requirements presently are selected by guesswork by figuring the typical signal levels in and the conservative level out, which, when hooked to a system, should limit leakage to the required maximum. Unfortunately, the physical size, shape and cables connected to the passive are as much a factor as the device itself. Calculating resonances and reflections, therefore, is only trial and error at best. In reality, the industry standard is set by the latest product available from manufacturers. Three years ago −80 dB shielding was acceptable, two years ago −100 dB was the standard. Now −120 dB is minimally acceptable (specifically with splitters).

Due to the physical non-symmetry of most passives, test procedures, readings and equipment cannot come close to determining an overall leakage value such as −100 dB. They can only measure a subjective, relative difference between two devices in similar cases. In addition, the splitter cases must be in a size range having frequency proportionality to the testing chamber.

By knowing the FCC's maximum allowable field radiation limits, a bench method of testing can be devised that correlates its leakage measurements to the FCC field spec.

The following are some standard EMI (electromagnetic interference) test methods. Organizations like the IEEE (Institute of Electrical and Electronic Engineers) are resources for vast information on the subject of EMI and shielding. In many other industries with similar problems to ours, advanced EMI testing and shielding is commonplace.

1) *Far field testing.* This method entails placing a device in an open field and rotating it until a maximum reading occurs. A directional broadband antenna and a spectrum analyzer are used. Far field testing is primarily used for active devices that self-generate harmonics like those in Part 15 FCC tests.

2) *Near field testing.* This consists of measuring any leakage with an untuned loop antenna from distances of less than ¼ wavelength. This testing can determine specific leaking areas but it does not lend itself to measuring total energy radiation levels accurately. Near field measurements can isolate the electric and magnetic components of the RF leakage.

3) *Shielded room testing.* This method is similar to far field testing. The device being tested is placed in an EMI sealed room that is a size greater than a few wavelengths of the test frequency. In this method it is believed that all leakage will remain in the test room and can be measured with broadband antennas.

The room shielded with anechoic material is primarily used for active devices that generate signals, but it also has been used (with suitable corrections) on passive devices. Problems arise when testing passives primarily due to standing waves or reflections occurring from the shape of the test sample, the room size, the room shape and the reflective constant of the wall lining. However, even experts using state-of-the-art equipment disagree with these findings. They say, "It's an art," not yet a science. The problems of reflections and standing waves usually require shielded rooms to be a minimum of 20 by 30 feet in size to measure a small device correctly.

4) *Untuned chamber method.* The most common leakage test method in the CATV industry uses a sealed cylindrical chamber and a (supposedly) impedance-matched pickup cylinder (Figure 1). →

Figure 2: Typical leakage test results

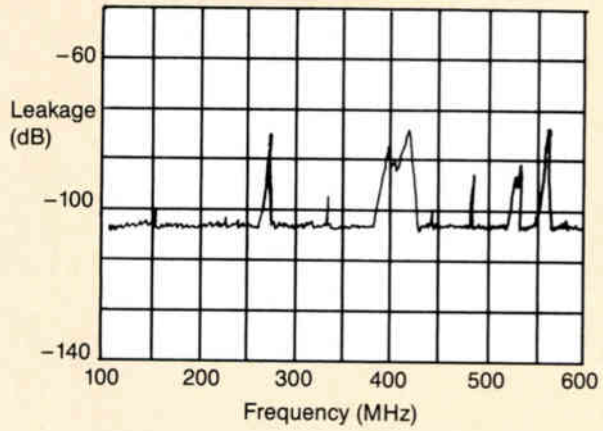
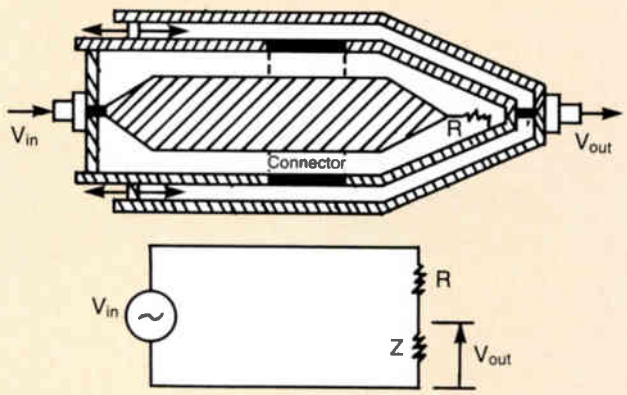


Figure 3: Leakage test by tuned chamber method



This technique assumes that when a signal is injected into a device being tested, all the signal that is radiated from the device is picked up by the chamber's inner cylinder. It is believed that the difference between the signal put into the device and the signal you get out of the chamber is leakage.

This theory appears straightforward until you test it by injecting a signal through an open connector or antenna in the chamber. For the test to be accurate, we would measure the signal level out as being the same as that injected. The results are disappointing.

Suppose you measure −50 dB out of the chamber when you put 50 dB in with only a wire antenna inside, fully radiating. Then you get the same −100 dB with a passive under test. What is the result? Is it −100 dB, the difference, or the change in noise floor? If this method were correct the same amount of signal would be emitted as was originally put in. This is not presently the case, thus invalidating the process. Even though quantitative measurements might not be accurate, comparative measurements between two devices of similar size can be made with a high degree of accuracy.

Chambers are considered acceptable because slight leakage differences between devices of the same size and shape can be detected. Couldn't the apparent differences in leakage level be changes in the test device's resonance that is caused by leakage, rather than the RF leakage itself? The ability to make comparative measurements has led to the belief that we actually are reading pure leakage levels, such as −80, −90 and −120 dB.

For example, the following is a typical CATV measurement setup and typical test results (see Figure 2). Consider:

a) Each chamber emits distinctive signal peaks. Do you measure spike tips or noise floor for RF reference levels?

b) These peaks are inherent in the chamber as a resonance. An open wire signal feed will produce spikes at same frequency points.

c) If the amplitude and the width of the resonant peaks can be varied by testing different passive devices (with the frequency varied only minimally), are you shifting the standing waves in the chamber or actually radiating a measurable signal?

d) If an open wire antenna is placed in the chamber and 50 dB of signal is injected, 50 dB should be measured at the output. If not, can the test be accurate?

e) Placement: Strong RFI in the location can skew findings. Should the whole test fixture be placed in a shielded room?

f) Cable placement: Cable placement and location of the spectrum analyzer and generator are critical when measurements of −120 dB or greater are desired.

g) Direction of sample in chamber: Should it be taken into account when after turning the sample the findings change?

h) Terminators on unused ports: Are they matched? Change them and the leakage readings also will change.

i) Size: How about different size samples? This changes the entire result. How do you explain the results achieved in two-way splitter comparisons? All are sealed differently, resulting in different resonant points. That is why the width and the peaks of the sweep output vary the most. Put some different size holes in devices and notice the non-linear changes.

Right now the chamber method can be effectively used for general comparisons, but not as a quantitative method claiming that a device is −120 dB shielded and another is −117 dB.

5) *Tuned chamber method.* Another method used in this type of EMI product testing is the tuned concentric chamber, which can be used only on symmetrical cylindrical devices such as a cable or connectors (Figure 3).

The concentric chamber relies on perfect impedance matching between the chamber and the shield as it measures the change in impedance of the shield. The shielding, or leakage, is then mathematically computed. There is a whole series of military specification test procedures that use this technique (such as MIL-C-35999H).

In general, this method centers on the belief that a radiated signal is determined by the level of mismatch on the outer case of the connector, cable, etc., to its load. The voltage developed in this slight mismatch has nowhere to go but outward as radiation. Therefore, one is never trying to receive or capture this signal, which is in most cases too minute to measure effectively. This is similar to to measurements using light interferometers in other sciences.

The shielding effectiveness of a device in this test is defined as:

$$S = 20\log \frac{V_{out}}{V_{in}}$$

where:

V_{in} = the injected signal into the test fixture applied across R

V_{out} = the voltage developed across the test sample (in this case a connector) of unknown impedance.

The ideal situation exists with maximum shielding when $V_{out} = 0$.

Specific calibration typically is set to MIL-C-38999H, where the VSWR (voltage standing wave ratio) is better (i.e., less) than 1.5:1. This method uses a directional coupler as a return loss bridge measuring the VSWR from reflected and forward voltages. The chamber matching of 1.5 VSWR is accomplished by tuning slugs that are moved in the chamber for optimization of return loss.

In summary, this method relies upon symmetrical devices in order to determine case matching. Splitters and other passives do not fall into this category, although the technique might aid in solving our problem. One error is to assume the level of accuracy that exists in the tuned method for symmetrical devices can apply to the untuned for non-symmetrical devices.

In Europe an accepted method of leakage testing consists of connecting the passive device to a cable and using a moving directional coupler to measure changes in VSWR along the cable. These changes are then used to calculate leakage with the same method the tuned chamber uses. That is, the change in SWR represents energy that ultimately would radiate. ■

Reference

Burwasser, A.J. "Taking the Magic out of the Magic Tee," *RF Design*, May/June 1983.

This article was presented at a seminar during the Society of Cable Television Engineers' Cable-Tec Expo '88.

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C229870	OUTPUT CONV. 6350 CH-12
C229871	OUTPUT CONV. 6350 CH-13
C229872	OUTPUT CONV. 6350 CH-A
C229873	OUTPUT CONV. 6350 CH-B
C229874	OUTPUT CONV. 6350 CH-C
C229875	OUTPUT CONV. 6350 CH-D
C229876	OUTPUT CONV. 6350 CH-E
C229877	OUTPUT CONV. 6350 CH-F
C229878	OUTPUT CONV. 6350 CH-G
C229882	OUTPUT CONV. 6350 CH-K
C229884	OUTPUT CONV. 6350 CH-M
C229888	OUTPUT CONV. 6350 CH-Q
C229890	OUTPUT CONV. 6350 CH-S
C230250	SPECTRUM INVRT. 6350
C274780	LO REF. LOOP THRU 6350
C342690	AUDIO MOD. 6350
C345153	OUTPUT CONV. 6350 CH-A+
XRPG-3	PILOT CARRIER GENERATOR
122006-02	POWER SUPPLY TRUNK AMP
142000-01	BRIDGER AMP T4XX
142014-02	BRIDGER AMP
300199-01	POWER SUPPLY T4XX
E-417E	LINE EXTENDER
E-417H	HOUSING FOR E-417E
T400H	HOUSING W/PS T4XX
T400HB	HOUSING BER T4XX
T421-002	TRUNK AMP
T470-002	TRUNK AMP
T470-003	TRUNK AMP
T470-030	TRUNK AMP
T470-051	TRUNK AMP
T470-052	TRUNK AMP
T500H	HOUSING W/XF T5XX
T507-030	TRUNK AMP
JLE-300	LINE EXTENDER 300 MHZ NH
JLE-300H	HOUSING FOR JLE 300
JLE-7400-2W	LINE EXTENDER 400 MHZ
JLE-7450-2W	LINE EXTENDER 450 MHZ
JLH	HOUSING FOR J SERIES L.E.
RCG-115N	RETURN CARRIER GENERATOR
SAM	AUTO SLOPE MOD.
SAM-PT	AUTOMATIC MODULE
SAM-PT-300	AUTOMATIC MOD. 300 MHZ NH
SAS-300	AUTO SLOPE AMP 300MEG
SAS-S	AUTO SLOPE AMP
SAS-S-300	AUTO SLOPE AMP 300 MHZ NH
SBM-300	BRIDGER MAN. 300 MHZ NH
SBM-P	BRIDGER MODULE
SBM-S	BRIDGER MODULE
SCD	TRUNK CHASSIE
SCD-2W	CHASSIE FOR TRUNK AMP
SCD-2W-300	TRUNK AMP 300 MHZ NH
SCD-2W-300H	HOUSING FOR SCD-2W-300
SCD-2W-R115	TRUNK CHASSIE W/RFC-115
SCD-2W-T108	TRUNK CHASSIE W/TRA-108M
SCD-2W-T30	TRUNK CHASSIE W/TRA-30M
SCD-2WD	CHASSIE FOR TRUNK AMP
SCD-2WE	BASEPLATE CHASSIS
SCL	TRUNK CHASSIE
SCL-2W	CHASSIE FOR TRUNK AMP
SCL-2WD	TRUNK CHASSIE

