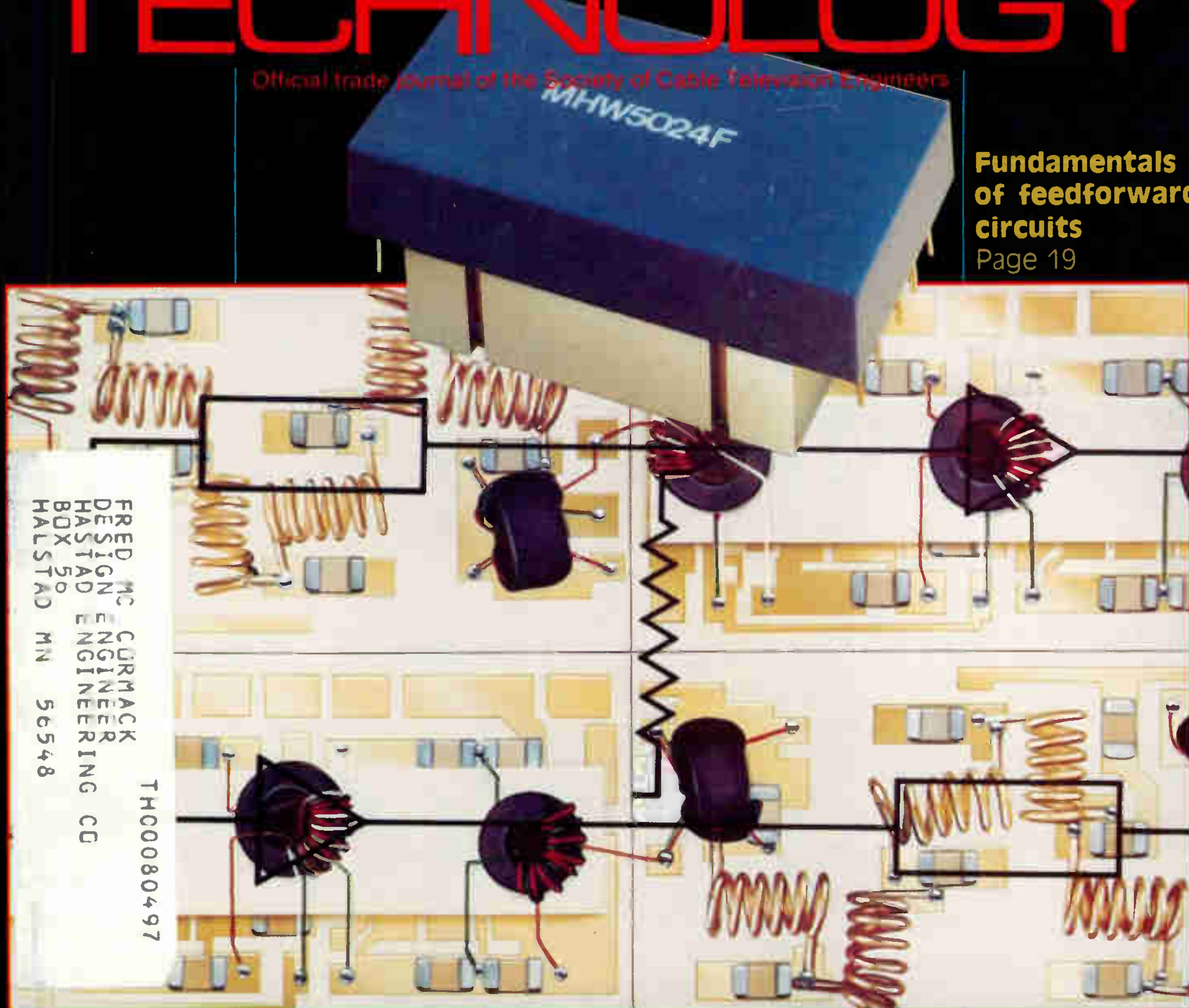
COMMUNICATIONS TECHNOLOGY

Official trade journal of the Society of Cable Television Engineers



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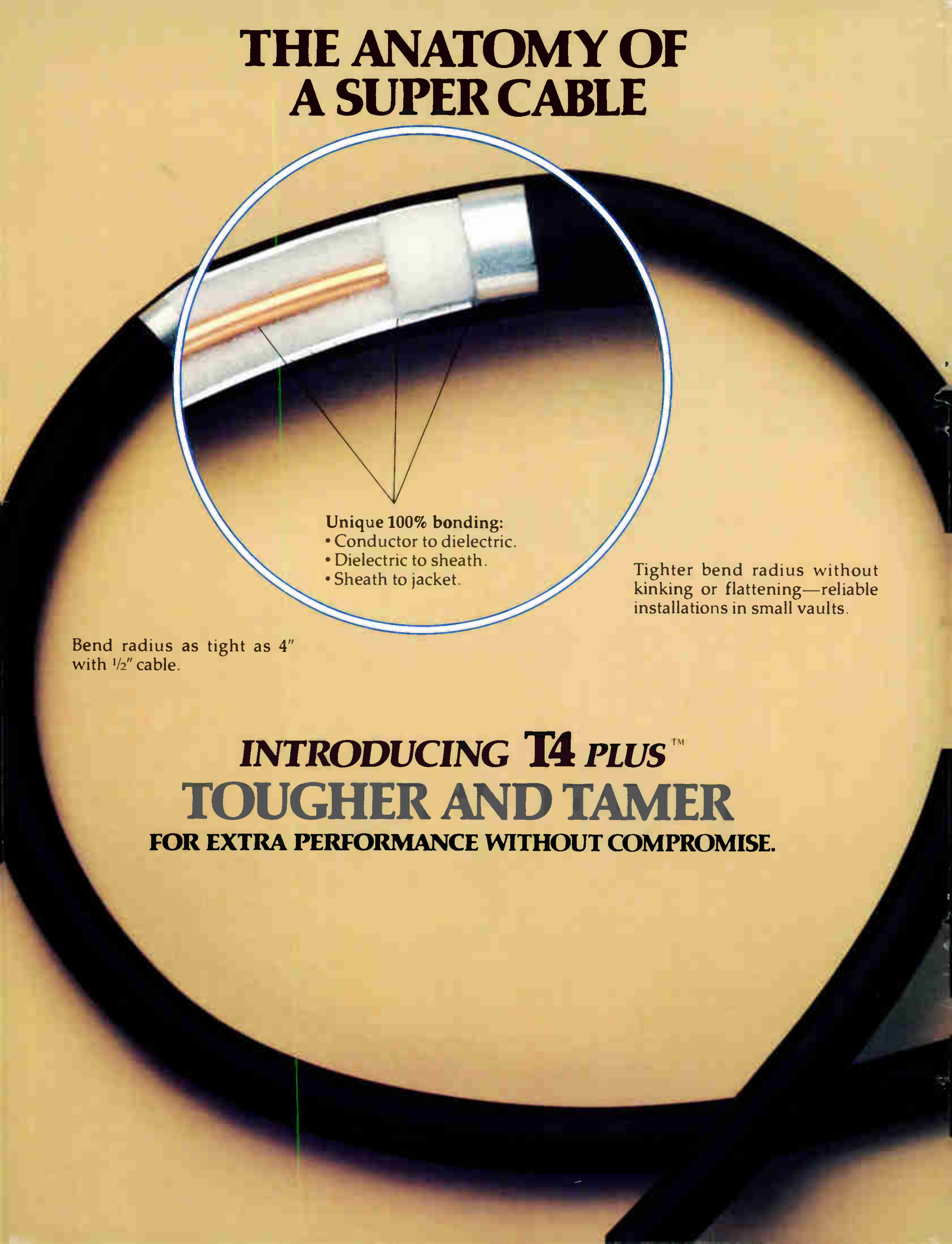
