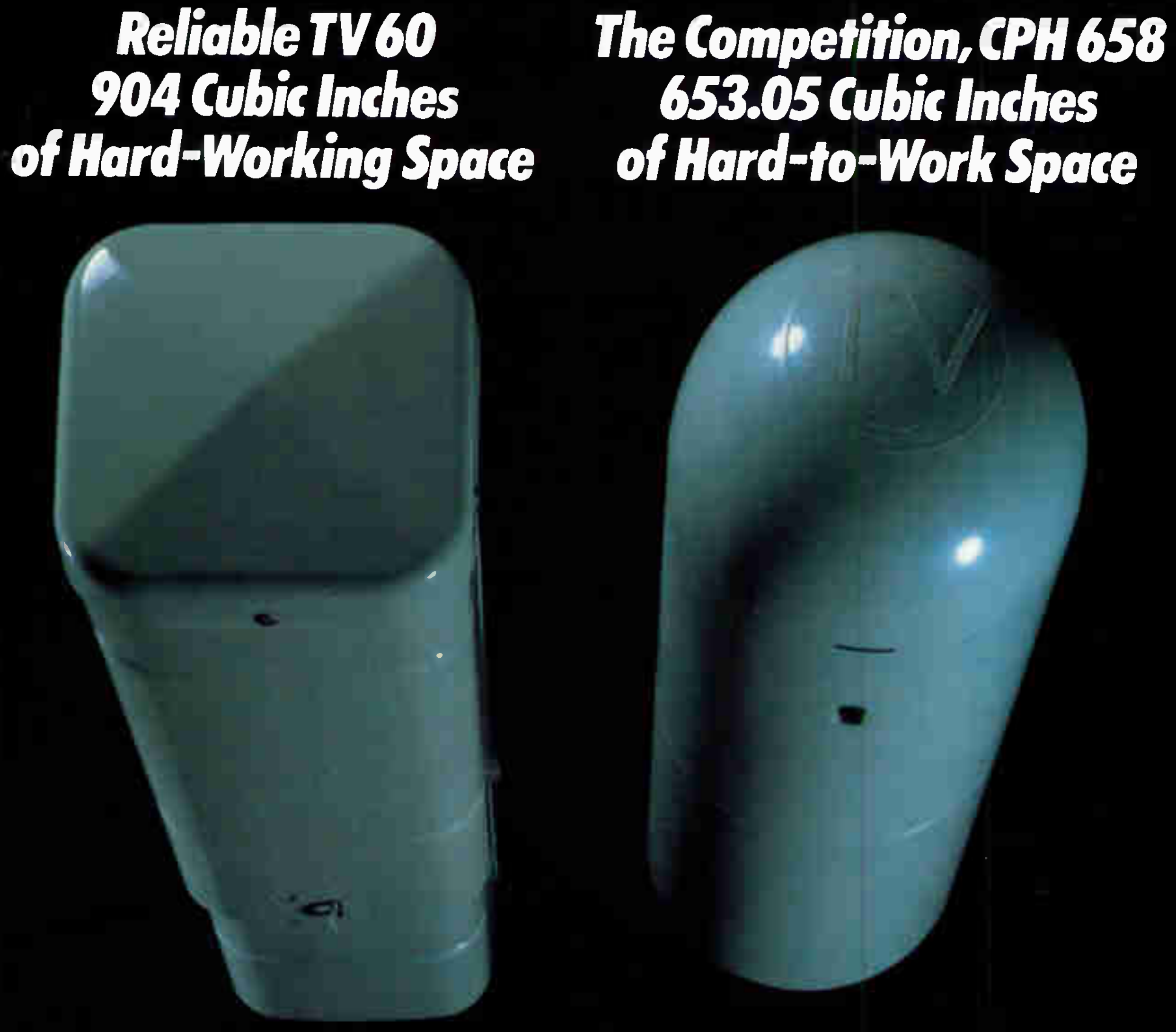
COMMUNICATIONS
TECHNOLOGY

Official trade journal of the Society of Cable Television Engineers

Microwave: The non-cable alternative
Page 19

Preparing SMATV for the future
Page 62

July 1985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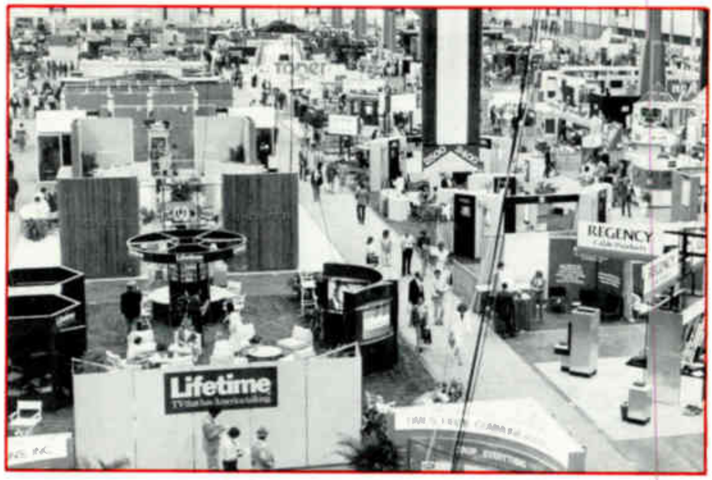
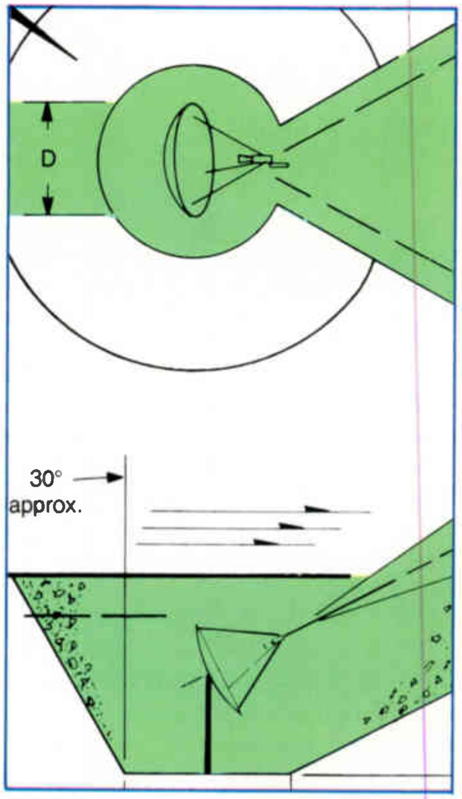
CONTENTS

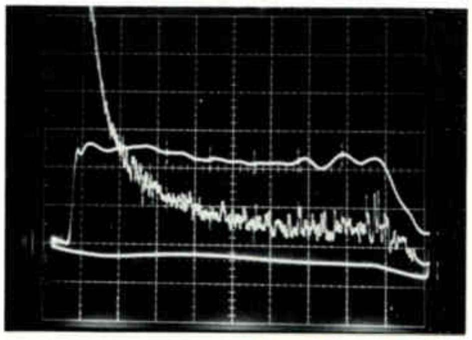
Departments


Oscar & Associates Inc

Product News 74



TVRO Interference 66



System Economy 12

Features

Cover
Mission Cable microwave installation photo courtesy of Hughes Microwave. Holiday Inn SMATV photo courtesy of Star Com.

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Remember, back in 1951, when TV stations were low in power and antennas not very efficient? Milton Jerrold Shapp, the founder of Jerrold, didn't realize he was helping to create a new industry when he developed an amplifier that Bob Tarlton needed for his Lansford, PA community antenna system.

Cable was new, but it grew rapidly. And Jerrold grew with it, developing improved amplifiers, channel equipment, and numerous innovations that increased revenue potentials for operators, and established Jerrold as the leading supplier in the industry.

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GENERAL INSTRUMENT

EDITOR'S LETTER

The battle ground changes

Two short years ago SMATV (satellite master antenna television) was an infrequently used acronym. To cable operators, SMATV represented a thorn in the foot . . . those nasty "cream skimmers." Programmers wouldn't sell them programming, manufacturers didn't offer much SMATV hardware and the legal status of the industry was indefinite.

Both CATV and SMATV have reaped benefits from the FCC's deregulatory actions over the past few years. With the emphasis on competition in the marketplace, SMATV has indeed flourished. At the recent NCTA show in Las Vegas it was evident that numerous manufacturers have recognized the SMATV marketplace and have developed products tailored to it. Programmers also are offering their services to SMATV operators.

HBO and Showtime are currently testing M/A-COM's Videocipher scrambling system. The scrambling will protect their signals from unauthorized theft, and allow them to more openly sell to SMATV. Most SMATV operators feel this is a good idea.

The point is that SMATV is cleaning up its act, legally and technically. A SMATV operator in Indianapolis has just received a franchise from the city to wire numerous complexes. Private cable engineers also have become increasingly more sophisticated. Of course, private cable system managers have realized that subscribers do insist upon high-quality signals.

So what's the good news? The good news is that SMATV as an industry has inspired the development of technologies that can help CATV operators. An example of this is the infrared link, originally designed to help SMATV operators legally cross city streets. Several CATV systems are now using the technology to cut down on the cost of underground construction and to interconnect systems.

SMATV also has increased the demand for a variety of cable-related products including antennas, modulators, character generators and amplifiers. The increase in demand has not only made new products available, it also has lowered the cost of many products. In the same vein, there are several programming services out there that at least partially owe their existence to SMATV.

As we recognize that CATV will never crush SMATV, and that SMATV will never overpower CATV, it becomes obvious that the battleground has changed. It has clearly moved out of the courtrooms and conference rooms into the home of the complex owner and the subscriber. In this battlefield CATV operators must realize that their greatest weapons are competitive services, competitive pricing and competitive marketing.

True, competition does make it harder to earn a dollar. But, ultimately, competition can best serve the consumer by creating the best possible product. We are convinced that CATV can more than hold its own in the competitive marketplace!

Striving for excellence

Even during a good football season, a team will scout around for players who will add a little bit more to make the team better. This year, by the way, the Denver Broncos are going to the Superbowl!

We at *Communications Technology* also strive to publish the best. The best technical publications for the cable industry. To augment our forces (in this case, our advisory board) we have added an engineering expert who will lend tremendous support to the magazine. Dan Pike, vice president of engineering for Prime Cable, is that expert. He joined the cable industry in 1973 as a project engineer for United Cable. In 1977, Pike became a staff engineer for the corporate office of Communications Properties Inc., an Austin, Texas-based MSO. When Times Mirror bought CPI in 1979, he remained with the company as a division engineer. In 1981, Pike joined Prime Cable, an MSO with 350,000 subs. He is also a senior vice president of the SCTE, and a member of the IEEE and SMPTE.

Our sincerest congratulations to *CT* advisory board member Abe Sonnenschein. Sonnenschein was awarded the 1985 Science and Technology Award, NCTA's engineer-of-the-year award. He has made numerous contributions to the cable industry and we're proud to be associated with engineers of his caliber. For more about NCTA's awards, please see page 9.

Toni I. Barnett

W&S Systems. Making history in cable television.

For more information on the SM 2001, contact:

W&S Systems Company
Westinghouse Building
Room 1880
11 Stanwix Street
Pittsburgh, PA 15222
1-800-323-9935

A Westinghouse Electric Division

The formation of W&S Systems, a partnership involving Westinghouse and Sanyo, launched a new concept in cable equipment technology. Our combined energies have led to a dramatic breakthrough in stereo sound with the introduction of the SM 2001.

The most advanced stereo module available, it is compatible with virtually every converter for integration in cable systems.

Extremely versatile, the SM 2001 offers the following benefits:

- FM stereo from premium video/stereo channels
- FM stereo from audio/stereo channels
- Hi-fi sound from non-stereo TV channels
- Automatic video and audio tracking of monaural and stereo channels
- Second Audio Program (SAP)
- VCR audio stereo outputs

Channel mapping capability provides the cable operator with greater flexibility in TV and FM channel selection and programming. Use of an EEPROM gives the SM 2001 its impressive compatibility characteristics. The unit can be reprogrammed to tailor the system's mapped channels, and matching the converter output channel.

Among the outstanding functional features of the SM 2001 are:

- Separate right and left audio outputs
- Option of 2, 3 or 4 selection at the input of the unit from the converter
- Last channel memory
- FM/TV automatic audio level
- 1ST and 2ND TV audio channel

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BPA membership applied for November 1984.

Microwave guru receives NCTA tech award

LAS VEGAS, Nev.—The National Cable Television Association presented its National Awards at the conclusion of its 34th annual convention at the Las Vegas Hilton.

Abe Sonnenschein, program manager at Hughes Aircraft Co.'s microwave products division, received the 1985 Science and Technology Award.

The award, presented annually to an engineer who has made significant contributions to the technical advancement of the CATV industry, was made for pioneering work performed by Sonnenschein and others at Hughes in the development of microwave and satellite transmission techniques for cable distribution. He also played a key role in the implementation of the first interactive cable TV system, in El Segundo, Calif., in the 1970s.

The remaining National Awards and their recipients follow.

The Vanguard Awards—given to a man and a woman whose leadership and foresight have placed the cable industry in the vanguard of the new communication technologies—were presented to John Saeman, vice chairman and chief executive officer of Daniels & Associates, Denver; and Susan Greene, senior vice president of corporate affairs, Home Box Office, New York.

The Challenger Award, honoring outstanding achievements of an individual 40 or under, was presented to James Cownie, president of Heritage Communications Telecommunications Group, Des Moines, Iowa.

Recipients of the 1985 President's Award were Joseph Gans Sr., president of Cable TV Inc., Hazleton, Pa., and John Frazee Jr., executive vice president of Centel Corp. and president of Centel Communications Co., Oak Brook, Ill.

Sonnenschein

John "Jay" Levergood, president and chief operating officer of Scientific-Atlanta Inc., received the Associates Award, which recognizes the contributions of the industry's programmers and equipment suppliers.

T.W. "Skip" Meadows, general manager of Decatur Telecable, Decatur, Ala., received the State/Regional Association Award; Gerald Maglio, executive vice president of marketing and programming, Daniels & Associates, Inc., Denver, received the Marketing Award.

SCTE moves ahead with BCT/E program

WESTCHESTER, Pa.—Chairmen have been appointed for the six remaining categories in the Society of Cable Television Engineers' BCT/E Professional Designation Certification Program. The BCT/E chairmen will head committees that will develop examinations for candidates in their respective categories. The new chairmen are: Alex Best, Scientific/Atlanta—signal processing centers; Paul Beeman, MTV Networks—video, audio signals and systems; Abe Sonnenschein, Hughes Microwave Products—transportation systems; Ernie Tunmann, Tele-Engineering Corp.—data networking and architecture; Bud Campbell, ATC—terminal devices; and Wendell Bailey, NCTA—management, professional ethics.

Vacancies exist in some committees for additional members. Contact the chairmen listed above or the Society of Cable Television Engineers national headquarters, 319 J. Westtown Rd., West Chester, Pa., 19380, (215) 692-7870.

For those interested in BCT/E certification, the distribution systems exam, category IV, will be given this month and next by local chapters. The Golden Gate Chapter will administer the test on Tuesday, July 16 in San Jose, Calif. The Delaware Valley Chapter will have a test session on Aug. 21 (see this month's *Interval* for details).

FCC allows marketing of Comband system

PORTSMOUTH, Va.—The Federal Communications Commission issued an order May 31, 1985, that General Electric's Comband system can be marketed for use by cable systems for any signal, including Class I. This order was in response to a petition for Special Relief of the requirements of Section 76.55 (a) (1) of the commission's rules.

The decision of the FCC was that Section 76.55 (a) (1) is not directly applicable to the Comband system and that the Comband equipment and Comband signal processing techniques are not subject to commission approval prior to marketing.

With respect to the aural carrier tolerance, the FCC will permit use of the Comband baseband converter in any cable system whose operator complies with the conditions in the Viacom Order and files the appropriate notification with the commission.

Co-op up and running

OVERLAND PARK, Kan.—The Mid-America National Cable Television Cooperative has opened its national office in suburban Kansas City. "We've purposefully kept a low profile 'till now," said John Thompson, president of the cooperative. "We felt it was better to wait until we were ready to actively solicity membership and begin our talks with suppliers."

The Mid-America National Cable Television Cooperative is a not-for-profit organization of cable TV system owners and operators whose major goal is to reduce their operating costs.

"We're sure there are middle-ground positions of interest to both cable operators and suppliers that can be turned into agreements beneficial to both parties, said Executive Director Michael Pandzik. "We don't want bigger discounts or different treatment than we deserve, just fairness and rates commensurate with our combined purchasing power. That's the same thing the biggest MSOs expect and get."

The Mid-America National Cable Television Cooperative's mailing address is P.O. Box 25828, Overland Park, Kan. 66225. Its telephone number is (913) 888-1030.

Fiber networks are taking shape

DENVER—CableBus Systems Corp. will supply security system components for a fiber-optics videocommunications network to be installed in Lake Forest, a Dallas suburb. Lake Forest is a 300-acre planned community.

Installation of the system will provide residents and the public schools at Lake Forest with cable television and alarm/security systems. When completed, the system will serve 2,200 subscribers of single family homes, multi-housing units, and some retail establishments in the first phase of the project.

In related news, MCI Telecommunications Corp. has selected the AM Communications Division of AM Cable TV Industries to construct a 96-mile segment of MCI's eastern corridor communications network.

The contract awarded calls for installing

¾-inch fiber-optic cable along 85 miles of underground and 11 miles of aerial system, including multiple bridges and tunnels. MCI will supply all cable and strand. Completion of the project, which stretches from Patterson Creek, W.V., to Points of Rock, Md., is expected by Aug. 2, 1985.

Zenith acquires Inteq

GLENVIEW, Ill.—Zenith Electronics Corp. has acquired Inteq. Inc., a privately held firm involved in the development of technology used to modify microcomputer products for high-security applications. Zenith issued 900,000 shares of common stock to complete the acquisition agreement.

Inteq, based in Herndon, Va., develops proprietary technology used in Tempest microcomputers and peripherals to prevent electronic eavesdropping. Inteq has licensed its Tempest technology and supplies the peripherals to Zenith Data Systems (ZDS) and others.

In October 1984, ZDS, a wholly owned subsidiary of Zenith, was awarded a $100 million contract to supply Tempest microcomputers and peripherals using Inteq technology to the U.S. Air Force and Navy.

The acquisition has been accounted for as a pooling of interests. Inteq, which was established in 1977, will be operated as a wholly owned subsidiary of Zenith Electronics.

RMS relocates West-Coast office

MISSION VIEJO, Calif.—RMS Electronics Inc. announced that it has relocated its western operations office. The new office address is at 27281 Las Ramblas, Suite 200B, Mission Viejo, Calif. 92691. Telephone numbers remain the same. In California, (800) 247-8435. In the continental United States, Puerto Rico, U.S. Virgin Islands, Alaska and Hawaii, (800) 624-2511.

CATV consultant announces new firm

RINGWOOD, N.J.—Cable television consultant Alan Hahn announced the formation of a new consulting firm, Hickory Mountain Associates Inc. The new firm will serve as general telecommunications consultants, with particular emphasis on cable television system engineering, construction and operations.

The new firm's mailing address is P.O. Box 732, Ringwood, N.J. 07456; its telephone number is (201) 962-6299.

JVC creates new division

NEW YORK—The JVC Service and Engineering Co. (JSCA) has formed a separate Pro Video Service Division. Sharing the title of division manager are Matt Yamauchi and Dan Roberts. Service will be coordinated through district sales managers and the JSCA regional service manager.

Demand for electronic wire, cable to increase

NORTHPORT, N.Y.—The U.S. market for insulated wire and cable used in electronic applications will total $1.8 billion in 1985, and by 1990 will grow to $3.4 billion. The increase represents an annual growth rate of 13.9 percent, which is almost 7 percent higher than the growth rate for non-electronic wire and cable products during this period. This is one of the conclusions reached in a new report titled *Electronic Wire and Cable*, published here by Worltech Reports Inc.

According to the report, many segments of the electronic wire and cable market will demonstrate growth rates far above the market average over the next five years. Included in this group are fiber-optic cables for local area network and data transmission applications; flat woven cables; miniature coaxial cables, and undercarpet data cables.

The report covers coaxial cables, multi-conductor cables, hook-up wire, flat cables, fiber-optic cables, local area network cables, undercarpet cables, high growth market opportunities, applications, prices and competitive conditions.

Compucon to provide ABC interference assessment

DALLAS—Compucon Inc., a subsidiary of A.C. Nielsen Co., has been chosen by ABC to provide interference analysis, frequency coordination and on-site RFI measurement services. Currently, Compucon is working on approximately 50 ABC stations located on both the East and West Coasts. This project is a part of ABC's plans to convert the entire network to satellite feeds.

S-A receives order from TCA

ATLANTA—Scientific-Atlanta Inc. received a $265,000 order from TCA Cable Inc. for headend electronics to be used in 18 of TCA's cable systems. The equipment, which includes S-A's Model 6330 and 6350 modulators, Model 6130 and 6150 signal processors, and Model 6602 and 6650 receivers, will be used by TCA for both rebuilding and upgrading.

TCA Cable Inc. is a Tyler, Texas-based MSO with 60 cable systems in operation throughout Texas, Louisiana and Arkansas. TCA currently has approximately 260,000 subscribers over 5,200 miles of cable plant.

W&S's product launch

PITTSBURGH—W&S Systems Co., a division of Westinghouse Electric, has begun volume shipment of its first product, the SM2001 stereo module. Compatible with most converters for integration into a cable television system, the SM2001 has undergone marketing evaluation by more than 25 MSOs representing nearly 50 cable systems in the United States.

In keeping with this, W&S announced the signing of a contract with Group W Cable to supply 30,000 stereo modules over the next 17 months.

Group W Cable serves more than 2 million customers in 33 states. It began a field trial of stereo television service in May as part of a plan to develop cable stereo audio as a new service to the company's subscribers.

Pico's OTAS used in SMATV

LIVERPOOL, N.Y.—Pico Products announced that Sol-Sat will utilize Pico's OTAS (outdoor terminal addressable system) in its SMATV build in Greensboro, N.C. Sol-Sat will provide installation of the OTAS equipment, which will utilize the outdoor terminal configuration in conjunction with cable-ready sets and "plain Jane" converters for the 300 MHz build in the MDU application. Pico's data controller will be located at the site headend with full subscriber control from the business office located 25 miles away.

Installation began in June, with additional sites to be added. Pico's software package will provide a management system that will generate monthly statements, work orders, trouble call reports, marketing reports and customer files. An IBM PC-XT computer will provide commands to the data controller at the headend.

DCA equipment selected by PaineWebber

NORCROSS, Ga.—PaineWebber, an investment and brokerage firm, has selected Digital Communications Associates Inc. equipment for its expanded data communications network. The contract for networking equipment is valued in excess of $250,000.

The network will link PaineWebber's new uptown location with its downtown New York computer center by using four DCA System 375 network processors and four DCA Netlink T1 time division multiplexors operating at 56K bps. The System 375 is designed for operation in large private data networks.

Warner Amex-Houston picks Pioneer's BA-5130

COLUMBUS, Ohio—Pioneer Communications of America Inc. announced an agreement under which Warner Amex Cable Corp. will purchase Pioneer's BA-5130 addressable converter. Warner Amex will be installing the converter with an M3 system controller, capable of managing 500,000 subscriber terminals, in its cable television system in Houston.

Anixter carries Lectro power supplies

SKOKIE, Ill.—Anixter Communications has made an agreement to distribute Burnup & Sims Lectro power supply line. The complete Lectro product line is being stocked at key Anixter locations throughout the United States for immediate delivery.


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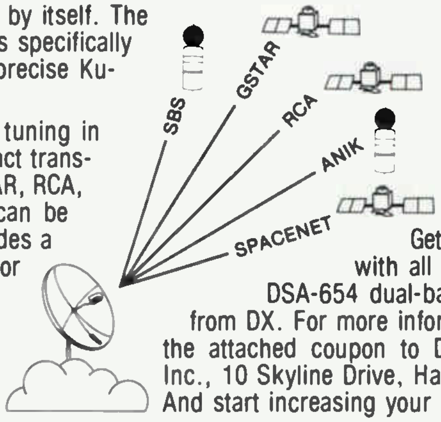
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Getting the most out of your bench sweep

Part I (CT, May 1985) of this series discussed the economy of effective bench sweep testing—for example, identifying potential problems with equipment before it is installed in the field, and avoiding costly service calls to correct those problems later. Part II (CT, June 1985) highlighted common measurement techniques and some of the errors that can affect the accuracy of bench sweep testing. This month in Part III we'll look at return loss measurements using your bench sweep.

By Ron Hranac
Corporate Engineer Jones Intercable Inc

An RF circuit consists of three basic components: an RF source, the signal path, and a load (Figure 1). Under ideal conditions, that is, when the impedance of these three components is identical, an RF signal transmitted by the RF source travels along the signal path and is absorbed completely by the load. Should the impedance of any of the components of the RF circuit vary, then part of the transmitted signal will be reflected back toward the source, and only part of it will be absorbed by the load.

The CATV distribution network—cable, amplifiers, splitters, taps, connectors, headend equipment—generally has a nominal impedance of 75 ohms. Because of manufacturing tolerances and practical circuit limitations, most CATV components are not exactly 75 ohms; they usually fall into an area that is within a few ohms of the specified impedance. Even variations this slight are enough to cause some portion of the signal to be reflected back toward the source. It is these reflections we are concerned with when measuring return loss.

A return loss bridge is a device used to measure return loss; the bridge detects impedance differences between an internal reference and the component under test. Return loss bridges come in two types: fixed bridges, with a fixed impedance internal reference; and variable bridges, with an adjustable impedance internal reference. The mismatch between the bridge internal reference impedance and the impedance of the component under test is a function of the amount of signal reflected by the component under test.

Fixed bridge measurements

Fixed bridges are used when measuring the return loss of devices such as splitters, taps, couplers, amplifiers, converters, headend equipment—CATV components other than the cable itself.

To perform return loss measurements with a fixed bridge, configure your bench sweep equipment as shown in Figure 2. (Do not connect the bridge yet.) Adjust the sweep generator for the required bandwidth, sweep rate and amplitude. Set both the balance and reference attenuators to 0 dB; connect the two test leads together with a suitable barrel, and adjust the reference and test traces until they match.

Now connect the test leads to the bridge's thru ports; leave the bridge test port open. The test trace will have moved lower on the display oscilloscope—this corresponds to the insertion loss of the bridge. Adjust the balance attenuator until the two traces line up again (12 to 13 dB.)

To verify the accuracy of the setup, connect

Figure 1: Basic RF circuit

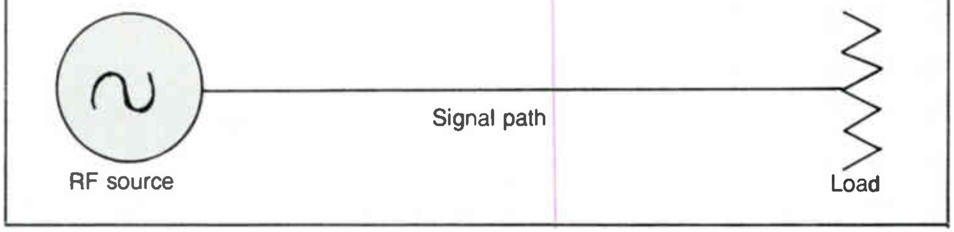
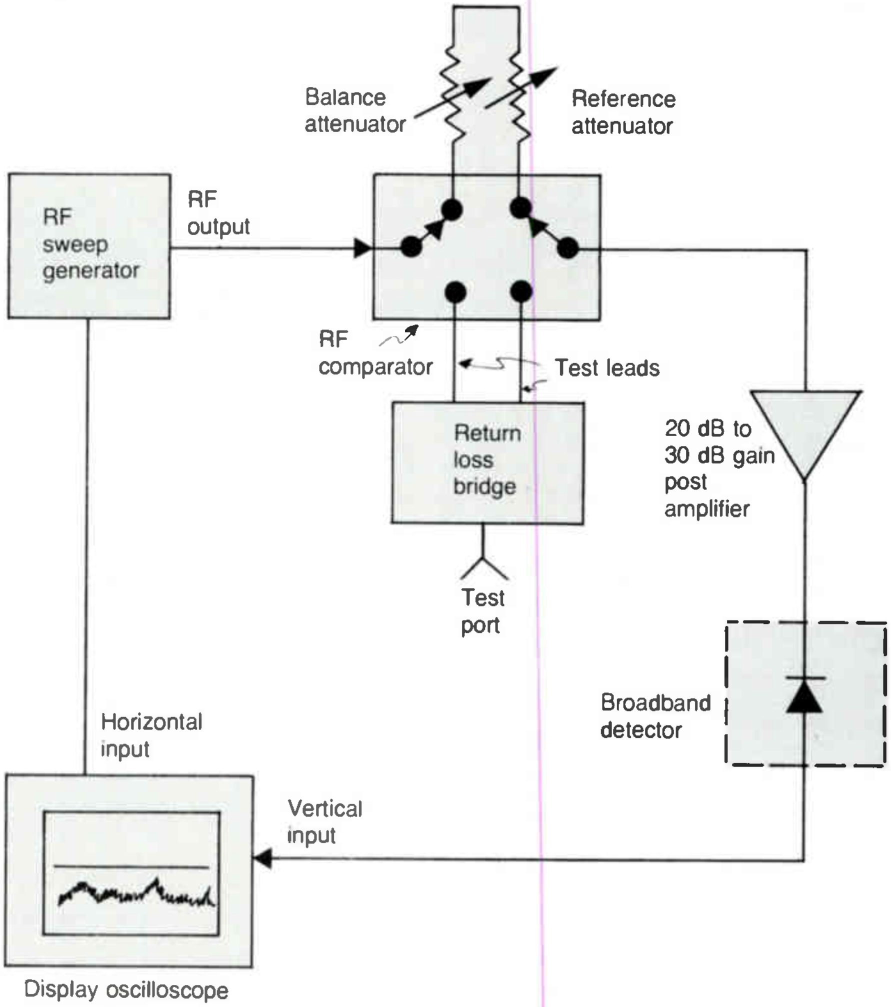


Figure 2: Test equipment configuration for return loss measurements



a precision mismatch to the bridge test port. The test trace will move lower on the display oscilloscope. Adjust the reference attenuator to match the two traces (you may have to adjust the vertical gain/position controls on the oscilloscope to bring the traces into view.) The amount of attenuation required in the reference attenuator should equal the value of the mismatch.

When measuring the return loss of devices with more than one port, it is very important that all ports other than the one being measured are terminated. Your measurement will be limited by the type of termination used. Photo 1 shows the degraded high-frequency return loss of a resistor-type termination that measured 75 ohms with a digital ohmmeter. This is unacceptable for accurate measurements.

If you don't have access to laboratory-grade terminations, you can make a suitable substitute by connecting several high-value attenuators in series and then terminating the end of the attenuators with a resistor-type termination. Provided the attenuators are well made, this configuration will produce an acceptable termination with a return loss in excess of 40 dB (Photo 2.)

Photo 3 shows the return loss of the input port of a two-way drop splitter. To make this measurement, the test port of the bridge is connected to the input port of the splitter being tested. Both of the splitters' output ports are terminated, then the reference attenuator adjusted until the reference and test traces line up at the frequencies of interest. The amount of attenuation in the reference attenuator is equal to the return loss.

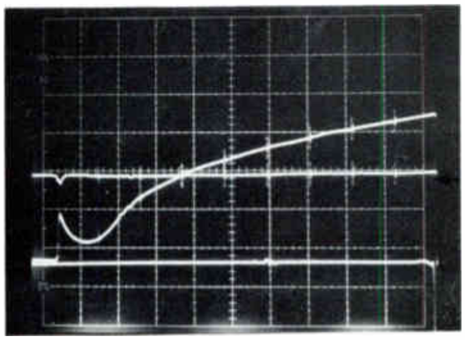
The same procedure would apply to the other ports of the splitter, as well as any other device being measured. Again, be sure to terminate all ports other than the one being measured.

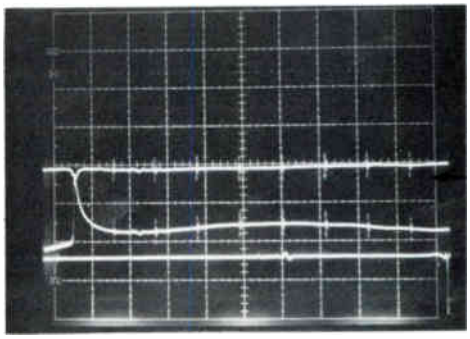
Variable bridges

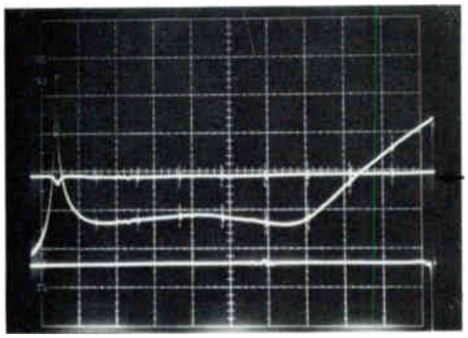
A variable return loss bridge is necessary to obtain an accurate measurement of coaxial cable return loss. Variable bridges are equipped with both resistance and capacitance adjustments, which allow the bridge to be matched to the average impedance of the cable under test. The apparent return loss of a reel of cable measured with a fixed bridge can vary considerably from the return loss measured at the cable's actual impedance.

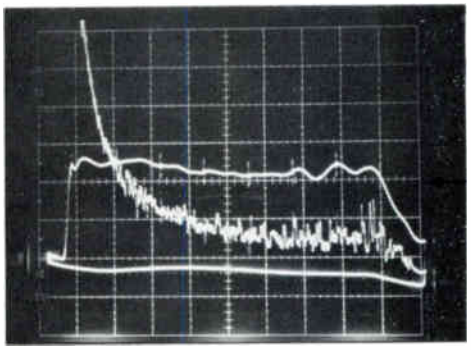
Although measurement accuracy is usually satisfactory using a fixed lab-grade termination at the far end of the cable, accuracy can be enhanced, especially for short lengths of cable, by using a variable termination instead. Adjusting the variable bridge and variable termination to match the cable under test as close as possible will result in the greatest accuracy.

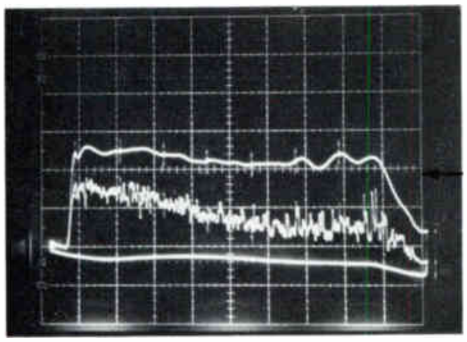
To make measurements using a variable return loss bridge, configure your equipment the same as was done for fixed bridge measurements. After the sweep equipment has

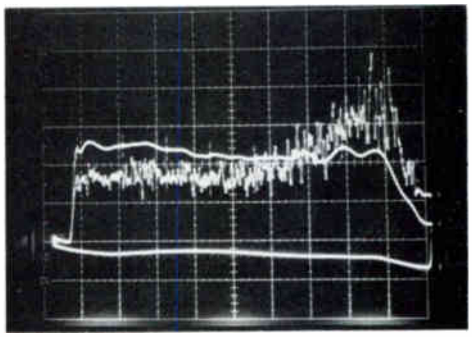

1) Return loss of a resistor-type 75 ohm terminator—30 dB at 100 MHz, 22 dB at 400 MHz. (Note: Arrow on photos indicate the reference line.)