Item Number	Description
SDH-P	DISTRIBUTION MOD.
SDHP-300	DIST. AMP 300 MHZ NH
SJAS-400	TRUNK AMP 400 MHZ NH
SJBM-300	BRIDGER MODULE 300 MHZ
SJBM-301	BRIDGER MAN. 300 MHZ NH
SJBM-400	BRIDGER MAN. 400 MHZ NH
SJBM-450	BRIDGER MANUAL 450 MHZ NH
SJDL-301	DIST. AMP 301 MHZ NH
SJDL-400	DIST. AMP 400 MHZ NH
SJDL-405	DIST. MOD.
SJDL-450	DIST. AMP 450 MHZ NH
SJM-400	TRUNK AMP 400 MHZ NH
SJMM-300	MANUAL MODULE 300 MHZ NH
SJMM-301	MANUAL MODULE 301 MEG
SJMM-400	MANUAL MODULE 400 MHZ NH
SJMM-450	MANUAL MOD. P/P 450 MHZ NH
SJSP-60	POWER PACK 60V
SJSW-30	POWER PACK
SJSW-60	POWER PACK 60V
SLE-2P	LINE EXTENDER
SLE-300	LINE EXTENDER
SLE-300-2W	LINE EXTENDER 300 MHZ NH
SLE-300A-2W	LINE EXTENDER 300 MEG
SLE-300H	HOUSING FOR SLE-300
SLH-2	STARLINE L.E. HOUSING
SLR-300-2W	LINE EXTENDER
SMM	MANUAL MOD.
SMM-P	MANUAL MOD. NH
SMM-PT	MANUAL MODULE
SMM-S	MANUAL MODULE
SMMS-300	MANUAL MOD. 300 MHZ NH
SPCM-30	POWER CONTROL MOD 30V
SPCM-60	POWER CONTROL MOD 60V
SPP	POWER PACK
SPP-30	POWER PACK
SPP-60	POWER PACK 60V
SPP-S-30	POWER PACK
SPP-S-60	POWER PACK 60V
SPS-12	POWER SUPPLY 12V
SPS-30	POWER SUPPLY 30V
SPS-30B	POWER SUPPLY 30V
STH-7	STARLINE TRUNK HOUSING
STH-7B	HOUSING BER
TRA-108A	RETURN AMP
5-D440	DISTRIBUTION AMP 440 MHZ
5-T330	TRUNK AMP 330 MHZ
5CC-440	COMPLETE CONTROL 440 MHZ
5LE-440/30	LINE EXT. 440 MHZ 30V
5LE-440/60	LINE EXT. 440 MHZ 60V
MX-504H	HOUSING FOR MX-504
CEPS-3	POWER SUPPLY (CASCADE)
234430	TRUNK I/T FORWARD NH
CTN-1200	POWER SUPPLY
KCMG	MANUAL GAIN BRIDGER
PCAB-1	TRUNK AGC BRIDGER
PCAD-1D	BRIDGER TRUNK AGC NH
PCAD-1H	HOUSING FOR PCAD-1D
PCM-4	TRUNK AMP NH
PCM-4H	HOUSING FOR PCM-4
PCMB-2	TRUNK AMP NH
PCMB-2H	HOUSING FOR PCMB-2
PCRA	RETURN AMP

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Item Number	Description
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PH	HOUSING—P SERIES TRUNKS
T3LE	LINE EXTENDER NH
T4CM	CONTINUITY MOD. NH
TFAV	TRUNK AMP AGC
TFM	TRUNK AMP MGC
TFPS	POWER SUPPLY
TH	HOUSING FOR T SERIES L.E.
XH	HOUSING FOR X SERIES L.E.
XR2A	FORWARD AGC MOD.
XR2B	BRIDGER INTERMEDIATE
XR2B-2	BRIDGER 2 OUTPUT
XR2B-4	BRIDGER 4 OUTPUT
XR2DA	DIST AMP HYBRID AGC
XR2DM	DIST AMP HYBRID MGC
XR2F-1	INPUT MOD.
XR2F-13	INPUT MOD.
XR2F-14	OUTPUT MOD.
XR2F-19	OUTPUT MOD.
XR2F-3/110	INPUT MOD.
XR2F-4	INPUT MOD.
XR2F-5	OUTPUT MOD.
XR2F-7/110	OUTPUT MOD.
XR2F-8	OUTPUT MOD.
XR2HA	LINE AMP HYBRID HRC
XR2HM	LINE AMP HYBRID HRC
XR2LA-PS	POWER SUPPLY
XR2LAF-1	POWER INPUT MOD.
XR2LAF-2	POWER INPUT MOD.
XR2LAF-3	POWER OUTPUT MOD.
XR2LAF-4	POWER OUTPUT MOD.
XR2LARA	REVERSE AMP MOD.
XR2LS-3	LINE EXT.
XR2M	FORWARD MGC MOD.
XR2PS	POWER SUPPLY
XR2RHA110	REVERSE AGC MOD.
XR2SPH	HOUSING FOR XR2SP
XRBI	INTERMEDIATE BRIDGER
XRCE-3	LINE EXT.
XRCE-6	LINE EXT.
XRDC-16	LINE EXT.
XRDC-8	LINE EXT.
XRLA	LINE EXT.
XRLS-2	LINE EXT.
XRLS-3	LINE EXT.
XRPR	POWER SUPPLY
XRRP	LINE EXT.
XRSP	LINE EXT.
N4-S5	TRAP CH. 5
BPF-B	BAND PASS FILTER CH. 8
BADC	B.A. DIRECTIONAL COUPLER
BAEQ-12-1	B.A. EQUALIZER
BAEQ-3-3	B.A. EQUALIZER
BAEQ-8-1	B.A. EQUALIZER
BASP	B.A. SPLITTER
CSA-300-3	EQUALIZER T4XX
DISP-3	DISTRIBUTION SPLITTER 3-3
EQ-450/13	EQUALIZER 450 MHZ 13DB
EQ-450/15	EQUALIZER 450 MHZ 15DB
EQ-450/8	EQUALIZER 450 MHZ 8DB
EQA-1A	EQUALIZER T4XX
EQA-220-2	EQUALIZER T4XX
EQA-220-4	EQUALIZER T4XX
EQA-220-6	EQUALIZER T4XX
EQS-0	EQUALIZER LAN 0DB
EQS-186-4	EQUALIZER LAN 4DB
EQT-450/10	EQUALIZER 450 MHZ 10DB
PB-0	PAD 0DB
PB-1	PAD 1DB
PB-2	PAD 2DB
PB-5	PAD 5DB
PB-6	PAD 6DB
PPLUG	POWER PLUG T4XX
DS-200	SPLITTER 2-WAY 3.5 DB
DS-300	SPLITTER 3-WAY 5.5 DB
DS-3EL	SPLITTER 3-WAY 5.5 DB
DS-400	SPLITTER 4-WAY 6.5 DB
DS-4GB	SPLITTER 4-WAY 6.5 DB
DS-800	SPLITTER 8-WAY 11DB
FFT4-10D	TAP 4W 10DB
FFT4-10F	TAP 4W 10DB
FFT4-14	TAP 4W 14DB
FFT4-14D	TAP 4W 14DB
FFT4-14F	TAP 4W 14DB
FFT4-17	TAP 4W 17DB

Item Number	Description
FFT4-17D	TAP 4W 17DB
FFT4-17F	TAP 4W 17DB
FFT4-20	TAP 4W 20DB
FFT4-20D	TAP 4W 20DB
FFT4-20F	TAP 4W 20DB
FFT4-23	TAP 4W 23DB
FFT4-23D	TAP 4W 23DB
FFT4-23F	TAP 4W 23DB
FFT4-23H	TAP 4W 23DB
FFT4-26	TAP 4W 26DB
FFT4-26D	TAP 4W 26DB
FFT4-29	TAP 4W 29DB
FFT4-29D	TAP 4W 29DB
FFT4-32D	TAP 4W 32DB
FFT4-7T	TAP 4W 7DB
FFT4-7TD	TAP 4W 7DB
FFT8-4D	TAP 8W 4DB
SHS-2	HYBRID SPLITTER
SO-2	FEEDER MAKER
SO-4	FEEDER MAKER 4DB
SPJ-2	POWER COMBINER
SPJ-3C	DIRECTIONAL COUPLER 3DB
SPX-0.5	PAD 0.5DB
SPX-00	PAD 00 DB
SPX-01	PAD 01 DB
SPX-02	PAD 02 DB
SPX-03	PAD 03 DB
SPX-06	PAD 06 DB
SPX-09	PAD 09 DB
SPX-1.5	PAD 1.5 DB
SPX-12	PAD 12 DB
SSP-12	POWER INSERTER
STC-12	DIRECTIONAL COUPLER
STC-12C	DIRECTIONAL COUPLER 12DB
STC-16	DIRECTIONAL COUPLER
STC-3	DIRECTIONAL COUPLER
STC-3B	DATA LINE
STC-3C	DATA LINE
STC-3D	DIRECTIONAL COUPLER 3DB
STC-8	DIRECTIONAL COUPLER
STC-8B	DIRECTIONAL COUPLER 8DB
STC-8C	DIRECTIONAL COUPLER 8DB
STC-8D	DIRECTIONAL COUPLER 8DB
DCW-06DB	MINITAP 06 DB
DCW-09DB	MINITAP 09 DB
DCW-12DB	MINITAP 12 DB
DCW-16DB	MINITAP 16 DB
DCW-20DB	MINITAP 20 DB
2-14BW	TAP
2-17BW	TAP
2-20BW	TAP
2-23BW	TAP
2-26BW	TAP
4-08BW	TAP
4-14BW	TAP
4-26BW	TAP
4-32BW	TAP
8-17BW	TAP
8-20BW	TAP
8-26BW	TAP
8-29BW	TAP
8-32BW	TAP
EQ-04DB	EQUALIZER 450MHZ
EQ-08/250	EQUALIZER
EQ-08/300	EQUALIZER
EQ-08DB	EQUALIZER 450 MHZ
EQ-12/300	EQUALIZER
EQ-15DB	EQUALIZER 450MHZ
EQ-16DB	EQUALIZER 450MHZ
EQ-18DB	EQUALIZER 450MHZ
PCSPL-1	SPLITTER
PCSPL-2	SPLITTER
PCSPL-3	SPLITTER
PD-0	PLUG-IN PAD 0DB
PD-3	PLUG-IN PAD 3DB
PD-6	PLUG-IN PAD 6DB
PD-9	PLUG-IN PAD 9DB
PPLUG	POWER PLUG
T4BDC-8	PLUG-IN PAD
T4BDL-12	PLUG-IN PAD
T4SPL	PLUG-IN PAD
VEQ-08/300	EQUALIZER
VEQ-12/250	EQUALIZER
VEQ-12/300	EQUALIZER
XR2-13	TAP 4WAY 13DB

Observations on a couple of HDTV receiver schemes

By Lawrence W. Lockwood
President, TeleResources
East Coast Correspondent

Of the many that are available, no HDTV (high-definition TV) transmission method or methods have yet been selected as a standard (except perhaps by their proponents). It is now time to begin thinking seriously about what is required by one of the most important (if not the most important) part of the whole HDTV system—the receiver. If a *single* HDTV transmission method were selected for all areas (terrestrial broadcast, cable, VCR, etc.) and its performance parameters (scanning, resolution, etc.) were firmly defined with no anticipation of change or upgrade, then the receiver problem would be a straightforward one—simply design, manufacture and sell the same type to all.