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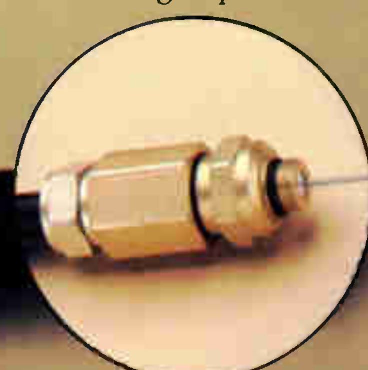

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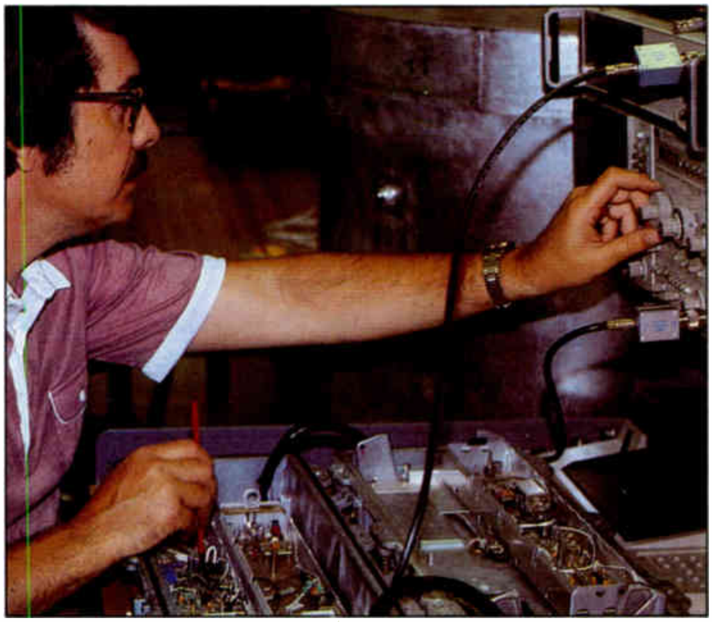