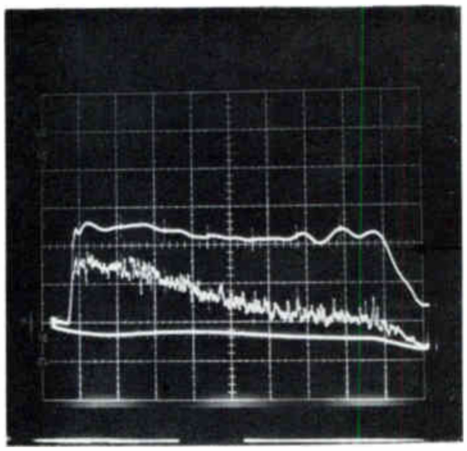

2) Using a series of high-value attenuators in conjunction with a resistor-type terminator produces satisfactory return loss (>40 dB).

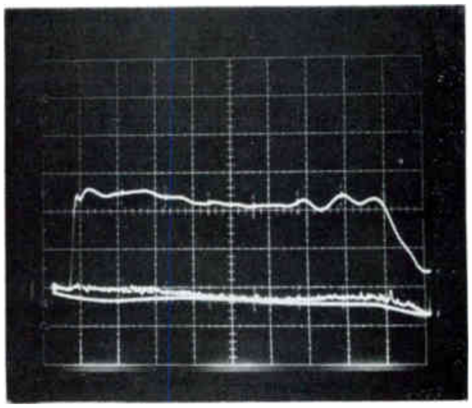

3) Return loss of the input port of a two-way drop splitter.


4) End of reel of coaxial cable unterminated.


5) Termination installed at end of cable.


6) Bridge capacitance improperly adjusted.

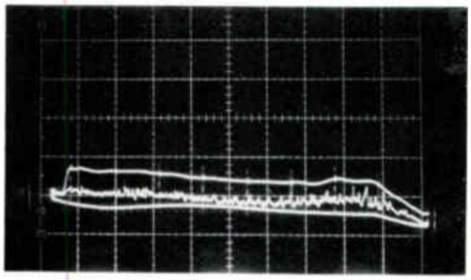

7) Correctly adjusted bridge capacitance.


8) Variable bridge controls properly adjusted to match the average impedance of cable under test.

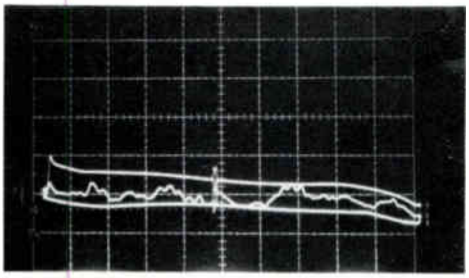
been adjusted and calibrated, remember to compensate for the insertion loss of the variable bridge by adjusting the balance attenuator to match the test and reference traces on the display oscilloscope.

A precision mismatch should be used to verify the accuracy of your setup. Connect the mismatch to the test port of the bridge; adjust the reference attenuator to the equivalent value of the mismatch, then adjust the resistance and capacitance controls on the bridge to align the test and reference traces again. (Some adjustment of the display oscilloscope's vertical gain/position controls may be necessary to bring the traces into view.) If your equipment has been properly calibrated, the bridge resistance control should be at or very close to the 75 ohm mark. Remove the precision mismatch and set the reference attenuator to 30 dB.

Now attach the bridge test port directly to one end of a reel of cable using a lab-type connector. Do not use intermediate adapters, since this will reduce the accuracy of your measurements. The display oscilloscope should look similar to Photo 4. The rapid rise at the lower frequencies is caused by the lack of a termination at the other end of the reel of cable. With a termination installed, the display should look like Photo 5.



9) Reference trace lowered near return loss spikes.



10) Decrease swept bandwidth to reduce detector error.

Adjusting the bridge capacitance control will change the upper frequencies as shown in Photo 6. When properly adjusted, the *minimums* will be nearest the baseline as in Photo 7.

It is important when adjusting the bridge to observe the baseline of the trace, and not the return loss spikes. Incorrectly adjusting the bridge by reducing the spike amplitudes instead of the baseline will result in measurement errors. (An RMS voltmeter connected in parallel with the detector output may be helpful to locate the null condition.)

Changing the bridge resistance control will affect the lower frequencies. Optimum adjustment of the bridge will produce a response similar to Photo 8. The reference attenuator can not be set to position the reference trace near the highest return loss peaks (Photo 9.) In order to eliminate detector rise-time error, reduce the swept bandwidth until the fastest rise-time spike within the bandwidth being tested no longer increases in amplitude. Again adjust the reference attenuator to position the reference trace at the highest peak (Photo 10.) The amount of attenuation in the reference attenuator is equal to the return loss at the observed frequency.

Repeat the entire measurement procedure at the other end of the reel of cable. The return loss of that particular reel of cable is the worst measured at either end.

The importance of thorough and effective bench sweep testing cannot be overstated. The several thousand dollar investment required for a good bench sweep system can be paid back in a relatively short period of time with the implementation of a good QC program at the system level. Effective use of bench sweep equipment will enhance the operation of any cable system, and provide time and money savings.

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Reader Service Number 9.

BLONDER'S VIEW

The case for the 1 percent solution: Act One

By Isaac Blonder
Chairman, Blonder-Tongue Laboratories Inc

Scientific Detective I.M. American gingerly opened the door with its newly shattered glass panel, hoping the missile was inert. Lying on the floor, half buried in glass and other debris, was an old telephone. Upon closer examination, he noticed the base was stamped "Eastern Electric," a great addition to his private museum of obsolete products from vanished companies.

Since it was still daylight, he could see his way up the flight of stairs to his office, a small room in the 100-year-old Clerk Thread and Mill factory. The building was converted in the '20s into an equally huge electronics plant—the Semi-Automatic Radio Co., which met its demise in the '60s—but now is a vast wasteland of rubble and ill-financed primordial businesses living from day to day.

As soon as he settled into his chair the phone rang. It was his answering service.

"Our association wants an immediate report on the current and future status of American consumer electronics factories in the United States and your recommendations for remedial action. Please bill us at your usual rate and"

The connection was suddenly broken. I.M.A. sat back in his seat with a soft sigh of resignation. Someone was collecting copper again and the lights would be next to go—which they did, following closely upon his thoughts. He lit the candle on the desk and pulled toward him the little De Forest crystal set and adjusted the earphones comfortably on his head. After placing a wee drop of scotch on the Galena crystal, he found a sensitive spot with the catswhisker and tuned in Gus Gloom's talkshow on investments.

"Deficits up, imports up, business down."

I.M. American growled harshly at himself, "The country needs me, hit the road."

His first stop was Courtland Street at Sam's Surplus Electronics Store. Sam knew everything about everybody.

"How's business?" he asked Sam.

"Terrible, nobody's buying anything," replied Sam, "but if I could find a good assistant, sales might pick up. I'm looking for a bright young engineer, hours 8-8, 6 days a week, clean toilets, sweep floors, $25 weekly. Oh, he has to work the first two weeks for free to prove he is okay. Nobody has applied for the job for the last 30 years, so maybe I'll take on a foreigner. Anyway, my wife is filling in and I guess I can hold out for a good man."

Two blocks away on the 3rd floor of a dingy, graffiti-covered old iron pillared building he greeted Joe Impelliteri with a cheerful voice as he noticed Joe had a cast on his right arm.

"What happened to you?"

"The flywheel of my old 10 ton press came off and, what the hell, I should get a new one but we ain't profitable so. . ."

"Business not so good, heh?"

"You betcha it's no good; who wants terminal strips, tube sockets and pilot lights anymore? Maybe you can find somebody to buy my old machine shop?"

On every street corner in this old sector of the city were electronics stores supporting front windows saturated with wonderous gadgets advertised as the lowest priced anywhere. I.M.A. entered the store of "Bankrupt Barney" whose promotions were no baloney; he would go bankrupt if you bought at the advertised prices.

"What's selling?", he asked Barney.

Barney looked up at his old friend, "Great, great, great, next week I get the first shipment of stereo cassette players from Red China. Cost me $5.95 and I'll get $25 unless that bum Henry down the street uses it as a price leader. Gets so an honest guy can't make a buck in this business!"

"Do you carry any American made electronics?"

"What, you think I'm crazy? Let the government keep those bums with their high prices alive, not me; besides, what have they got new? Show me."

Further north in a rambling, well-preserved concrete and brick warehouse, I.M.A. visited the former home of Telequeen, a manufacturer of television sets in the '40s and '50s. The only elevators in the buildings were intended for freight, but he spurned the stairs—which reeked with the odor of human excrement—and persuaded the elevator operator to lift him to the fifth floor.

The interim use of the building as a warehouse had not erased the signs of a TV manufacturing plant. Portions of the rectangular production line still remained, burdened by boxes instead of TV chassis strapped to wheeled carts for the journey from naked chassis to the finished product. In one dusty corner, some old battered cabinets bearing the insignia of Telequeen remained for the lowly service of waste baskets. I.M.A., who once worked as a test engineer on this very floor, could still hear the strident voice of the line foreman, the intermittant sounds of audio through the test bays, and the chatter of iron wheeled bins. Presiding over this enterprise was the intrepid Ben Silver, otherwise known as "Slavedriver," who singlehandedly increased the output of television sets from 100 to 500 per day with the same staff. A large banner on the outside praised the conversion of the building to condominiums with the blessing of the mayor.

Across the river in a corner of its former quarters, I.M.A. visited one of the few survivors in consumer electronics, the Bright Radio Co. The company was assembling foreign made components in high-styled cabinets.

"Can I look in on your production line?"

"Yes," replied the owner, "but keep your hands behind your back, keep your voice down, and don't point."

"Why?"

"If I try to criticize production quality or the workers, they walk out on strike."

"How about the supervisors?"

"They belong to the same union."

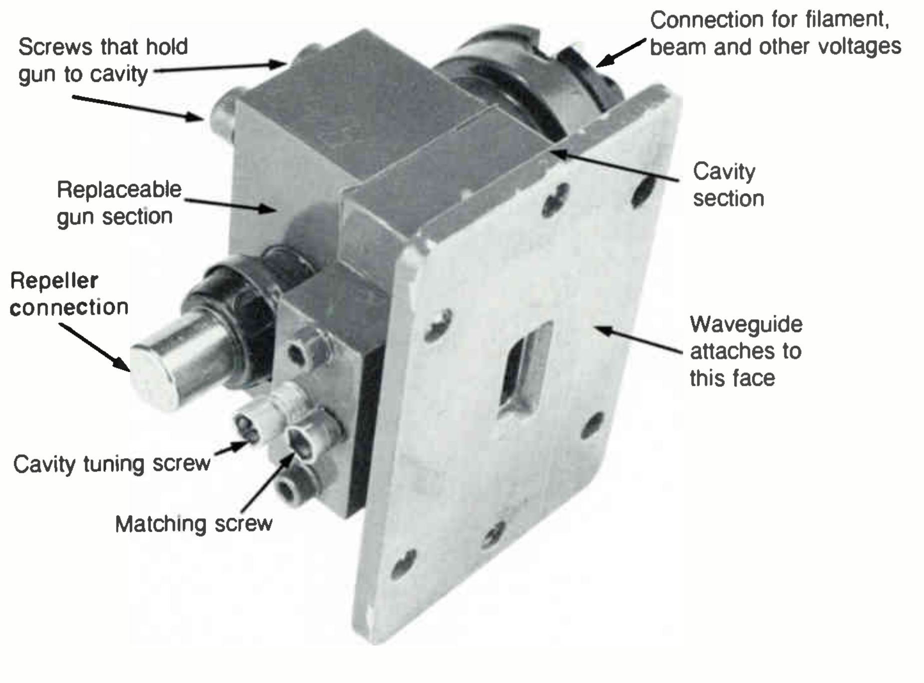
"Oh." I.M.A. left.

Next stop was Washington, D.C., at the tall building occupied by the Radio Manufacturers Association. The meeting I.M.A. attended was on the subject of spurious radiation from consumer products. As he listened to the quiet technical presentations, he took careful note of the parent companies of the attendees. Although several old American companies were represented, there seemed to be no discussion about measurements in the lab or on the production line, but on how to achieve certification that the product met FCC rules in order to pass customs. Did this mean that all consumer items were made abroad?

Late that same afternoon, I.M.A. entered the warehouse of the Z Mart Discount Stores, determined to solve the mystery. A close scrutiny of the products in the retail store had failed in many cases to reveal the country of origin, which was often faintly embossed in dark plastic on the bottom. But the original packaging was clearly marked and I.M.A. received permission from the guard to examine the warehouse. Suddenly, at 6 p.m. sharp, the lights went out and all sounds ceased. I.M.A. had been forgotten and the burglar alarms were set! What to do?

Continued next month with Act Two.

CARS band reflex klystron built by Varian with a replaceable gun.



Intro to microwave

The technician who is suddenly faced with a failure in a piece of equipment that he or she doesn't really understand can appreciate the value of basic knowledge. Microwave equipment could very possibly be one of those areas of technology that you missed in your training. It also could be somewhat mysterious because it is rather different than conventional, lower-frequency processing and transmission equipment. Being required to find and fix a problem in the microwave system would most likely seem pretty awesome under such circumstances.

Presented here is a description of microwave basics; the general theory, the various devices and the complete system. None of this presentation will be highly technical, meaning that a knowledge of basic electronic theory is all that is needed to understand the fundamentals of microwave.

By Lowell Williams
Engineering Director, National Cable Television Institute
and Thomas G. Elliot
Director of Research & Development, Tele-Communications Inc.

A good place to start is to identify the position of microwave frequencies in the overall radio frequency (RF) spectrum (see Figure 1). Microwaves have very short wavelengths in comparison to VHF and even UHF television signals. The wavelength of an electromagnetic wave is simply the distance the signal travels in the time duration of one cycle. Since all electromagnetic radiation travels through free space at the same speed (300,000,000 meters per second), the higher frequencies have shorter wavelengths. Wavelength (λ) is found by using the formula:

$$\lambda \text{ in meters} = \frac{300{,}000{,}000}{\text{Frequency in Hz}}$$

The wavelength for VHF channel 2 picture carrier is:

$$\lambda = \frac{300}{55.25 \text{ MHz}} = 5.43 \text{ meters}$$

The wavelength for UHF channel 83 picture carrier is:

$$\lambda = \frac{300}{885.25 \text{ MHz}} = 0.339 \text{ meters (339 mm)}$$

The wavelength for cable antenna relay service (CARS) microwave (12.7 GHz to 13.2 GHz) is between 22.7 and 23.6 millimeters.

Common carrier and CARS microwave

Microwave signals are used to transport television signals over long distances and over or around geographical obstacles where a coaxial cable transportation trunk would not serve the purpose. To achieve the least degradation to the video signal, frequency modulation (FM) is used on common carrier and CARS microwave signals. Because this form of modulation is incompatible with the standard TV set, the microwave signals must be processed differently at the CATV headend than the over-the-air signals. This is accomplished by first demodulating and then remodulating the video and sometimes the audio signal. The audio signal is usually carried on the microwave system on a frequency-modulated, 4.5 MHz subcarrier and is not usually demodulated to baseband audio when it is processed. Additional subcarriers, higher in frequency than the 4.5 MHz aural subcarrier, are used to carry information such as FM radio signals and other audio services, data services, microwave equipment fault alarm signals, and the maintenance communications circuit.

Microwave transmitter

The transmitter (Figure 2) consists of a pre-emphasis network, a modulator, a frequency

Figure 1: Common carrier and CARS microwave frequency allocations

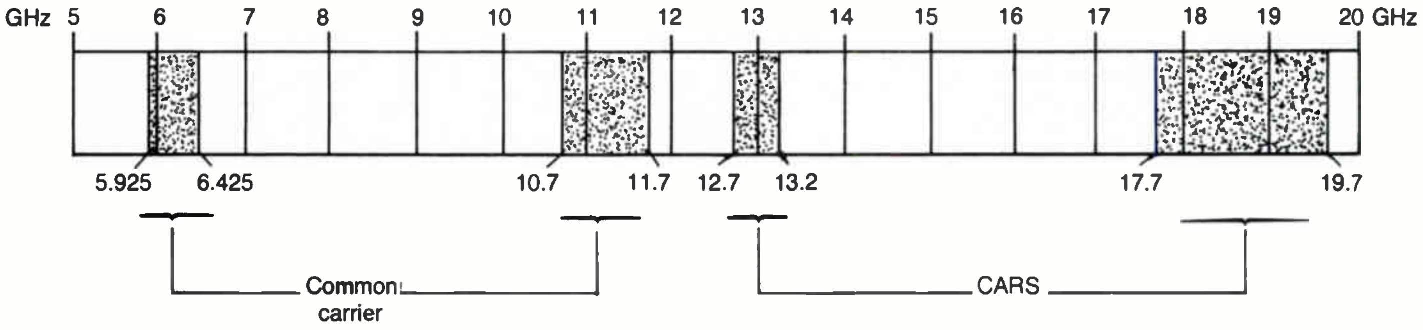
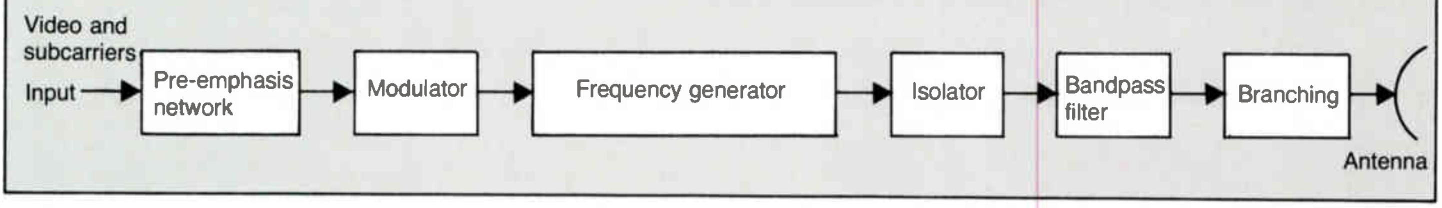


Figure 2: Block diagram of typical remodulating microwave transmitter



generator, an isolator and a bandpass filter. Each of these devices plays an important part in the transmission process.

Pre-emphasis network: Before the composite video and audio subcarrier signal is modulated onto the microwave carrier it passes through a high-pass filter that reduces the amplitude of the low-frequency component. The effect is to emphasize or increase the relative amplitude of the high-frequency components of the signal. This is done to improve the phase distortion and noise characteristics of the microwave system. The newer microwave equipment uses a 525-line CCIR (International Radio Consultative Committee) video pre-emphasis curve as shown in Figure 3.

Modulator: There are two basic methods of modulating a carrier. One is to vary the amplitude of the carrier, the other is to vary the duration of the cycles of the carrier. This second method is called angle modulation and can be accomplished in two ways. Frequency modulation is accomplished by varying the carrier frequency and phase modulation is accomplished by varying the phase of the carrier. Microwave equipment generally uses frequency modulation. In FM, the frequency deviation (amount of frequency variation either side of the center frequency) of the carrier is proportional to the amplitude and independent of the frequency of the modulating signal. The phase shift of the carrier is proportional to the amplitude and inversely proportional to the frequency of the modulating signal.

Theoretically, the FM signal contains an infinite number of sideband frequencies, but only a few have an effective amplitude. All sidebands that are less than 1 percent of the center-frequency level are considered to be not effective. The bandwidth of an FM waveform is determined by the frequency space between the extreme upper effective sidebands and the extreme lower effective sidebands.

In an FM microwave transmitter, the modulator varies the frequency of the carrier in accordance with the amplitude of the video and subcarrier modulating signals. The modulation index is determined by the amount of deviation. The formula for modulation index is $MI = \Delta F/Fm$; where ΔF is the amount of frequency change in hertz and Fm is the frequency of the modulating signal in hertz.

Frequency generator: The frequencies from 1,000 MHz (1 GHz) to 100,000 MHz (100 GHz) are generally considered to be microwaves. The generation of RF energy at microwave frequencies was made possible by the invention of the tuned-cavity oscillator. A common tuned-cavity oscillator is the reflex klystron used extensively in microwave transmission systems in the past. The state-of-the-art today is the solid-state source, which takes many forms but basically consists of a cavity-controlled fundamental oscillator and a frequency multiplier. To maintain the frequency stability of the fundamental oscillator, it is compared to a reference oscillator in a phase detector and the resulting DC error signal is fed back to the fundamental oscillator as a correction voltage. The reference oscillator operates at a much lower frequency than the fundamental oscillator. The frequency multiplier increases the frequency from the fundamental oscillator to whatever frequency is required for the microwave band in use.

One of the more common failure modes is loss of output power. This is generally associated with the fundamental oscillator. This loss of output power can be brought on by several things. Occasionally, the RF device, being such a high-performance unit with a resulting narrow base-width region and relatively low breakdown voltages, may fail without any external stimulation. However, this does not occur very frequently and is considered of relatively minor importance.

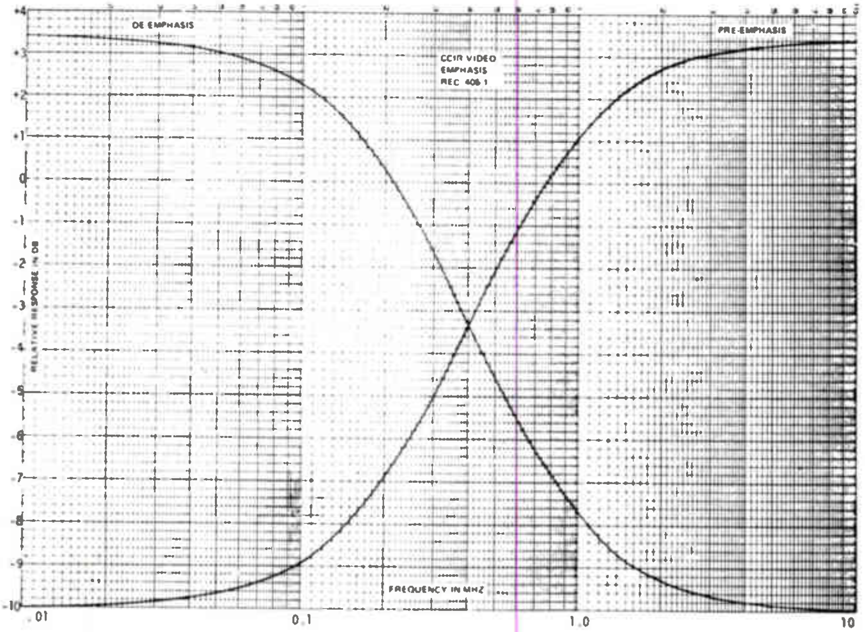
Over-voltage or reverse-voltage also can destroy the oscillator transistor. This failure will generally occur in the base resistor, which will open. This element normally fails at a current lower than the burn-out current of the transistor. Although reverse-voltage can possibly damage the oscillator transistor, this is not a likely occurence. However, reverse-voltage will destroy other components of the source. Repair of the fundamental oscillator circuit cannot be accomplished in the field.

Linearizer: A klystron exhibits a somewhat non-linear frequency versus repeller voltage characteristic. This characteristic can be minimized by putting a tunable mismatch in the klystron's output circuit. This linearizer is tuned to reflect energy of the frequency and phase needed to cause the klystron to deviate in a linear manner. In effect the cavity is pulled a controlled amount as it deviates so the result is linear frequency modulation.

Isolator: This is a magnetic-ferrite device that has nominal 0.5 dB loss in the forward direction and from 20 to 40 dB loss in the reverse direction. It is used to isolate the frequency generator from the bandpass filter and any voltage standing wave ratio (VSWR) problems that may occur.

Bandpass filters: These filters are used to prevent out of band energy from being radi-

Figure 3: Standard CCIR pre-emphasis curve




For converter repairs, we're still light-years ahead.

ated. They also are necessary when branching is done to allow the use of phasors and circulators. A filter consists of one or more waveguide resonators. The two most common type bandpass filters are constructed by inserting either posts or irises in the waveguide to form resonant circuits. These resonators then can be tuned to the desired frequency with a tuning screw.

The waveguide, feedhorn and antenna

At microwave frequencies a hollow, metal tube called a waveguide is used to convey the carrier signal from the transmitter to the antenna. Most waveguide is rectangular in cross-section, but circular and oval waveguide also are used. The longest cross-sectional dimension of the waveguide must be greater than one-half wavelength of the frequency carried. If it is not, the attenuation will be very high. Also, it is not desirable to use waveguide with a dimension more than twice the cutoff frequency, which is approximately three-fourths of a wavelength.

A waveguide can be made to curve or twist gradually and the beam will follow the curve or twist. This allows the waveguide to be routed from the transmitter to the antenna with little difficulty. A probe placed in the waveguide radiates energy, which then flows within the waveguide. Energy can be removed from a waveguide by inserting a probe parallel with the direction of the electric field lines of force. For coupling energy from one waveguide to another a directional coupler is used.

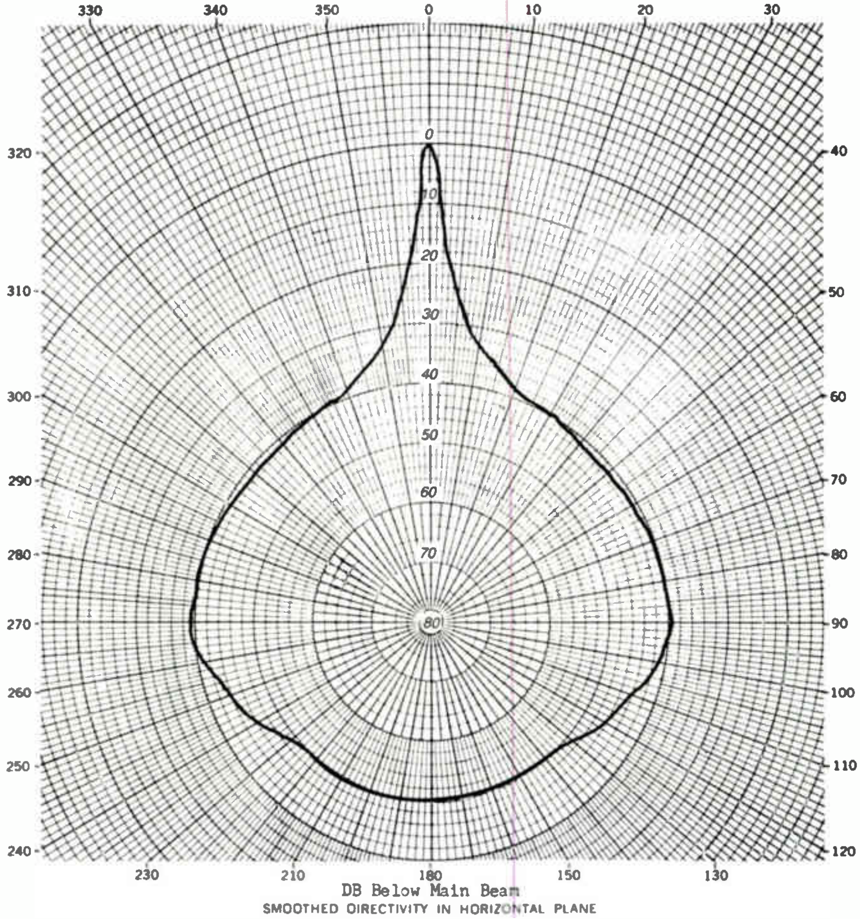
The waveguide has a characteristic impedance of 50 ohms. This is matched to radiate into space by use of a flared horn or feedhorn, which also eliminates reflections back into the waveguide. The feedhorn contains no resonant elements and is usable over a wide frequency band.

When the signal from the feedhorn is directed into a metal parabolic reflector, it is reradiated or reflected from the parabola in a narrow beam. This concentration of the energy represents an enormous power gain. Nearly all the energy is directed into the one narrow beam and sent in the direction where it is to be received. (An antenna that is used to receive microwave signals is no different than the ones used to transmit the signals.)

In the antenna, the maximum energy is directed along the axis of the reflector. The amount of radiated energy decreases as the angle to the left and the right of the axis increases. The angle at which the radiated power equals only 50 percent of the maximum is called the half-power point. The angle between the two half-power points, left and right, is the beamwidth of the antenna (see Figure 4). The beamwidth describes the directivity of the antenna. The antenna design determines the beamwidth and, in general, the larger the antenna diameter the greater the focusing effect and the narrower the beamwidth.

The energy leaving an antenna is in the form of electric (E) and magnetic (H) fields. These fields are at right angles to each other and both are at right angles to the direction of the beam. The radio wave is said to have horizontal polarization when the electric field is in a plane parallel to the earth's surface. Vertical polarization is when the electric field is in a plane perpendicular to the earth's surface.

Figure 4: Plot of antenna beamwidth



Propagation

The electromagnetic energy radiated from a microwave transmit antenna tends to travel in a straight line. When this beam is directed to the receive antenna, which is pointed directly toward the incoming signal, maximum energy will be received. Basically, it is almost that simple. However, there are several factors that affect the path of the signal and the amount of energy received.

The first and most obvious of these factors is the curvature of the earth. When the transmit antenna and the receive antenna are 20 miles apart the curvature of the earth results in a rise of approximately 67 feet between the two locations (see Figure 5). This indicates that each antenna must be raised to 67 feet or more above the ground in order to have a line-of-sight path between the two. This assumes, of course, that the ground is smooth and level, which usually is not the case.

The second factor is refraction or curving of the microwave beam. Since the atmosphere becomes less dense with height, the top of the microwave beam travels slightly faster than the lower portion. This causes a slight downward curving of the beam, which allows it to follow the curvature of the earth to some extent. Disregarding other factors, the effect is as though the radius of the earth were one-third greater. In the 20 miles previously mentioned, the effective rise of the earth would be 50.25 feet, rather than 67 feet.

If the curving of the microwave beam was constant this would be a beneficial phenomenon. However,the curving depends on the refraction index of the atmosphere, which in turn depends on the atmospheric conditions at any given instant. The conditions can sometimes cause an upward curving of the microwave beam.

In addition to this curving of the beam, which is not constant, it is necessary for another reason to have more than line-of-sight clearance between the antennas. If the height of the antennas is gradually decreased, portions of the wavefront will strike the earth. This energy will be reflected much like a rock skipping off the surface of water. Some of this energy will reach the receive antenna, but since the path it followed was longer than the direct path it will arrive later than the energy in the center of the beam. This is equivalent to a shift in phase and

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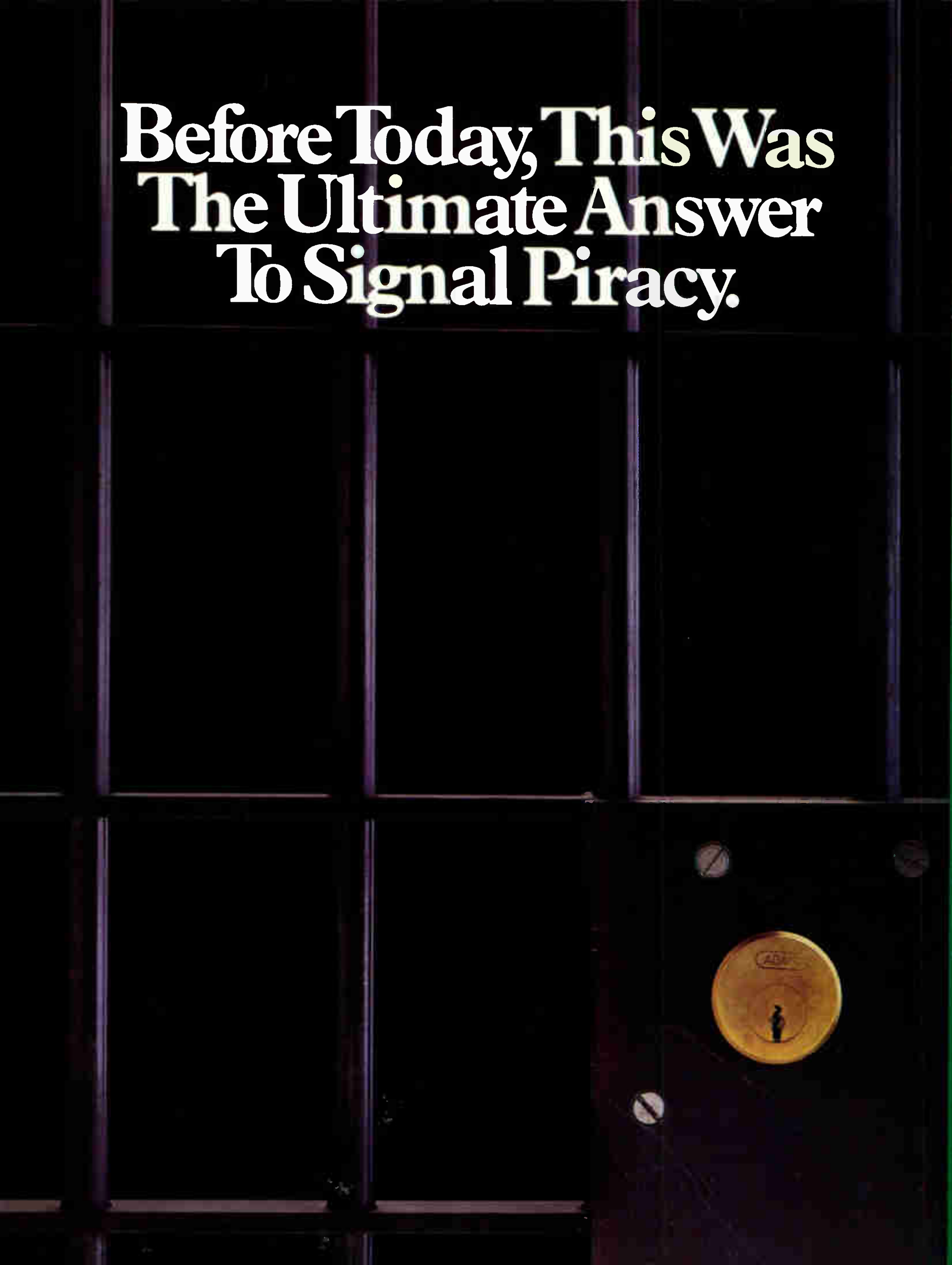
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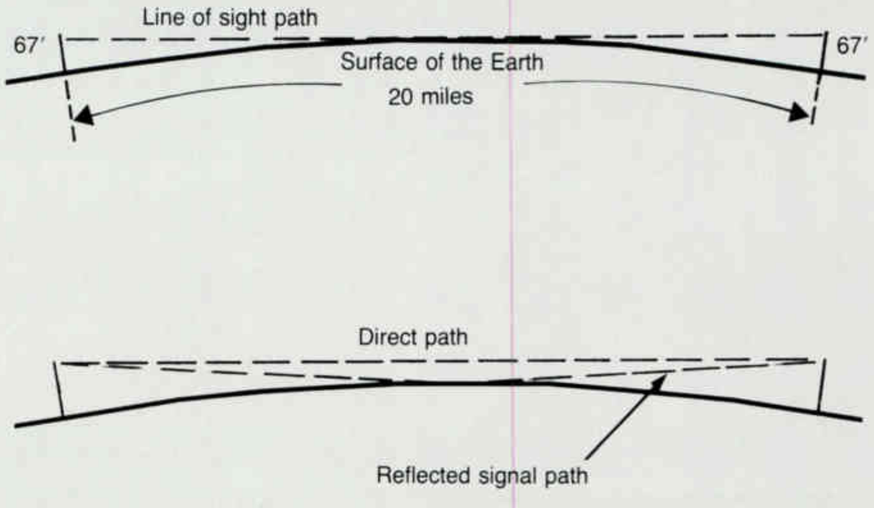
will decrease the signal level at the antenna if the phase shift is near 180° and increase it if the phase shift is near 360°. Distortion also results at all other phase angles.