It is unlikely that life will be this kind or simple—maybe, but unlikely. It is more probable that we will require "flexible" receivers. The flexibility would be required to enable the receiver to accommodate the development and expansion of HDTV technology along one of the two (or possibly both) of the possible or likely paths of HDTV evolution.

One developmental path might see different transmission methods accepted (formally or de facto) for different areas; i.e., different ones for terrestrial broadcast and cable, VCR, videodisc, etc. Another path of development could be the evolution or upgrade of the performance parameters of a given system after its acceptance. This second path might very well be applied to any of the methods developed for the first path. Hence, the requirement for receiver flexibility.

Open architecture and ATV multiport

In a past column ("Ruminations on HDTV transmission," May 1988) I have described the concept of the "open architecture" receiver proposed by Professor William Schreiber of Massachusetts Institute of Technology. Schreiber first publicly proposed the open architecture concept in his testimony before the House Telecommunication Subcommittee in October 1987. Regarding a receiver of this type, he said additional "capabilities can be introduced by adopting a bus-structured open architecture. If we think of a modular receiver consisting of a tuner (input section), processing section and display section—the latter including the refresh memory—it is clear that with the right arrangement, the processing section can be made very flexible....The input and display sections are fixed, while the processing section is under control of a small amount of digital data transmitted along with the signal. A more advanced concept would place the detector in the processing section....A programmable receiver of this type would permit improvements in the system to be added at a later date, as we learn more about the video processing problem. It also would allow third parties to design plug-in software or hardware modules to give special capabilities, such as interactivity and easy connection to a wide variety of peripherals. These might include computers, cable, VCRs, etc." (See Figure 1.)

The ATV (advanced television or HDTV) multiport concept is under consideration by the FCC Advisory Committee's Alternative Media and Broadcast Interface Subcommittee, chaired by Edward Horowitz, senior vice president of technology and operations, HBO. This scheme also can provide the required receiver flexibility (Figure 2).

However, in the ATV multiport receiver, the flexibility is provided by a *separate* device from the receiver via the multiport cable. The ATV multiport concept has been presented in more detail than the open architecture scheme, although neither has been demonstrated even in prototype hardware. The multiport cable design can be com-

"Reportedly, TV receiver manufacturers are not enamored of the open architecture scheme but may be more amenable to the ATV multiport approach."

Figure 1: Open architecture receiver

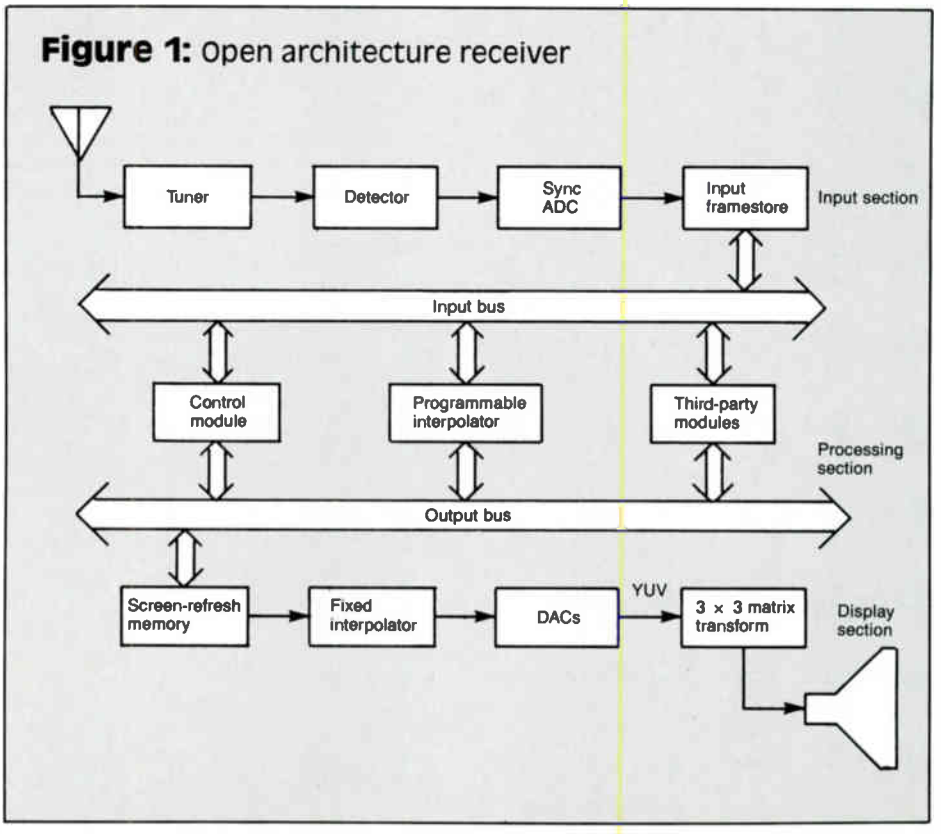
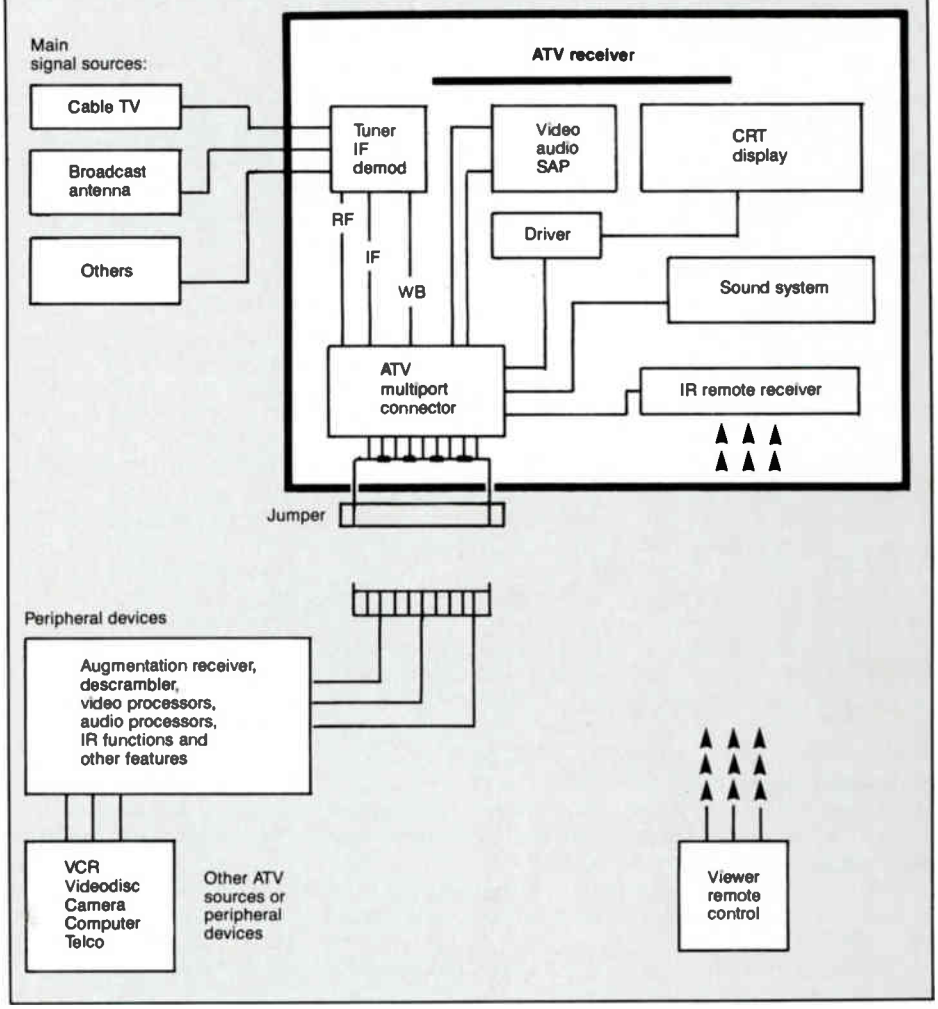


Figure 2: ATV multiport receiver



pared to that of the IS-15; i.e., the plug and cable connect to a separate box that provides the added capabilities to the TV receiver. The multiport cable carries much more information than the IS-15. At its present proposal state its connector has 36 pins carrying 17 signals with such information as:

- undetected signal (if required for the augmentation receiver)
- baseband video
- luminance video
- red video
- green video
- blue video
- sync
- aspect ratio mode
- scan mode
- audio baseband and much more

Anyone desiring a copy of the current proposal on the ATV multiport ("ATV Multiport—A Consumer Interface for NTSC and Advanced Television Systems," Version 1.6, Nov. 11, 1988) may obtain it by writing Virgil Conanan, Home Box Office, 1100 Avenue of the Americas, New York, N.Y. 10036.

Although, as noted, the details of the presentation of the multiport are greater than that of the open architecture, the general capabilities of both systems and the technical functions required to achieve these capabilities are quite similar. This may not be apparent from the block diagrams alone, but careful reading of Schreiber's statements reveal that his *proposals* embody the same capabilities offered by the multiport but are presented in a much more general and broad manner. Of course *wherever* (in the modules of the open architecture receiver or in the separate box connected to the multiport receiver) these capabilities are provided, the same technical functions will have to be performed. Functions such as determining what transmission method is being used and producing the proper scanning (interlaced or progressive), along with the proper aspect ratio—also decompressing the video in the manner required by the transmission method to achieve the maximum resolution and many others. In both systems, all these activities will be directed by a digital signal or "tag" carried in the transmitted signal.

Reportedly, TV receiver manufacturers are not enamored of the open architecture scheme but may be more amenable to the ATV multiport approach. But whatever HDTV receiver system may finally be adopted, the flexibilities provided by it will help promote and speed the wide acceptance of HDTV in the overall market.

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Professional Services

Your vote really counts

By Ron Hranac
President, Society of Cable Television Engineers

Once again it's time for the SCTE's annual elections. At stake are five regional and two at-large director positions on the Society's national board. This is your chance to have a voice in the future of the SCTE.