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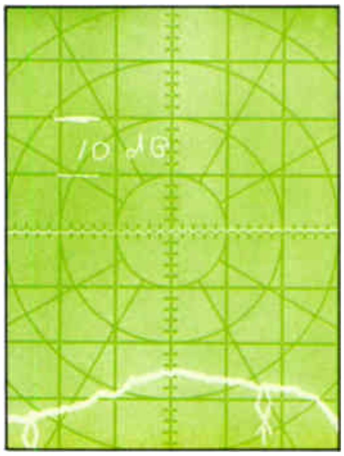

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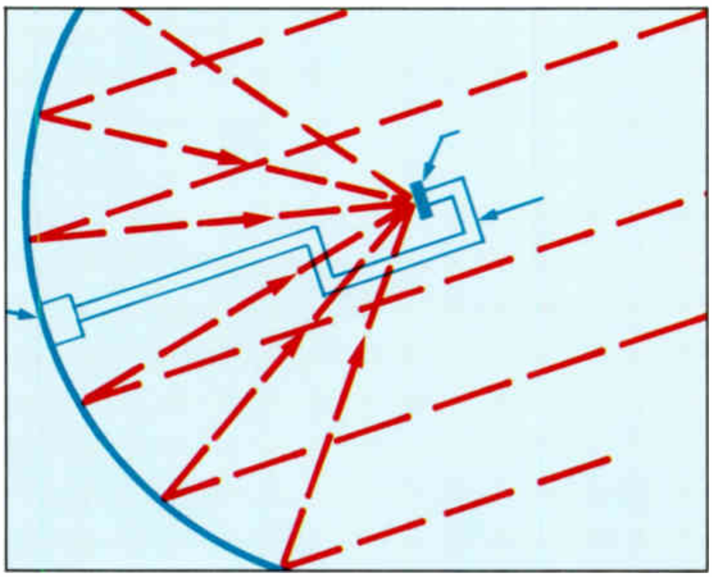

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Features

Cover
Illustration of feedforward component used in C-COR amplifiers provided by Motorola. Earth station photo courtesy of Scientific-Atlanta.

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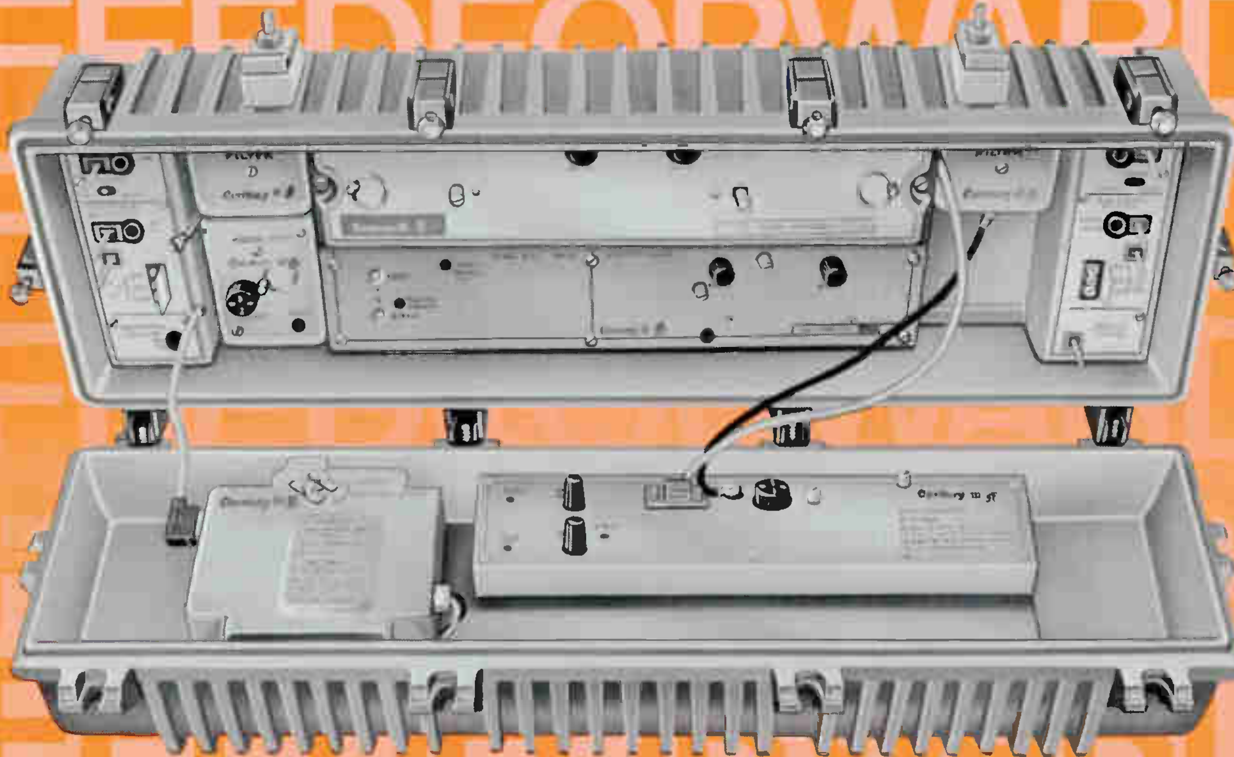