The surface of the earth is not the only cause of reflections that the microwave beam may encounter. Since the beam spreads out in the form of a narrow cone it is possible for obstacles slightly to one side of the beam path to reflect an out-of-phase signal to the receive antenna. Also, the upper portion of the beam may enter a region of the atmosphere that abnormal conditions have caused to momentarily assume a very small index of refraction. This will bend the beam downward and can cause it to arrive at the receive antenna out of phase with the direct beam. The action of the beam in this manner causes fading due to multiple paths, hence the term “multipath fading.” This kind of fading is usually severe but has a very short duration.

A third factor that can greatly affect the microwave signal-path loss and the amount of energy received is rain. The wavelength at 6 GHz is long enough (50 millimeters) that average rain drops are not large enough to have a great effect. However, at 12 GHz a rain drop one-half inch in diameter is equal to one-half wavelength and can cause severe attenuation. In some areas rain drops of that size are not uncommon. Because of the atmospheric and rainfall effects an adequate fade margin must be provided. This should usually be 30 to 40 dB, i.e., under ideal conditions the received signal sould be 30 to 40 dB higher than the minimum required. The formula for free space loss = 96.6 + 20 log F + 20 log D: where space loss is in dB, F = frequency in GHz and D = distance in miles.

Figure 5: Curvature of the Earth and signal paths



The receiver

Figure 6 is a block diagram of a typical demodulatng microwave receiver. The following will describe its main components and their respective functions.

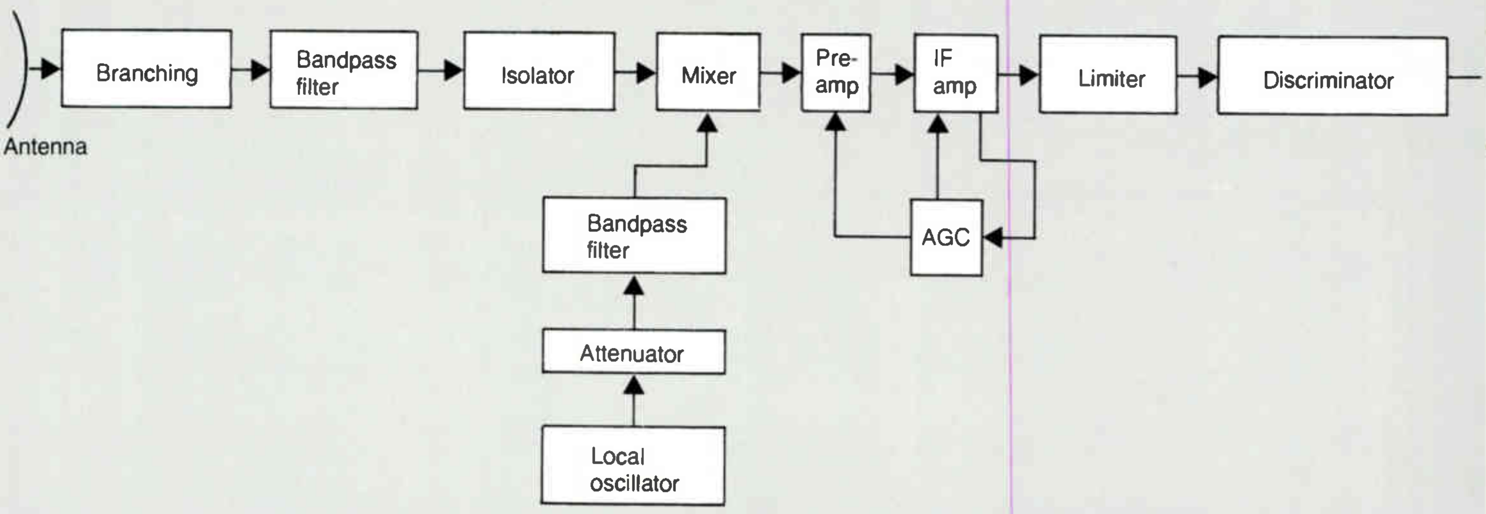
Bandpass filter (preselector): The receiver preselector filter passes the desired microwave energy and rejects unwanted, out-of-band energies. The filter also is necessary to accomplish diplexing of more than one receiver to a common antenna.

Isolator: The load isolator is a ferrite device that prevents the preselector filter and mixer from interacting. Typically isolators have a forward attenuation of 0 15 dB and a reverse attenuation from 20 to 40 dB. The isolator also works in conjunction with the preselector to reduce the level of the local oscillator signal reaching the mainline waveguide.

Mixer: The signal frequency is changed to 70 MHz in the mixer circuit by heterodyning. An unmodulated carrier signal that is produced by the local oscillator in the receiver has a frequency 70 MHz different than the incoming microwave carrier signal, and is usually on the high side. Among the products of this kind of mixing are signals that have the two original frequencies, the sum of the two original frequencies, and the difference between the two original frequencies. Only the 70 MHz difference frequency is used from this point on in the microwave receiver. This frequency can be easily selected by filter and amplifier bandwidth techniques. It should be noted that this heterodyning or mixing action does not affect deviation (frequency swing). Therefore, the deviation of the incoming carrier now becomes the deviation of the 70 MHz intermediate frequency.

Local oscillator: The local oscillator is tuned to a frequency either above or below the received carrier by an amount equal to the intermediate frequency (IF). In a microwave receiver the local oscillator is used to drive the mixer into the non-linear or mixing area of its operating curve. The drive level is adjustable so that best possible mixer operating parameters can be achieved. This includes opti-

Figure 6: Block diagram of typical demodulative microwave receiver



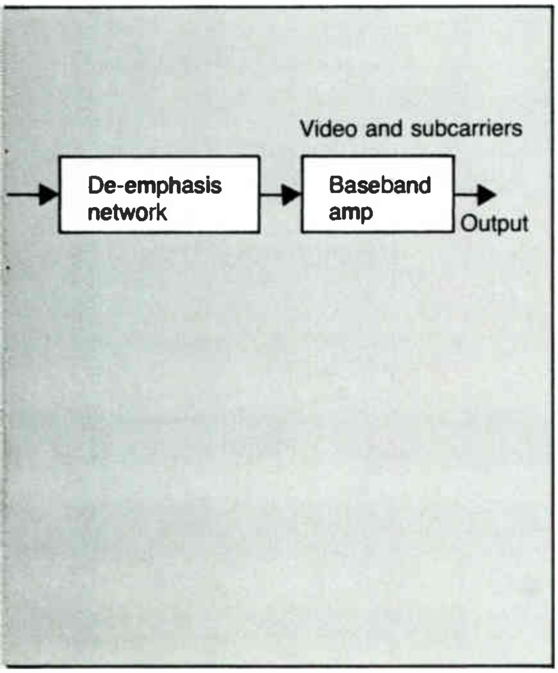
mum noise figure, minimum conversion loss, linear mixing, rejection of spurious signals, etc.

Preamplifier: The preamplifier and mixer are the most important circuits with regard to receiver noise figure. Therefore the preamplifier is designed to have a low noise front end. Average gain is 30 to 40 dB. The preamplifier also serves as an impedance match between the mixer and IF.

IF amplifier: The IF amplifier has multiple functions. The first, of course, is to greatly increase the signal strength. The second is to provide additional rejection of all signals outside the bandpass of the one microwave channel desired. The third function is signal amplitude regulation. The microwave carrier signal, and consequently the 70 MHz IF signal, are frequency modulated with the video and audio information that is desired. The receiver should have enough gain to use AGC, limiting, and to drive a discriminator. The IF section (preamplifier and IF) accomplishes these tasks. A filter/equalizer, IF amplifier with AGC, and a limiter are the three main components normally referred to as the IF. A typical IF has 75 dB of gain and a flat bandwidth of 30 MHz. Following is a brief description of the three main IF components.

1) IF filter/equalizer: An IF filter (shaping) is utilized for selectivity. An equalizer is used to compensate for the relative delay that is inherent in any band-limited system. An attempt is made to minimize the relative delay (envelope delay) that occurs both at RF and IF.

2) Automatic gain control: AGC serves several important functions in an FM receiver. First, it tries to keep the signal input to the limiter constant thereby aiding the limiting process. AGC is applied to the IF amplifier stages to prevent overload. Changes of bandpass and linearity are minimized by operating an amplifier at a fixed output level. One method of AGC is to simply rectify the IF, then compare this voltage to an AGC reference and use the difference voltage to vary pin-diode attenuators to keep the IF amplitude constant.



A typical microwave antenna (note the arrow pointing to the feedhorn).

3) Limiter: The basic requirements of the limiter are to remove all forms of amplitude variations from the received signal and supply an output that is independent of both amplitude variations and rate of change of amplitude variations. The ideal limiter should be able to take an input signal that is varying in both amplitude and frequency and provide an output of constant amplitude that retains the frequency deviations. Most receivers in use today use diode or transistor limiters.

Discriminator: The purpose of the discriminator is to convert the carrier frequency deviation, in a linear manner, into baseband frequencies. Normally the discriminator used in microwave applications is a Foster-Seely type. A Foster-Seely discriminator converts the carrier frequency deviation into AM and then detects the AM producing a baseband output.

De-emphasis network: The de-emphasis network is a low-pass filter that has a curve exactly opposite of the pre-emphasis. In other words, the pre-emphasis and de-emphasis when connected back to back should be a flat loss pad of the pre-emphasis value.

Automatic frequency control: The local oscillator must stay locked to the incoming carrier so that the IF frequency is maintained. This is accomplished by amplifying the discriminator DC and applying it to the local oscillator repeller via AFC circuits. Adjustable clamp circuits establish the minimum and maximum values of correction voltage that can be applied to the local oscillator repeller. This assures that the receiver recognizes signals only within a specified frequency range.

Baseband amplifier: An amplifier used to amplify the received information to a useable level and provide a means to couple this signal to a terminal device.

Typical heterodyne microwave

A typical IF heterodyne repeater uses basically the same receiver as a remodulating repeater. The difference is that the IF is heterodyned up to the transmit frequency, then amplified to obtain the proper transmit power. This means that the information signal is never demodulated to baseband. Consequently the information signal does not suffer the inherent distortion of the demodulating/remodulating process. The following is a brief description of the heterodyne upconverter and power amplifier.

Seventy MHz insert oscillator: The 70 MHz insert oscillator supplies a 70 MHz signal to the upconverter in the event of a path failure or receiver failure. This clears the system of noise and allows the maintenance communications circuit, monitoring information, etc., to continue to be transmitted.

Seventy MHz amplifier: This device amplifies the IF signal from the receiver to a level that can be used to mix with the upconverter local oscillator (pump) to generate the transmit frequency.

Mixer: A frequency changer used to heterodyne the 70 MHz IF up to the outgoing transmit frequency.

Local oscillator or transmitter pump: An oscillator that is displaced either above or below the transmit frequency by 70 MHz. This oscillator is used to upconvert one or more subcarriers that are modulated with the monitoring, maintenance communications, control, switching, etc., signals.

Insert amplifier: This unit is utilized as an interface and amplifier for the various signals that modulate the upconverter local oscillator.

Power amplifier: The power amplifier amplifies the upconverted signal to the licensed outgoing power. It should be a linear power amplifier with good bandwidth, linearity, noise figure, etc.

Knowledge breeds success

The various pieces of equipment and devices used in a microwave system are somewhat different than the CATV headend processing equipment with which you are familiar. However, the principles can be readily understood if the information is available. Here, we have examined the basics of microwave that are all too often lacking in the present-day equipment manuals. For detailed information, circuit descriptions, etc., related to a specific piece of microwave equipment, consult the manufacturer's manual.

Most of the "microwave" problems that are experienced in the field are not actually with the microwave portion of the system, but are in fact the traditional level, mechanical and misadjustment problems that plague any communications system. Careful attention to the proper installation, powering, grounding and mechanical integrity will eliminate the bulk of these problems. The proper use and a thorough understanding of test equipment will prevent simple errors like double terminations, incorrect level settings, false frequency readings, etc. Like any other transportation system, a thorough, routine preventative maintenance program (including well-kept logs) executed by technicians that are well-founded in basic maintenance and troubleshooting procedures will prevent virtually all but the very unusual problems.

Denver-based National Cable Television Institute was founded in 1968. It offers a comprehensive on-the-job, self-study training program for CATV technicians and installers. For more information, contact Byron Leech, (303) 761-8554.

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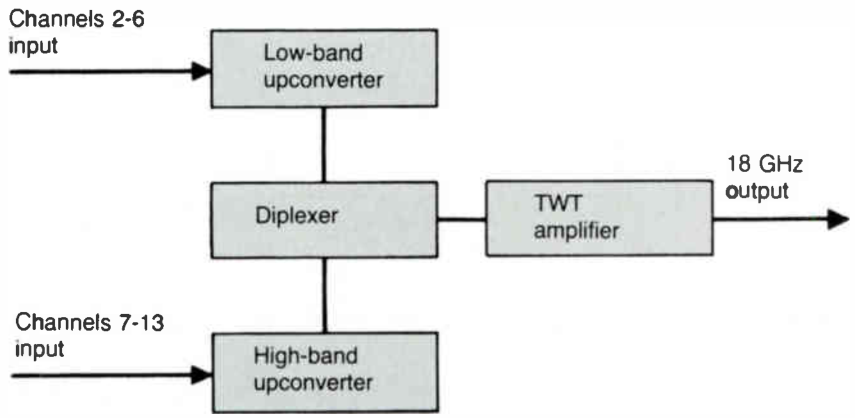
Figure 1: Block diagram of experimental AML transmitter (circa 1968)



> *'To improve the range capability of the block upconversion type transmitter, one can trade off (composite triple beat) for power output'*

Trade-offs in multichannel microwave system design

The recent development of the Hughes AML microwave line extender block upconversion type multichannel transmitter provides additional options for the CATV system designer. To optimize the overall system, it is necessary to understand both the capabilities and limitations of this new type of AML transmitter. Power output may be traded off against composite triple beat (CTB). Secondarily, transmitter gain and noise need be considered with regard to desired triple beat performance. The impact of the microwave subsystem trade-offs on the overall CATV system also must be taken into consideration since the block upconversion type microwave system is not nearly as "transparent" as the standard AML system. When these factors are properly evaluated, the all solid-state, outdoor-mounted AML line extender transmitter can provide attractive solutions to various CATV system design problems.

By Dr. Thomas M. Straus
Chief Scientist, Hughes Aircraft Co., Microwave Products Division

Utilization of AML microwave within CATV systems has for many years been an established means of providing the local distribution of a large number of television signals from a central point to a multiplicity of microwave receiver hubs from which the signals are transmitted by cable to the individual subscribers. In such systems, the primary reasons for utilization of the microwave is to achieve better signal quality than would be possible with a long trunk amplifier cascade and to derive the economic benefits associated with the centralization of the headend processing functions. Recent developments have made possible the extension of these benefits to smaller systems and subsystems where utilization of traditional AML transmitters would be uneconomical due to the limited number of subscribers serviced through the microwave path.

The standard AML transmitter separately converts each VHF TV signal to microwave and then provides a passive microwave combining network to minimize distortion and maximize power output. This design is an outgrowth of the severe limitations experienced with the experimental block upconversion 18 GHz AML in the late 1960s. With the recent advent of medium-power microwave GaAs FET technology, it has been possible to return to the simpler block upconversion techniques while achieving modest output power and acceptable intermodulation distortion within an outdoor, all solid-state transmitter unit. Applications of such a "microwave line extender" transmitter to CATV system design include the surmounting of a natural barrier such as river, the repeating of a microwave path where direct line of sight between the central transmitter and the ultimate receive point is unavailable, the temporary restoration of service during planned outage or rebuild, and the feeding of the microwave signal to small isolated pockets of potential subscribers who cannot be economically serviced by alternative means.

AML transmitter comparisons

The forerunner of the now familiar CARS band AML microwave system was an experimental 18 GHz AML system, which operated

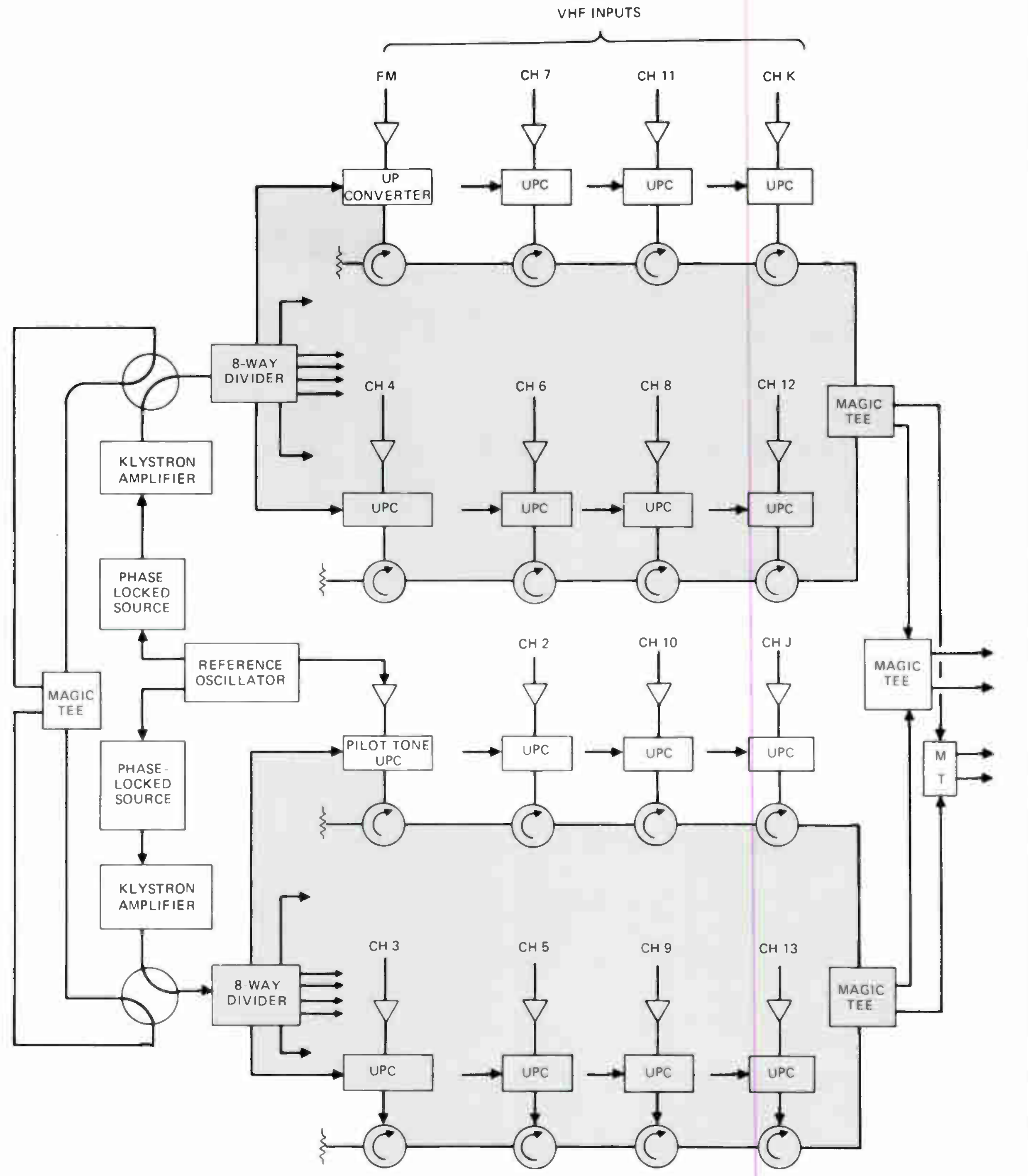
Table 1: MTX-132 AML transmitter performance summary

No. of channels	No. of racks	No. of outputs	Power output* (dBm)
8	1	2	+16
16	2	4	+13
24	3	4	+12
32	4	8	+10
40	5	8	+9
48	6	16	+7
56	7	16	+7
64	8	16	+7

*For on-channel and adjacent-channel beats down 58 dB with audio −17 dB and color −20 dB below video.

within the Teleprompter Manhattan CATV system in the late 1960s.[1] This 12-channel system utilized separate low- and high-band block upconverters, which in turn fed a high-power traveling wave tube amplifier at the transmitter output. A block diagram of this transmitter[1] is shown in Figure 1. The high-power amplifier had a saturated output capability of 250 watts and had to be liquid cooled to prevent it from overheating. Despite this high saturation power capability, the amplifier had to be backed off to a mere 50 mw (17 dBm) per channel output in order to obtain the desired synchronous cross-modulation performance in this 12-channel system. A consequence of

Figure 2: Block diagram of two-bay MTX-132 channelized transmitter



this large backoff was that the carrier-to-noise ratio (C/N) was limited *at the transmitter* to a maximum of 45 dB. A more serious drawback was the maintainability difficulties of the freon cooled TWT. Fortunately, the 1969 FCC decision[3] established the CATV local distribution service and allocating it into the 12 GHz CARS band necessitated a complete redesign of the microwave system.

With the bittersweet experience of the early 18 GHz AML transmitter in mind, the CARS band AML transmitter design introduced at the 1971 NCTA convention was based on a channelized high-level upconverter approach.[4] A block diagram of the original two-bay MTX-132 transmitter, which soon became the industry workhorse, is shown in Figure 2. The individual VHF input signals are separately processed and provided to each upconverter input. A 40-watt klystron feeds up to eight separate parametric upconverters (a fail-soft redundancy feature allows the klystron output to be divided among 16 upconverters) with the required high-level microwave "pump" power. Each upconverter incorporates a high Q bandpass filter to select the desired upper sideband mixing product at the upconverter output. The filter performs two additional key functions: it provides approximately 14 dB attenuation of the undesired $2f_{video} - f_{audio}$ third order mixing product, which falls in the next adjacent lower channel, and it also allows circulator multiplexing of the various channels when channel separation is greater than 10 MHz. "Magic Tees" are then utilized to multiplex adjacent channel circulator strings.

Table 2: OLE-111 AML transmitter power output—"transparent" CTB operation*

No. of channels	Power output (dBm)
12	-3
24	-6
35	-8
54	-10
60	-11

*Transparent operation defined as 65 dB composite triple beat measured with CW carriers. Power output would be 4 to 6 dB greater if specification were given for modulated carriers.

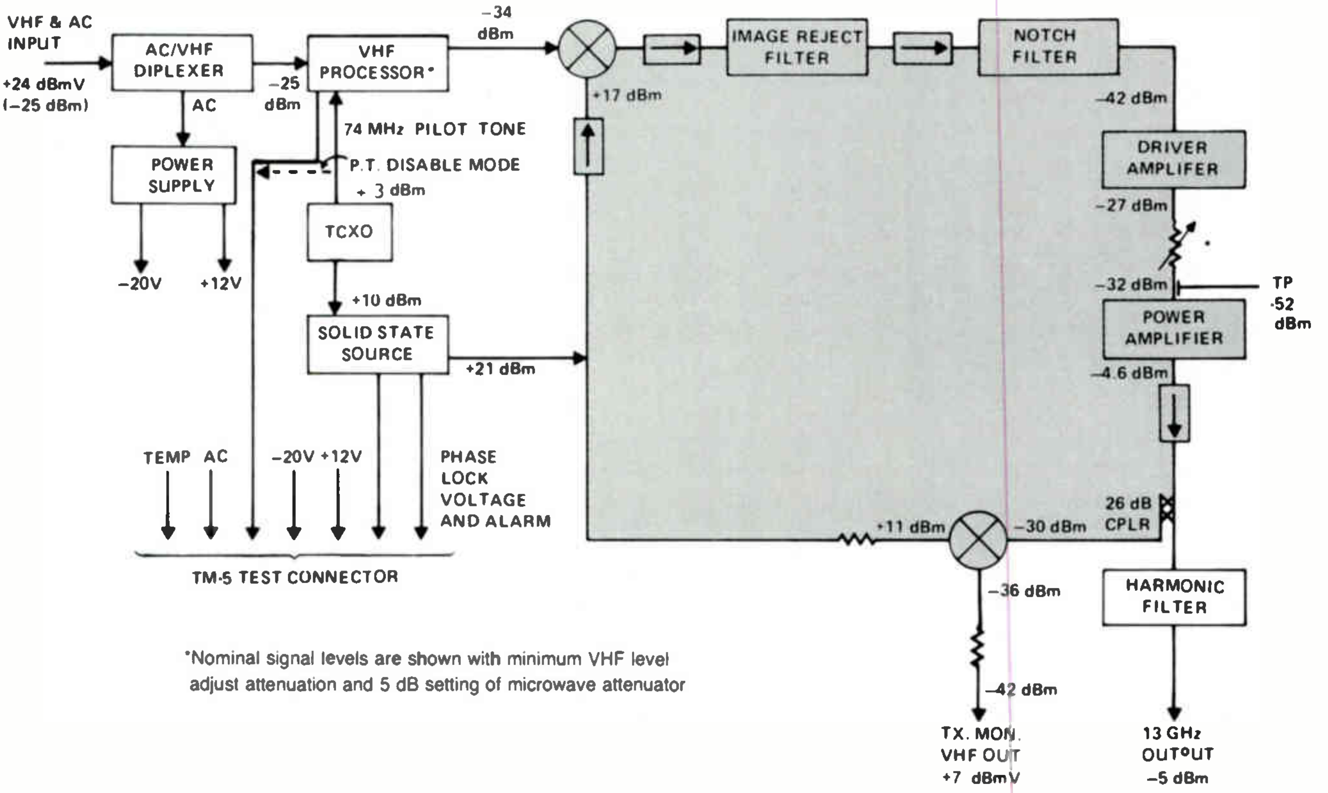
As a consequence of the 3 dB hybrid combining, the number of outputs is doubled for each layer of Magic Tee combining. Thus in the 16-channel, two-bay configuration shown, there are four outputs, each carrying all 16 channels. This basic block diagram has remained unchanged as the required number of channels has increased over the years. With four bays, up to 32 channels can be accommodated and eight outputs are provided. The eight-bay configuration offers 64-channel capability at each of 16 outputs.

Table 1 summarizes the MTX-132 transmitter performance capability. The power output is limited by third order distortion in the upconverter, which creates the undesired $2f_v - f_a$ beat falling in the lower adjacent channel and the $f_v \pm (f_a - f_c)$ beats that fall in-channel. The specification stipulates that these beats are at least 58 dB down when the audio carrier is 17 dB down and the color subcarrier is 20 dB below the video. Since channel combination is strictly passive, no interchannel beat products are created in the AML MTX-132 transmitter. On the other hand, in both the AML receiver and in the cable system trunk and distribution amplifiers, video/audio and video/audio/color beats are essentially negligible because these broadband units must be designed to handle the much higher level multichannel video beats.

Thus, in designing the overall CATV system, there is nothing to trade off with respect to the transmitter output. The only microwave system trade-off arises from the AML receiver, which is specified to provide an 81 dB, 54-channel composite triple beat for a C/N of 53 dB. By changing the receiver AGC setpoint, the normal two-for-one trade between C/N and carrier-to-composite triple beat ratio (C/CTB) can be made.

As the number of channels gets larger, both the size and cost of the MTX-132 transmitter necessarily increases. The number of available outputs also may be well in excess of the number of receive sites that are to be imple-

Figure 3: AML OLE-111 block diagram



*Nominal signal levels are shown with minimum VHF level adjust attenuation and 5 dB setting of microwave attenuator

mented. Clearly, for applications involving only one or two outputs and where cost is all important, the channelized transmitter approach for a very large number of channels is no longer an optimum solution. What if one returns to the simpler block upconversion approach? Fortunately, because of recent developments in medium-power GaAs FETs, output levels that are usable for moderate path length microwave applications can be obtained provided antenna waveguide run losses are kept to a minimum.

Table 2 summarizes the OLE-111 AML microwave line extender output for a composite triple beat specification of 65 dB. Comparing this to Table 1, one sees a difference of up to 18 dB between the OLE-111 single output and any one of the multiple outputs from the MTX-132. Even if one were to allow a 4 dB waveguide loss advantage for the outdoor-mountable OLE-111 transmitter, the power difference is still a husky 14 dB. Furthermore, a 65 dB composite triple beat might appear to eat substantially into the NCTA-recommended[5] CATV system carrier wave (CW) CTB goal of 53 dB. Fortunately, this is not the case since power addition of the microwave FET amplifier generated CTB, rather than voltage addition with the CTB generated in the remainder of the cable system, can be anticipated. More about this later. If, then, one accepts that power addition will apply, the OLE-111 would contribute only ¼ dB to the overall system CTB and can be considered as essentially transparent, just like the MTX-132 transmitter. Nevertheless, the block upconverter type OLE-111 transmitter is clearly not even in the same performance ballpark as the channelized MTX-132 transmitter.

OLE-111 transmitter description

The previous related performance limitations exist despite the fact that the OLE-111 transmitter utilizes a state-of-the-art 2-watt FET power amplifier. As shown in Figure 3, this output stage is preceded by a driver amplifier. Just as the power amplifier determines the transmitter CTB, the low-noise driver amplifier in conjunction with the manually adjustable microwave gain determines the transmitter output noise level. The broadband microwave signal is generated in the mixer, which combines the input VHF with a high-level local oscillator. The upper sideband is selected by the image reject filter while the notch filter provides additional rejection of the local oscillator leakage. All of the microwave components benefit from the tightly controlled temperature environment provided by the field-proven (in the AML receiver) gravity gradient freon thermal control system. The constant temperature keeps the amplifier gains, and hence both output power and CTB constant. The temperature control also keeps the notch filter from detuning, thereby ensuring compliance with the FCC spurious emission requirements throughout the full −40 F to +120 F outdoor temperature range.

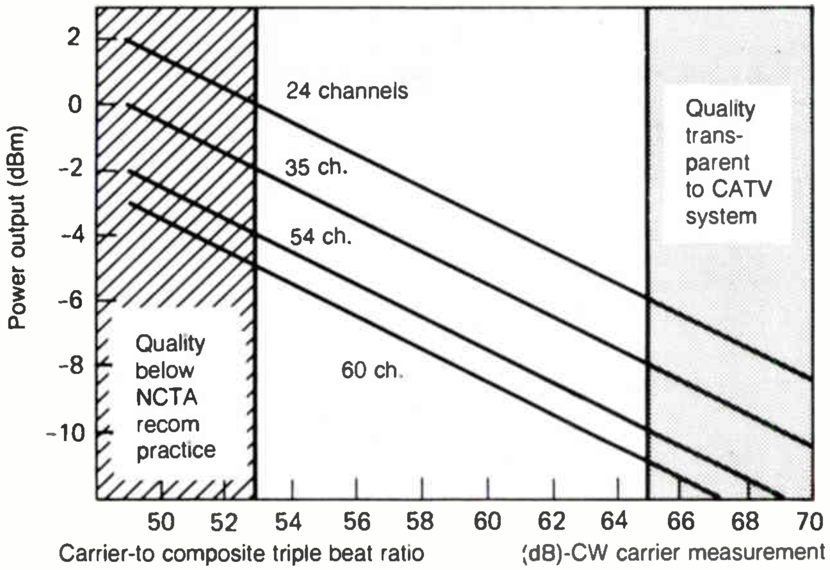
The VHF input sections of the AML microwave line extender consist of totally passive components, which provide for insertion of an internally generated 74 MHz pilot signal that is required when the AML phase-lock receiver is utilized in the microwave link. Independent VHF level adjust attenuators are provided to set both signal and pilot tone to the desired microwave output levels. A built-in calibrated transmit monitor provides a convenient test point at VHF frequency that can be used to check the transmitter power output external to the transmitter enclosure. A multipin test connector also is brought to the outside of the transmitter to enable routine maintenance monitoring of various voltages just as in the familiar outdoor AML receiver. However, a different test connector, which also allows monitoring of the temperature-controlled crystal oscillator (TCXO) frequency, is utilized. This facilitates the once-a-year frequency measurement mandated by the FCC for microwave transmitters.

The OLE-111 transmitter is cable powered from 30 to 60 volts. A ferroresonant transformer and DC regulators convert this input to the desired internal operating voltages. The AC/VHF diplexer, which separates the input AC and VHF, is identical to that used in the outdoor AML receiver, as also is the transmitter enclosure.

OLE-111 performance trade-offs

If the OLE-111 were to be operated at the

Figure 4: Two-for-one trade-off of C/CTB for power output in OLE-111 block upconversion transmitter

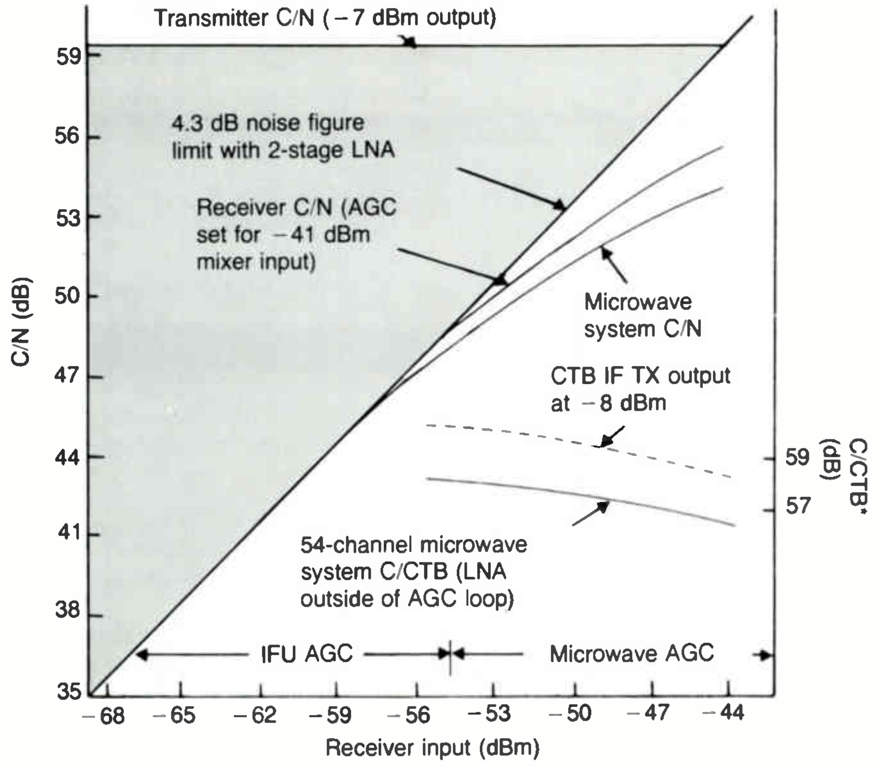


power levels summarized in Table 2, the microwave path length would be severely restricted, particularly for a large number of channels. For instance, using 10-foot antennas, the receiver input for a 54-channel application at a range of five miles is barely -47 dBm so that a standard 53 dB C/N cannot be maintained. However, since the path is short, microwave system availability to the commonly accepted 35 dB C/N level would still be excellent for average rainfall areas.