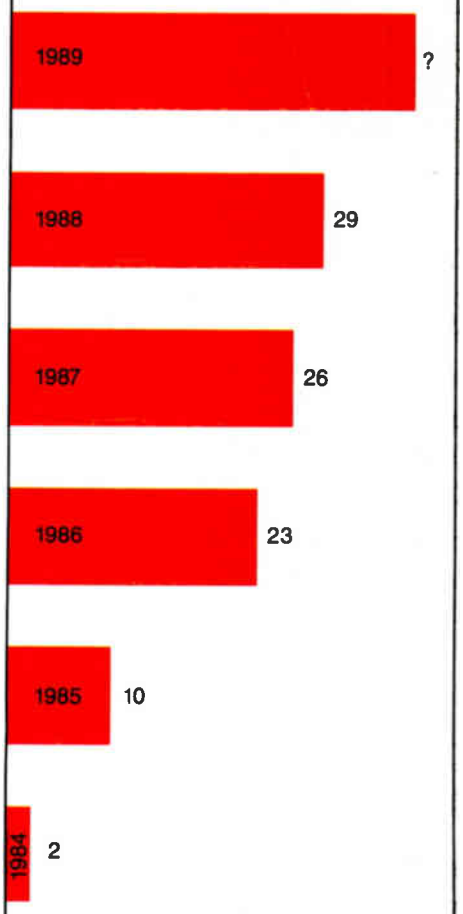
Paralleling the growth of our organization over the past several years is the participation of its membership in the annual elections (see accompanying figure). For example, in 1984 only 2 percent of national members voted in that year's elections. Contrast that with 1988's elections: 29 percent or nearly one-third of the membership voted.

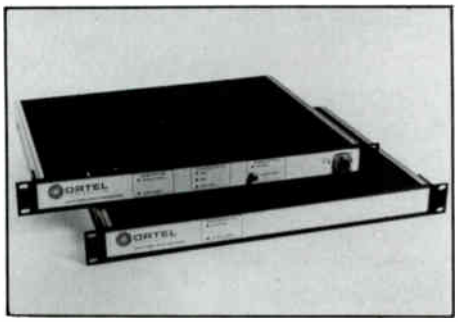
What will that figure be for 1989? Well, that's up to you. This month SCTE headquarters will mail ballots to all national members. You'll have until March to decide who you're voting for, but I urge you to make your choices and return the ballot as soon as you receive it.

Know the candidates

Read through the biography of each candidate carefully, talk to other people in the industry and weigh the abilities and accomplishments that each candidate brings to the SCTE. If you're still not sure, contact some of the candidates directly and ask them about the issues that are important to you. When you've made your decision, vote accordingly and return the ballot before March 15.

Percentage of SCTE membership voting in annual elections





Model 5601A Broadband Link

Fiber-optic links

Ortel's Model 5601A Broadband Link is a VSB/AM format multichannel link that can transmit up to 20 AM video channels through a single optical fiber over distances in excess of 10 km. The system utilizes a Fabry-Perot laser without an isolator and a new PIN photodiode receiver with ultra-low noise and distortion. (For more information on the broadband link, circle #112 on the reader service card.)

The System 6000 TVRO fiber-optic link is used to transmit the LNB output from a satellite earth station antenna to a remote receiver or headend over distances up to 15 miles. It consists of a 6300A fiber-optic laser transmitter and 6400A photodiode receiver and can transmit all 12 channels from a single polarization. (For more data on the TVRO link, circle #111 on the reader service card.)

Also new, the Model 4605A CATV fiber-optic receiver operates near the theoretical limit of noise performance with virtually no distortion, according to Ortel. To achieve an output carrier-to-noise ratio greater than 53 dB with a modulation depth per channel of 5 percent, the receiver only needs an optical power input of −6 dBm. (For more information on the receiver, circle #110 on the reader service card.)

For more details, contact Ortel Corp., 2015 W. Chestnut St., Alhambra, Calif. 91803, (818) 281-3636.

Model ALM673 audio level control

Audio control

FM Systems introduced its ALM673 Audio Level Master "dual mono" audio level control system that uses split spectrum control, program-dependent time constants and independent noise gating. The unit can be converted from two separate monaural channels to one stereo with the flip of a switch. (For more information on the ALM673, circle #139 on the reader service card.)

Also new, the VVM digital video voltmeter is a hand-held battery-operated unit. It measures sync pulse amplitude, white level and overall composite video level in terms of volts peak-to-peak or IRE units on a terminated or loop-through bridging basis. (For more on the voltmeter, circle #136 on the reader service card.)

For further details, contact FM Systems, 3877 S. Main St., Santa Ana, Calif. 92707, (714) 979-3355.

Status monitor

The Model MLM/DSS-MI from Magnavox is a line monitor with modem interface for status monitoring in CATV systems and local area networks. Its monitoring features are similar to the MLM/DSS-60* but it can operate in a one-way system or remote site. It also has application for dual-cable LANs. The MI version is generally used where a return RF cable path is not available, frequency spectrum is too crowded or the two-way system is not directly linked to the central computer by the CATV or LAN medium.

For additional details, contact Magnavox CATV Systems, 100 Fairgrounds Dr., Manlius, N.Y. 13104, (315) 682-9105; or circle #118 on the reader service card.

Model CLM-1000 cable leakage monitor

Leakage products

Wavetek introduced the CLM 1000 Condor leakage field strength meter designed for use in compliance with FCC cumulative leakage index regulations. It can be configured to measure field strength with direct readout in microvolts per meter at any distance from 10 to 100 feet, with any appropriate antenna. (For more on the field strength meter, circle #108 on the reader service card.)

The CLR-4 is a hand-held four-channel scanning leakage detector/locator that emits a tone that varies in pitch in proportion to signal strength. As the detected field strength increases, the pitch locator tone increases. LEDs indicate which carrier frequency is being received. (For more on the CLR-4, circle #107 on the reader service card.)

The CLR-1 Ferret is a pager-sized, belt clipped leakage detector. It also emits a tone and provides a visual indication of relative field strength. (For more on the CLR-1, circle #106 on the reader service card.)

For further details, contact Wavetek RF Products, 5808 Churchman Bypass, Indianapolis, Ind. 46203-6109, (317) 788-9351.

Model DPBB7300 baseband converter

FO products

General Instrument's Jerrold Division introduced an FM fiber-optic supertrunk and a point-to-multipoint AM fiber backbone system. The FM supertrunk is used in headend-to-headend and headend-to-hub linking applications and allows for a 20 dB optical loss budget. The AM backbone uses standard Jerrold line equipment housing to accommodate optical receivers that convert the optical signal to electrical for continuation down coaxial cable. (For more information on the fiber products, circle #114 on the reader service card.)

Jerrold also unveiled two new converters. The DQNV7 digital plain converter features volume control, last channel recall, favorite channel programming and parental control. The Model DPBB7300 baseband model is capable of impulse ordering with an internal Starfone or Starvue module. It has all the features of the DQNV7 as well as stereo pass-through and enhanced security baseband descrambling. (For more on the converters, circle #113 on the reader service card.)

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

Video tuner

New from MultiVision, the MV 2.1 is a digital video tuner compatible with any TV or video monitor. It has picture-in-picture (PIP) capability, full-function wireless remote control, six-bit digital processing of PIP and 139-channel direct access tuner. It also features four sizes of inset picture, four-position inset control, swap inset, full-screen pictures and freeze frame for the inset picture.

For more details, contact MultiVision Products, 3000 Sand Hill Rd., Bldg. 4, Suite 230, Menlo Park, Calif. 94025; or circle #131 on the reader service card.

Addressable system

AM Cable TV Industries' TGT System is an addressable system control that employs a

jamming technique to totally disallow unauthorized video and audio signals entering a subscriber's home. No unauthorized reconstruction, decoding or descrambling of the signal is possible once it has been jammed. A keystroke command from the business office will lift the jamming and pass a clear signal.

The system does not depend on the converter to control signal passing, so standard plain converters may be used (or no converters for subscribers with cable-compatible TVs and VCRs). This lowers system equipment costs, according to the company.

For additional information, contact AM Communications, AM Drive & Route 663, P.O. Box 505, Quakertown, Pa. 18951, (215) 536-1354; or circle #134 on the reader service card.

SuperSwitch A/B device

HDTV system

Zenith Electronics recently unveiled its "Spectrum Compatible" encoding and transmission system that takes 30 MHz of complex video and audio data necessary for high-definition television and squeezes them into a 6 MHz signal that can co-exist with today's TV channel allocations. (For more on the HDTV system, circle #119 on the reader service card.)

The company also presented its PCC II remote control that operates 100 different devices (39 TV brands, 45 VCR brands and 16 cable converters) and has built-in remote control codes. (For more on the remote, circle #121 on the reader service card.)

Zenith's SuperSwitch is an A/B device that allows subscribers with cable-compatible TV to use a remote without flipping a manual A/B switch. (For more data on the SuperSwitch, circle #120 on the reader service card.)

For further details, contact Zenith Electronics, 1000 Milwaukee Ave., Glenview, Ill. 60025, (312) 391-8181.

Location service

Cable Exchange is making its CATV equipment data base available to the industry. The network, which typically lists more than 50,000 items, will be an on-line service where users may access the system via any personal computer through a dialup service that will be toll-free in many metropolitan areas in the United States and Canada. The service also will be a source for manufacturers' technical service bulletins, news releases, software support services, the UNiWAND fulfillment program and an electronic bulletin board.

For additional information, contact Cable Exchange, 5730 E. Otero Ave., Englewood, Colo. 80112, (303) 694-6789; or circle #105 on the reader service card.

Cable connectors

Armex unveiled its CATVFIVE and Commander pin-type connectors with a patented field focusing insulator that is said to assure 42 dB minimum structural return loss from 0 to 500 MHz. Both connectors feature minimal RF leakage from −50 to 170°F, minimal insertion loss, no cold flow of plastic materials, self-aligning center conductor and gripper assembly and rounded corners and edges. The Commander incorporates most of the features of the CATVFIVE and is designed for use where installation and working space is limited.

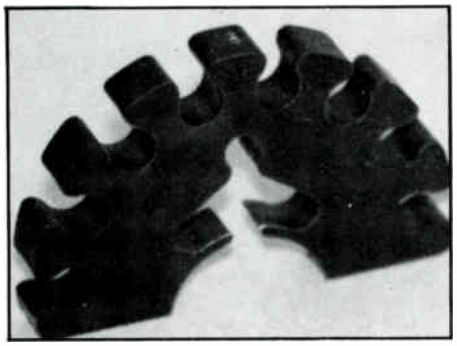
For more information, contact Armex Cable Corp., 2700 E. Nine Mile Rd., Warren, Mich. 48091, (313) 755-2030; or circle #115 on the reader service card.

Remote controls

Now available from ABC Cable Products is its V2 line of compatible CATV wireless remote controls for converters made by Jerrold, TOCOM, Oak, Sylvania, Texscan, Regency, Eastern, Pioneer, Panasonic, RCA, Scientific-Atlanta, Hamlin, Zenith, Kanematsu-Gosho and others. New features include four memories, parental control and up/down channel scan that

work even for converters that do not offer these features.

For more information, contact ABC Cable Products, 5730 E. Otero Ave., Suite 700, Englewood, Colo. 80112, (303) 694-6789; or circle #109 on the reader service card.



Drop saddle

Telecrafter Products introduced its Owsley drop saddle that replaces up to eight ty-wraps to improve the visual appearance and serviceability of drop cables exiting taps. The product is designed to keep drops organized for accuracy in audit control and to reduce time spent in service calls. It accepts RG-6, RG-59 and RG-59 quad cable and allows for expansion and contraction of cable without pinching or binding.

For more details, contact Telecrafter Products, 12687 W. Cedar Dr., Suite 100, Lakewood, Colo. 80228, (303) 986-7700; or circle #104 on the reader service card.

Control software

According to Oak, its Oasis addressable control software package is designed to allow small- and mid-sized systems to use the Sigma addressable system economically. Because it runs on a single IBM PC-AT personal computer, it does not require entry of data, computer maintenance contracts, computer room environment, special wiring or interfaces. In addition, its normal operating mode is fully automatic.

For additional details, contact Oak Communications, 16516 Via Esprillo, Rancho Bernardo, Calif. 92127, (619) 451-1500; or circle #116 on the reader service card.

Anticopy system

Macrovision's new anticopy system is designed exclusively for protecting pay-per-view programs from unauthorized copying by affecting the AGC circuitry and color recording mechanism of the VCR. This system is effective on all formats (VHS, S-VHS, Beta, ED-Beta, U-Matic, 8 mm, ¾ inch and 1 inch) and works for live as well as prerecorded programs.

Although the process severely distorts unauthorized copies, it is transparent to the subscriber. According to the company, it is easily installed and operated at the headend, available for NTSC and PAL systems and compatible with major scrambling systems.

For more information, contact Macrovision, 10201 Torre Ave., Suite 330, Cupertino, Calif. 95014, (408) 252-9600; or circle #117 on the reader service card.

Fault locator

Riser-Bond introduced the Model 1210 time domain reflectometer cable fault locator for testing coaxial, twisted pair or any metallic paired cable. The instrument has adjustable velocity of propagation and output impedance settings. Digitized waveform, auto-distance calculation and fault severity are all displayed simultaneously. Opens, shorts, impedance discontinuities, faulty connectors, water problems and system components can all be tested with this unit.

For further details, contact Riser-Bond Instruments, 505 16th St., P.O. Box 188, Aurora, Neb. 68818, (402) 694-5201; or circle #122 on the reader service card.

Cable conduit

According to Wesflex, its Flex-Con high-density polyethylene conduit is designed to simplify direct burial and maintenance of long length runs of distribution and drop cable. It can be supplied with its component CATV cables pre-installed or empty with footage-marked mule tape or pull cords and is delivered on reels.

It has a brittle point of −148°F (−100° C) and gives when subjected to frost heave shear forces. It also is resistant to impact and abrasion, water, acids, alkalis, salts, detergents and other chemicals likely to be found in the soil.

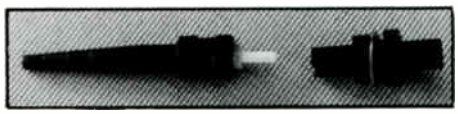
For more information, contact Wesflex, 1880 Garden Tract Rd., Richmond, Calif. 94801, (415) 233-6670; or circle #129 on the reader service card.

Test set

Biddle's three phase TTR transformer turn ratio test set is designed to speed up turn ratio tests for all types of transformer windings. It can measure turn ratios from 0.8 to 2,700, covering current and potential transformers with typical ranges from 5/1 to 2,700/1.

Ratios are digitally displayed and stored in the instrument's microprocessor-based memory, which also conducts a self-test of its calibration and circuitry. The unit also provides application-related switch settings for all transformer connection combinations and error messages to identify incorrect test connections or windings problems.

For additional details, contact Biddle Instruments, 510 Township Line Rd., Blue Bell, Pa. 19422, (215) 646-9200; or circle #140 on the reader service card.



FO connector

According to Amphenol Fiber-Optic Products, its single-mode 953 Series ST-compatible connector is constructed of a glass reinforced polymeric body and captivated ceramic ferrule, providing superior environmental stability and long-term mechanical and optical performance.

Insertion loss is 0.35 dB typical and operating temperature is −20° to +70°C. The ferrule/ceramic adapter system maintains repeated mates/demates with less than 0.1 dB loss deviation. Mechanical durability has been tested over 20,000 mate/demate cycles with no degradation of the optical fiber.

For more details, contact Amphenol Fiber-Optic Products, 1938C University Lane, Lisle, Ill. 60532, (312) 960-1010; or circle #138 on the reader service card.

DC-AC inverter

Atlantic Solar products introduced the Pocket Power Inverter, a 12 VDC to 115 VAC power supply. The unit measures 1.2 × 3.5 × 4.5 inches, weighs 14 ounces and can fit into tool boxes, glove compartments and briefcases. It plugs into a vehicle's cigarette lighter to operate electronic test equipment or recharge battery powered devices.

The product features automatic shutdown in the event of overloading and excessive discharging of the battery and audible low battery voltage alarm. The input operating range is from 10 to 15 VDC with a voltage out of 115 ampere, 200 watt surge capability.

For more information, contact Atlantic Solar Products, 9351-J Philadelphia Rd., P.O. Box 70060, Baltimore, Md. 21237, (301) 686-2500; or circle #141 on the reader service card.

Spectrum analyzer

Advantest's R3261/3361 synthesized spectrum analyzers cover the frequency ranges of 9 kHz to 2.4 GHz (R3261A/3361A) and 9 kHz to 3.6 GHz (R3261B/3361B). The overall accuracy level of 1 dB is complemented by a displayed dynamic range of 120 dB that allows measurements to 110 dB.

The analyzers also feature stop, start and center frequency resolution to 1 Hz and a built-in frequency counter with 1 Hz resolution. Quasi-peak value measurements of 70 dB can be made without switching the attenuator. Occupied bandwidth and adjacent-channel leakage power are available as options.

For further information, contact Advantest America, 300 Knightsbridge Pkwy., Lincolnshire, Ill. 60069, (312) 634-2552; or circle #126 on the reader service card.

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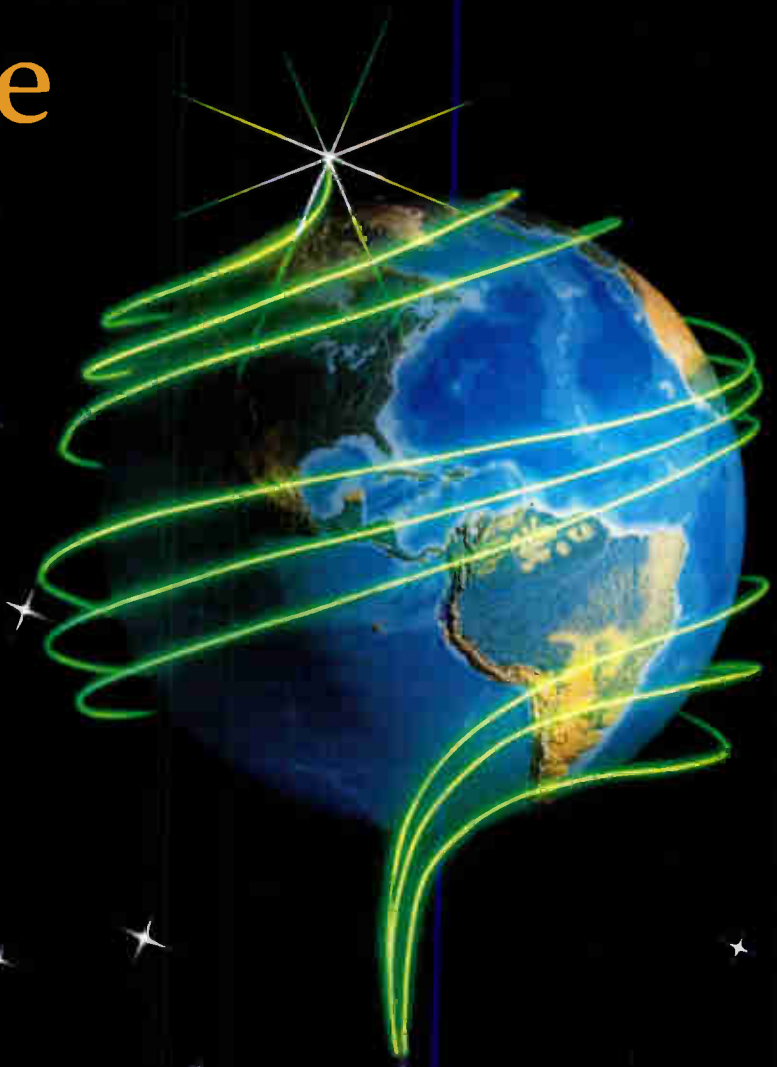

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CT PUBLICATIONS CORP. FOCUS

January 1989

Coming back from a quite successful Western Show, we can't help but be excited about the possibilities and challenges that lie ahead of us in '89. The strength to face these opportunities can be found in our people. And, since last month, some new faces were brought on board. Please meet them below and be reintroduced to a few others. We're working for you, stronger than ever!

Paul R. Levine
President/Publisher

We're Working for You!

(Front row, seated) Brad Hamilton, Danielle Kelley, Shelley Bolin, Lu Ann Curtis; (middle row) Sharon Lasley, Marla Sullivan, Marty Laven, Marie Beert, Mary Sharkey, Patti Wilbourn; (rear) Wayne Lasley, Toni Barnett, Paul Levine, Kenny Edwards, Kathleen Jackson, Rikki Lee, Geneva Hobza, Neil Anderson.

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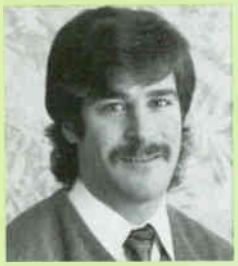

Chuck Grossman
Editorial Assistant

Jim Watts
Asst. Production Coordinator

Looking Back, Looking Ahead

Since 1984—when we started the company and launched **Communications Technology**—we've been working for you. Over the years, we've added new projects, new publications, new people. And our products have always kept pace with the industry, changing and growing with it.

Our past growth is only a foreshadowing of the future. So, after five years, where do we go from here? We will continue to listen and respond to your input as well as improve planning to better serve our readers and advertisers. Some examples: A marketing director with extensive system operations experience has just joined our staff. Also, we plan to add to the marketing mix with special events, direct mail, telemarketing and merchandising. Plus, a new editor for **Cable Strategies**, who is a cable system veteran, has also come aboard. And we plan exciting new things for all three publications, including circulation audits for **Installer/Technician** and **CS** and expanding the scope of **CT**. In the near future, we plan to hire additional staff and to move our headquarters to a bigger, better workspace.

We've been successful five years, but we're not sitting on our laurels. The best years are yet to come as we continue to dedicate ourselves to the cable TV industry.

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MA-12X troubleshooting procedure

By Ron Hranac
Jones Intercable Inc.

The data contained herein appears courtesy M/A-COM MAC Inc.

This procedure assumes that the antennas are aligned correctly, polarization has been set and line-of-sight exists between the end sites. *Apparatus:* digital multimeter, frequency counter (12 GHz or 200 MHz), scope (10 MHz), spectrum analyzer, field strength meter, slotted screwdriver, external power supply (±12 V), test adapter (See Figure 1), high impedance probe, video source, video monitor, attenuator set (20-60 dB) WR-75 and WR-75 to Type "N" adapter. *Procedure:*
Step 1) Look up the indicated alarm or failure mode (A).
Step 2) When alarm or failure is located, move to B for possible fault cause.
Step 3) Select a cause and move to *C* and locate evaluation parameter.
Step 4) If evaluation parameter is incorrect, move to D for corrective action.
Step 5) If evaluation parameter is correct, move to E for next step or cause.