To improve the range of capability of the block upconversion type transmitter, one can trade off CTB for power output. Just as with CATV amplifiers, a normal two-for-one trade-off exists. This is illustrated by Figure 4. Note that all CTB performances are specified with CW carriers just as for CATV amplifiers. If the specification were in terms of modulated carriers, either the CTB would appear to be an 8 to 12 dB better number, or the power output would be 4 to 6 dB higher[5,6,7] but the actual transmitter performance would clearly not be thereby improved. In any case, increasing the transmitter power output will mean that it is no longer "transparent" if the 53 dB system CW CTB is required.

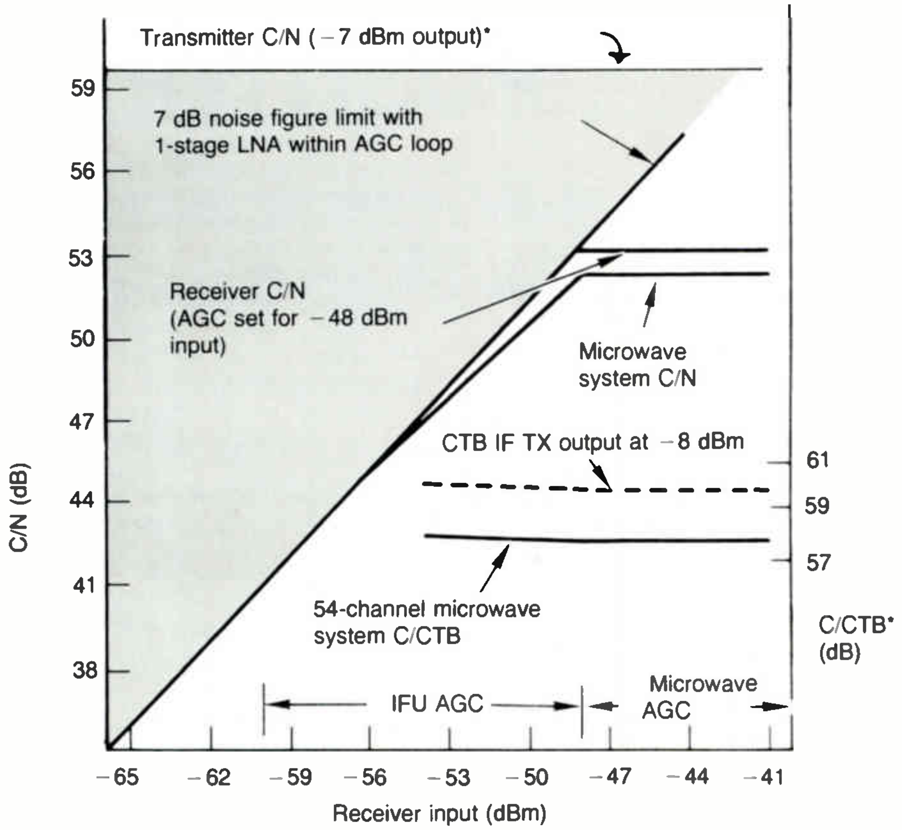
A second performance trade-off involves transmitter gain and noise output. The maximum transmitter gain is specified to be a minimum of 20 dB. For instance, if -10 dBm output is desired, a -30 dBm (+19 dBmV) input will guarantee that this output can be obtained. However, with maximum microwave gain the noise output would typically be -60.5 dBm in a 4 MHz bandwidth and thus the C/N at the transmitter would be 50.5 dB. By setting the microwave interstage attenuator to 8 dB, the noise output is reduced to -66.5 dBm (noise from the power amplifier now contributes non-negligibly to the total noise output) and the transmitter C/N is improved to 56.5 dB for the same -10 dBm output. The VHF input may now have to be +27 dBmV to ensure this output. In either case, the transmitter noise power adds to the receiver noise as shown in Figure 5. The microwave system C/N is least affected by transmitter noise during deep

Figure 5: Microwave OLE-111 system C/N and C/CTB vs. receiver input (path fade)



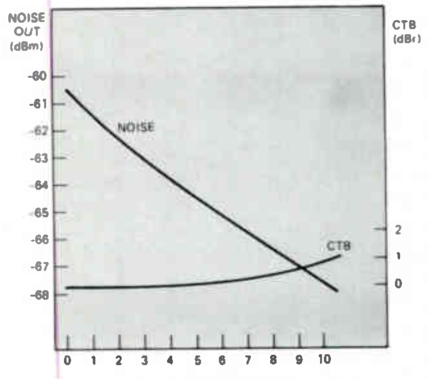
*Microwave interstage attenuator set at 8 dB

a) Weak signal configuration



b) Short path strong signal configuration

Figure 6: Noise and CTB vs. microwave gain (RF attenuator) at fixed output



*O dBr reference provided by Figure 4

fades since the transmitter noise is attenuated along with the signal.

As the microwave gain is decreased and the output maintained constant, the contribution of the mixer and the driver amplifier to CTB becomes evident as shown in Figure 6. The interesting phenomenon illustrated by this performance is that the curve is in almost perfect agreement with a calculation of CTB based on power addition. It has been assumed that the mixer, being an essentially different type of device than the FET amplifiers, would power add its CTB contribution. But if the FET driver CTB had voltage added to the FET power amplifier CTB as expected, the transmitter CTB degradation at 10 dB interstage attenuator setting would have been a readily measurable 3.2 dB instead of 1.2 dB. A possible explanation is that the relative phase of the third order distortion products is randomly different when created in the power amplifier as compared to the mixer and driver amplifier combination. In any case, since CATV system VHF amplifiers are substantially different from microwave FET amplifiers, a realistic approach to system design should assume power addition of the CTB created at microwave to the CTB created at VHF. A further verification of this assumption has been provided by a laboratory experiment in which the CTB of the microwave line extender was observed to power add, rather than voltage add, to the CTB of the AML receiver.

System applications

The microwave line extender may be used in a variety of applications involving different types of situations. One such recent application, which typifies the surmounting of natural obstacles, was for a 6.6-mile path across Monterey Bay. The system carries 35 channels and can provide very high-quality pictures because the CATV trunk cascade is only three amplifiers long as shown in Figure 7.

A second type of application is one involving repeatering of a microwave signal where the original AML transmitter does not have a direct


10
1979
1980
1981
1982
1983
1984

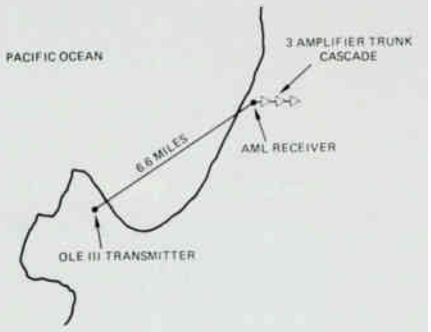


Figure 7: OLE-111 application across Monterey Bay

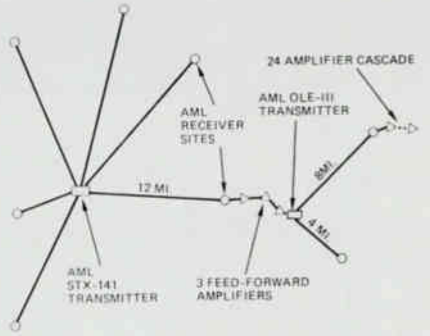


Figure 8: OLE-111 microwave repeater application in Oklahoma

line of sight to the ultimate receive point. An example is provided by a system in central Oklahoma. One of the receiver sites of a STX-141 microwave network feeds three feed-forward trunk amplifiers carrying 21 channels. At this point, the cable is connected to the AML OLE-111 input. The microwave line extender output is split by a 6 dB coupler, which feeds paths of eight and four miles. As shown in Figure 8, at the receive point of the eight-mile path, the signals feed into a trunk amplifier cascade that is 24 amplifiers deep.

A third type of application involves the utilization of the OLE-111 as a frequency agile transmitter providing an emergency backup for a large channelized AML transmitter. In a not yet installed major urban application, the microwave line extender provides backup for any one of 48 STX-141 channels being fed to four different receive sites. In single-channel applications, the third order intercept point of the OLE-111 allows an output of +18 dBm while maintaining a 58 dB $2f_v - f_a$ intermodulation ratio. Unlike the situation that prevails with channelized transmitters, this intermodulation product cannot be suppressed with a filter in the broadband OLE-111. For the STX-141 backup application, the +18 dBm output is somewhat mismatched to the +23 dBm available from the STX-141 at this level of multiplex combining. A more optimum OLE-111 operating level for this case is +20 dBm, which will result in 57 dB carrier-to-interference ratio (C/I) in the channel just below that which is temporarily assigned to the OLE-111. Intermodulation in the OLE-111 channel resulting from products generated by the adjacent STX-141 channels will be better than 55 dB. The OLE-111 output capability is generally better matched to the MTX-132 channel module than to the high-power STX-141. Figure 9 shows how the OLE-111 might be multiplexed into the 54-channel MTX-132 transmitter. Note that if the OLE-111 were to share a circulator combining string with other channel modules, it could neither provide backup to any such channels nor to the next adjacent frequency channels.

How far will it go?

A question often asked about the OLE-111 is: How far will it go? The answer, as we have seen, depends on a number of factors. The most important of these factors includes the number of channels and the signal quality expected at the end of the microwave link. This, in turn, will depend on the performance capability of the cable plant and on the required "last subscriber" picture quality. The largest acceptable antenna size also will play a key part in resolving the question. Once the major parameters are determined, the system can be optimized by trading power for CTB at the transmitter. If sufficient VHF input is available, microwave gain is reduced for best transmitter C/N. Selection of the receiver configuration usually dictates an LNA outside of the AGC loop for lowest possible noise figure. The receiver AGC threshold is then selected for further system optimization. Conservative CTB calculations are based on voltage addition of contributing VHF elements, including the AML receiver's mixer amplifier followed by power addition to the voltage-added microwave distortion of the OLE-111 and the LNA preceding the receiver.

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Reprinted from the "1985 NCTA Technical Papers" handbook.

Figure 9: OLE-111 transmitter as frequency agile backup to 54-channel MTX-132 transmitter

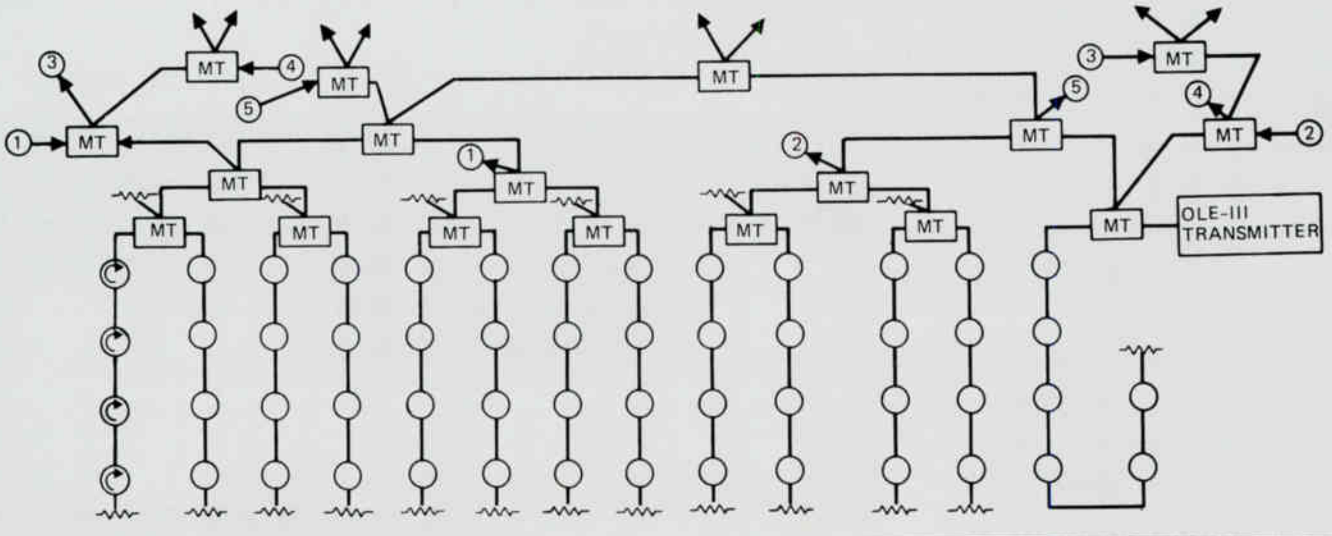
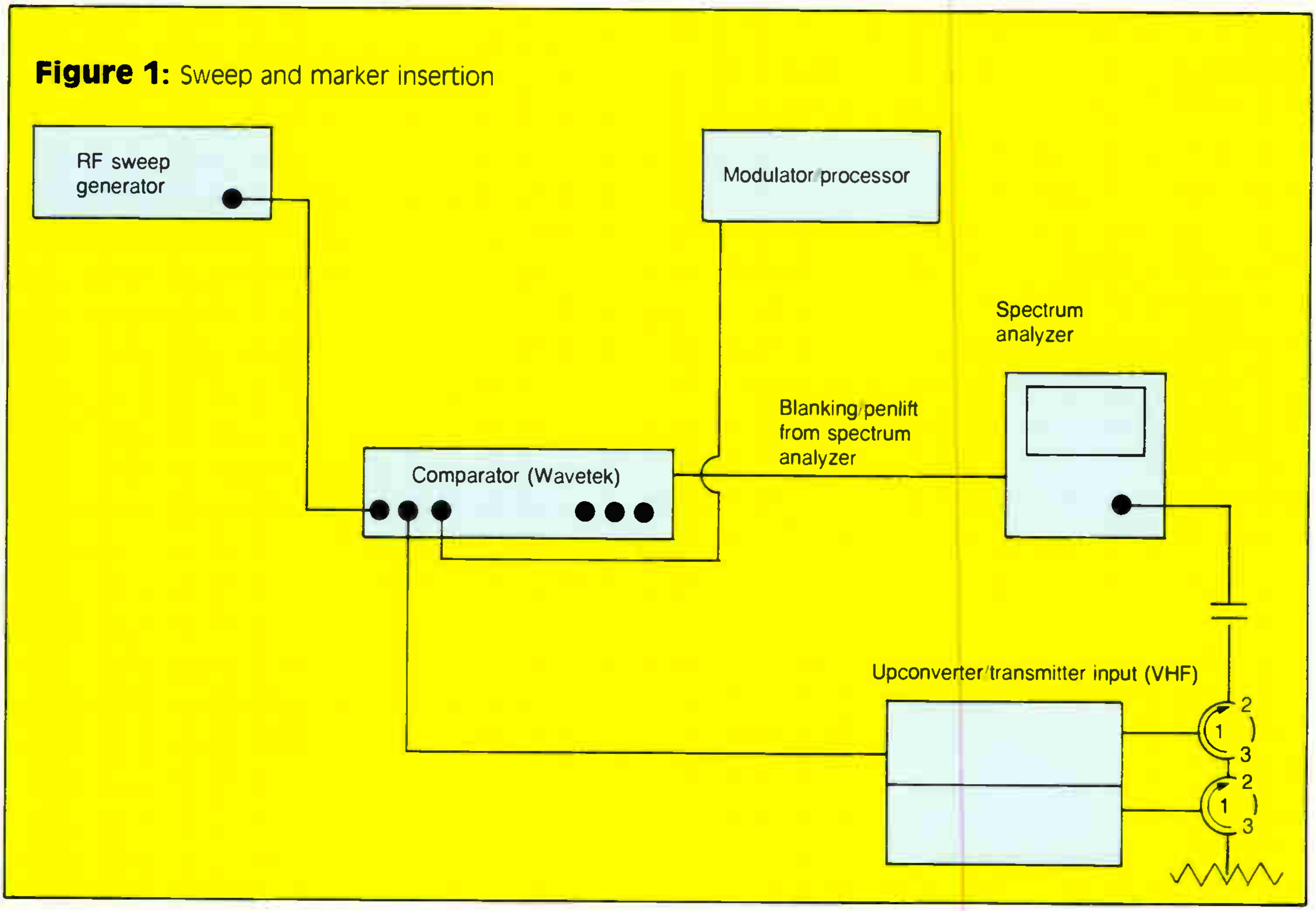


Figure 1: Sweep and marker insertion



AML microwave system analysis

By Terry Snyder
District Field Engineer, Group W Cable

For the many cable operators who depend on amplitude modulated link (AML) microwave for delivery of signals to their customers, maintaining the microwave system quality is of major importance.

All of the test procedures presented here are for determining individual upconverter response, then total system response. All swept responses are in the frequency domain and, therefore, require some test equipment that may not be readily available or affordable to purchase. However, all of the equipment can be leased or rented on a short-term basis.

Since these test configurations utilize the actual channel outputs as markers, the frequency of each VHF channel should be verified; any corrections need to be made before sweeping the AML upconverters; and all sweep generators should be checked for flatness and proper power output levels before being used. Likewise, all frequency counters must be calibrated with traceability to the National Bureau of Standards; power meters should be calibrated and proper operation verified; and lastly, all serial numbers, model numbers, and calibration dates of the test equipment should be recorded in the station logs.

On the low-power AML, one of the first steps is to remove the detector on the cross guide coupler; and, if necessary, (using a power meter) adjust the klystron power output to the correct power level.

On both high- and low-power systems, all levels should be set to the upconverters prior to sweeping the AML. Once the levels have been verified, the next step is to remove all VHF carriers except the pilot tone and adjust the power out (at 12 GHz), according to the manufacturer's procedure.

Upconverter sweeping

Figure 1 shows a means of sweep testing the upconverter for flatness. The advantage of

Figure 2: Upconverter response—before and after adjustment

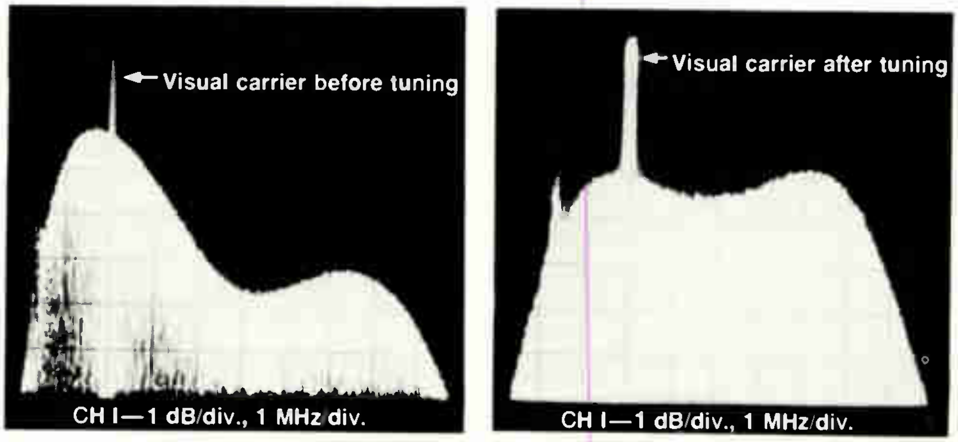


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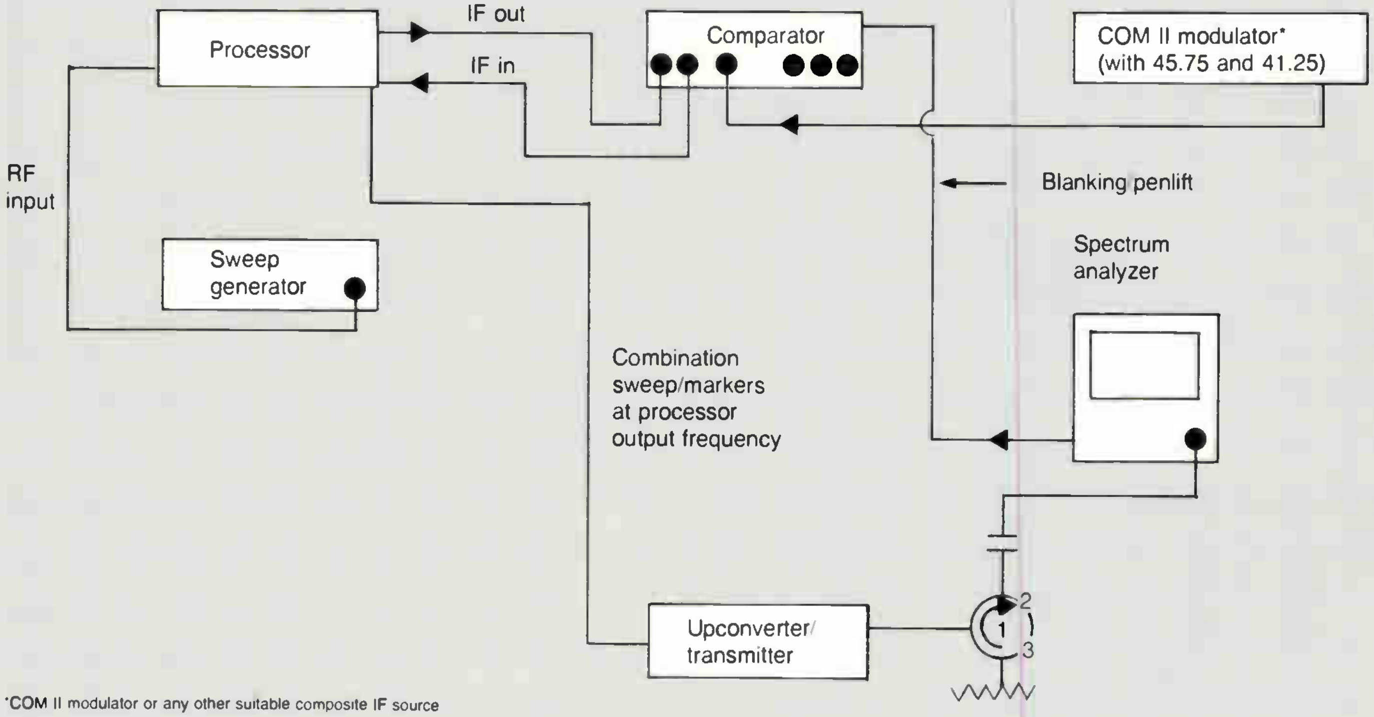
Figure 3: Combination sweeping of processor and upconverter simultaneously



*COM II modulator or any other suitable composite IF source

using this particular test configuration is that channel markers (visual and aural carriers) are present along with the swept response. It also shows the filter response with the adjacent channels present.

The comparator triggering ramp is supplied by the spectrum analyzer to switch the comparator at an independent rate from the sweep generator. This results in a fast switching rate for the comparator and a slow sweep time, producing a more defined response.

Our particular tests were conducted using a spectrum analyzer capable of viewing 12 GHz directly. However, providing the VHF recovery system has been swept for flatness, the VHF test point can be used for viewing with a spectrum analyzer. For any meaningful test results, the spectrum analyzer *must* have storage capability.

After obtaining a response, switch the spectrum analyzer to 1 MHz per division and 1 or 2 dB per division. Bear in mind the flatness of in-channel response must include from .5 MHz below the visual carrier to about 5 MHz above it in order to include the aural carrier. If the displayed response indicates that tuning is required, it can be done using the same test configuration, by simply speeding up the sweep rate of the generator a little. A typical response is 1 dB or less (see Figure 2).

In the low-power system, there is one channel filter involved. In the high-power version, there are two channel filters involved, plus the bandpass and match adjustments on the klystron. The tuning of all filters requires patience.

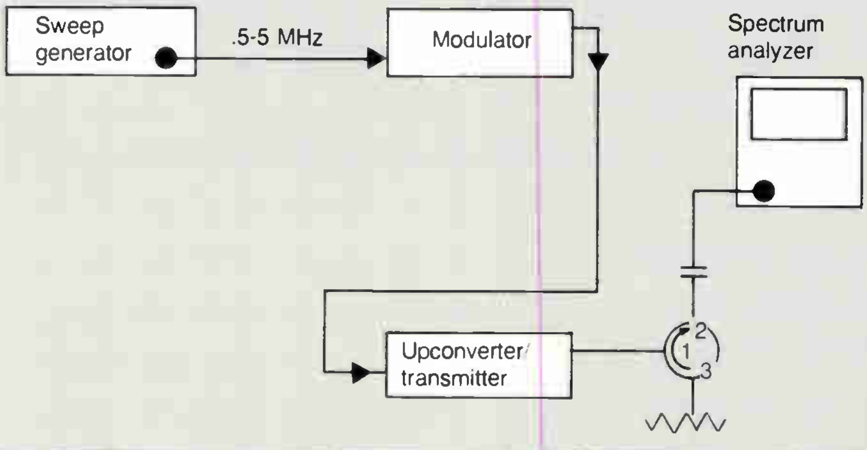
When the final tuning of the filter is achieved, reset the power output for the proper level. If a modulator is involved, remove the video input and check to see if the unit (upconverter) still meets the intermodulation specifications. If a processor is involved (Figure 3), drive it with a composite IF source, such as the Commander II, making sure the IF levels are matched, the processor is in the manual gain control (MGC) position, and the output levels are matched. Then check for intermod.

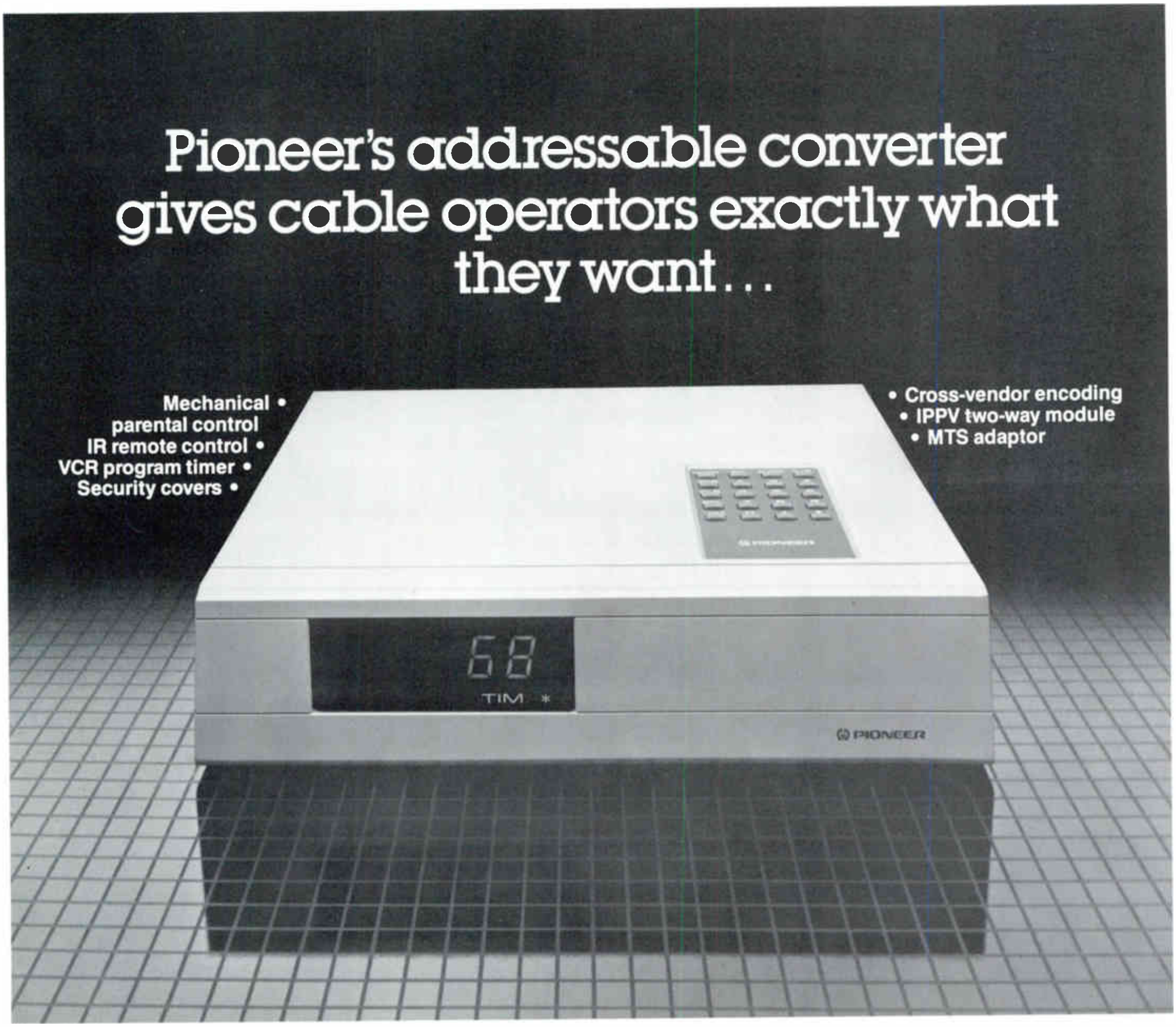
If this is a scrambled channel, check the intermod level with the scrambler on and off (or in standby) and see if the intermod level is met. If intermod occurs when the channel alone is inserted, and is not there when the signal is routed through the comparator, then check the lead from the modulator or processor to the upconverter. A severe mismatch due to a defective lead sometimes will produce this condition.

Once all the upconverters have been swept for response, the modulators and processors should be swept in combination with the upconverters.

(Continued on page 52.)

Figure 4: Combination sweeping of modulator and upconverter simultaneously





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(Continued from page 40.)

Combined sweep tests

Figures 3 and 4 are test configurations for obtaining swept responses with markers. A few points should be made here:

- Again, if the VHF recovery system is swept first and proves to be flat, then the VHF test point can be used to recover the swept response.
- Adjacent channel traps must be set properly on the processors to prevent unwanted carriers from being transmitted over the microwave.
- The Commander II modulator in Figure 2 must have an audio modulator module (AMM) to produce the sound IF carrier, not a 4.5 MHz module.

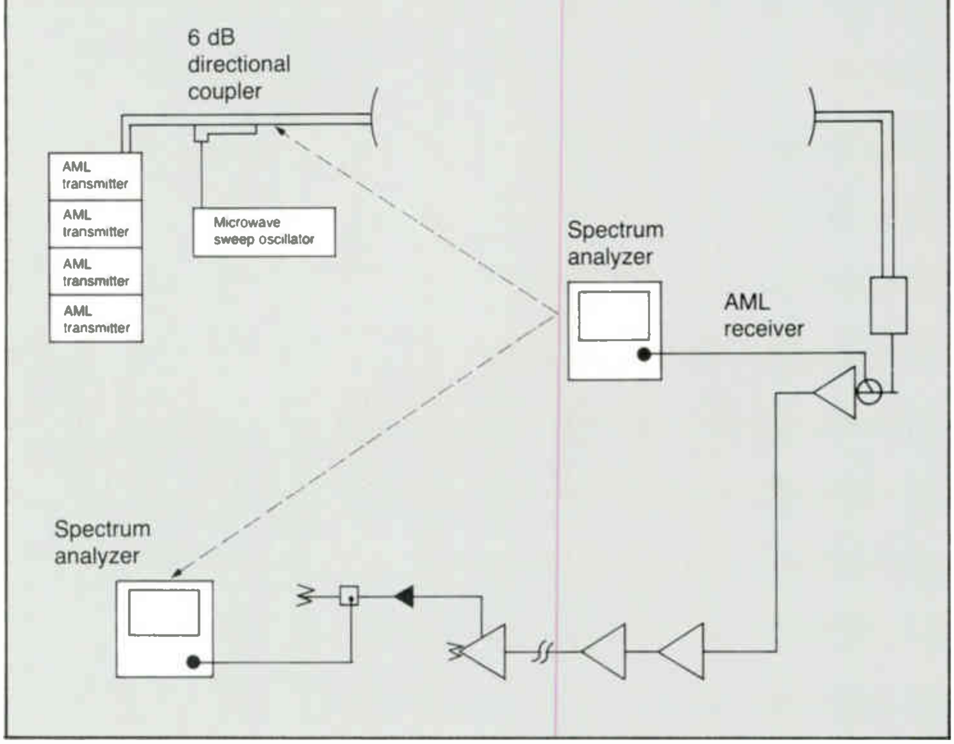
While sweeping the processors, the units must be taken out of automatic gain control (AGC) and the output levels matched in the manual gain position.

When sweeping through scrambled channels, the scrambler must be bypassed or in the standby mode. Most scramblers require the baseband video be looped through the unit. If the sweep (.5 – 5 MHz) is inserted through the scrambler, an unacceptable response may be the result. Bypass the scrambler and insert the test sweep directly into the video input of the modulator to determine which piece of equipment is at fault.

The swept response of the combination should be as flat as possible to allow for a larger variation at the system test point.

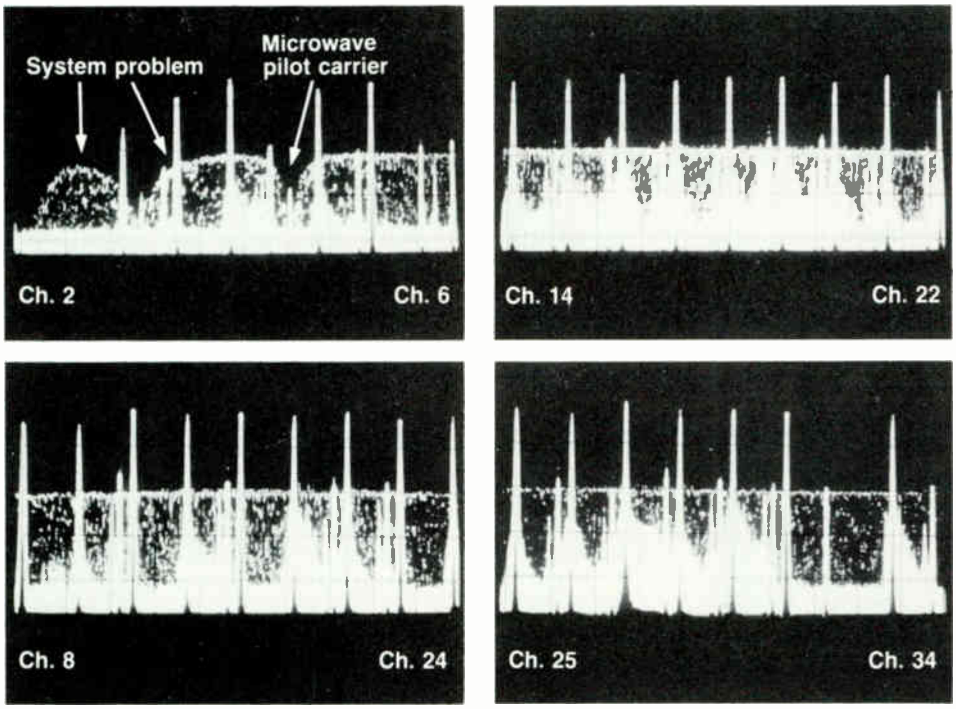
Figure 5 represents a test configuration that encompasses the microwave antenna system, the AML receiver, the interface unit (IFU), and the plant to the system test points.

Figure 5: Antenna sweep/receiver sweep/system sweep—simultaneous



First, a mention about the Hewlett-Packard test equipment used. The microwave sweep oscillator consists of an 8620C mainframe with an 86260A RF plug-in module installed (12.4 – 21 GHz). The spectrum analyzer used was a 181T mainframe with a 8559A plug-in module for viewing the microwave frequencies and a 8558B plug-in for viewing the VHF.

Figure 6: Combined microwave/system response at subscriber test point



Once the waveguide is broken and the waveguide directional coupler is inserted, the output port of the directional coupler should be checked with the spectrum analyzer, to ensure that the flatness of the sweep oscillator and the directional coupler have been maintained. Set the sweep oscillator to sweep the microwave channels authorized by the Federal Communications Commission for transmission from that site. Adjust the sweep oscillator for a slow sweep rate. At this point, all the microwave carriers and the sweep oscillator should be displayed on the screen of the spectrum analyzer. Once the sweep oscillator has been set, the 8559A spectrum analyzer plug-in can be changed to the VHF plug-in module (8558B). Check the amplitude calibration of the spectrum analyzer and recalibrate if required, then proceed to the receive site.

This combined signal (carriers plus sweep) is transmitted to the receiver and then can be viewed on the spectrum analyzer at VHF at the IFU test point (20 dB down). If receiver output is flat, then store the display presentation and photograph. Proceed to one of the system test points and repeat the procedure. Remember that the display can be expanded to 1 MHz per division for viewing individual channel response if desired.

This particular test configuration will save a tremendous amount of time where multiple receive hub sites are concerned. It also provides a very good analysis of system flatness. An example is given in Figure 6, where the test configuration in Figure 5 was used for analysis in the Rochester, Minn., system. This system consisted of 35 channels of high-power AML, distributed to seven hub sites.

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AML microwave system maintenance considerations

This article addresses certain aspects of the maintenance of AML microwave equipment manufactured by Hughes Microwave Communication Products. Many of the suggestions made are, of course, applicable to the products of other manufacturers. The article presents a plan for getting organized, and suggests a preventive maintenance schedule.

By Neal McLain
Manager of Technical Services Complete Channel TV Inc

Like everything else in a cable system, the better job you do when you build an AML microwave system, the fewer problems you'll have later on. If you have the opportunity to be around when an AML system is first installed, you can save yourself a lot of headaches; insist on a careful installation. But even if you weren't around, there are many things you can do to make the maintenance job easier. It's worth taking the time to get things organized; preventive maintenance will go more smoothly, and you'll be prepared for emergencies.

Things to check

1) Make sure the transmitter is located in an enclosed room, with good lighting and good air-conditioning. The air conditioner should be capable of maintaining the temperature at around 65 F in the transmitter room, even on the hottest summer days. And it should provide an essentially dust-free environment (a build-up of dust on the equipment inhibits heat dissipation).

2) Are the input levels correct? Don't try to fudge it. The levels should be:

AML-MTX-132	+ 39 dBmV
AML-STX-141	+ 41 dBmV

Hughes allows a tolerance of ± 2 dB in each case. If you use an accurate meter, there's no reason you can't hit the correct level dead-on.

3) Make sure your transmitter has a redundant master oscillator, and that it's putting out the right frequency and signal level.

4) Get at least one extra receiver, and set it up at your headeand as a "hot standby." Connect it to the transmitter output, and to a monitor you watch fairly frequently. This will save you a lot of trouble if one of your other receivers fails.

6) If you have to feed a trunk cable directly out of the headend, I suggest you take it from the transmitter monitor, rather than trying to mix it from the outputs of the modulators and processors. If not, you'll be forever trying to get all the levels balanced so that both the transmitter input and the trunk cable levels are flat across the band. Moreover, in taking it from the transistor monitor, you'll have fewer problems with spurious products; a direct cable, from a modulator output to the transmitter input, won't allow any beat products from some other modulator to creep in. And besides, if you live near the headend, and monitor that trunk cable at home, you'll know what your transmitter is doing.

6) Make sure the waveguides are airtight and pressurized. And don't fall into the "it won't hold pressure, so let's just forget it" trap. If you've got a waveguide leak, find it and fix it. Keeping pressure on the line is the only way to keep outside air from entering the waveguide. Otherwise, you're inviting an outage: water vapor will condense inside the waveguide and, before you know it, you've got snowy pictures at the other end.

7) Use nitrogen, not air, to pressurize the line. Theoretically, you should be able to use one of those air-pressurizing pumps that passes the air through a tank of desiccant; however, I've noticed two problems with this. First of all, you're never really sure that the dessicant has removed *all* the water vapor. Second, dry air still contains about 20 percent oxygen. Oxygen plus water vapor leads to corrosion, and corrosion leads to signal attenuation. Look inside your waveguide—if there's any discoloration, you've got a corrosion problem. A properly pressurized line, using dry nitrogen, will be as bright and shiny 10 years later as it was the day it was installed.

8) Make sure the receiver is set up properly. For most path situations, using a standard (10 dB noise figure) receiver, this means:

	300 MHz receiver	440 MHz receiver
Receiver input at threshold ..	−45 dBm	−45 dBm
Receiver output.....	+24 dBmV	+27 dBmV

Using these figures, the carrier-to-noise ratio (C/N) at the output of the receiver is 53 dB. The fade margin can then be determined for each path: it's the difference, in dB, between the actual (measured) input level and -45 dBm. If things are working correctly, the AGC will kick in at any input level above -45 dBm, and attenuate the level to -45 dBm.

9) Once you've got the receivers set up properly, measure and document the normal AGC voltage level at each receiver. If possible, take your "hot standby" receiver to each receive site, and establish the normal AGC voltage for it as well. This will give you a basis for comparison if anything abnormal happens in the future.

> *'Air-conditioning is absolutely essential in an AML transmitter facility, especially with the high-powered AML-STX-141 transmitter'*

10) Make sure all your paths are designed properly, and that they're operating as designed. Run through the path calculations (Figure 1) to determine what the receiver input level should be. The calculated level should allow for at least 3 dB of fade margin as an absolute minimum; 8 or 10 dB would be better. The actual (measured) level should be within a couple dB of the calculated value. If the actual level misses the calculated level by more than 2 dB, here are some things to look for:

- Slight misalignment of one or both antennas.
- Slight misadjustment in antenna polarization. Both antennas should be the same (either both horizontal or both vertical; check your license to determine which).
- Slight misadjustment of the feedhorn position. Generally the feedhorn is held in place with three guywires. These should be adjusted so that the feedhorn is exactly "on boresite." You can do this by trial and error, while monitoring the received signal level.
- A damaged antenna. If the reflector isn't a perfect parabola, it won't reflect all the energy to the feedhorn. To check this, grab the edge of the antenna, while monitoring the received signal level, and force the edge of the antenna in both directions. Do this at four or five places around the circumference of the dish. If the reflector is in good condition, the signal level always will *decrease* when you do this. If you find that the level *increases*, you've got a warped dish. Your best bet is to replace it.
- Moisture in the waveguide. If you've been running a tight ship, you shouldn't have this problem; nonetheless, check it. In an extreme case, you may have a pool of water that will drain out when you take the connectors apart. In less extreme cases, you won't have water, but you'll still have corrosion. If the corrosion is minor (slight discoloration), you can probably live with it. In any case, get the line pressurized with dry nitrogen!

11) Make sure the transmitter output is flat. All carrier levels should be the same. The best way to check this is with a spectrum analyzer. It's a $20,000 investment, but it's worth it. You should be able to adjust all carriers flat to within a quarter of a dB.

12) Make sure the output of the receiver is flat. Again, all carriers should be the same. If the transmitter output is flat but the receiver output isn't, look for damaged waveguide (a sharp bend in elliptical waveguide, or a dent in

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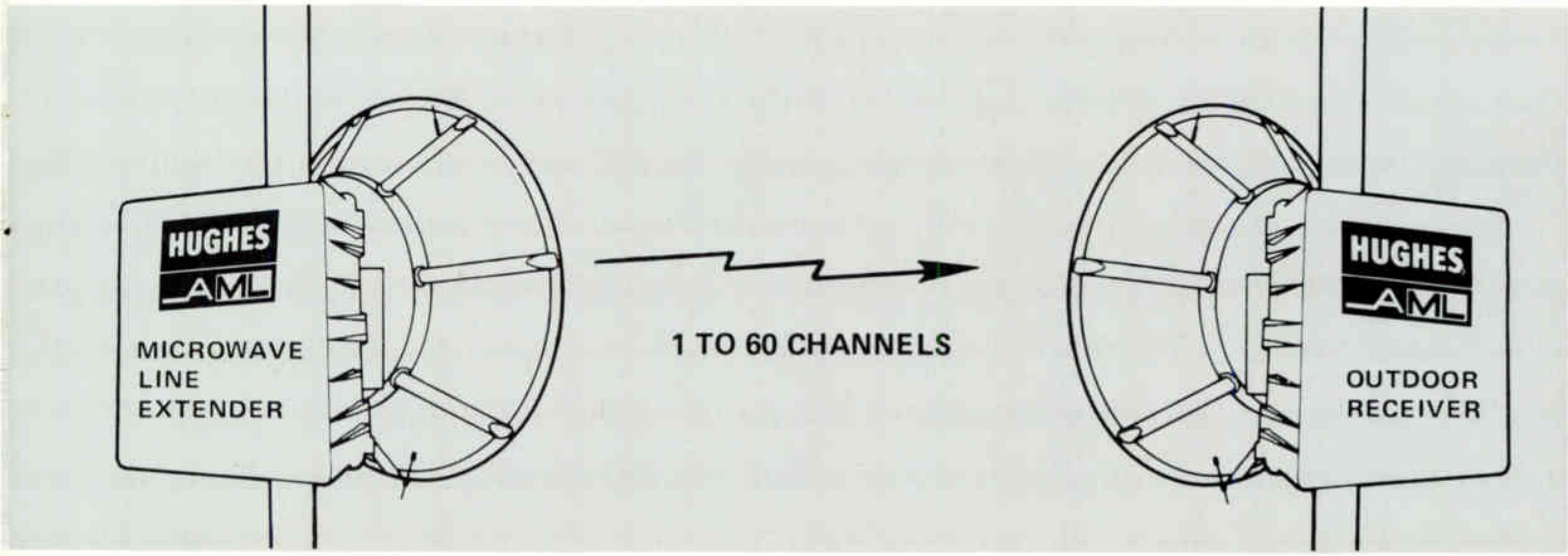

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circular waveguide). Damage of this sort will cause a standing wave, which will result in a regular up/down pattern across the band. On a spectrum analyzer display, you almost can see a sine wave riding along the tips of the carriers.

13) Make sure the receiver is serviceable. What this means is largely up to your judgment. To me, it means the receiver should be at ground level, *not* at the top of a tower, and it should be enclosed in a building. I realize that Hughes has designed the receiver for outdoor use, and that the path calculations may require that the receiver be right behind the antenna. But in the real world, receivers *do* fail, and at the most inconvenient times. If the receiver is high on the tower, you're at a handicap: any kind of tower work is tricky, but under emergency conditions, especially in bad weather, it can be just about impossible. The basic design of the receiver requires that it operate at a constant (and very warm) temperature; merely opening the receiver cover for service will change the temperature and affect the stability of the local oscillator. All this adds up to monumental inconvenience with a potential for real disaster. Putting the receiver in a building (even if it isn't heated) at least gives you a fighting chance.

Figure 1: Path calculations in a nutshell

Following is a simplified procedure for checking path calculations for an AML system operating in the 12 GHz CARS band.

Start with transmitter output .... + ________ dBm

AML-MTX-132	1-bay	+16 dBm
AML-MTX-132	2-bay	+14 dBm
AML-MTX-132	4-bay	+10 dBm
AML-MTX-132	8-bay	+ 7 dBm
AML-MTX-132	16-bay	+ 4 dBm
AML-STX-141	1-bay	+30 dBm
AML-STX-141	2-bay	+26 dBm
AML-STX-141	4-bay	+23 dBm
AML-STX-141	8-bay	+20 dBm
AML-STX-141	16-bay	+17 dBm

Subtract transmit waveguide loss .... − ________ dB

Circular = 1.3 dB/100 feet
Elliptical = 3.6 dB/100 feet

Add transmit antenna gain .... + ________ dB

6-foot dish = 44.7 dB
8-foot dish = 47.2 dB
10-foot dish = 48.4 dB

Subtract transmit radome loss .... − ________ dB

No radome = 0.0 dB
6-foot radome = 1.7 dB
8-foot radome = 1.8 dB
10-foot radome = 2.1 dB

Subtract free-field loss .... − ________ dB

$L = 96.6 + 20 \log(F) + 20 \log(D)$

Where:

L = Free-field loss in dB
F = Frequency in GHz = 13.2
D = Path distance in miles

Subtract receive radome loss .... − ________ dB

Add receive antenna gain .... + ________ dB

Subtract receive waveguide loss .... − ________ dB

Subtract 3 dB "field factor" .... − 3.0 dB

CALCULATED RECEIVER INPUT LEVEL .... − ________ dBm

The receiver threshold level is -45 dBm. The difference between this threshold level and the calculated receiver input level is the "fade margin." The fade margin should be at least 3 dB; the higher, the better.

14) Read the manuals! AML equipment is extremely reliable, and it will perform well for extended periods of time, but it does have to be set up properly. Read the manuals carefully, and study the set-up procedures.

Preventive maintenance

Once an AML microwave system is running smoothly, a good preventive maintenance program should be instituted to keep it running.

First of all, set up a record-keeping system. You'll have to do this anyway, since the FCC requires that you keep a log. But a good set of records also is essential to good maintenance. By observing how parameters change over time, you'll be able to catch potential failures before they occur.

Check the transmitter oscillator frequency. For a Group C AML transmitter (which most of them are), the VCXO frequency should be 73.956140 MHz ± 187 Hz. That may sound like an exceedingly tight tolerance; however, it's not difficult to maintain. This should be measured, and logged, at least monthly; weekly would be better. And don't forget to check the redundant oscillator. It should be on frequency too, and have the same output level as the primary oscillator.

Pay attention to the transmitter input levels. Measure the input signal levels at least weekly, record the results, and adjust the headend if necessary. And watch for changes. You're far more likely to have erratic level changes coming out of the headend, simply because there's so much more equipment involved.

Measure the transmitter klystron current. This is easy since the meter is built into the power supply. Keep a careful record; it tells you a lot about the history of a particular klystron. Normally, the current will be around 120 ma; as the klystron ages, the current will drop off. When it gets down to around 70 ma, it's time to order a replacement.

Transmitter klystron voltages practically never change, but it's a good idea to record the results anyway, so you'll have the history.

To measure transmitter output power accurately, you'll have to remove modulation from all headend carriers. Fortunately, you don't have to do this very often; once a year is adequate. The best way to measure it is with the spectrum analyzer; it allows you to see all the carriers at once and check for flatness at the same time. If you don't have access to a spectrum analyzer, a microwave power meter will work fine; it just takes longer, and it's trickier to use.

Waveguide pressure should be measured

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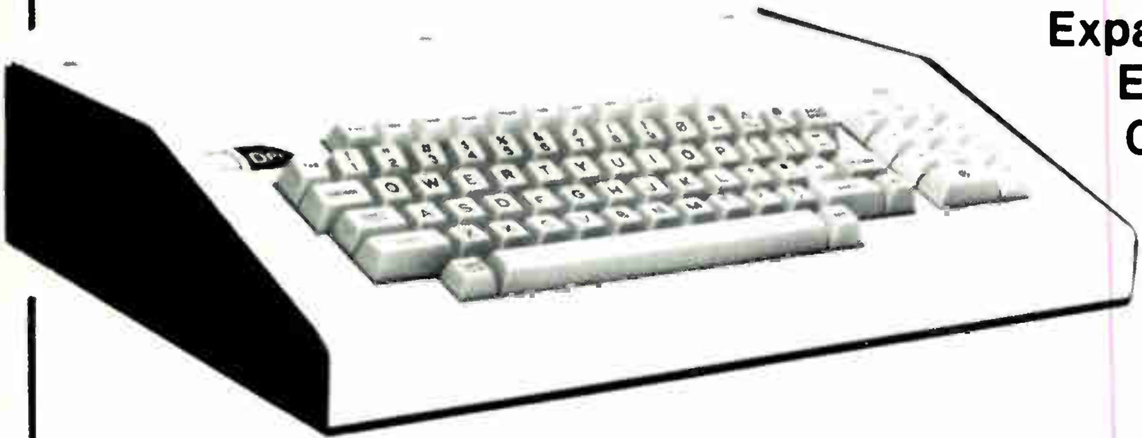

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both at the transmitter and at each receiver. Again, record the results; if your pressure regulators are working properly, this will change very little from reading to reading. You also should record the pressure in the nitrogen tank itself, so you can track how fast you're using up the supply. Most industrial gas suppliers consider the tank to be empty when the pressure gets down to around 50 psig; they're likely to be upset if you run the pressure down to zero.

Check the receiver operating parameters and output levels at least once a month. Use a pre-printed form to log your observations; Figure 2 shows our form. Use a Hughes Model RM-2 test box to make these measurements, and log the results on the log form. All parameters should fall within the ideal range specified on the log form. Pay particular attention to the AGC voltage. If you've established the normal reading at the outset, you'll be able to relate any changes in AGC voltage to changes in received signal strength. On windy days, if the AGC voltage varies, you may have a tower or antenna that's moving in the wind.

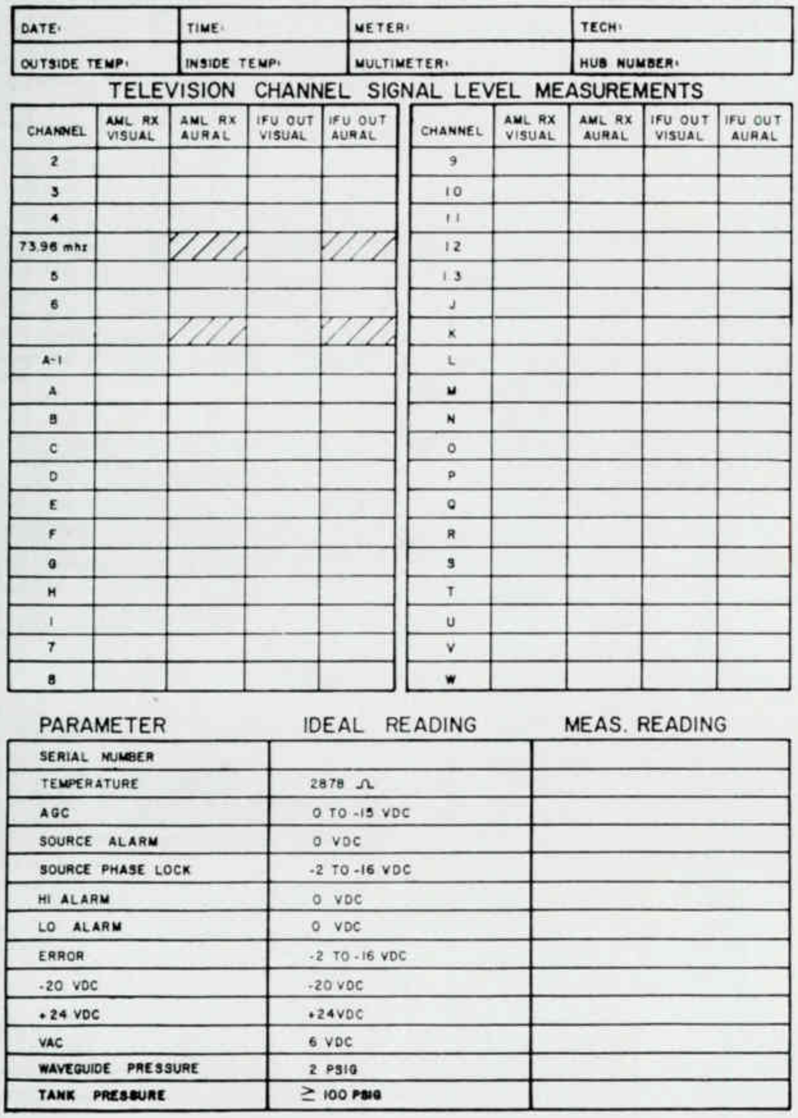
Low-noise amplifiers

I have made some suggestions here that may not be possible in your situation. There are lots of AML paths out there where you simply won't be able to maintain 3 dB fade margin and still put the receiver at ground level, especially if you use the AML-MTX-132 ("multichannel") transmitter. What then?

Consider removing one or both radomes. Other things being equal, radomes should be used, especially if there is a possibility of feedhorn damage due to falling ice. However, if you have to choose between radomes and adequate fade margin, vote for the fade margin.

Consider replacing long runs of elliptical waveguide with circular. The breakeven point is about 60 feet of waveguide; below that point, you'll lose as much in transitions as you gain by using circular. Above that point, circular has the advantage.

Figure 2: Microwave receiver log form



DATE:	TIME:	METER:	TECH:
OUTSIDE TEMP:	INSIDE TEMP:	MULTIMETER:	HUB NUMBER:

TELEVISION CHANNEL SIGNAL LEVEL MEASUREMENTS

CHANNEL	AML RX VISUAL	AML RX AURAL	IFU OUT VISUAL	IFU OUT AURAL
2				
3				
4				
73.96 mhz		▨		▨
5				
6				
		▨		▨
A-1				
A				
B				
C				
D				
E				
F				
G				
H				
I				
7				
8				

CHANNEL	AML RX VISUAL	AML RX AURAL	IFU OUT VISUAL	IFU OUT AURAL
9				
10				
11				
12				
13				
J				
K				
L				
M				
N				
O				
P				
Q				
R				
S				
T				
U				
V				
W				

PARAMETER	IDEAL READING	MEAS. READING
SERIAL NUMBER		
TEMPERATURE	2878 ⎍	
AGC	0 TO -15 VDC	
SOURCE ALARM	0 VDC	
SOURCE PHASE LOCK	-2 TO -16 VDC	
HI ALARM	0 VDC	
LO ALARM	0 VDC	
ERROR	-2 TO -16 VDC	
-20 VDC	-20 VDC	
+24 VDC	+24VDC	
VAC	6 VDC	
WAVEGUIDE PRESSURE	2 PSIG	
TANK PRESSURE	≥ 100 PSIG	

Consider using larger antennas, bearing in mind that a larger antenna will put a heavier load on the tower.

Consider using a low-noise amplifier at the receiver. It sounds like the easy way out; just stick an LNA on the back of the receive antenna (just like a TVRO), and you can eliminate the receiver waveguide and improve the receiver noise figure all in one stroke. Unfortunately, it's not that easy. Using an LNA in an AML environment is vastly more complicated than using one on a TVRO, due to the possibility of introducing unacceptable levels of CTB and intermodulation distortion. To understand this, it is necessary to consider the following:

- A typical AML microwave system uses up to 54 carriers, instead of the usual 12 encountered in TVRO service. As with any other amplifier, the more carriers, the greater the number of intermod and CTB products.
- AML signals are far more vulnerable to atmospheric attenuation ("rain fades") than satellite signals. There are two reasons for this: 1) the frequency is higher (12 GHz for AML vs. 4 GHz for satellite signals), and 2) the entire AML path passes through the atmosphere, whereas most of the satellite path is in the vacuum of space, and only the last half-mile or so passes through the atmosphere.

The net result is that an LNA used at an AML receiver is far more likely to be overdriven, causing unacceptable intermodulation and CTB distortion. To prevent this from happening, the LNA must be located *inside* the receiver AGC loop, i.e., *after* the ferrite attenuator. And that means that you have to put the LNA inside the receiver cabinet, at the base of the tower, *after* the waveguide loss.

So what, then, is the point of doing it at all? The answer lies in the improvement in noise figure: adding an LNA will gain you somewhere between 3 and 5 dB in improved noise performance. Hughes claims 3.5 dB improvement; our experience is closer to 5. In any case, you can use this improved noise figure to *reduce* the threshold input to the receiver, while still maintaining the same output level and C/N.

Let's take an example. Assume we install an LNA in a standard 300 MHz receiver, and gain an improvement in noise figure of 3.5 dB. The operating parameters would then be:

	Without LNA	With LNA
Receiver input at threshold . .	−45 dBm	−48.5 dBm
Receiver output level.	+24 dBmV	+24 dBmV
Receiver output C/N	53 dB	53 dB

You can now adjust the receive for a threshold input level of -48.5 dBm, thereby increasing your fade margin by 3.5 dB.

Installing an LNA in an existing receiver is a fairly simply matter; however, we've noted one peculiar problem: the physical proximity of the power supply to the LNA causes hum to be induced into the LNA. Hughes provides a "mumetal" shield to prevent this.

It is, of course, not impossible to put the LNA, with the ferrite attenuator, directly behind the antenna. If all else fails, this approach should be considered. Keep in mind, however, that you'll still have an active component, the LNA, on the tower, where service is difficult.

Air-conditioning

Air-conditioning is absolutely essential in an AML transmitter facility, especially with the high-powered AML-STX-141 transmitter. The klystrons throw off an enormous amount of heat; if the heat isn't removed, the room temperature can rise to dangerous levels very quickly. Our 40-channel high-power transmitter is capable of sending the room temperature up at a rate of 1 degree per minute! It is therefore essential that you approach air conditioning maintenance with the same care you use for the transmitter itself. I suggest a four-part program: preventive maintenance, a temperature-sensing system, an action plan for emergency cooling, and an action plan for getting the system fixed if it fails.

The program starts with preventive maintenance: replacing filters, periodic inspections, and twice-a-year check-ups. Set up a regular schedule for the filters: you can replace them yourself. You also can inspect the system at the same time.

Have a regular heating/cooling contractor check the system at least twice a year (spring and fall). You won't have to tell the contractor what to do; any reputable contractor will have a standard service routine. But picking the right contractor is worth some serious thought: remember, the contractor you choose for preventive maintenance is the one you'll have to call in an emergency. Does he provide 24-hour on-call service? Will you be able to get in touch with him on a hot Sunday afternoon in August? What spare parts does he keep in stock?

Next on the program is a temperature-sensing system (a system that lets you know if the temperature starts to rise in the transmitter room). Ideally, it should be a two-sensor system: the first sensor (say, around 80 F) triggers an alarm, and the second sensor (90 F to 95 F) shuts off the transmitter. The alarm should be rigged to call for help. How you accomplish this is up to your ingenuity. We have ours wired in with our building security system, and the security company dispatcher has a list of phone numbers. If you don't have a building security system, it could be wired to an automatic telephone dialer.

The second sensor should be wired to shut the transmitter off altogether. You don't want your transmitter to shut itself off from overheating!

The third part of the maintenance program is a plan for emergency cooling if the air conditioner fails. No matter how reliable your air-conditioning contractor, you and your technicians will be there first, and you should be able to get some sort of cooling going in a hurry.

If I were building my dream transmitter building, I'd put in a redundant air-conditioning system and an automatic sensing system to switch it on. An acceptable alternative is to use fans and keep the doors open. Four or five of those big square window fans, judiciously placed in doorways and behind the racks, will do a reasonable job. Of course, in leaving the building doors open, you may have to pay a technician to stand guard all night, but it's still cheaper than a redundant air conditioner.

The last part of the program is an action plan to get the air conditioner fixed. And here's where your choice of heating/cooling contractor will pay off. If you've picked the right contractor, you'll be able to get in touch with him any time. He'll jump on the problem immediately, and he'll have the necessary parts in stock.

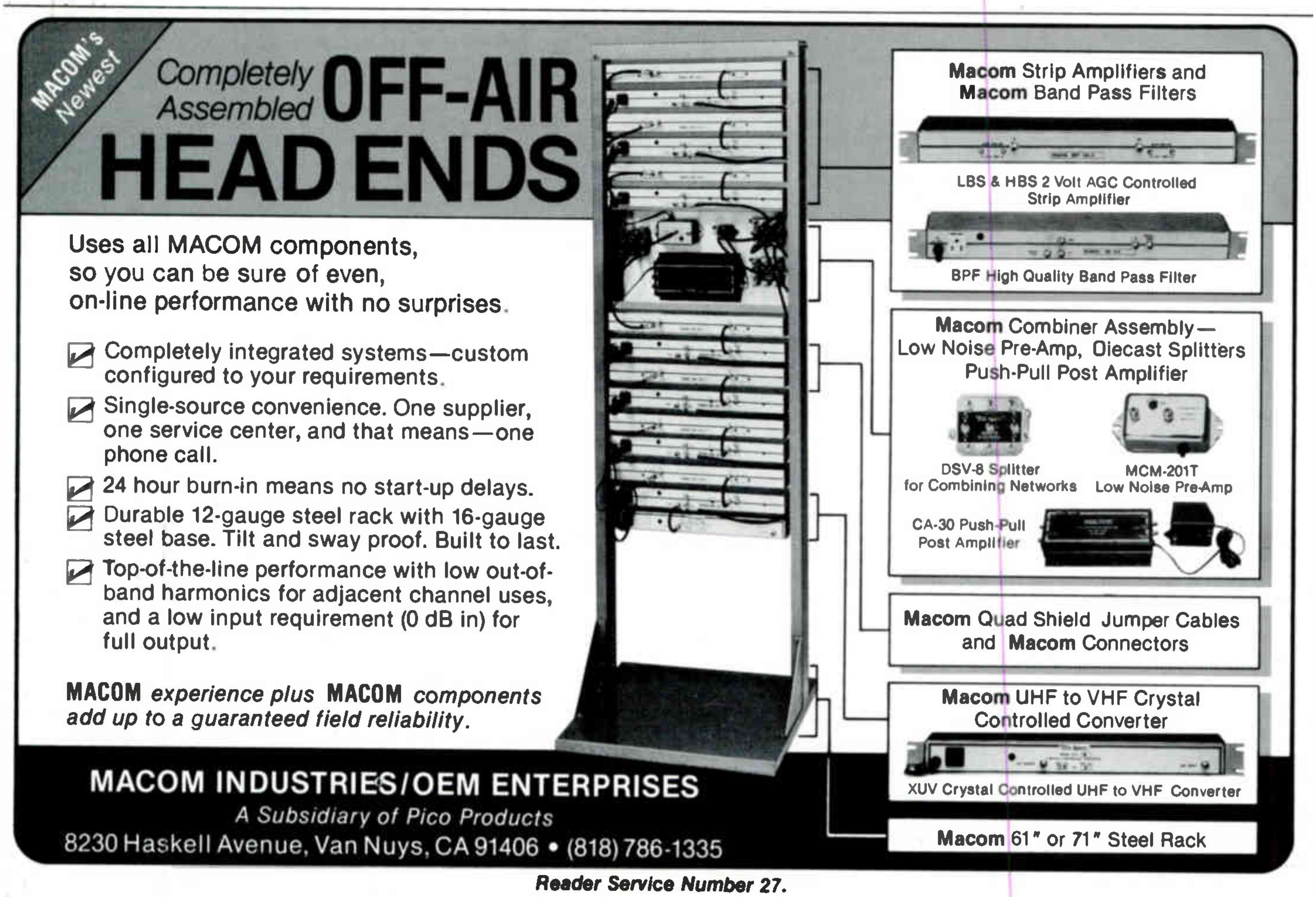
Author's note: Special thanks to Jeff Kaczor, engineering foreman at Complete Channel TV, and to Bob McCoy, one of the field engineers at Hughes, for their help in developing this article.

References

Robert F. White, Ed., *Engineering Considerations for Microwave Communications Systems*, Lenkurt Electric Co. Inc., 1970.

Hughes Aircraft Co., Microwave Communications Products, *LNAs for Multichannel Microwave Receivers*, 1985.

Also, there is the Hughes seminar, and the seminar manual that accompanies it. The seminar is a good introduction to the AML system. The manual is a comprehensive explanation of basic theory and operation.



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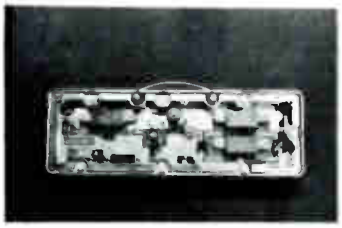

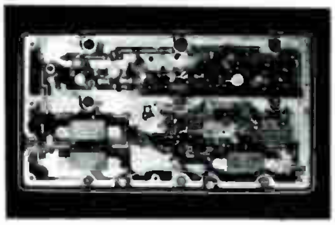

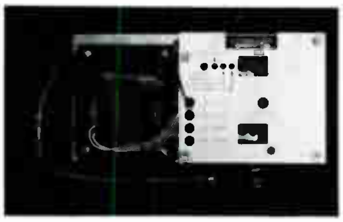

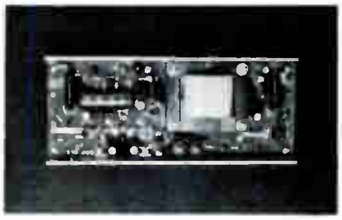

SPECIFICATIONS

STATION FUNCTION	TR. AMP W/ASC BR. AMP.	TR. AMP — BR. AMP.	TR. AMP W/ASC —	TR. AMP — —	TERM./INT. TR. BR. AMP.	LINE EXTENDER
STATION MODEL NUMBER AVAILABLE in P^2 OR PUSH PULL ONLY						
PASSBAND	50 to 330 MHz			50 to 400 MHz		
RESPONSE FLATNESS (See Note 1) Trunk Amplifier	±.2dB	± .2dB	±.2dB	±.2dB		
Bridger or Distribution Amplifier	±.5dB	±.5dB			±.5dB	±.5dB
MINIMUM FULL GAIN (See Note 2) Trunk Amplifier	29 or 31dB	30 or 32dB	29 or 31dB	30 or 32dB		
Bridger or Distribution Amplifier	30dB	30dB			44dB	28dB
RECOMMENDED OPERATING GAIN at 330 MHz, without equalizer Trunk IN to Trunk Out	26/22dB	26/22dB	26/22dB	26/22dB		
Trunk IN to Bridger (Distribution) OUT	40/34dB	40/34dB			38/32dB	26dB
TYPICAL OPERATING LEVELS for 40 channels, with equalizers IN	9dBmV	9dBmV	9dBmV	9dBmV	10dBmV	
Trunk OUT 330 MHz Linear TILT	34/30dBmV	34/30dBmV	34/30dBmV	34/30dBmV		
Trunk OUT 400 MHz Linear TILT	34/29dBmV	34/29dBmV	34/29dBmV	34/29dBmV		
Bridger (Distribution) OUT)	49/42dBmV	49/42dBmV			49/42dBmV	48/42dBmV
DISTORTION CHARACTERISTICS (typical for op. levels)						
2nd Order Beats, Chs. 2, 20(g), 13 Trunk Amplifiers	-84dB	-85dB	-84dB	-85dB		
Bridger or Distribution Amplifier	-72dB	-72dB			-70dB	-71dB
Composite Triple Beat Trunk 330 MHz	-90dB	-91dB	-90dB	-91dB		
Trunk Amplifier Trunk 400 MHz	-87dB	-88dB	-87dB	-88dB		
Bridger or Distribution Amplifier 330 MHz	-69dB	-69dB			-67dB	-69dB
Cross Modulation 400 MHz	-64dB	-64dB			-62dB	-65dB
HUM MODULATION (by 60 Hz line)	70dB ALL STATIONS					
MAXIMUM NOISE FIGURE, without equalizers 330 MHz	7.0dB	7.0dB	7.0dB	7.0dB	8.0dB	9.0dB
400 MHz	7.5dB	7.5dB	7.5dB	7.5dB	9.0dB	9.5dB
MANUAL GAIN CONTROL RANGE, mimimum Trunk Amplifier	8dB	9dB	8dB	9dB		
Bridger or Distribution Amplifier	9dB	9dB			9dB	9dB
OPTIONAL INPUT LEVEL PADDING	AVAILABLE PLUG IN PADS S X P'S					
MANUAL SLOPE CONTROL RANGE, minimum in Bridger or Distribution Amplifier (Ch. 2/36)	8dB	8dB			9dB	7dB
AUTOMATIC SLOPE AND GAIN CONTROL For changes in cable (ref. to 330 MHz)	+3/-3dB		+3/-3dB			
Amplifier output at pilot frequency holds at	±.5dB		±.5dB			
CONTROL CARRIERS AGC factory tuned to Ch. AS REQUESTED	AS REQUESTED					
Operating Level, minimum/maximum dBmV	SELECTABLE PLUG IN PAD S X P's					
THERMAL COMPENSATION for ambient changes in amplifier over °F.	AVAILABLE AS OPTION					
THERMAL MATCH at 75 ohm Impedance	16dB MINIMUM ALL PORTS					
POWER REQUIREMENT (In Station Housing) Using QRF-JPP2 60 V System Watts Amps	1.07A	1.02A	.650A	.590A	.590A	.505A
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Reader Service Number 28.