A: Failure mode/alarm—TX power LED not illuminated.

B	C	D	E
POSSIBLE CAUSE	EVALUATION	CORRECTIVE ACTION	NEXT STEP
a No ac input	a Confirm ac feed	a. Apply ac feed	a See defective LED.
b Defective LED	b Measure + 18V to lamp	b. Check line fuse If incorrect, replace	b See defective power supply
c. Defective power supply	1) Confirm ac input and dc output of power supply	1) Check secondary, with CR1 disconnected, for short or open circuit	1) See defective regulator.
	2) Check diode junctions for short or open	2) Replace CR1	2) See defective regulator
	3) Check E1 to ground if shorted	3) Replace C1	3) See defective regulator
	4) Check E2 to ground if sorted	4) Replace C2	4) See defective regulator
d Defective regulator	1) Check all interconnect wires and harness	1) Repair	1) Check + 18V (E2)
	2) Measure + 18V on E2 of regulator	2) Replace U2	2) Check E1 (12V)
	3) Measure E1 (12V input) with A4P1 disconnected	3) See defective power supply	3) Defective Q1
	4) Measure junctions of Q1 (power off) for short	4) Replace Q1	4) Defective CR1, CR2, or CR3
	5) Check CR1, CR2, and CR3 for shorts	5) Replace defective item	5) Defective U3
	6) Check E4 (5V)	6) Replace U3	6) Check all interconnections and wiring If correct, replace LED

A: Failure mode/alarm—TX fault LED illuminated.

a No video input	a Confirm video input	a Apply video	a Confirm video at J3 and P3 to Digital AFC
b Defective jumper J3 to P3	b Measure video level at P3	b Replace jumper if video presence at J3	b See defective Video Presence Detector
c Defective Video Presence Detector	c Check signal at R51 and R52	c Check Q8 and Q9	c Incorrect TX deviation
d Incorrect TX deviation	d Check deviation	d Attach TX output to a spectrum analyzer Replace the video input lead with a 2 33 MHz test tone at 1 V P-P Display should show a spectrum nulled at the middle Adjust R2 (front panel) for first bezel zero	d See defective fault circuit
e Defective fault circuit	e Check U9 and Q14	e Replace defective item	e Replace defective Digital AFC module

A: Failure mode/alarm—RX power LED not illuminated.

a No ac input	a Confirm ac feed	a Apply ac feed	a See defective LED
b. Defective LED	b Measure + 18V to lamp.	b Check line fuse If incorrect, replace	b See defective power supply
c. Defective power supply	1) Confirm ac input and dc output of power supply	1) Check secondary, with CR1 disconnected, for short or open circuit	1) See defective regulator
d Defective regulator	d Measure + 18V on E2 of Limiter.	d Replace regulator.	d. Check harness and wiring If correct, replace LED

A: Failure mode/alarm—RX squelch LED illuminated.

B	C	D	E
POSSIBLE CAUSE	EVALUATION	CORRECTIVE ACTION	NEXT STEP
a Confirm TX power output See no TX output power fault procedure *			
b Confirm TX power LED See no TX LED fault procedure *			
c Confirm TX frequency See TX Gunn alignment procedure *			
d Confirm RF input to RX *			
e Confirm squelch card is properly grounded *			
f Misaligned RX squelch adjustment	f Confirm squelch setting (37 dB signal-to-noise) (79 dBm input)	f Adjust squelch adjustment located on the front face of the RX Turning the adjustment clockwise (cw) increases the squelch setting	f See incorrect RX IF frequency
g RX IF frequency incorrect	g Measure AFC volts, TP2 (7 8 to 11 5V) Factory pre-set 8 5 to 9V for 43 75 MHz	g See RX Gunn alignment procedure and RX off frequency fault	g See defective RX Gunn/ Mixer assembly
h Defective RX Gunn Mixer	h Measure Mixer output (12 dB less than RCL) at input to IF Amp for 43 75 MHz	h Replace Gunn assembly	h See defective IF Amp
i Defective IF Amp	i Confirm 0 dBm output at J1	i Adjust R19 for 0 dBm output at J1	i See defective Limiter/ Descriminator
j Defective Limiter Descriminator	j Check Q12 and Q13 video circuit	j Replace defective item	j Check harness

A: Failure mode/alarm—No TX output power.

a Confirm TX power LED is illuminated *			
b Defective harness	b Confirm + 18V on AFC Reference J1, Pins 3 and 4	b Check interconnect harness	b See defective Gunn Regulator
c Defective Gunn Regulator	1) Confirm power supply output to Gunn Regulator (Pins 5 and 6) If good, Confirm + 18V on Pin 7	1) Replace Gunn Regulator	1) Measure Gunn voltage
	2) Confirm Gunn Regulator output (Pin 3, 7 to 9V)	2) Remove wire from Pin 3 and remeasure If incorrect, replace regulator	2) See defective TX Gunn
d Defective TX Gunn	d Measure AFC voltage on AFC module Pin E3 (6.0 to 9.0V)	d See TX off frequency fault procedure	d See TX off frequency fault procedure

A: Failure mode/alarm—TX off frequency.

a See no TX LED fault procedure *			
b Defective Gunn Mixer	b Remove lead at E3 (AFC) and attach an external + 7 5V source to the lead and attach the output of the TX Mixer to a spectrum. The output should be – 30 dBm at 50 MHz sidebands 25 dB below IF signal.	b See TX Gunn alignment procedure If incorrect, replace Gunn assembly	b See defective Oscillator/ X2 Multiplier
c. Defective Oscillator/X2 Multiplier	c Confirm XTAL frequency at E1 of Oscillator/X2 Multiplier	c Replace XTAL	c. Check interconnect connectors and harness
d Defective Digital AFC.	d Check for intermittent leads and connectors	d Repair or replace.	d Replace Digital AFC.

*Indicates see noted procedure first.

A: Failure mode/alarm—RX off frequency.

B	C	D	E
POSSIBLE CAUSE	**EVALUATION**	**CORRECTIVE ACTION**	**NEXT STEP**
a Confirm TX frequency If incorrect, see TX alignment procedure *			
b Confirm TX power If incorrect, see no TX output power fault procedure *			
c See RX frequency alignment procedure *			
d Defective Gunn Mixer	b Remove lead at E1 (Limiter Discriminator) and attach an external +8 5V source to the lead and attach the output of the RX Mixer to a spectrum The output should be 15 dBm at 43 75 MHz	b See RX Gunn alignment procedure Check interconnect harness If good, replace Gunn/Mixer	b See defective IF Amp
e Defective IF Amp	e Measure output of IF Amp (J1, 0 dBm, 43 75 MHz) See test adapter Figures 1 and 3	e Adjust R19 for 0 dBm If incorrect, replace IF Amp	e See defective Limiter Discriminator
f Defective Limiter Discriminator	f Remove external voltage and reattach lead to E1 (Limiter Discriminator) Adjust R33 on Limiter for 8 5 to 9V (E1) Check IF frequency (43 75 MHz) using test adapter, Figures 1 and 3	f Replace Limiter Discrim-	f Reconfirm procedure

A: Failure mode/alarm—Low or no video output.

a Confirm TX AFC voltage If incorrect see TX off frequency procedure (6-9V) *			
b Confirm RX AFC voltage If incorrect, see RX off frequency procedure (7 8 to 11 5V) *			
c Confirm TX video input (140 IRE 1V P-P) *			
d Check all interconnect cables and connectors *			
e Incorrect TX deviation	e Confirm TX deviation	e Attach output of 12X TX to a spectrum analyzer Apply a 2 33 MHz test tone (1V P-P) to the TX video input connector Adjust TX gain adjustment R52 for first bezel zero	e See defective Digital AFC
f Defective Digital AFC	f Measure video level at J1 (2 to 3V)	f Check Q8, Q9, Q10, Q11, Q12, Q13 and C33	f See defective RX Limiter Discriminator
g Defective Limiter Discriminator	g Confirm gain, Q5 and Q6	g Replace or repair	g See defective Video Amp
h Defective Video Amp	h Confirm gain (Q7, Q8, Q9 and Q10)	h Replace or repair	h See misadjusted RX video gain adjustment
i Misadjusted RX video gain adjustment	i measure RX video output level	i Confirm TX video input level and deviation If correct, adjust the RX video output adjustment located on the front panel for 1V P-P output	i Recheck all interconnect cables and wiring

A: Failure mode/alarm—Poor video response.

a Confirm TX AFC voltage If incorrect, see TX off frequency procedure (6-9V) *			
b Confirm RX AFC voltage If incorrect, see RX off frequency procedure (7 8 to 11 5V) *			
c Confirm TX video input (140 IRE/1V P-P) *			
d Confirm TX deviation, see test set-up procedure *			
e Check all interconnect cables and connectors *			

*Indicates see noted procedure first

B	C	D	E
POSSIBLE CAUSE	**EVALUATION**	**CORRECTIVE ACTION**	**NEXT STEP**
f Misaligned Limiter Discriminator	f Adjust C28, high frequency response	f Check/replace C33 on Digital AFC	f See IF Filter misaligned
g Misaligned IF Amp	g Realign IF filter or return to factory		

A: Failure mode/alarm—Horizontal lines on video.

a Confirm TX AFC voltage If incorrect, see TX off frequency procedure (6 to 9V) *			
b Confirm RX AFC voltage If incorrect, see RX off frequency procedure (7.8 to 11 5V) *			
c IF Amp	c Measure output level of IF Amp, J1, 0 dBm This level must be measured with a high impedance probe into a spectrum analyzer Do not disconnect output cable	c Adjust R19 for correct level	c See defective Gunn
d Defective Gunn	d Check condition of the TX and RX Gunn tuning slugs If loose, replace Gunn	d Confirm TX video input	d Check for external interference

A: Failure mode/alarm—Hum bars on video.

a Confirm video source *			
b Confirm proper grounding of all equipment and cables *			
c Check ac source regulation and ripple *			
d Defective TX power supply	d Measure voltages on E2, E3, and E4 of TX Regulator, with a scope DC line should be clean	d Check for defective component	d See defective TX power supply transformer
e Defective TX power supply transformer	e Install a hum shield underneath the Digital AFC card	e Return to factory for upgrade	e See defective RX power supply transformer
f Defective RX power supply	f Measure voltage on RX Gunn Regulator and Power with a scope DC line should be clean	f Check for defective component	

*Indicates see noted procedure first

Frequency alignment

Transmitter

See Figure 1 (test adapter), Figure 2 (TX setup) and Figure 3 (RX setup).

Step 1) Attach a 20 dB attenuator to the TX output port.

Step 2) Attach a WR-75 to "N" adapter to attenuator.

Step 3) Attach item 2 to the frequency counter.

Step 4) Remove the lead from E3 (digital AFC) and apply an external +7.5 V to the lead. Allow 30 minutes for TX to warm up.