TV stereo sound: What it means to SMATV

By R. Martin Eggerts
Product Planning Manager Blonder-Tongue Laboratories

Television broadcasting has primarily been a visual entertainment medium. Technical advances have focused mainly on the picture: from black-and-white to color, improvements in brightness and sharpness, larger screen sizes, culminating in today's projection systems. Meanwhile, the quality of television audio took a back seat and improvements in the delivery of sound were minimal. Recently in an attempt to bring audio quality in line with existing video capabilities, stereo (or binaural) sound was introduced. Obviously the transmission system for stereo had to be compatible with millions of non-stereo TV receivers in use today, as well as fit within the present TV broadcasting standards.

In order to address the compatibility problem, the Electronic Industries Association (EIA) assigned its Broadcast Television Standards Committee (BTSC) to evaluate and choose a suitable stereo transmission system. In December 1983, after appraising three competitive systems, the committee recommended a single industry standard, specifically one developed and proposed jointly by Zenith (modulation and sub-carrier allocation) and dbx Inc. (audio companding). In addition to stereo capability, this system also provides a separate audio program (SAP) channel that can be used for program-related material (such as bilingual transmissions) or a totally separate service. On March 29, 1984, the Federal Communications Commission (FCC) approved the BTSC system for multichannel television sound (MTS) transmissions, thus establishing it as a standard, although other systems can theoretically still be proposed, as long as they protect the BTSC pilot tone.

Now that a single transmission system has been established, the development of TV stereo sound broadcasting can be expected to proceed rapidly, driven by the competitive forces of the marketplace. As it stands, due to eminent obsolescence, no manufacturer of TV sets can continue to offer exclusively monophonic receivers. Therefore, all manufacturers are rushing to stock dealers' shelves with the latest technology—TV sets equipped for the reception and reproduction of TV stereo sound.

Similarly, a competitive scramble among TV broadcast stations to be the first with stereo in their respective locations has already begun. As the base of stereo-equipped TV viewership increases, all TV stations will be forced to join the format. The only aspect that may lag in this forecast is the initial lack of worthwhile stereo programming. However, an increasing stereo-capable audience will be the driving force to develop this new medium.

Stereo and SMATV

As the TV stereo market develops and significant numbers of stations deliver stereo programming to an ever increasing number of stereo-capable TV sets, the question arises: What happens to SMATV, the distribution system that often interfaces between the received signal and the viewer? Fortunately, a well-designed SMATV system is generally compatible with the BTSC MTS standard. There are, however, a few areas that should be watched.

The signals for many SMATV channels originate off-air from standard TV broadcast stations, but other sources include satellite (TVRO) feed, redistribution of a cable (CATV) drop and local origination (tape or camera). First, let us examine the off-air components:

- *Antennas*—Since the BTSC stereo system is within the framework of existing channel and frequency allocations, any well-designed antenna will receive stereo sound as well as the present mono.
- *Preamplifiers* usually have sufficient bandwidth and flatness to appear "transparent" to the signal.
- *Headends* for SMATV include three different types of amplification/processing:

1) Broadband—One amplifier boosts all channels. A broadband amplifier is generally flat and "transparent" and presents no stereo problems. However, as TV stations switch from mono to stereo transmissions, some may increase the transmission power of their aural carriers (to improve the signal-to-noise ratio). If a number of stations on several channels do this, and the total of signal levels in the amplifier are run close to its output capability, an overload condition may occur, resulting in visible intermodulation in the picture. In most cases, cutting back the amplifier gain or attenuating the input signal will remove it, but under a combination of unfavorable conditions, some amplifiers may have to be replaced.
2) Stripamps—Each channel has a separate amplifier, usually with automatic gain control (AGC) to keep all channels at equal and constant levels. Well-designed stripamps, are also "transparent" and should cause no problems.
3) Heterodyne processors—Each channel is processed separately, as in stripamps, but not at the original frequency. The incoming signal is downconverted to a lower intermediate frequency (IF) then upconverted back to a TV channel frequency for distribution. In this type of headend, problems can be encountered, depending on the design of the equipment. For instance, in many cases, the picture and sound carriers are processed separately, employing narrow bandwidth filtering that could impair a BTSC stereo transmission. A separate audio AGC system also may be affected. Most newer processors are designed to be fully BTSC-compatible from the ground up.

In addition, a headend, particularly one with a broadband and/or strip amp, also may contain channel converters,used most often to convert UHF (Ch. 14-83) to VHF (Ch. 2-13), and band pass filters (to clean up signal spillover if adjacent channels are used in the system). Both converters and bandpass filters should not impair the stereo signal in any way.

- *Distribution systems* consist of passive splitters, tapoffs, walltaps, etc. Since these are broadband devices, they have no effect on the characteristics of the signal carried. However, if the distribution system uses reamplification, line distribution amplifiers, or line extenders, the same overload caution as with broadband headend amplifiers applies.

BTSC stereo and satellite signals

In addition to off-air channels, a typical SMATV (or private cable) system provides other channels of premium services. These services are delivered by satellite and received by an earth station (TVRO), consisting of an antenna (dish), a low-noise amplifier (LNA) or low-noise converter (LNC) and a satellite receiver. All of these components are totally compatible with both mono and stereo transmissions, as the sound portion is carried on a separate subcarrier. In fact, many services deliver a stereo sound already, utilizing two subcarriers. Depending on the practice of the particular stereo audio provider, the two carriers are modulated with left/right or L + R or L + R/L − R audio information respectively. If the stereo signal is BTSC-encoded at the uplink, only one subcarrier is needed.

A satellite receiver provides baseband video and baseband audio outputs. A modulator is then used in the headend to put the baseband signals on to a TV channel to be carried by the system in standard broadcast format. Presently, in the case of a stereo program service, the receiver has two audio outputs (L and R or L + R and L − R). A special multiplex generator/FM modulator is used to generate a broadcast FM stereo multiplex signal in the FM band. A baseband mono audio signal also is provided (in case of L + R/L − R encoding, the L + R audio signal can be taken directly) to be used for A/V modulating the TV channel.

How will BTSC stereo affect this situation? It is difficult to predict, but the program supplier will call the shots. He has the choice of either encoding the stereo sound in BTSC format prior to satellite uplink or use two separate audio signals in transmission, as at present. If the satellite program is encoded in BTSC format, a simple circuit modification (possibly made in the field) will permit existing modulators to provide stereo. If, however, two unencoded audio signals are transmitted, then, in order to obtain a stereo signal that can be received by stereo-capable TV sets, a BTSC

format generator is required ahead of the modulator. An economical BTSC format generator is not yet generally available.

SMATV systems that use set-top decoders for premium service delivery must be evaluated for BTSC compatibility. Although some systems will have no problems, many will have to be retrofitted or replaced, depending on the security and/or scrambling scheme used.

Even video-only scrambling, with audio in the clear, is not guaranteed to be compatible because decoding or addressing information may be carried as an audio subcarrier. In general, trap (both positive and negative) and trap-derived addressable technology is stereo-ready. On the other hand, most complex baseband scrambling methods are totally incompatible and will need "outboard" adaptors at the very least.

In conclusion we have to note that, paradoxically, the simpler and more straightforward the SMATV installation, the more likely it is to accommodate the new stereo era without difficulty.

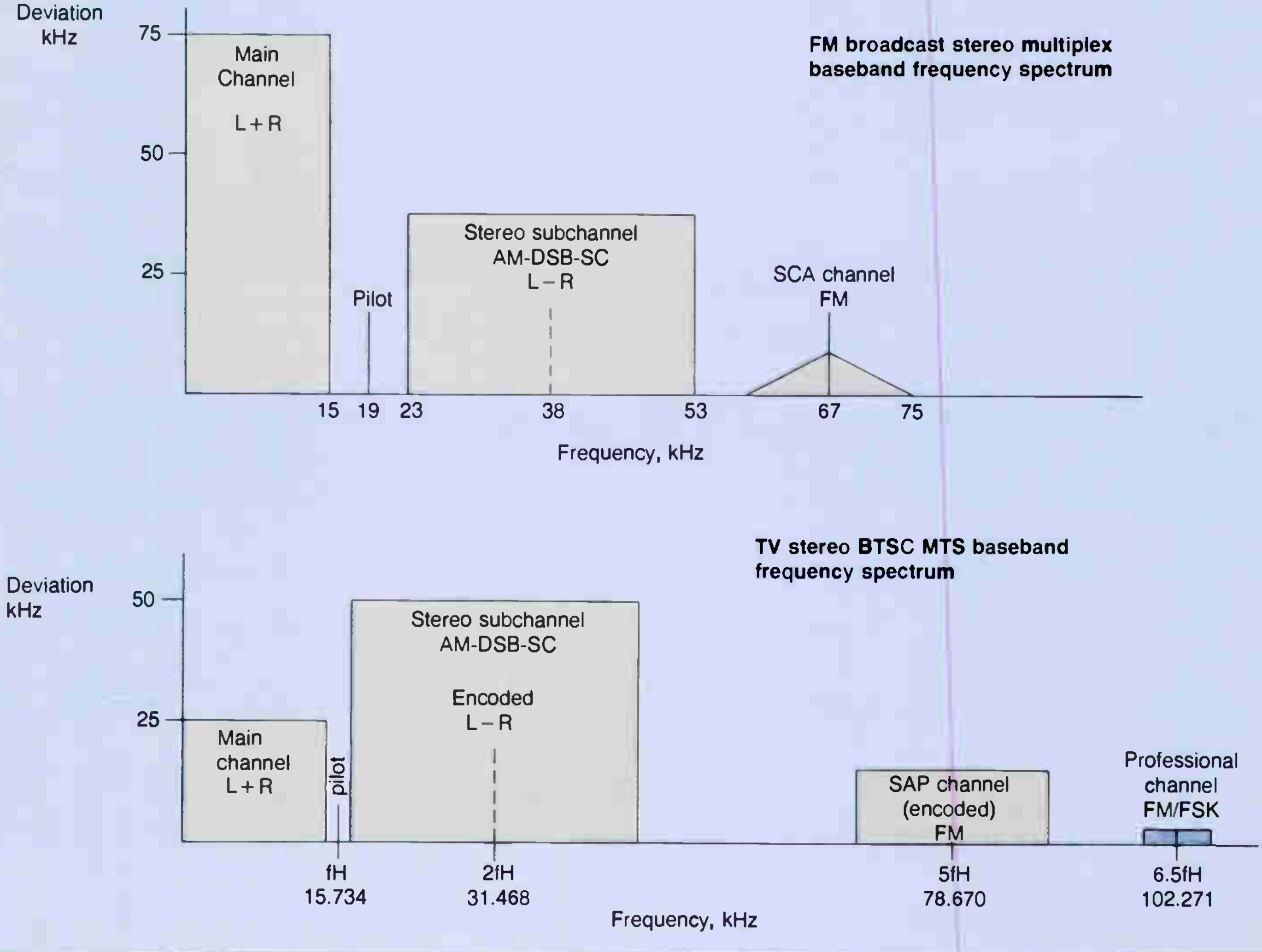
Inside the BTSC stereo transmission system

Since television audio uses a frequency-modulated carrier, similar to that of broadcast FM stations, the BTSC transmission system bears strong similarities to FM stereo, long familiar to us. The TV audio baseband frequencies are utilized as follows: A summed signal of the left and right audio channels (L + R) occupies the spectrum up to 15 kHz. This is demodulated and reproduced by standard TV sets as monophonic sound, thus achieving compatibility. A pilot tone is broadcast at 15.734 kHz (which is "1H," or the horizontal picture scanning frequency chosen for minimum picture/sound interference). The pilot tone is used to activate stereo processing circuitry in stereo TV sets. Next, a stereo difference signal (L − R) amplitude modulates a suppressed subcarrier at 31.468 kHz ("2H," twice the horizontal scanning frequency). In combination, when demodulated and matrixed, the sum and difference signals give discrete left and right audio channels to be processed by a standard stereo audio system.

Further in the spectrum, a SAP channel can be carried (frequency modulated and centered around "5H," or 78,670 kHz), which can be used for either program related material (such as bilingual broadcasting) or a totally separate audio service, similar to the supplementary carrier authorization (SCA) that is used for background music and other services on broadcast FM stations. Another limited quality FM channel is available at "6.5H" for telemetry, data or other purposes. A comparison between the baseband spectrum of BTSC TV stereo system and the FM multiplex stereo broadcast system is shown in Figure 1.

In order to improve the signal-to-noise ratio of the transmission, the L − R and SAP (if used for program-related material) subchannel audio is compressed before modulation and expanded after demodulation, using a complex proprietary scheme developed by dbx Inc. This noise reduction system requires an encoder at the transmitter and a special decoder in each BTSC stereo-capable TV set.

Figure 1: Baseband spectrum comparison between FM broadcast and TV stereo



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Reader Service Number 30.

Frequency coordination or interference suppression?

By Glyn Bostick and Patricia Tagg
Microwave Filter Co. Inc.

Professional frequency coordination provides a reliable means for predicting interference-free reception for commercial television receive-only earth stations (TVROs). Unfortunately, many commercial TVROs suffer microwave terrestrial interference (TI) because this service was not used or because owners ignore some of its findings. When this happens, one must resort to interference suppression techniques at the site.

Frequency coordination is an analysis used to determine the interference environment of a proposed TVRO site. It is usually done as a part of the licensing process, but also is available as a pre-construction precaution. This work is available from a number of professional frequency coordinators.

Coordinators maintain a computer data base that processes the location and characteristics of all licensed transmitting sites in the United States. This includes the individual antenna sites of the transcontinental microwave relay system used by common carriers in the 2, 4 and 6 GHz frequency ranges. The carriers in the 4 GHz terrestrial microwave band account for the majority of interference to C-band TVROs.

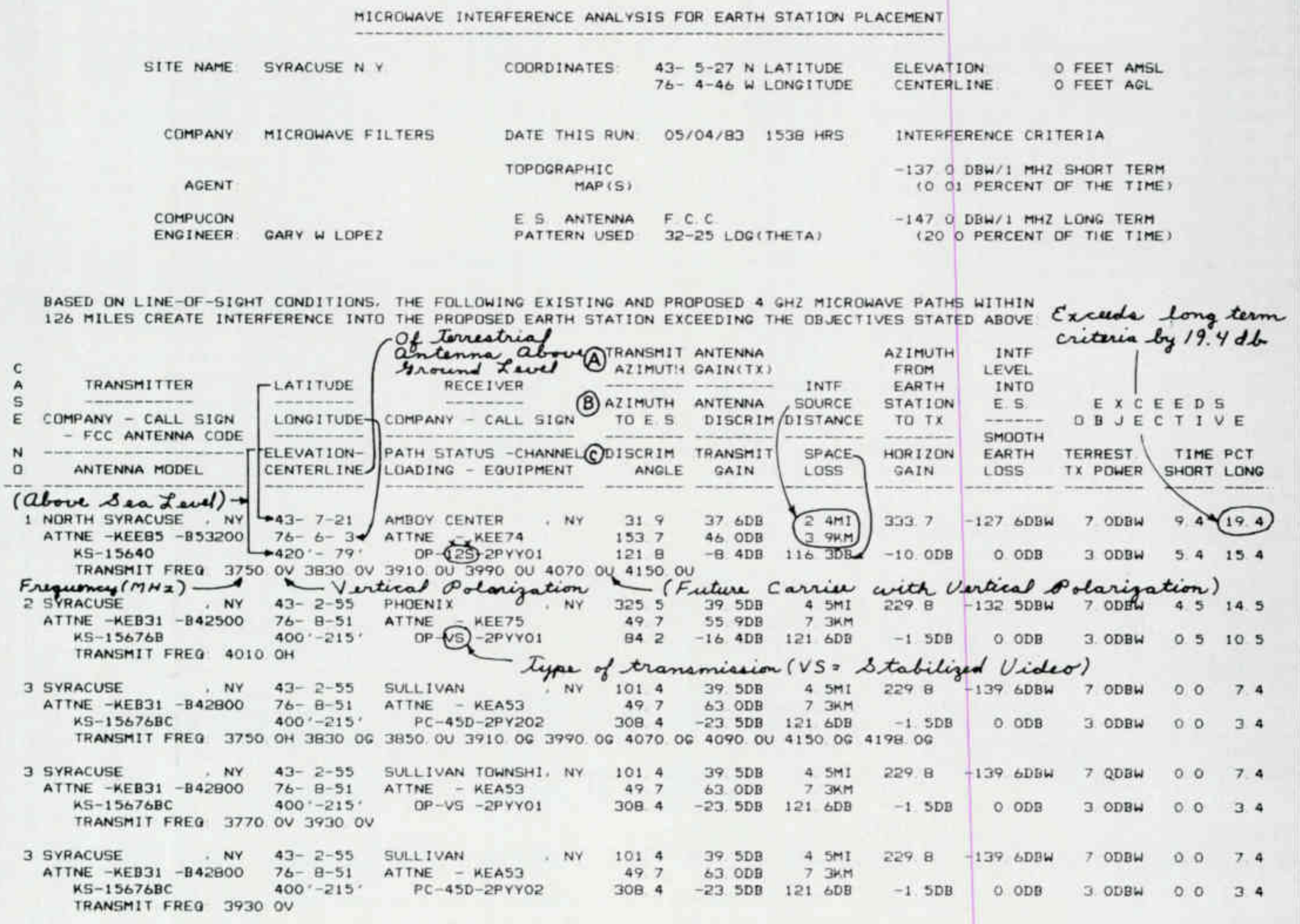
Given precise longitude and latitude of the proposed site, the coordinator produces a printout (Figure 1) predicting the effect on TVRO reception quality of terrestrial transmitters within a specified radius. The data bases are continually updated with new Federal Communications Commission approved sites and additional frequencies for existing transmitter sites. Therefore, these predictions also warn of interference to be expected in the future.

Correlation with field measurements shows these predictions to be reliable. If anything, they tend to be pessimistic; blockage of interference by buildings, trees and other structures in the TVRO's immediate vicinity cannot be taken into account in the computer-based prediction. Coordinators can, however, verify marginal computer predictions with an on-site survey testing actual levels of interference.

Licensing TVRO sites

Licensing is now voluntary and is available for sites using large antennas—five meters or greater. Licensing affords protection against future sources of interference, but is allowed only if the petitioner proves (via frequency coordination) that the proposed site is curren-

Figure 1: Interference printout for a proposed TVRO site.



```
                        MICROWAVE INTERFERENCE ANALYSIS FOR EARTH STATION PLACEMENT
                        -----------------------------------------------------------

        SITE NAME   SYRACUSE N Y           COORDINATES   43- 5-27 N LATITUDE     ELEVATION      0 FEET AMSL
                                                         76- 4-46 W LONGITUDE    CENTERLINE     0 FEET AGL

          COMPANY   MICROWAVE FILTERS      DATE THIS RUN  05/04/83  1538 HRS     INTERFERENCE CRITERIA

                                           TOPOGRAPHIC                           -137 0 DBW/1 MHZ SHORT TERM
            AGENT                                MAP(S)                            (0 01 PERCENT OF THE TIME)

         COMPUCON                           E S  ANTENNA  F C C                  -147 0 DBW/1 MHZ LONG TERM
         ENGINEER   GARY W LOPEZ            PATTERN USED  32-25 LOG(THETA)         (20 0 PERCENT OF THE TIME)


  BASED ON LINE-OF-SIGHT CONDITIONS, THE FOLLOWING EXISTING AND PROPOSED 4 GHZ MICROWAVE PATHS WITHIN
  126 MILES CREATE INTERFERENCE INTO THE PROPOSED EARTH STATION EXCEEDING THE OBJECTIVES STATED ABOVE

                                                         TRANSMIT ANTENNA            AZIMUTH   INTF
C                                                         AZIMUTH GAIN(TX)           FROM      LEVEL
A      TRANSMITTER         LATITUDE        RECEIVER      -------- --------   INTF    EARTH     INTO
S      -----------         --------        --------       AZIMUTH  ANTENNA   SOURCE  STATION   E S         E X C E E D S
E  COMPANY - CALL SIGN     LONGITUDE   COMPANY - CALL SIGN  TO E S  DISCRIM  DISTANCE TO TX    ------      O B J E C T I V E
     - FCC ANTENNA CODE    ----------  -----------------  -------- --------  -------- -------  SMOOTH
N  --------------------    ELEVATION-  PATH STATUS -CHANNEL DISCRIM TRANSMIT  SPACE   HORIZON  EARTH     TERREST    TIME PCT
O      ANTENNA MODEL       CENTERLINE  LOADING - EQUIPMENT   ANGLE    GAIN    LOSS    GAIN     LOSS      TX POWER  SHORT LONG
-------------------------  ----------  -----------------  -------- --------  -------- -------  --------  --------  ----- ----
 1 NORTH SYRACUSE   , NY   43- 7-21    AMBOY CENTER    , NY   31 9   37 6DB    2 4MI   333 7  -127 6DBW   7 0DBW    9 4  19 4
  ATTNE -KEE85 -B53200     76- 6- 3    ATTNE  - KEE74        153 7   46 0DB    3 9KM
     KS-15640              420'- 79'      OP-12S-2PYY01      121 8   -8 4DB  116 3DB   -10 0DB   0 0DB    3 0DBW    5 4  15 4
     TRANSMIT FREQ  3750 OV 3830 OV 3910 OU 3990 OU 4070 OU 4150 OU
 2 SYRACUSE         , NY   43- 2-55    PHOENIX         , NY  325 5   39 5DB    4 5MI   229 8  -132 5DBW   7 0DBW    4 5  14 5
  ATTNE -KEB31 -B42500     76- 8-51    ATTNE  - KEE75         49 7   55 9DB    7 3KM
     KS-15676B             400'-215'      OP-VS -2PYY01       84 2  -16 4DB  121 6DB    -1 5DB   0 0DB    3 0DBW    0 5  10 5
     TRANSMIT FREQ  4010 OH

 3 SYRACUSE         , NY   43- 2-55    SULLIVAN        , NY  101 4   39 5DB    4 5MI   229 8  -139 6DBW   7 0DBW    0 0   7 4
  ATTNE -KEB31 -B42800     76- 8-51    ATTNE  - KEA53         49 7   63 0DB    7 3KM
     KS-15676BC            400'-215'      PC-45D-2PY202      308 4  -23 5DB  121 6DB    -1 5DB   0 0DB    3 0DBW    0 0   3 4
     TRANSMIT FREQ  3750 OH 3830 OG 3850 OU 3910 OG 3990 OG 4070 OG 4090 OU 4150 OG 4198 OG

 3 SYRACUSE         , NY   43- 2-55    SULLIVAN TOWNSHI, NY  101 4   39 5DB    4 5MI   229 8  -139 6DBW   7 QDBW    0 0   7 4
  ATTNE -KEB31 -B42800     76- 8-51    ATTNE  - KEA53         49 7   63 0DB    7 3KM
     KS-15676BC            400'-215'      OP-VS -2PYY01      308 4  -23 5DB  121 6DB    -1 5DB   0 0DB    3 0DBW    0 0   3 4
     TRANSMIT FREQ  3770 OV 3930 OV

 3 SYRACUSE         , NY   43- 2-55    SULLIVAN        , NY  101 4   39 5DB    4 5MI   229 8  -139 6DBW   7 0DBW    0 0   7 4
  ATTNE -KEB31 -B42800     76- 8-51    ATTNE  - KEA53         49 7   63 0DB    7 3KM
     KS-15676BC            400'-215'      PC-45D-2PYY02      308 4  -23 5DB  121 6DB    -1 5DB   0 0DB    3 0DBW    0 0   3 4
     TRANSMIT FREQ  3930 OV
```

Exceeds long term criteria by 19.4 db

Of terrestrial antenna above ground level

Ⓐ Ⓑ Ⓒ

(Above Sea Level)

Frequency (MHz)

Vertical Polarization

(Future Carrier with Vertical Polarization)

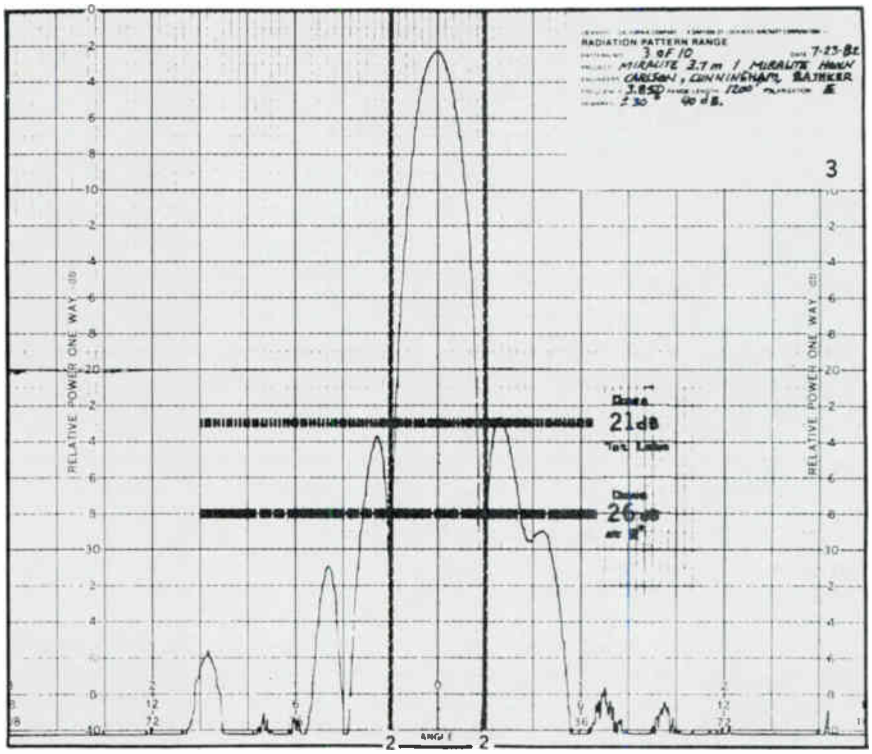
Type of transmission (VS = Stabilized Video)

Predicts incidence of interference levels by frequency at the site. (Courtesy of Compucon Inc.)

'In view of the growth of the number of terrestrial interference sources, additional protection against future interference would appear to justify the expense of licensing'

tly "interference free." Once licensed, the TVRO operator is entitled to formal notice when additional sources of potential interference are proposed.

Figure 2: Radiation pattern of a 3.7 GHz antenna



This antenna has first side lobe gain of -21 dB (relative to main beam gain). Courtesy of Miralite.

Table 1: Location of potential 4 GHz interfering carriers

Satellite* Transponder	Possible interfering carrier
1-(3720) MHz	3710, 3730 MHz
2-(3740)	3730, 3750
3-(3760)	3750, 3770
4-(3780)	3770, 3790
5-(3800)	3790, 3810
6-(3820)	3810, 3830
7-(3840)	3830, 3850
8-(3860)	3850, 3870
9-(3880)	3870, 3890
10-(3900)	3890, 3910
11-(3920)	3910, 3930
12-(3940)	3930, 3950
13-(3960)	3950, 3970
14-(3980)	3970, 3990
15-(4000)	3990, 4010
16-(4020)	4010, 4030
17-(4040)	4030, 4050
18-(4060)	4050, 4070
19-(4080)	4070, 4090
20-(4100)	4090, 4110
21-(4120)	4110, 4130
22-(4140)	4130, 4150
23-(4160)	4150, 4170
24-(4180)	4170, 4190

*Satcom/Comstar 24 transponder satellite

There is general agreement that it is prudent to license any revenue-generating TVRO: CATV systems, commercial SMATV systems, and TVROs for newsgathering, rebroadcasting and business data transferring. Yet, surprisingly, only a small percentage of eligible systems are licensed. Realization of good reception quality would seem enough business justification for a frequency coordination study. And in view of the growth of the number of terrestrial interference sources, additional protection against future interference would appear to justify the additional expense of licensing.

The existence of TI

Many commercial TVRO sites suffer terrestrial interference to one or more transponder channels. These cases arise from a number of circumstances:

1) Failure to obtain frequency coordination services and "trust to luck" or conduct one's own site test. Unfortunately, such self-surveys cannot predict interference sources planned for future turn-on dates. Also, such tests cannot detect sources that are temporarily inoperative, but which are present in the frequency coordinator's data base.

2) Failure to follow up the coordinator's print out with a verifying field check. Field surveys are expensive and, given a clean bill of health from the read-out, some TVRO owners opt to pass up this "clincher." Sometimes though, a field survey will show unexpected interference levels. This is due to unpredictable reflections from structures in the vicinity of the proposed site.

3) Terrain alteration after TVRO installation. Drastic changes in the terrain, such as extensive excavations, earth build-up, or the addition of new buildings or substantial structural modifications create reflections that may increase interference levels at the TVRO site. Unfortunately, these are unavoidable and cannot be predicted even through the frequency coordination process.

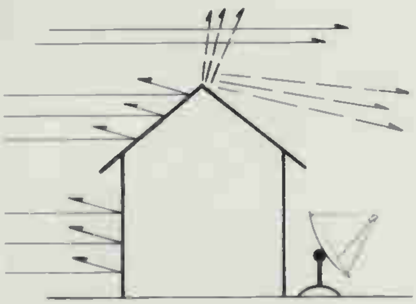
4) Inaccuracy in the frequency coordination process. Although experience has shown that a coordinator's printouts are consistently accurate, there could be a mistake in the data base, such as delays in adding newly approved transmitters. This is extremely rare however.

Suppressing terrestrial interference

There are a number of different ways to suppress TI, depending on the exact nature of the interference (direction, frequency, signal strength), property features and specific TVRO systems. However, each of these falls into one of two road categories of suppression strategy: TVRO antenna shielding and TVRO system filtering.

Antenna shielding methods are superior to filtering; they add no distortion to the satellite signal and hence produce better video quality. They also tend to protect against future turn-on of additional sources of microwave interference. In addition, they can suppress a wide interference spectrum normally not filterable. On the other hand, system filtering is often less expensive and can be installed more quickly.

Figure 3



The TVRO should be mounted near the blocking screen or structure to minimize reception of microwave energy diffracted from the edge.

Antenna shielding

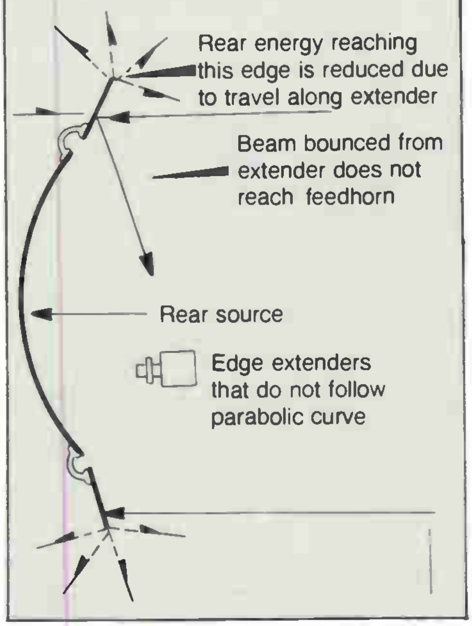
How does the TI get in? The majority of TI gets to the pickup horn by edge diffraction; unwanted signals hit the edge of the dish and then reradiate in all directions, including toward the horn. Even interference approaching from the rear of the dish reaches the horn this way. Another way of saying it is, TI is received by the antenna side and back lobes (Figure 2). All antennas are imperfect in that they have dozens of small beams besides the desired main beam. These are legitimate antennas. Direct transmission of the TI signal to the horn is rare and accounts for a very small percentage of interference.

Anything one can do to the antenna to reduce the gain of these minor lobes, relative to the gain of main beam, will reduce the susceptibility to TI. Logically then, choosing an antenna with small minor lobes ranks with frequency coordination as a first step in reducing susceptibility to TI.

Antenna relocation should be the first, and is usually the cheapest, *on-site* TI suppression manuever. The idea is to move the antenna behind an existing structure to block reception of TI (Figure 3). This is more successful in cases where the TI approaches the antenna from the side or rear. When TI arrives from the forward hemisphere of the dish, it becomes "stickly" to block TI without blocking the "bird."

If antenna relocation is not feasible, artificial shielding is the next manuever. It can be more expensive than relocation because you have to build additional structures like blocking screens. Important parameters of effective construction are materials, size of the screen and exact location relative to the TVRO antenna. Where interference transmissions are received in the "high risk" zone, screens may not be feasible but you may be able to modify the dish edge to reduce diffraction, and hence, reception of the interference. "Dish extenders" (Figure 4) can reduce the minor lobe reception by extending the diffraction edge to a larger off-axis angle where the reception sensitivity of the pickup horn is reduced. Alternatively, the outer edge of the dish may be covered with microwave absorbing material (Figure 5) to dissipate the incident interference, and reduce diffraction.

Figure 4: Edge extender



Placing the antenna in a pit, below the ground line, is the most effective shielding but

Remote Revenues

Simplicity. That's how you generate revenues with Texscan's Textop Converters. A remote control transmitter gives convenience to your customers and more cash to your system.

Aside from its simple, reliable operation, the Textop converter offers many features; Synthesized tuning eliminates the need for fine tuning, microprocessor controlled with virtually no mechanical parts to wear out.

Choose from two types. The Textop Ultra provides a 20-button, direct access, IR wireless remote transmitter. Its favorite channel memory is capable of storing up to 60 channels. Options include: AB cable selection for up to 120 channels, 36 to 60 channel roll over, SAW resonator output, and parental control.

The Textop Plus features 36 channels, expandable to 60. Its modular design allows additional features by simply adding plug-ins. The Plus' optional remote control is a 4 button wireless transmitter.

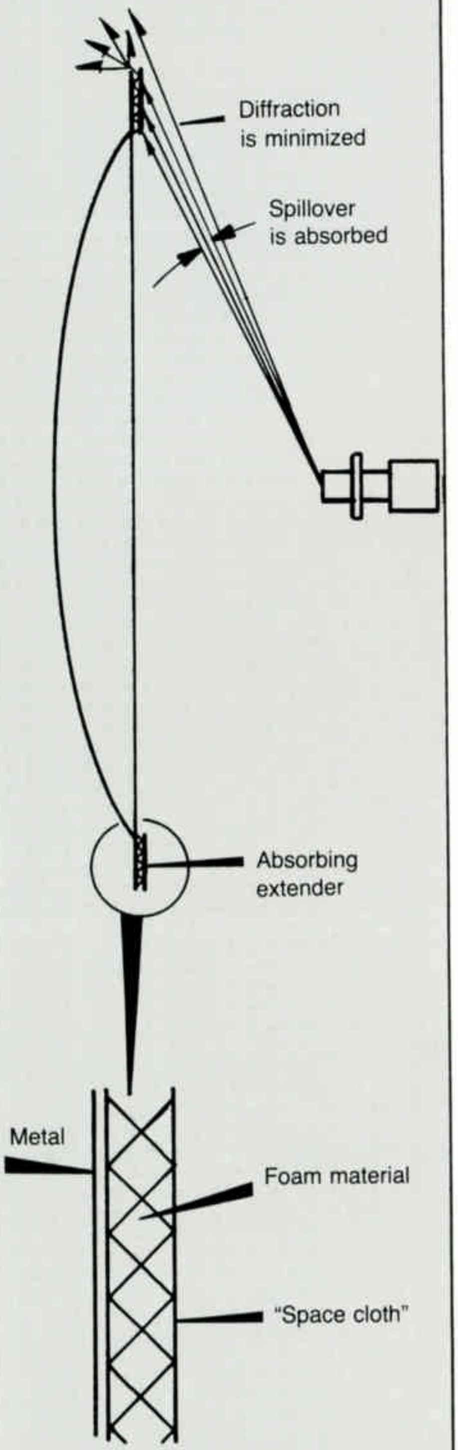
Texscan
CORPORATION

Texscan El Paso Division
10841 Pellicano Drive
El Paso, TX 79935
(915) 594-3555

Reader Service Number 32.

also the most expensive (Figure 6). The pit is necessary when the site is plagued with severe, multi-directional interference. This can make artificial shielding complex, expensive or not feasible, as when the interference attacks from the front of the dish. The superior effectiveness of the pit is due to the fact that microwave interference is present in horizontally traveling "rays" that are largely avoided if the entire antenna is below ground level. The great expense of the pit is due to the large amount of earth that must be removed, the need to install a drainage system and the need to harden the sides of the pit for personal safety.

Figure 5: Absorbing edge extender



Antenna extenders of "tuned absorber" to absorb spillover and reduce side and back reception lobes.

System filtering and types of TI

Filters connected into the TVRO system introduce signal distortion that degrades reception quality to some extent. While the resulting video is acceptable to a wide range of viewers, it may not be up to commercial or rebroadcast standards. Since suppression by antenna shielding does not degrade video quality, filtering should be considered only after determining that antenna shielding is not technically feasible or cost-effective.

TI can be classified into three types depending on the frequency range of the interfering carrier:

1) *In-band* interference is caused by carriers in the TVRO 3.7-4.2 GHz band. These are radiated from the terrestrial microwave network operated by the telephone companies and common carriers. Table 1 lists permissible transmit frequencies of this network and the TVRO channels that can be affected by them. Figure 7 shows that these carriers are midway between transponder center frequencies. A given terrestrial microwave carrier will give some interference to the two transponders adjacent to it, with heavier interference to the transponder co-polarized with the interfering signal. When this results in non-destructive interference (some of the picture is still visible), IF notch filters usually work (Figure 8).

Microwave interfering carriers are offset ±10 MHz from the center of the microwave transponder band so that downconverted interference occurs at ±10 MHz from IF center frequency, i.e., at 60 MHz and/or 80 MHz for 70 MHz IF center frequency. Hence, notch filters tuned to 60 MHz and/or 80 MHz would be placed between the downconverter and receiver to counter this type of interference.

When the interfering signal is sufficiently strong, destructive interference may occur; the picture becomes completely wiped out. In this case, IF traps will not cure the problem.

Figure 6: Using an earthen pit for artificial shielding

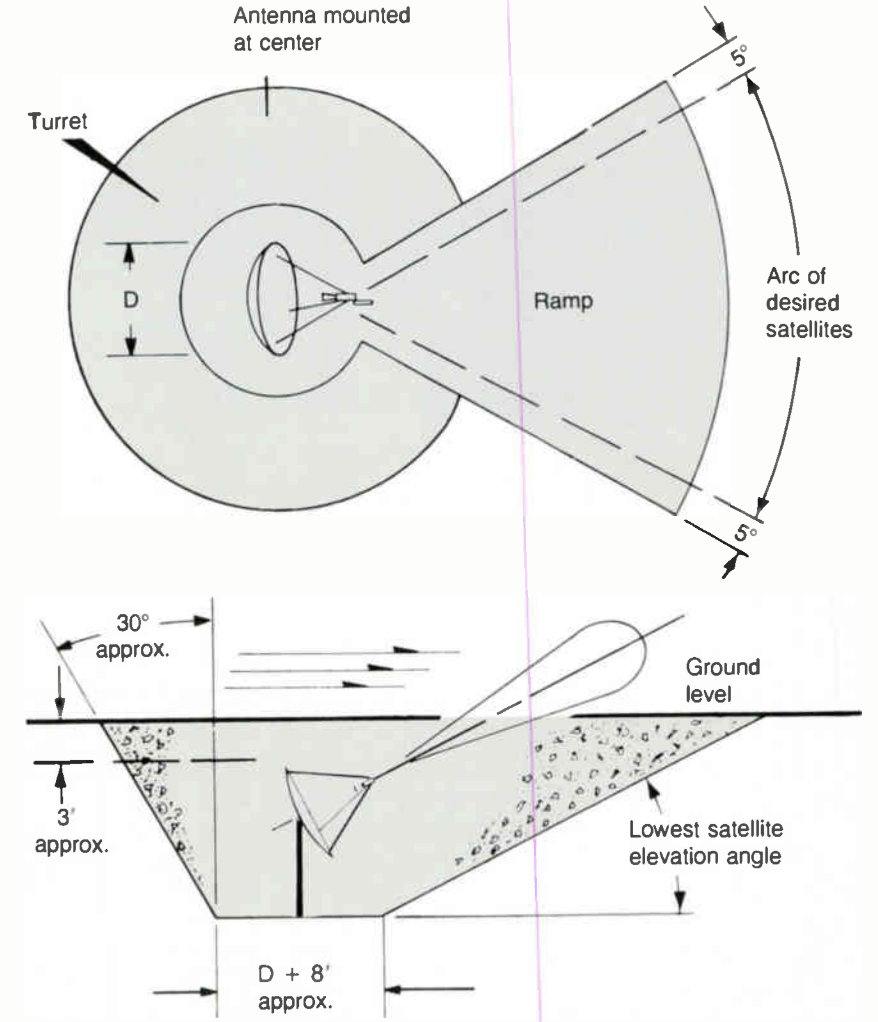
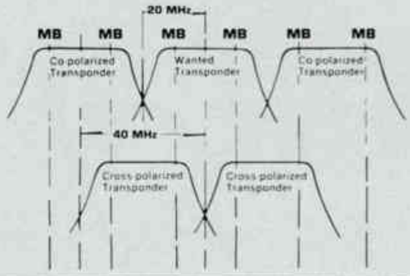


Figure 7: Carriers in the 3.7-4.2 GHz band



Either the downconverter is saturated and non-intelligent downconversion is taking place, or the automatic frequency control (AFC) circuit has locked onto the stronger interference carrier and detunes the receiver. In this case, microwave notch filters, one for each interfering carrier, are required before the downconverter (Figure 9). Since a terrestrial network antenna is permitted to transmit up to six frequencies, six microwave notch filters are often required. Of course, if the TVRO is dedicated to only one transponder, as with newsgathering for example, then a maximum of two notch filters are required: one at +10 MHz and the other at -10 MHz from the transponder center frequency.

2) *Out-of-band* interference is due to one of

Figure 8: Filtering non-destructive interference

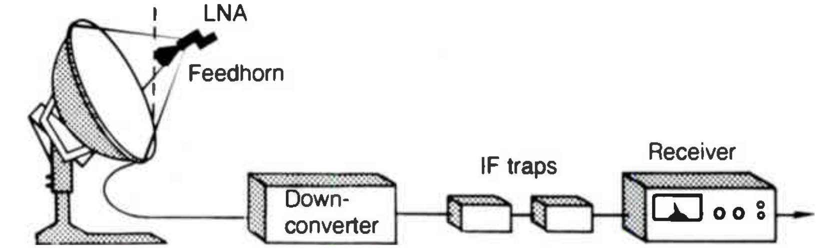


Figure 9: Filtering destructive interference

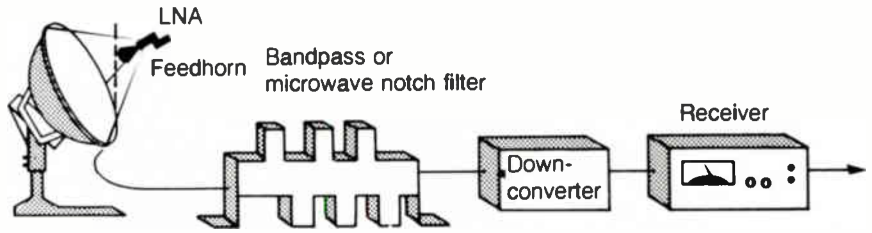
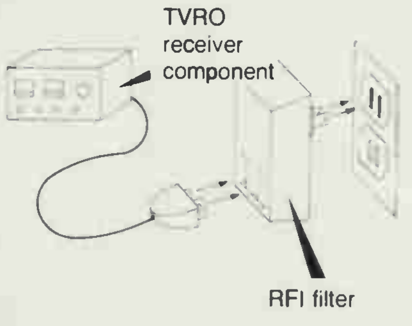


Figure 10: Filtering co-channel interference



the many microwave sources operating below or above the 3.7-4.2 GHz band (see Table 2). If sufficiently strong, these carriers can desensitize the downconverter and cause visible interference, especially on transponders having the same polarization. This type of interference can usually be cured with a microwave bandpass filter connected between the LNA and downconverter. Such a filter would have a passband of 3.7-4.2 GHz to pass all transponders with minimum loss and suppress all carriers below 3.7 GHz and above 4.2 GHz.

3) *VHF ingress* interference is due to pickup of a terrestrial VHF signal in the approximate 5 to 500 MHz band by the electronics, because the antenna is incapable of picking up these low frequencies directly. The general symptom is the same type of defect on all channels and to the same extent. Its cause is usually due to VHF pickup on the downconverter-receiver coaxial cable or "back door" ingress via the power cord; house wiring is sometimes an excellent VHF antenna.

A frequent ingress is pickup of a local TV channel having the same frequency as the TVRO's RF modulator. This is called co-channel interference and usually shows up as "venetian blinds" across the screen or another video program in the background. This occurs for all transponder channels. In this case, changing the TVRO RF modulator channel will cure the problem. In most other cases, a cure is usually effected by installing an RFI filter at the wall plug (Figure 10) supplying power to the receiver and downconverter and grounding the braid of the coaxial cable at, or just after, entry to the building. To do this, peel off a small ring of vinyl covering and ground the braid to a good earth ground with a short copper wire. The ground may be a metal rod driven into the earth, or inside the house, a large pipe or grounded metal radiator.

Table 2: Potential antenna interference frequencies

Frequency (GHz)		Nature of potential offender
0 960 1 350		Land based air navigation systems
1 350 1 400		Armed forces
1 400 1 427		Radio astronomy
1 427 1 435		Land mobile police fire forestry railway
1 429 1 435		Armed forces
1 435 1 535		Telemetry
1 535 1 543		SAT—maritime mobile
1 605 1 800		Radio location
1 660 1 670		Radio astronomy
1 660 1 700		Meteorological—Radiosonde
1 700 1 710		Space—research
1 710 1 850		Armed forces
1 990 2 110	②	TV Pick up
2 110 2 180		Public common carrier
2 130 2 150		Fixed point to point (non public)
2 150 2 180		Fixed—omnidirectional
2 180 2 200		Fixed point to point (non public)
2 200 2 290		Armed forces
2 290 2 300		Space research
2 450 2 500		Radio location
2 500 2 535		Fixed SAT
2 500 2 690		Fixed point to point (non public) Instructional TV
2 655 2 690		Fixed SAT
2 690 2 700		Radio astronomy
2 700 2 900		Armed forces
2 900 3 100		Maritime radio navigation
2 900 3 700	③	Maritime radio location
3 300 3 500		Amateur radio
3 700 4 200	①	Common carrier (telephone) Earth Stations
4 200 4 400	③	Altimeters
4 400 4 990		Armed forces
4 990 5 000		Meteorological—radio astronomy
5 250 5 650		Radio location (coastal radar)
5 460 5 470		Radio navigation—General
5 470 5 650		Maritime radio navigation
5 600 5 650		Meteorological—Ground based radar
5 650 5 925		Amateur
5 800		Industrial and scientific equipment
5 925 6 425	②	Common carrier and fixed SAT
6 425 6 525		Common carrier
6 525 6 575		Operational land and mobile
6 575 6 875		Non public point to point carrier
6 625 6 875		Fixed SAT
6 875 7 125		TV pick up
7 125 8 400		Armed forces
8 800		Airborne Doppler Radar

Interference frequencies listed in the order of occurrence on TVROS:
1) Telephone carrier spectrum co-located with TVROs.
2) Widely distributed common microwave carriers.
3) Seldom occurring frequencies close to TVRO band.

Some illustrations in this article are reprinted from the "ASTI Interference Handbook," courtesy of Microwave Filter Co., Inc.

The tiger's in our tank

Oscar & Associates Inc

Oscar & Associates Inc

To borrow an NCTA Chairman Ed "Tony the Tiger" Allen expression, this year's NCTA show was *Grrreat!* From programming—to new regulations—to products, the show shined with intelligent, innovative and long-overdue news. Although there were fewer attendees this year than last (13,261 vs. 14,800), the quality of the speeches, technical sessions and conventioneers could not be beat.

New legislation, most notably the Federal Cable Act of 1984, has lead to signs of renewed growth, profits and fair competition in the cable industry. NCTA President James Mooney, who addressed conventioneers at the opening general session on June 3, said the convention was "designed to be a celebration of hard-won victories, and an affirmation of confidence in the future." He said that red ink was already turning to black; and the projections presented at the show by Arthur D. Little Inc. and Malarkey-Taylor Associates certainly agreed with him.

Ed Allen also spoke of long-overdue freedom and position. He identified cable as an electronic publishing industry with First Amendment rights and he touched on how this improved cable operators' relationships with franchising authorities, brokers, Wall Street and subscribers. Allen then labeled future problems/issues as stimulating challenges and golden opportunities.

FCC Chairman Mark Fowler applauded the existence of fair competition. Addressing conventioneers live from Washington, D.C., via satellite, he said: "The name of the game in communications today is free market competition, not government regulation." He went on to say that marketplace competition is indispensible in providing the communication needs of the American people.

This sentiment is shared by many in the industry, as evidenced by the quality of the technical sessions and exhibits at the show. The technical sessions sought to educate attendees on current technical issues. Many of the issues, when completely worked out, will improve the cable industry's position in terms of other video services. So conventioneers eagerly listened to papers on fiber optics, ingress/egress, addressability, pay-per-view, signal relay, digital transmission and plant design, to name a few. Hopefully the new knowledge will help technicians, engineers and executives to better serve subscribers.

Exhibitors made quite a showing this year with the introduction of many new products designed to solve current technical problems and increase operator revenue. Goals included making cable more convenient and varied for subscribers. Areas that received attention in terms of development were pay-per-view, stereo and VCR compatibility. Overall, exhibitors were pleased with the number of sales and contacts generated at the convention.

For specific product information, read on.

- **Zenith Electronics Corp.** announced many new products at the show. The first was a technology that offers one-way addressable cable systems a way to deliver impulse-pay-per-view programming. Called Phonevision, the system uses a new telephone-based ordering system. Phonevision is built around the company's Z-TAC addressable decoder system and hardware and software at the cable operator's headend studio. It requires no additional hardware in the home. Phonevision is based on automatic number identification (ANI) technology, which has been used in telephone switching networks. ANI technology (commonly used when a caller dials an 800 or 900 telephone number) allows data to bypass the central telephone switches, eliminating the overload problem. When subscribers want to order a program, they enter on their telephone a code listed in their program guide. The Phonevision system automatically switches the data from the primary telephone network and routes it to the cable operator's headend computer.

Zenith's new VCR interface is a device that allows consumers to simultaneously record a pay channel and watch a network channel, without connections or A/B switches. It works with any VCR and with any type of cable converter system, and can be installed by the subscriber.

Zenith also demonstrated the TAC-Timer, a remote-control transmitter that can be used to program the Z-TAC decoder to change channels automatically, for recording programs

Zenith's Phonevision is built around a new CATV headend hardware and software system that can process more than 1,000 program orders per minute.

unattended. The TAC-Timer uses a Z-TAC remote-control transmitter with a built-in programmable event timer and channel selector that allows the subscriber to independently pre-set both the Z-TAC decoder and a VCR to record at a later time. A liquid crystal display on the remote control features a digital clock, channel indicator, and day and week indicator.

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

Scientific-Atlanta's 4.5-meter antenna for receive-only applications.

- **Scientific-Atlanta** has developed BTSC-stereo format compatible equipment for cable. The equipment consists of the Model 6380 stereo headend encoder and Series 8500 set top terminals. The equipment is compatible with sync suppression techniques used by other vendors. Subscribers with stereo television sets can connect to a Series 8500 set-top terminal for stereo sound delivered by the Model 6380 stereo headend encoder. Subscribers wishing to listen to the sound through their home stereo equipment would add a left-right output attachment available at consumer electronics outlets.

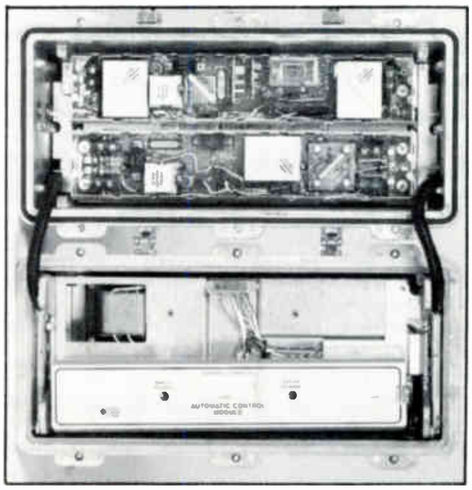
S-A's Model 8525 set-top terminal features a method of programming service authorizations, utilizing the unit's infrared remote-control receiver to configure the set-top's non-volatile memory. There is no PROM used. The unit need never be opened by the operator. Other features are a 15-favorite-channel memory and electronic parental control.

S-A also unveiled the Series 2400 PPV entertainment system, to help hotel/motel operators market premium programming services. The computerized pay-per-view system uses a set-top terminal located in the guest's room. This interactive device lets the guest choose between free viewing and viewing premium channels for a fee. All operations are automatic. Guests enter requests for the desired programming on the set-top terminal's keypad, while the control computer authorizes and monitors viewing, bills for the services delivered, and then de-authorizes the channel. The system can handle up to four premium channels and features teleconferencing capabilities. The Series 2400 consists of PPV set-top terminals, a PPV system manager computer, and a PPV two-way addressable transmitter. The system is capable of delivering programming from several media.

S-A's new C⋆DATA series of computer data marketing products also appeared at the show. These products permit the CATV operator to distribute and control computer data to subscribers in the same manner as premium television programming. With a C⋆DATA receiver, the subscriber can attach an IBM PC or compatible system to the cable just like a television set. With the corresponding C⋆DATA headend transmission unit, the cable operator can deliver X-PRESS, a new data service soon to be offered by X-PRESS Information Services Inc., of Denver. The subscriber can use X-PRESS menus displayed on the PC's screen to select the services and specific information desired. Local data-generation services and delivery of future services are also possible with the products.

An advanced 4.5-meter earth station antenna designed for receive-only applications in the C- and Ku-bands was also exhibited by S-A. The new antenna, called the Series 8345, is suited for CATV operations receiving satellite video programming. The parabolic reflector is made of 12 precision stretch-formed aluminum panels. The 4.5-meter antenna has a standard elevation-over-azimuth mount, and both the C- and Ku-band feed systems provide dual-polarization capability.

S-A's Series 6500 parallel hybrid (PHD) distribution amplifiers were also shown. The new PHD products include a 32 dB gain bridging amplifier and a 32 dB gain line extender. Both are available in bandwidths from 300 MHz up to 550 MHz. The products feature lower distortion and increased output capability, according to S-A.



S-A's series 6500 parallel hybrid distribution amplifier includes a 32 dB gain bridging amplifier and a 32 dB gain line extender.

The Autoserter, a commercial insertion system that can be upgraded from sequential to random access, also was introduced by S-A. The new commercial insertion system allows cable operators to sell local advertising time on certain cable networks. The basic Autoserter is a sequential access system. Commercial spots are recorded onto an insertion tape in a specified order and inserted on the network in that same order. The tape automaticallly rewinds when all the spots have been aired. Each Autoserter mainframe controls from one to four networks, and additional channels may be added by using a second Autoserter. The Autoserter also serves as the basis for the random access system. The random access system is computer-controlled, allowing commercials to be randomly inserted. The computer stores the contents of each tape, along with the location of each spot (series of commercials), in a tape library. The computer also stores a schedule of the spots in the order they are to run.

Scientific-Atlanta displayed its new Model 8555 addressable set-top terminal for operation in expanded bandwidth (550 MHz) CATV systems. The product is capable of handling up to 80 channels.

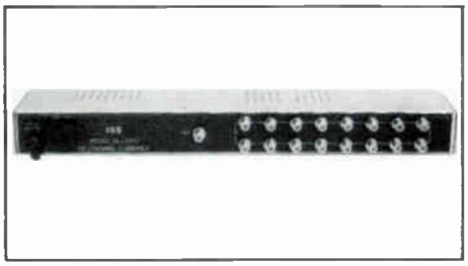
S-A also came out with an RG-59 type coaxial cable manufactured for use in CATV headend applications. The cable features a tinned, copper-clad steel center conductor and dual 96 percent copper braid shield that can be terminated.

For additional information, contact: Scientific-Atlanta Inc., 1 Technology Parkway, Box 105600, Atlanta, Ga. 30348, (404) 441-4000.

- The Video Information Systems Division of **Adams-Russell Co.** announced two new options to its Arvis-7000 family of automatic insertion equipment: the Arvis 7740 remote switch for creating an interconnect, and the Arvis-7904 computer interface. The Arvis-7740 remote switch provides a method of interconnecting two cable systems. The feature allows for the insertion of commercials originating from an insertion system to distant is high, the transformer's saturating core automatically limits its output voltage to 60 volts. In a brownout, the battery need not come on until the utility voltage drops below 90 VAC.

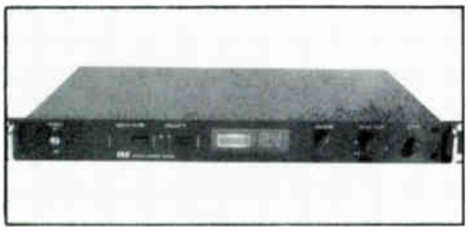
Lastly, ISIS, a new integrated subscriber institutional system, was unveiled by Magnavox. ISIS uses 550 MHz and 600 MHz equipment to carry both subscriber and institutional services on one cable. The system carries return signals in the 5-108 MHz bandwidth and forward signals in the 150-550 or 600 MHz bandwidth. As a result, a 600 MHz ISIS system can carry 55 subscriber channels and have about 100 MHz in both the forward and return paths.

For more details, contact Magnavox, 100 Fairgrounds Dr., Manlius, N.Y. 13104, (315) 682-9105.



The Model GL-1600 active combining network by International Satellite Systems.

- **International Satellite Systems** introduced the GL-1600 16-input active combining network. The unit combines RF signals from CATV modulators into one +60 dBmV output to drive the cable distribution system. Gain from input to output is 15 dBmV. Isolation between ports is better than 45 dB, according to ISS.

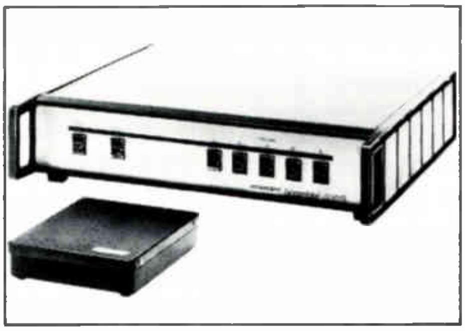


International Satellite Systems' commercial satellite receiver.

ISS also introduced the GL-5000 commercial block conversion satellite receiver for CATV, SMATV and data services. Features include: built-in HV IF polarity switching and interference filters that are activated by front panel control; a synthesized receiver; and unclamped loop-thru baseband signals.

For more information, contact ISS, 1004 Del Norte, Menlo Park, Calif 94025, (800) 227-6288.

- **Intercept Corp.** introduced its System 330 addressable descrambler. System 330 provides up to five tiers of service, which includes an unlimited number of channels per tier as well as pay-per-view. Up to two pay-per-view events can be simultaneously programmed for each subscriber. The system incorporates the DEC Model 350 to address control and billing tasks. A software package provides the operator with detailed billing data for all levels of service.



Intercept's System 330 addressable descrambler.

For further information, contact Intercept Corp., 220 Entin Rd., Clifton, N.J. 07014, (800) 526-0623.

- **Compucon Inc.** announced a data base designed to evaluate potential terrestrial microwave path blockage by manmade obstructions, and assist in the location of existing towers. It is used in the planning of terrestrial microwave systems. This computer system stores information on existing and planned buildings, towers, etc., throughout the United States. A feature of this system is the ability to evaluate potential terrestrial microwave path blockage by manmade obstacles before going on-site for a field inspection and survey.

For more details, contact Compucon, P.O. Box 809006, Dallas, Texas 75380-9006, (214) 680-1000.

- **Sadelco Inc.** debuted its latest signal level meter, the Super 600. It is capable of measuring signals from 4.5 to 600 MHz with an accuracy of ±0.5 dB. The built-in 73.5 MHz crystal-controlled calibrator has an output level of +20 dBmV with an accuracy of ±0.1 dB. The Super 600 also can measure signal-to-noise ratio, hum, volts and ohms. Features include LCD microammeter range indicator, internal AFC circuitry, car battery charging facility and night illumination. The meter is portable and comes in a custom extruded aluminum housing, which is protected by a water-resistant carrying case.

For further information, contact Sadelco Inc., 75 W. Forest Ave., Englewood, N.J. 07631, (201) 569-3323.

- **General Electric**'s cable TV products operation announced that it will be offering the new GE Control Central programmable remote-control device. Up to four remote-control products can be controlled through this system, including televisions, videocassette recorders, compact discs, cable converters or stereo amplifiers. The remote unit works with any brand as long as it is an infrared remote. When placed "head to head" with the component's original remote control, Control Central's microcomputer learns the infrared codes to command all of the component's features. Control Central is equipped with a computerized memory and a liquid crystal display that shows the specific functions programmed into the computer's memory as they are selected. It can be reprogrammed so new electronic products can be added to a home entertainment system.

For complete specs, contact General Electric, College Blvd./Mail Drop 17, Portsmouth, Va. 23705, (804) 483-5064.

- The **TOCOM Division of General Instrument Corp.** demonstrated a new VCR-compatible model of its 5503 baseband addressable converter at the NCTA show. The new converter permits unattended recording of cable programming. Model 5503-VR incorporates an integral VCR timer that enables subscribers to program the converter to turn on and tune to a cable channel on a specific day at a designated time. The subscriber's VCR unit is programmed to record the 5503-VR output on these same days and times. Up to four events may be programmed over a one-week period.

Subscribers can program the timer via the 5503's IR remote-control unit. Programming parameters (day, time and channel) can be entered, reviewed and edited, or new data inserted in minutes, according to TOCOM. An electronic A/B switch, operated from the remote, allows switching between VCR outputs and 5503-VR outputs to the TV display. TOCOM offers a special VCR interconnect kit, the VCR-Mate, which enables subscribers to connect the 5503-VR converter to the VCR unit.

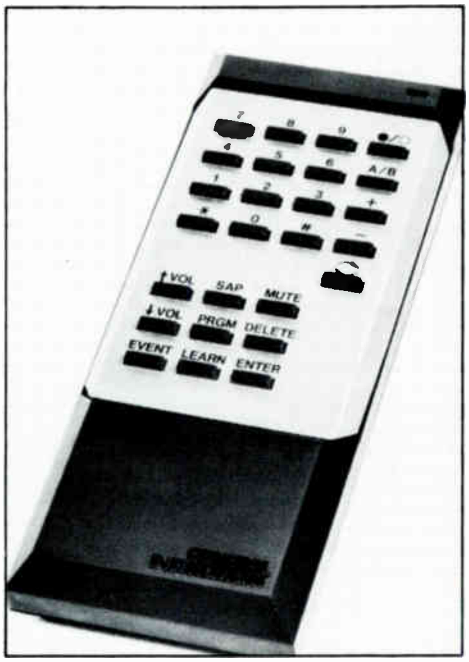
TOCOM also introduced an Oak-compatible model of its 5503 baseband addressable converter. The TOCOM Plus 5503-OC contains all the features of the 5503 and descrambles the Oak 1H scrambling technique.

The Micro-ACS addressable control system from General Instrument's TOCOM Division.

Finally, TOCOM displayed its new PC-based headend control system at the NCTA show. Based on the IBM PC-AT computer line, the Micro-ACS is a multi-tasking system designed to control the functions of the

TOCOM Plus baseband addressable system. Its features include addressing/scrambling control and the ability to authorize converter operation, initiate and change subscriber services, and manage premium and pay-per-view programming. The system accommodates up to 32,000 subscribers and supports up to three CRT terminals. The Micro-ACS is equipped with 512 kb of random access memory, 20 Mb disk storage capacity, and an eight-port expansion board. It will operate as a stand-alone unit or with a billing interface and is compatible with a variety of printers.

For further information, contact the TOCOM Division, P.O. Box 47066, Dallas, Texas 75247, (214) 438-7691



The remote-control unit from General Instruments' Jerrold Division.

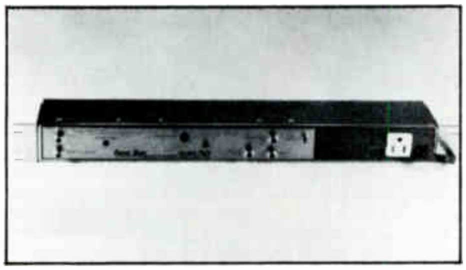
- The **Jerrold Division of General Instrument Corp.** announced a new computer program for analyzing rebuild/upgrade options. The program allows cable operators to input the parameters of their existing systems and receive recommendations for equipment needed to bring those systems to the desired channel capacity and bandwidth. The program takes 10 to 20 minutes to digest the information and arrive at an estimate, including specific equipment recommendations.

Two models of a new hand-held remote-control unit also were unveiled by Jerrold. Models SRC-1 and SRC-2 are compatible with Starcom addressable converters. The SRC-1 is designed to work with all Jerrold Starcom 450 addressable converters and the SRC-2 is compatible with all models of the Starcom VI converter line.

Also announced at the Show was Jerrold's deluxe hand-held unit. This remote-control unit is compatible with the installed base of all Starcom 400 and 450 digital converters. Using a microprocessor-based technology, the deluxe handheld, Model SRC-3, provides all normal hand-held functions in addition to featuring both last-channel and favorite-channel recall capabilities.

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

- **Channel Master** has expanded its private cable equipment line with the addition of audio/video modulators, single-channel AGC amplifiers, and a channel rejection filter. Audio/video modulators (Models 7632-7643) are designed for medium-to-large systems, and feature a fully-regulated power supply.

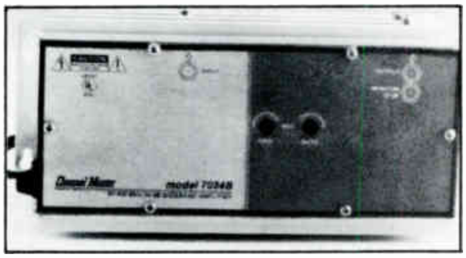


Model 7604 single-channel amplifier by Channel Master.

Covering channels 2-13, the units offer separate audio and video level controls, high output, an overmodulation indicator, and adjustable carrier ratios. Video inputs accept standard baseband sources. Audio inputs may be fed from tuners, satellite receiver audio outputs, video recorders or microphones.

The single-channel amplifiers (Models 7601-7613) cover VHF and mid-band channels. They feature an input filter, interchangeable broadband RF amplifier with integrated AGC circuitry, directional coupler output mixing and adjustable sound trap, plus input and output monitoring.

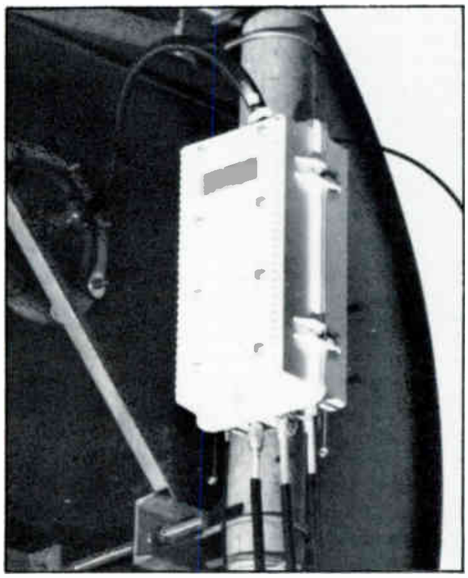
The channel rejection filter offers a minimum 55 dB trap depth, providing a 6 MHz-wide channel for use in private cable systems.



Channel Master's 30 dB wideband amplifier incorporates hybrid ICs.

Channel Master also showed a new 30 dB wideband distribution amplifier that incorporates hybrid ICs. The amplifier provides a flat response across the 50-500 MHz bandwidth, plus temperature/voltage stability and protection against static discharges.

Two new CARS band multichannel microwave systems also were exhibited by Channel Master. The new Micro-Beam products for cable plant expansion include a 300 MHz (36-channel) receiver, plus a 450 MHz transmit/receive system. These microwave units are designed for outdoor mounting directly behind an antenna. Existing structures such as water towers may be used for mounting. The Micro-Beam system also allows transmission in multiple directions.



Channel Master's Micro-Beam multichannel CARS band microwave system for cable plant expansion.