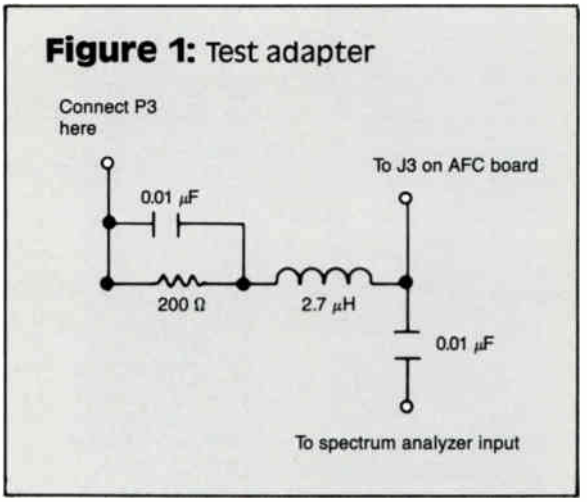
Step 5) Adjust the TX Gunn for desired frequency by adjusting the TX Gunn tuning slug.

Step 6) Remove P3 from J3 (digital AFC). Install the adapter (Figure 1) between P3 and J3. Then, attach to a spectrum analyzer. Set spectrum for 50 MHz. Adjust the tuning screw and peaking capacitor on the X60 multiplier to a level of greater than −30 dBm. Adjust L1, L2, C11 and C13 on the reference oscillator/X2 multiplier to reduce the spurious signals to a minimum. During this process, maintain a 50 MHz signal per Step 5.

Step 7) Disconnect adapter and reattach P3 to J3.

Step 8) Disconnect external source and reattach lead to E3.

Figure 1: Test adapter



Step 9) Confirm TX frequency. AFC voltage should be +6.0 to 9.0 V. Adjust the TX Gunn slug carefully to center AFC voltage (7.5 to 8 V). If not, continue troubleshooting procedure.

Receiver

See Figure 1 (test adapter), Figure 2 (TX setup) and Figure 3 (RX setup). Confirm TX frequency prior to this process.

Step 1) Attach the TX unit to the RF unit with a 60 dB attenuator or, if over an antenna system, remove the RX from the rack and attach a section of flexguide between the RX and waveguide port. If to be bench tested without the proper attenuation, place the TX and RX units on the bench offset by 90°.

Step 2) Turn off all other TXs if to be tested within the equipment rack.

Step 3) Remove the lead from E1 (limiter/discriminator) and apply an external +9 V to the lead.

Step 4) Monitor the output of the IF Amp (J1) with a high impedance probe connected to a spectrum analyzer or counter. Adjust LO tuning screw to obtain 43.75 MHz.

Step 5) Disconnect the external power source and reattach the lead to E1.

Step 6) Adjust R33 (AFC) on the limiter/discriminator for 43.75 MHz. RX AFC voltage should be 8.5 to 9.8 V and is to be adjusted only if IF frequency is 43.75 MHz.

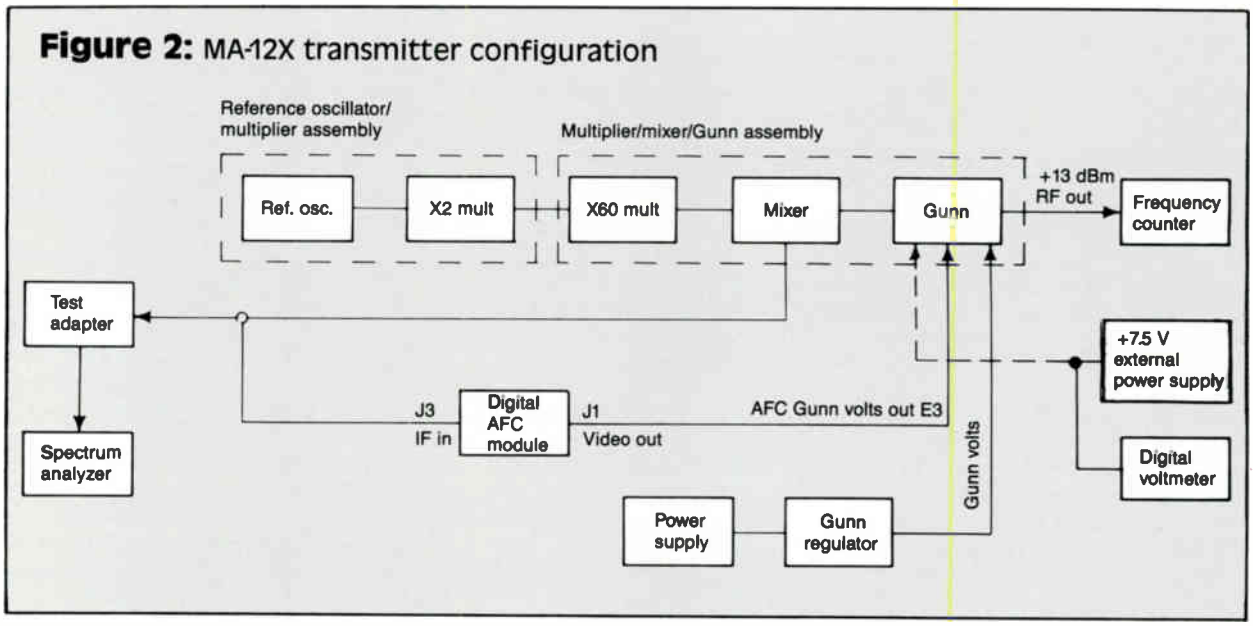


Figure 2: MA-12X transmitter configuration

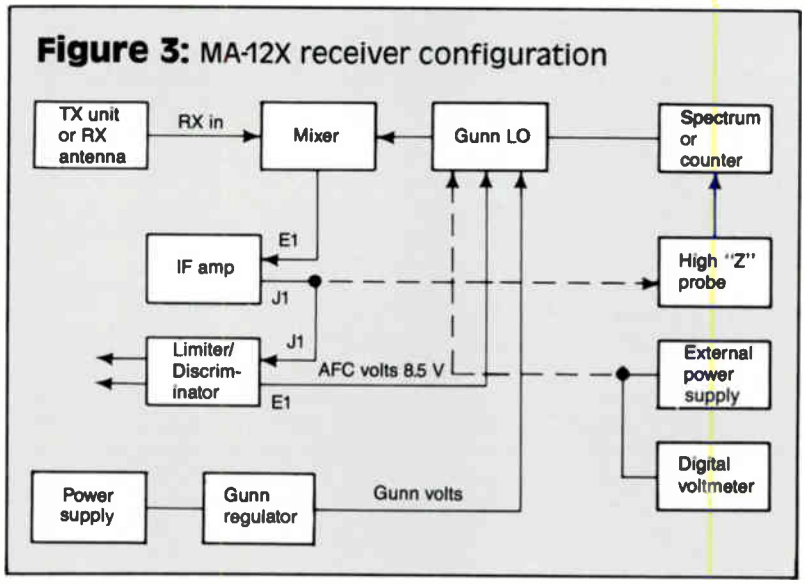


Figure 3: MA-12X receiver configuration

1988 retrospective, 1989 prospective

By Walter S. Ciciora, Ph.D.
Vice President of Technology
American Television and Communications Corp.

It is prudent at this point to review the technology events of the last year and to speculate on what the new year may hold. We do this in part as an intellectual exercise but in part to reap some of the psychic rewards of a lot of work well done. There is also an element of examination of conscience. In those areas where we might have done better, a little review may help as we formulate our new year's resolutions. This process will hopefully contribute to a 1989 that has even more accomplishment than 1988.

Cable Labs

By far the most important event of 1988 and the event that holds the most promise for 1989 and beyond is the formation of Cable Labs. It has both strategic as well as immediate impact. Many of the activities that have been carried on with volunteers on a part-time basis will now have the benefit of full-time staffing. Over 75 percent of the cable industry is represented as dues-paying members. Significantly, the dues commitment is for a minimum of three years with a requirement of a three-year notice of intention to withdraw. Approximately $8 million per year is raised by the dues payments. While this is a significant amount of money, it must be prudently spent because the needs exceed the supply.

The governing structure of Cable Labs includes a Board of Directors and a Technical Advisory Committee (TAC). The board is made up of chief executive officers of the sponsoring MSOs. TAC includes vice presidents of engineering from the sponsors; TAC membership is approved by the board. All founding members are entitled to have membership in TAC. The full TAC will meet twice a year to establish direction and review results. A Steering Committee will meet every other month to carefully provide guidance to projects. Actual work will take place in subcommittees focused on specific projects. Those interested in being where the action is should join and actively participate in subcommittees. The board makes policy and oversees the entire Cable Labs operation. TAC advises, reviews, plans and proposes the projects undertaken. Cable Labs will have a permanent staff to execute the projects. In many cases, the project execution will consist of selecting and supervising a recognized and respected laboratory or consulting firm to do the actual detailed work.

Cable Labs has three projects already underway: 1) a fiber-optics investigation, 2) advanced television (ATV) systems and 3) consumer electronics interface. These projects were started by the interim TAC and board as a way of building momentum before the full Cable Labs structure was in place. The interim activities were all undertaken in a manner that could be reversed if it were later determined that the full TAC and board disagreed.

The fiber-optics study is being carried out under contract by the consulting firm of Arthur D. Little. It proposes to review the activities and technologies of cable fiber as well as the practice of other industries. The goal is to define the options.

The ATV work centers on the issue of testing. The Federal Communications Commission's decision-making process requires proposed systems to be tested. The cable testing will be done by Cable Labs. However, Cable Labs has not committed to a blank check; it will test those systems that it determines to be of potential interest to the cable TV industry. Further, while the testing will be guided by the results of the committees assembling test plans, the actual tests conducted will be those that serve the needs of the cable industry in determining what course of action it should take.

Advanced television systems

1988 saw hundreds of meetings on advanced television systems. Most of them took place under the auspices of the FCC's ATV Advisory Committee and its many subcommittees and working groups. The Advanced Television Systems Committee (ATSC) and several trade organizations such as the National Cable Television Association and the National Association of Broadcasters added to the list.

The most important event of 1988 from a cable perspective was the FCC's Tentative Decision and Further Notice of Inquiry on ATV. The big fear has been that there will be an artificial ceiling imposed on the level of video quality cable can provide. This ceiling would be imposed under the guise of a single universal standard intended to provide a "level playing field" for broadcasters and cable.

This kind of thinking fails to take into account the reality that the competitive technologies are really prerecorded media and digital delivery via fiber by telcos. Cable must be free to compete with the best possible video that makes economic sense. While the good news is that the FCC seems to have recognized this, the bad news is that the decision is merely tentative and that strong political pressures still exist for a universal standard. As I wrote last month, I believe that the concept of a universal standard is a myth. Imposing a limiting standard on cable will only hobble its efforts to be competitive with new technology.

Cable's embarrassment in all this is the lack of participation in the committees and working parties. This is not primarily a fault of the cable technical community. We all know that cable technologists are active participants in obviously important industry affairs even to the usual detriment of personal affairs. There are two factors here that are the problem. Shorter-term topics tend to be viewed as more important than longer-term issues such as ATV. Secondly, there are too few cable technologists to do the job. The ongoing round of consolidation contributes to reducing our numbers. Somehow, in 1989, we must find a way to get more participation.

"By far the most important event of 1988 ...and beyond is the formation of Cable Labs."

Consumer electronics

The most important event of 1988 in consumer electronics was the introduction of the first improved definition television (IDTV) receivers. IDTV, you'll recall, involves only design improvements in the TV receiver itself; no changes are made to the transmitted signal. Typical improvements planned for the receiver include doubling the number of scan lines, nearly eliminating the NTSC color artifacts and significantly reducing noise. While only one such receiver has reached the market by the end of 1988, plans for 1989 include a wide variety of product. IDTV will increase the subscribers' sensitivity to video quality and reduce their tolerance of imperfections.