For more information, contact Channel Master, P.O. Box 1416, Industrial Park Dr., Smithfield, N.C. 27577, (919) 934-9711.

M/A-COM's Videocipher Series 2000E is designed for the consumer TVRO market.

- **M/A-COM**'s new Videocipher Series 2000E stand-alone satellite descrambler is a user-friendly device that is easily installed and can interface with most satellite television receivers. Designed as an add-on unit for consumers who already have home satellite receivers and wish to receive scrambled signals on a subscription basis, the descrambler will work with both C-band and Ku-band satellite transmissions and is capable of receiving any combination of up to 56 Videocipher scrambled signals.

Other capabilities of the Series 2000E include the ability to accommodate future programmer services, digital stereo, 28 on-screen assistance displays, selection of alternative program language, parental discretion, teletext-type message capabilities, impulse pay-per-view capabilities with credit and program history, personal message reception, and reception of program information and other text services that may be available.

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

COMMUNICATIONS TECHNOLOGY

Official trade journal of the Society of Cable Television Engineers

Upcoming editorial focus

August
- Data applications
- Commercial insertion
- Automated billing

September
- Theft-of-service
- Satellite security
- Upgrading

October
- Pay-per-view
- Audio advantages
- Plant design

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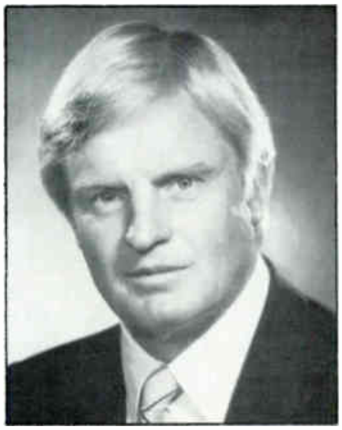

O'Brien

The board of directors of **Times Fiber Communications** has elected **Colin O'Brien** chairman in addition to his titles of president and chief executive officer. He succeeds Lawrence DeGeorge who recently retired as chairman. O'Brien joined Times in January 1984 and was named president and chief executive officer in June 1984. Prior to joining Times, O'Brien was employed for 12 years by General Instrument Corp., ultimately rising to the position of president of its Jerrold Division.

Dr. Penelope Peoples has rejoined Times Fiber in the newly created position of manager, public relations. Peoples will have responsibility for developing and implementing a comprehensive public relations policy and program. Prior to rejoining Times, Peoples served as an account executive for the EcuMed Venture. She had earlier worked as manager of development and communications for Times Fiber Communications Inc. Contact: 358 Hall Ave., P.O. Box 384, Wallingford, Conn. 06492, (203) 265-8500.

AM Cable TV Industries Inc. announced the promotion of **Joseph Preschutti** to president of the E-Com Products Division. Preschutti had held the position of vice president and general manager for the division He is a senior member of both the IEEE and SCTE.

In addition **Robert Hallett** has been named group leader, RF and communications engineering for AM Cable's E-Com Products Division. Hallett's responsibilities include directing RF and communications system design and support engineering for manufacturing. He formerly was senior project engineer for General Instrument/Jerrold Division in Pennsylvania with responsibilities for product design and development engineering of CATV headend products. He also held engineering positions with Delta Data Systems Corp. and General Electric Space Division. Contact: 1 AM Dr. and Rt. 663, Quakertown, Pa. 18951, (215) 536-1354.

Compucon Inc. announced the promotion of **Gary Friend** to vice president and manager of communications information services. In addition to managing the Washington, D.C., office, Friend's responsibilities include the marketing and management of several of Compucon's information services. Prior to joining Compucon in November 1983, Friend worked at CACI Inc. where he held several key positions including manager of product planning and manager of marketing research group. Contact: P.O. Box 809006, Dallas, Texas 75380-9006, (214) 680-1000.

Avantek Inc. announced the promotion of **Steven Allan** to the position of vice president and corporate controller. Allan has served as corporate controller during his five years with Avantek. The vice president title recognizes the increased complexity of the firm's top accounting job.

Avantek also announced two other appointments. **John Locke** has been appointed director of sales and marketing for the commercial communications products profit center of the Telecommunications Group. Locke has been responsible for product development and both domestic and international sales for M/A-COM, RCA and MSC as well as for his own entrepreneurial microwave company in which he sold his interest to the other principles. His most recent position was with M/A-COM Semiconductor Products in Burlington, Mass., where he held the position of vice president of sales and marketing.

Danny Wong has been promoted to the position of director of headquarters sales Wong has been with Avantek for five years, most recently in the position of national sales manager. He will be in charge of U.S. and Canadian component sales, coordinating the sales efforts of the headquarters sales team with Avantek's independent sales representatives and the new direct field sales team. Contact: 3175 Bowers Ave., Santa Clara, Calif. 95051, (408) 727-0700.


Howe

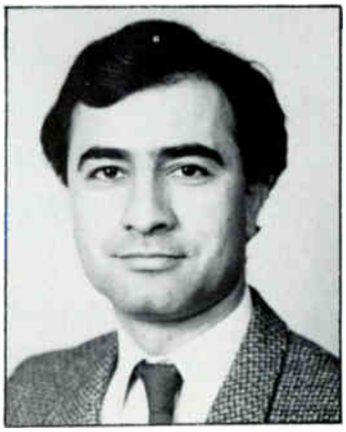
Douglas Howe has joined **General Electric's** Commercial Electronics Products Department as national sales manager cable TV products. In his new position, Howe will immediately begin to participate in demonstrations of the Comband system. Howe brings with him over 15 years of management experience. In his previous position, he was director, Western field operations for Oak Communications. Howe also has held senior management positions in marketing and product management at Van Camp Seafood Co. and Crown Zellerbach Corp. Contact: College Blvd./Mail Drop 17, Portsmouth, Va. 23705, (804) 483-5064.

General Signal Corp. announced the appointment of **Kenneth Tingley** as president of **Tau-tron Inc.** and group executive of the General Signal Telecommunications Group, which includes the units of Tau-tron Inc., Warren Communications, Dielectric Communications, and Telecommunications Technology Inc. Most recently, Tingley was president and chief executive of Sykes Datatronics Inc. and held prior management positions at Northern Telecom, Schlumberger, and Hewlett Packard.

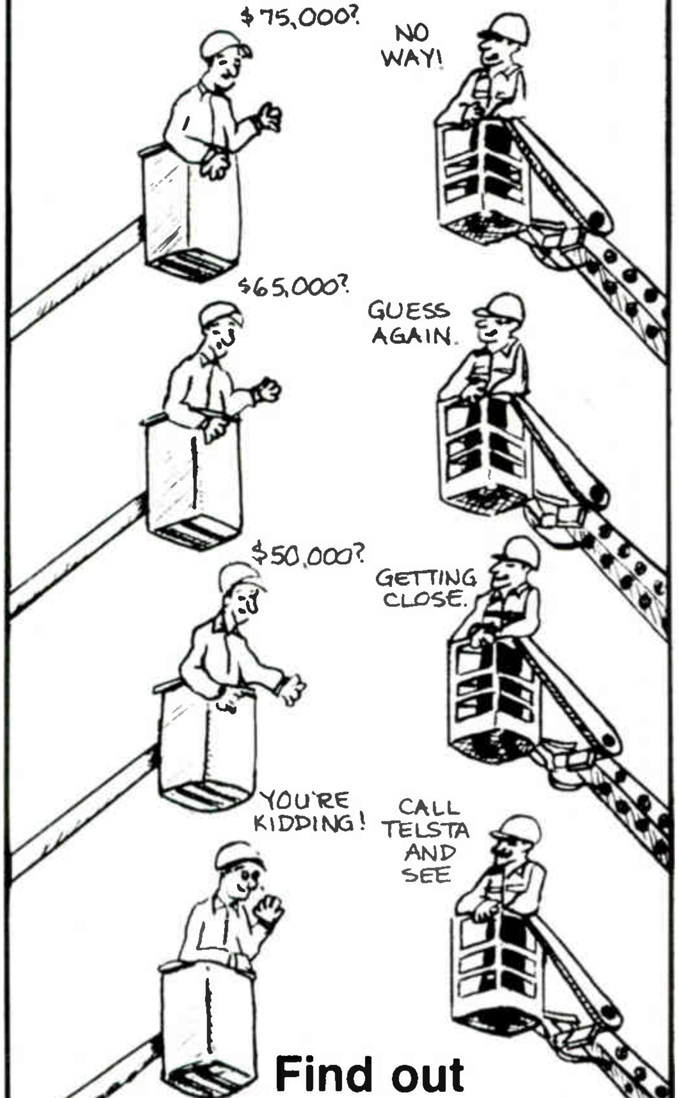
Tau-tron also made three other appointments. **William Rollins** has been promoted to the position of vice president of engineering and product planning. Rollins joined Tau-tron as engineering manager in 1979 and has been director of marketing for the past two years. Previously he held technical design and management positions at Raytheon in the telecommunications field.

Herbert Clark was promoted to the position of vice president of sales and marketing. He will have responsibility for the company's sales, both domestic and international, and customer support, along with Tau-tron's marketing division. Clark joined the firm as a sales representative manager in 1978, progressed to general sales manager, and for the past two years served as director of sales. Prior to 1978, he held various sales and marketing management positions for commercial, OEM and military markets.

Finally, Tau-tron announced the addition of **Amy Allen** to the fiber-optics products area. As applications engineer-fiber optics, her responsibilities include the introduction of new fiber-optics products, application documentation, training and technical customer assistance. Allen has had three years of fiber-optics engineering experience in optical systems and technology with PHALO, GTE and the Xerox Corp. Contact: 10 Lyberty Way, Westford, Mass. 01886, (617) 692-5100.


Manoochehri

Mohsen Manoochehri has been promoted to account manager in the **Jerrold** sales and service division of **General Instrument Corp.** He takes over



responsibility for Jerrold accounts in Southern California and the Times Mirror Cable TV account. Most recently, Manoochehri was addressable terminal products manager for the Subscriber Systems Division, and has served in various marketing positions since joining the company in 1981. Contact: 610 Neptune Ave., Brea, Calif. 92621, (714) 671-2800.

Donald Wadas has been named regional sales manager-North Central, for **C-COR Electronics Inc.** Based in the Chicago area, he will handle sales of C-COR's line of distribution and digital electronics for data communications and cable television systems. Wadas will be responsible for sales in Illinois Indiana, Kentucky, Michigan, Wisconsin, Iowa, Minnesota, North Dakota and South Dakota. Prior to C-COR, Wadas was employed for five years by AT&T Technologies Inc., first as a marketing planner and then as an account representative. Contact: 13 Whittington Course, St. Charles, Ill 60174, (312) 377-9194 or (800) 233-2267.

George Combs has been named national sales manager at **Tamaqua Cable Products**. Combs spent one year at Tamaqua in a training program to learn the operation and capacity of all plant equipment, followed by one year with the Fox-Rowden-McBrayer agency in Tampa, Fla., to become familiar with the manufacturer's representative sales program. In 1982, he moved to St. Louis and became Tamaqua Cable's Midwestern regional sales manager. As national sales manager, he will assume full responsibility for the marketing and sales of all of the company's product lines. Contact: P.O. Box 347, Schuylkill Haven, Pa. 17972, (717) 385-4381.

At its recent annual meeting, the **Association of Federal Communications Consulting Engineers** elected the following new officers for 1985-86: as president, **Warren Happel,** P.E., Scripps-Howard Broadcasting; vice president **Charles Gallagher,** P.E., consulting engineer; secretary, **Ronald Rackley,** P.E. du Treil-Rackley Consulting Engineers; and treasurer, **Alan Gearing,** P.E., Jules Cohen & Associates, PC, Consulting Electronics Engineers.

The following members were presented awards in appreciation of their continued outstanding support of the association: **Elizabeth Dahlberg,** P.E., Lohnes & Culver Consulting Engineers; and **Donald Everest,** P.E., Cohen & Dippell Consulting Engineers.

The membership of the association is made up of professional engineers who practice before the Federal Communications Commission, and engineering representatives from the communications industry. Contact P.O. Box 19333, 20th Street Station, Washington, D.C. 20036, (202) 223-6700.

Pioneer Communications of America announced the addition of **Ronald Coppock** to its sales staff as an account executive for Pioneer's Southern region. Coppock was previously employed with Oak Communications as a senior account executive in the Dallas area. He will be responsible for the sale of Pioneer's cable converter equipment to all new and existing accounts in Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Puerto Rico, South Carolina, Tennessee and Texas.

Pioneer also announced the addition of **Jim Lewis** to its sales staff as Western regional manager. Lewis' cable experience includes positions with Magnavox and RCA as an account executive, and his most recent position as district sales manager for Pico Products. He will be responsible for managing cable converter accounts in Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming. His sales office will be located in Denver. Contact: 2200 Dividend Dr., Columbus, Ohio 43228, (614) 876-0771.

The Arvis Division of the **Adams-Russell Co.** announced the appointments of **Linda Arnold** and **Susan Robinson** as account executives. Arnold comes to Adams-Russell from Pioneer Electronics Corp. Robinson has been with Adams-Russell since 1982. She was national affiliate sales manager for The Cableshop Advertising Service, an Adams-Russell enterprise. Contact: 1370 Main St., Waltham, Mass. 02154, (617) 894-8540.


DRAKE
VM2410 VIDEO MODULATOR
DEVIATION
DRAKE
ESR2240 EARTH STATION RECEIVER

The art of pulling cable

Parts one and two of this series dealt with strand placement and cable pulling/lashing operations. This third and final installment focuses on conduit pulling.

By Anthony J. DeNigris
President, Nationwide CATV Services Inc

In analyzing the operation of pulling cable—whether it be strand, coax, multicomponent fibers or armored underground cables—the single most important factor determining the success of the task will be the proper application of common sense. Tricks of the trade, as most experienced tradesmen will refer to, usually end up being nothing more than the refinement of the task from a commonsense point of view. The commonsense "tricks of the trade" necessary to get the job done the right way will be emphasized here. However, I cannot stress too strongly what the proper procedures and considations are, for in doing conduit cable placement, as compared to aerial cable, one does not get to see the mistakes so readily evidenced as a line crew might observe. Therefore, the conduit cable crew only gets one chance to do the job right; the first time.

Don't underestimate

When setting up a conduit project, the possibilities for error are countless, and unless every facet of the job is thoroughly analyzed prior to implementation you are bound for trouble. I am not stating that every time you bury conduit you've got a headache on hand. What I am saying is that in the event that you have a project going in with more than just a couple of small runs from a pole to a pedestal or such, you must plan the complete running and layout and take into account all the precautions and considerations in order to affect a quality placed and designed underground system.

Many times when underground (UG) is surveyed, the person doing the surveying does not know that the system is going to be in conduit, and therefore, certain steps are not taken from the onset.

It becomes quite obvious when studying certain strand maps, that many blunders take place at this stage. I was recently given maps of an area to place a UG system in where the surveyor took a measurement of the straightest distance between two points in order to get to where he decided the pedestal was going to be placed. The designer then set up the electronics as per the routing and measurements of the surveyor. Example: Cable going down the right side of the street to a location picked for a splitter, where at that point the route shows a direct straight line back across the street on a diagonal for 257 feet to a tap location. Needless to say, this measurement was as the crow flies, and the designer naturally did his thing by the same rules. The actual and only possible way to get to the tap location from that splitter point was to go under a road, under a sidewalk, up an embankment, across a parking lot and then through a flower garden to that location. Luckily for the cable company, we chose to show an alternate method of routing and design where the splitter point was moved prior to the original spot and the routing across the street was conveniently set up to minimize hard top work. The original 257 feet turned out to be over 400 feet when properly layed out from that first splitter point, but even then it would have required four bends (sweeps) in the cable to get to the tap location. The redesigned way lowered the footage to about 145 feet with only two sweeps.

When this type of thing appears on a set of maps, you can rest assured that you will see a lot more of the same kind of disregard for the finished product throughout the rest of the maps. The thing that bothers me most is that for the maps to be actually handed me by the system with a contract to go ahead and do the work tells me that we, the cable television industry, are still very far away from that degree of perfection that I hear so many executives and technological people boast of today. Many times as a contractor, you get the feeling that it is the blind themselves who expect to see the most light at the end of the tunnel. We are not miracle workers, but thank God we can think.

Sweeping up

When it comes to laying out a conduit system, perhaps the greatest blunder of them all is the misuse of conduit sweeps. First of all, polyethelene jacket or bare cable has such a degree of abrasion against the inside radius of PVC sweeps that I think it is a miracle in the first place that any cable even comes through more than two sweeps in a single run, let alone the possible damage that exists to both cable and conduit due to this abrasion. I strongly recommend substituting all steel sweeps for PVC and then using the largest possible sweep radius available. I previously wrote about cable binding up in a sweep and pulling it right out of the ground and that was no joke; it was pure fact.

Making the pull

When a properly layed out conduit system is installed the right way, there should be a clean and free path (plenty of room) for cable to be pulled through. Too many times, I have seen conduit installers lay the conduit in the trench and not wipe out the coupling (where PVC conduit is placed), give a swipe of glue around the inside and shove it together with the next section of conduit. Sounds like the right way, right? Well it is except for the fact that no precaution is taken against foreign objects from entering the conduit, specifically rocks.

All conduit should be plugged on both ends while it is being layed out in or along a trench until the actual cementing together. I have used vacuums to clean conduit systems out prior to running a line through and you wouldn't believe the debris and rocks that come out due to haphazard installation practices. When it comes time for the pull to be made, the first thing to do is to get a professional conduit vacuum and blow out the conduit. This is done by capping one end of the system and using the vacuum in the reverse mode at the other end to load the system with pressure. After a short time, the pressure will be so strong that when you quickly remove the cap at the other end you will have a fountain of air and possibly debris blowing out. Do this a couple of times and you can be assured of the system being pretty much free from small foreign matter.

At this time you must set the vacuum in the normal mode and place a special line puller at the other end attached to a spool of conduit lead line. The line puller is commonly referred to as a mouse. It is a small sponge-type ball with a hook in it, which one attaches the lead line to. It serves the purpose of plugging the conduit (the appropriate size plug must be used for each size conduit), thereby causing the vacuum to pull it along and the lead line. I must say that if the crew member is not holding the spool of lead line properly when he lets the plug (mouse) fly, as the vacuum is trying to suck it through, he is going to risk having the line slice through his gloves or possibly his fingers. This is where the rocks, if there are any present, show up; they usually get pulled through by the plug under force of the vacuum. After the lead line is sucked through, then a pulling rope can be attached to it and then the cable can be pulled through.

When pulling the cable through, plenty of lubricant must be applied in order to make the task easy. The only proper way of actually pulling the rope through and therefore the cable(s), is by the use of a pulling winch (Greenlee makes what I feel is the best device), not by a pully and pick up truck. The winch is set with a capstan and a slowly turning ratchet drive, and the operator has complete control over the force and speed of the pull. The experienced cable puller can tell if there is a possible snag or when to ease up and take the cable through at a crawl, or when to let it come at full speed. The trick to the proper job here is in the right equipment and the combination of common sense.

With the proper considerations in advance, one might not believe how long of a cable run can actually be placed in conduit. I guess the proper phrase for making it all happen is called having "the right stuff."

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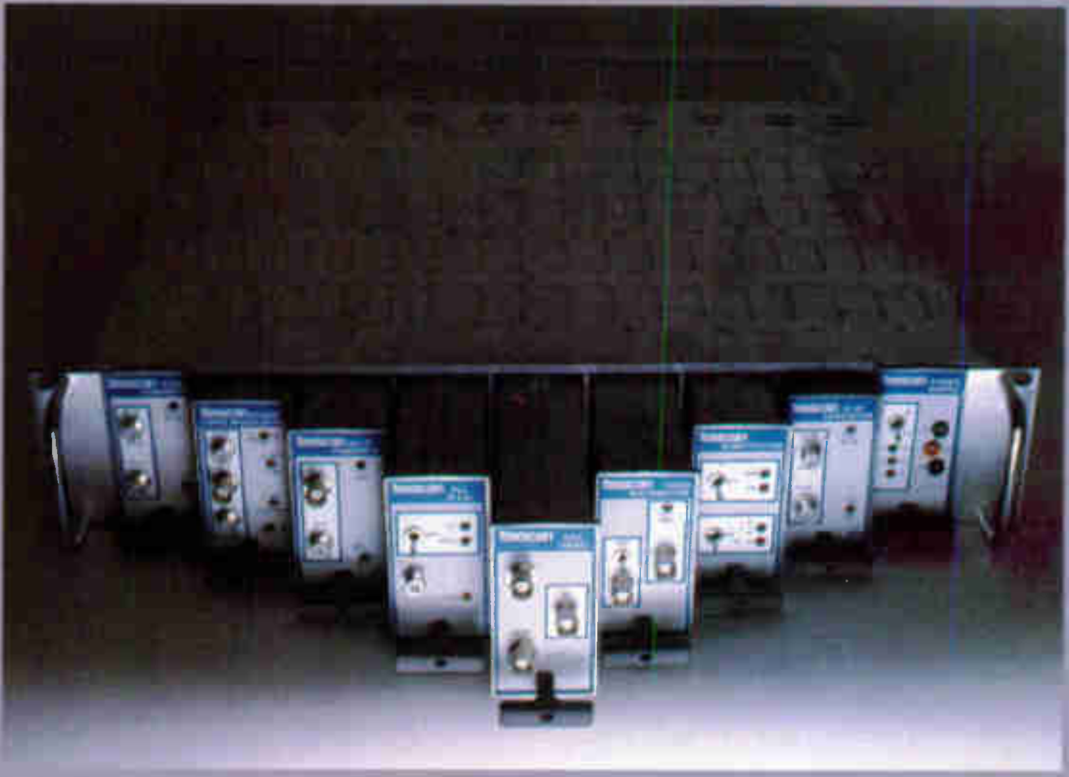

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CALENDAR

July

July 9-11: Online Conferences Inc. satellite and cable TV conference, "The Cable '85 Exhibition," the Brighton Metropole, U.K. Contact (212) 279-8890.
July 9-11: Jerrold technical seminar, Portland, Ore. Contact Beth Schaefer, (215) 279-8890.
July 10-12: Magnavox CATV training seminar, Detroit. Contact Laurie Mancini, (800) 448-5171; in New York, (800) 522-7464.
July 11: SCTE Florida Meeting Group seminar on CLI, signal leakage and an FCC update, Holiday Inn, Lakeland, Fla. Contact Richard Kirn, (813) 924-8541.
July 11-13: Montana Cable Television Association annual meeting and convention, Village Red Lion Motor Inn, Missoula, Mont. Contact Tom Glendenning, (406) 586-1837.
July 15-17: New England Cable Television Association annual convention. Dunfey Hyannis Hotel, Hyannis, Mass. Contact William Durand, (617) 843-3418.
July 15-18: American Federation of Information Processing Societies' National Computer Conference, "Technology's Expanding Horizons," McCormick Place, Chicago. Contact Helen Mugnier, (703) 620-8926 or (800) NCC-1985.
July 16-17: The Yankee Group seminar on software defined networks and alternatives, Washington, D.C. Contact (617) 542-0100.
July 17: SCTE Golden Gate Chapter meeting on scrambling systems, South San Francisco. Contact Pete Petrovich, (415) 463-0870.
July 17: SCTE North Central Texas Meeting Group technical session on signal leakage and the CLI. Contact Lynn Watson, (214) 241-1421.
July 17-19: Mississippi Cable Television Association convention, Royal D'Iberville, Biloxi, Miss. Contact David Bailey, (601) 437-8300.
July 18-19: Telecommunications Marketing Associates conference for telecommunications suppliers, Marriott Hotel, St. Louis Airport. Contact (703) 836-4422.
July 18-19: The Technical Marketing Society of America's conference on satellite communications, Washington, D.C. Contact (213) 534-3922.
July 23-25: Jerrold technical seminar, Williamsport, Pa. Contact Beth Schaefer, (215) 674-4800.
July 23-25: C-COR Electronics technical seminar, Boston. Contact Deb Cree, (814) 238-2461 or (800) 233-2267.
July 23-26: Florida Cable Television Association annual convention, Amelia Island Resort, Amelia Island, Fla. Contact Bob Brillante, (904) 681-1990.
July 24: SCTE Chattahoochee Meeting Group meeting on proof-of-performance testing, College Park, Ga. Contact Gary Donaldson, (404) 949-7370.
July 25: SCTE Appalachia Mid-Atlantic Chapter golf tournament, Chambersburg Country Club, Chambersburg, Pa. Contact Flint Firestone, (301) 252-1012.
July 25-28: Colorado Cable Television Association convention, Beaver Run Resort, Breckenridge, Colo. Contact Steve Durham, (303) 863-0084.
July 31: SCTE North Jersey Meeting Group meeting on proof-of-performance testing, Victors Holiday Inn, Wayne, N.J. Contact Bill Westerman, (201) 353-6157.

August

Aug. 13-15: Jerrold technical seminar, Minneapolis. Contact Beth Schaefer, (215) 674-4800.
Aug. 14-16: Rocky Mountain CATV Association's annual convention, Jackson Hole Racquet Club, Jackson, Wyo. Contact John Harrison, (307) 245-3392; or Oscar Davis, (505) 538-3701.
Aug. 17: SCTE Capitol Cities Meeting Group annual picnic, Fort Ward Park, Alexandria, Va. Contact Ed Milner, (703) 841-7723.
Aug. 19-20: University of California, Berkeley's intensive course on recent developments in telecommunications signal processing and ICs, Palo Alto, Calif. Contact (415) 642-4151.
Aug. 20-22: C-COR Electronics technical seminar, Minneapolis. Contact Deb Cree, (814) 238-2461, or (800) 233-2267.
Aug. 20-22: Texscan Instruments training program, Indianapolis. Contact Ron Adamson or Brenda Gentry, (317) 545-4196.
Aug. 21: SCTE Delaware Valley Chapter meeting on FCC rules update and field testing procedures, Willow Grove, Pa. Contact Bev Zane, (215) 674-4800.
Aug. 25-27: Southern Cable Television Association's annual convention, the Eastern Cable Show, Congress World Center, Atlanta. Contact (404) 252-2454.
Aug. 27-29: Security Equipment Industry Association and **National Burglar & Fire Alarm Association** "ISC Expo 85," New York Coliseum, New York. Contact Ann Feltes or Bill Campeau, (818) 965-7454.
Aug. 28-30: Missouri Cable Television Association annual convention, Lodge of the Four Seasons, Lake of the Ozarks, Mo. Contact Charlie Broomfield, (816) 453-3392.

September

Sept. 10-11: Society of Cable Television Engineers and **SCTE Rocky Mountain Meeting Group** technical seminar on signal leakage, CLI and the FCC, Denver. Contact Sally Kinsman, (303) 696-0380.

Planning ahead

Aug. 25-27: Annual convention of the Southern Cable Television Association, the Eastern Show, Congress World Center, Atlanta.
Sept. 18-20: Atlantic Show, Atlantic City, N.J.
Sept. 25-27: Great Lakes Expo, Convention Center, Indianapolis.
Dec. 4-6: Western Show, Convention Center, Anaheim, Calif.
March 15-18: National Cable Television Association annual convention, Dallas.
June 12-15: Cable-Tec Expo '86, Phoenix (Ariz.) Convention Center.

AD INDEX

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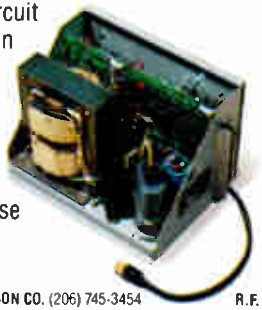

This concept needs fewer components which translates into **higher reliability**. Because the inverter cannot be activated, even with the line relay contact "stuck", this concept also gave us the fail-safe feature that helped us to obtain both **UL** and **CSA** approvals. And that gives a good product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

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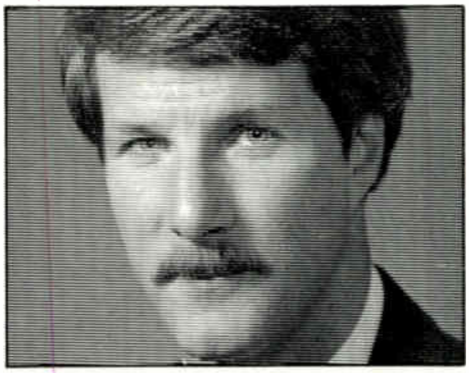
Reader Service Number 42.

Installers beware

The first half of this article (CT, June 1985) presented some hypothetical situations and pitfalls common to the installers' trade. This month, suggested company programs to alleviate the problems encountered by installers are offered.

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



Being exposed to the public day in and day out with limited direct supervision, the CATV installer is part of a high risk employment group. He is not alone in this category; plumbers, electricians, telephone installers, exterminators and others also are classified in this group of high risk employees. Neither are his experiences—whether positive as in saving a subscriber's life or more negative as previously described—unique only to the CATV installer. But because he is in this high risk group, it is important for both the company or operating system and the installer to recognize this and take measures to protect the installer as well as the subscriber.

Although the installer may be ultimately responsible for his actions, it should be the responsibility of the system to provide as solid a group of guidelines as possible for the installer. By establishing routine procedures regarding the installer's activities on the job, the installer knows what the boundaries are. Too often, the installer is left to make his own decisions as to proper conduct or handling of possibly explosive situations, avoiding future problem situations, and relieving the pressures and stress related to his high risk position.

Written policies

The first step for every system is to develop a clear set of written policies regarding installer conduct on the job and what to do if a situation develops where the installer becomes alerted to possible obvious subscriber temptations for misconduct. By defining both the company's expectations and the installer's responsibilities, some of the many grey areas associated with public exposure can be reduced.

It is amazing how few companies and operating systems currently have a written policy on such matters let alone any effective installer training to caution them about their non-technical occupational hazards.

Training and communication

The second step for systems is to establish regular training for all installers, as well as set up clear and specific channels of communication. For example, during monthly meetings, the system should schedule training sessions to discuss some of the "best known" pitfalls and ways to avoid them. In addition, systems should encourage open communication between installer and supervisor to allow installers to freely confide about pressures and temptations without fear of reprimand. Or, if installers are still reluctant or fearful to discuss problems with their own supervisors, systems should establish alternate outlets for installers by appointing a "neutral" supervisor for the same purposes.

Subscriber security

The third step is for systems to tightly secure subscriber information. All subscriber information should be absolutely off-limits to general system personnel. Anyone abusing system records or information should be carefully reviewed.

Additional programs

Other options to systems in establishing guidelines for installers exist that may at first appear as deterrents for the installer, but in fact help clarify, and hence, simplify the installer's responsibilities.

One such option is for system managers, chief engineers or installation foremen to periodically "drop by" installations in progress to break up the sense of an almost totally unsupervised opportunity month after month. Additionally, systems can develop subscriber feedback as a routine part of each installation or job. This can be accomplished, for example, either by providing a space on the work order for customer comments, having a customer service representative follow up on each work order (or at least a valid amount of randomly selected orders) or leaving a system-addressed "comment card" with the customer to be completed and mailed, similar to a warranty card. These feedback tactics allow the subscriber to express both satisfaction or dissatisfaction with the installer and work done.

> *'Although the installer may be ultimately responsible for his actions, it should be the responsibility of the system to provide as solid a group of guidelines as possible'*

Another option is to develop a cross-training program, which would allow the installer to rotate into a position totally isolated from the public such as dispatcher, pre-wire crew, regular construction crew, or stockroom or inventory control assistant. This process accomplishes two objectives: It provides the installer with additional on-the-job training and exposure to other areas of technical cable plant maintenance and operation, as well as briefly relieving the installer of the pressure and stress of constant public exposure.

Finally, because of the potentially very serious act of violence associated with this high risk position, managers should consider the use of psychological profile examinations for system personnel. These exams are readily available and are becoming increasingly standard for such job categories.

Be prepared

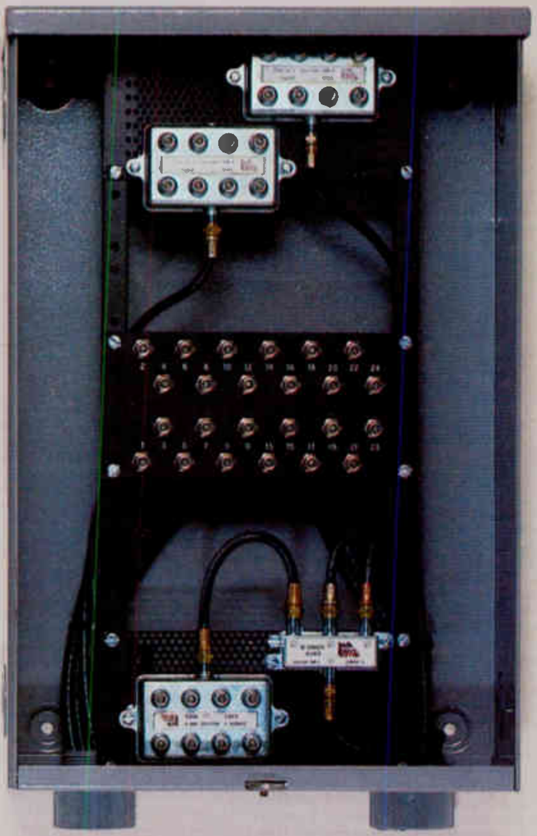
While every business and occupation has its risks, the CATV installer holds a position in one of the highest risk categories. Because of his easy, direct access and interaction with the subscriber, the CATV installer is frequently exposed to potentially dangerous situations, dangerous to himself and the subscriber.

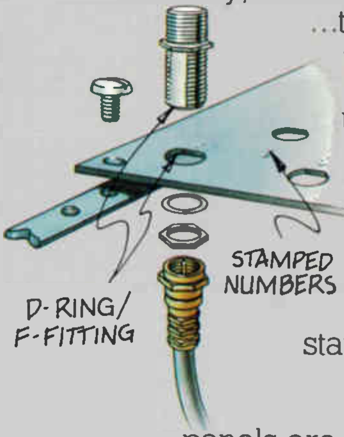
This exposure, in itself, is not the singularly destructive factor for the installer. What should be considered a destructive factor is this exposure coupled with the lack of training and written procedures in this area, or a supervisor who considers this aspect of the CATV installer's job as somewhat humorous rather than extremely serious, or a supervisor who does not provide either a sympathetic audience to a troubled installer or recommend professional help.

Lowering the risk for installers depends greatly on the installer himself for recognizing an explosive situation and reacting quickly to avoid an unpleasant incident. As well, it depends on his supervisor for recognizing the possible problems associated with this relatively unsupervised position and providing training and support, and finally, the CATV industry for recognizing the seriousness of this high risk yet indisposable employee and addressing the situation openly.

Messed Up.

Dressed Up.





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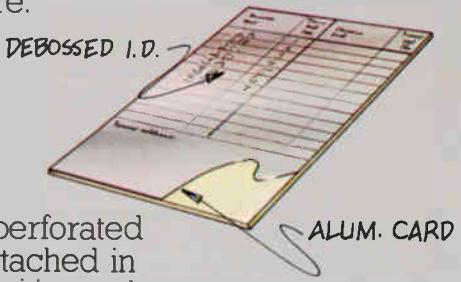

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