Laboratory tours in 1988 have uncovered the existence of projects to design high-definition TV (HDTV) consumer VCRs with up to 20 MHz of baseband width. These devices will create truly excellent pictures. They will set the competitive standard for cable.

"Universal" remote controls became a bit more universal. An important trend that appeared in 1988 was the inclusion of universal remote controls with high-end consumer electronics products. Nearly all major brands now have them both as options and as sales incentives to step up to the more expensive models. We'll see more of this in 1989. The major cable impact is to shorten the life of remote rentals. As universal remote controls become commonplace, cable will find it increasingly difficult to charge for the rental of the remote it imposed on its subscriber. Also, a number of non-traditional brands have arisen; Memorex now sells a universal remote.

IS-15, the Electronic Industries Association multiport, made slow progress in 1988. A few vendors of descrambling hardware continue to oppose this important technique for increasing subscriber satisfaction with cable. They fear the erosion of sales dollars on constant unit sales. They are unable to see the potential for increased unit sales if cable operators' subscribers are more satisfied with the product. The good news is that two vendors have promised product and appear to be on track for delivery in early first quarter 1989. The second piece of good news is that Cable Labs has hired a consultant to shepherd the consumer electronics efforts.

Competitive technology

The telephone company continues to be the

(Continued on next page)

CALENDAR

January

Jan. 7-8: National Cable Television Association seminar on FCC's signal leakage regulations, Airport Hilton, Seattle, Wash. Contact (202) 775-3637.

Jan. 8-10: Caribbean Cable TV Association annual meeting, Frenchman's Reef Beach Resort, St. Thomas, Virgin Islands. Contact Cathy Eaglen, (809) 795-5040.

Jan. 10: SCTE Cascade Range Chapter technical seminar. Contact Norrie Bush, (206) 254-3228.

Jan. 10: SCTE Central Illinois Chapter technical seminar. Contact Tony Lasher, (217) 784-5518.

Jan. 17: SCTE Florida Chapter's Central Florida Group technical seminar. Contact Keith Kreager, (407) 844-7227.

Jan. 18: SCTE Ohio Valley Chapter technical seminar. Contact Robert Heim, (419) 627-0800.

Jan. 18: SCTE Florida Chapter's Gulf Coast Group technical seminar. Contact Dick Kirn, (813) 924-8541.

Jan. 18: SCTE Mt. Rainier Meeting Group technical seminar on microwave, Oyster Bay Inn, Bremerton, Wash. Contact Sally Kinsman, (206) 867-1433.

Jan. 18: SCTE North Central Texas Chapter technical seminar. Contact Vern Kahler, (817) 265-7766.

Jan. 18: SCTE Razorback Chapter technical seminar, Days Inn, Little Rock, Ark. Contact Jim Dickerson, (501) 777-4684.

Jan. 23-25: Technology Dynamics Institute course on optical fiber communications systems, San Diego. Contact (213) 935-4649.

Jan. 24-25: National Cable Television Association seminar on FCC's signal leakage regulations, Hilton Hotel, Albuquerque, N.M. Contact (202) 775-3637.

Jan. 24-26: Jerrold technical seminar, Holiday Inn Airport, Orlando, Fla. Contact Jerry McGlinchey, (215) 674-4800.

Jan. 24-26: C-COR Electronics technical seminar, Los Angeles. Contact Shelley Parker, (800) 233-2267.

Jan. 25: SCTE North Country Chapter technical seminar on transportation systems. Contact Doug Ceballos, (612) 522-5200.

Jan. 31: SCTE Satellite Tele-Seminar Program, a BCT/E review course on Category V, 12-1 p.m. ET on Transponder 7 of Satcom F3R. Contact (215) 363-6888.

Planning ahead

Feb. 22-24: Texas Show, Convention Center, San Antonio, Texas.

May 21-24: NCTA Show, Convention Center, Dallas.

June 15-18: Cable-Tec Expo '89, Orange County Convention Center, Orlando, Fla.

Aug. 27-29: Eastern Show, Atlanta Merchandise Mart, Atlanta.

Sept. 20-22: Great Lakes Expo, Convention Center, Columbus, Ohio.

Oct. 3-5: Atlantic Show, Convention Center, Atlantic City, N.J.

February

Feb. 3-4: Society of Motion Picture and Television Engineers annual conference, St. Francis Hotel, San Francisco. Contact (914) 761-1100.

Feb. 5: SCTE Delaware Valley Chapter technical seminar on developing an in-house training program, Williamson Restaurant, Horsham, Pa. Contact Diana Riley, (717) 764-1436.

Feb. 7-8: Arizona Cable Television Association's annual meeting, Sheraton Hotel, Phoenix, Ariz. Contact (602) 257-9338.

Feb. 14-15: National Cable Television Association seminar on FCC's signal leakage regulations, Airport Hilton, Atlanta. Contact (202) 775-3637.

Feb. 15: SCTE Florida Chapter's South Florida Group technical seminar on system design and powering. Contact Dick Kirn, (813) 924-8541.

Feb. 21-23: C-COR Electronics technical seminar, Charlottesville, Va. Contact Shelley Parker, (800) 233-2267.

Feb. 22: SCTE Great Lakes Chapter technical seminar. Contact Daniel Leith, (313) 549-8288.

Feb. 22-24: Texas Show, Convention Center, San Antonio, Texas. Contact (512) 474-2082.

AD INDEX

Ciciora's Forum

(Continued from previous page)

competitive challenge of the future. While it isn't the only competitive technology we need to be concerned with, it certainly is the most important. Two things became clear in 1988. First, it appears that every state in the country is targeted for a fiber to the home test. Second, BellSouth and Southwestern Bell have both publicly claimed they will soon be able to justify fiber to the home in new construction and will have replaced all their copper plant by the year 2010. Telco seems to have backed off of the claim that video is needed to justify fiber to the home. Many are now saying that just "plain old telephone service" (POTS) will prove out the economics of fiber to the home.

None of the fiber to the home tests to date make economic sense. But that doesn't seem to be the purpose. Apparently publicity and exposure are the intent. Painting the telco industry as the high-tech information provider of the future is the goal. In this way regulators and legislators are expected to relax restrictions and allow telco into video.

Interesting times

1988 was a much more active year for technology than expected. If 1989 exceeds 1988, then the workload for cable technologists will be both more intense and even more interesting. True to the Chinese curse, we certainly live in interesting times.

High-definition TV—When?

By Archer S. Taylor
Senior Vice President of Engineering, Malarkey-Taylor Associates

Yves Faroudja told the recent SMPTE (Society of Motion Picture and Television Engineers) technical conference in New York that by the year 2000 we would be facing a major revolution in television by abandoning analog technology entirely in favor of digital. Of course, he also admitted that the year 2000 was mentioned merely because it is a "nice round number" and not the result of any scientifically projected forecast. Nevertheless, his point is that such a revolution could easily come upon us while we are still in the technological, economic and marketing throes of converting from NTSC to some future ATV (advanced TV) or HDTV (high-definition TV) standards.

Could we stand doing it all over again for digital TV? Would the public stand for it? Most would agree that digital TV would probably be the ultimate in near perfection. So, why not forget about HDTV until we can have it digitally and merely spruce up the NTSC system a bit until then?

First of all, wouldn't it be about as easy to stop the tides from rising or the sun from setting as to block the introduction of EDTV (enhanced definition TV) and HDTV tape or disc players and monitors? If clean, crisp, wide-screen pictures become available on videotape or disc, will cable TV sit back and wait patiently for the perfect pictures promised by the digital revolution? We know what broadcasters would do; they are already doing it by demanding new advanced TV standards so they can keep up with cable and VCRs.

There have been cases in the past where new products were kept from the public. Ever since I first shaved the peach fuzz off my face, I have heard rumors that Gillette has deliberately suppressed the technology that could produce a lifetime razor blade, usually identified as tungsten. We know that the film producers sometimes hold back on release dates in order to optimize sales and profits. There has been some suggestion that Hollywood is already holding back on Super-VHS tape product for its own reasons. But, even if they wanted to try, the suppliers of home TV equipment are likely to have no more success in delaying the marketing of new technology than the OPEC cartel has had in limiting oil production.

HDTV is driven by many forces:

- engineering perfectionism and technological elegance
- the appeal of a worldwide international TV standard
- nationalistic pride, bordering on hubris
- planned obsolescence to create new markets
- restoration of the consumer electronics industry in the United States
- protection of terrestrial TV broadcasting in the United States

No evidence

There is no evidence of public demand for higher resolution, wider aspect screens nor even elimination of the baseband artifacts on which so much engineering attention has been focused. When they see it, people like HDTV, but they have seldom (if ever) seen HDTV *after* it has been transmitted over-the-air on cable.

The public is much more likely to complain about ghosts, interference, beats, snow and color smear. Cable subscribers most often complain about unreliability and outages. These problems cannot be corrected with comb filters, sub-Nyquist sampling, progressive scanning or any of the other video tricks used to overcome baseband NTSC problems. In fact, HDTV could even exacerbate the defects about which the public complains.

Perhaps the most notable feature of HDTV pictures, at least on moderate size 20- to 30-inch diagonal screens, will be the wide aspect ratio. However, the higher resolution, freedom from visible scan lines, artifacts, ghosts, beats and snow will make larger viewing screens much more attractive than they are now.

Walt Ciciora recently wrote ("Cable's advanced television priorities," *CT*, October 1988) that "for ATV to be noticeably better than NTSC, the screen must be 2- to 3-feet high." At 16:9 aspect ratio, that is 50 to 75 inches on the diagonal, three to four times as large as the presently popular sizes. Actually, the size of any TV set is limited by the "30-inch rule": At least one dimension of the TV set must be less than 30 inches or it will not go through the average doorway. Imagine a picture tube 3 feet high by 5 feet 4 inches wide with a neck less than 30 inches. Scary.

"Although technology moves at a much faster pace these days, it could be many years before ATV or HDTV is anything more than an expensive novelty."

Ciciora also said that "ATV and really large-screen displays are so synergistic that one can't happen without the other." It hardly seems likely, however, that either rear-screen projection or direct projection on reflective screens will be acceptable except in the few upscale households that have large recreation rooms set aside as entertainment centers. For one thing, accommodating the necessary distance between projector and screen is much too intrusive for a small living room. Morever, the projection TV display is generally not bright enough for viewing in daylight or even normal artifical lighting without substantial darkening.

Therefore, the synergy of which Ciciora speaks seems most likely to exist between ATV and flat wall panel display systems based on the electroluminescence or LCD technology. The largest LCD display was recently claimed by Toshiba at slightly over 14-inch diagonal. Electroluminescence is still in the laboratory.

If Ciciora is correct, and I certainly believe he is, the public acceptance of any form of advanced TV beyond simply cleaning up some of the problems with the present NTSC display will most likely have to await the development of a reasonably priced, flat plane TV display screen. Ten years after the NTSC color standards were adopted, less than 10 percent of the TV sets sold included color; nearly 20 years later, color represented barely half of all TV set sales. Although technology moves at a much faster pace these days, it could be many years before ATV or HDTV is anything more than an expensive novelty.

Maybe Yves Faroudja is right. Maybe we will not see much real HDTV until we are ready for the ultimate: digital TV.

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