Critique and praise: Keeping pace with the future

The biggest ever, the most expensive, or the most extravagant would be adequate descriptions of past National Cable Television Association conventions. Not this time.

Those who attended no doubt noticed the changes. We think change is good, especially if it is thoughtful change, and reflects the needs of the industry as a whole.

There are some, such as Dr. Allen Konopacki, the 20-year trade show guru, who make a business of figuring out how to get more from the conventions. Konopacki and his company, Inncom, have determined that lots of people go to conventions for the wrong reasons, and many don't know why they're there.

We noticed some problems too. Trying to attend the technical, management and programming seminars, and give a fair look at the exhibits all at the same time really isn't possible. Of those who carefully planned their schedules at the show, how many got sidetracked along the way, and wound up missing a valuable session, or failed to spend enough time with technical representatives at booths, who had information on some needed new equipment?

Konopacki suggests that much of the trade show routine is a waste of time, and that showing products to carefully selected buyers will yield more sales. He has a point, but we aren't quite ready to agree completely. Instead, we're hoping the convention givers and goers will consider some suggestions:

- Schedule display hours and sessions so there is no conflict (i.e., one in the morning, the other in the afternoon.) The SCTE Cable-Tec Expo, held last March, did just that and it worked very well.
- Restructure some of the regional shows so they better reflect the flavor of their area, instead of trying to emulate the national show concept.

Bob Luff

- Exhibitors (for their own benefit) should put less emphasis on entertaining the casual lookers and more on reaching the "power" buyers.

According to Konopacki, the average person spends about four minutes at a booth comparing features, taking notes and talking with the representative, but too many of the reps have prepared for a half-hour pitch. The Doctor says booth reps should match their presentation to the time window, then follow up after the show with the serious buyers. The consequences of over-doing it with one looker may cost a sale to the buyer who hasn't the time to wait.

Konopacki and Inncom interviewed 2,000 executives and determined that 38 percent buy booth space either to match their competition, support the industry, or out of fear that people will talk about their absence. These reasons are all reactions, rather than positive, logical action, and all are poor management decisions, asserts Konopacki.

There are plenty of good ideas for improving the shows, and as the cable TV business matures, and necessarily changes, we hope the convention throwers will keep pace with the convention goers.

Kudos well deserved

The national show was not without its high points. All reports indicate the technical sessions were noteably quite well attended and thoughtfully orchestrated—to the credit of Wendell Bailey and his fine staff, especially Katherine Rutkowski.

All of us at *Communications Technology* extend our sincere congratulations to Bob Luff, recipient of NCTA's Science and Technology Award this year, and a monthly *CT* columnist.

Congratulations also are extended to SCTE's new and re-elected board members and executive committee members (see "News," p. 9). New Executive Committee President Jim Emerson has his hands full, but experience has demonstrated that Jim's deep commitment to the SCTE will do much to auger the society's advancement.

COMMUNICATIONS TECHNOLOGY

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NCTA Chairman Monty Rifkin, outgoing NCTA President Tom Wheeler and NCTA President-Elect Jim Mooney.

The Las Vegas Hilton Pavilion was the backdrop for NCTA exhibitors.

NCTA show provides upbeat cable forum

LAS VEGAS, Nev.—The National Cable Television Association's 33rd annual convention held here June 5-7, took off on an upbeat note amid laser beams and music. The opening session proudly blared cable's triumphs via a lively and colorful videographics display projected on a 100-foot screen. Speakers for the opening session were Gustave Hauser, NCTA convention chairman and chairman of Hauser Communications; NCTA Board Chairman Monroe Rifkin, president of Rifkin and Associates; outgoing NCTA President Thomas Wheeler; and NCTA President-Elect James Mooney.

"Cable: The Consumer's Choice" was this year's theme. The slogan was factually backed-up by a nationwide study conducted by Opinion Research Corp. and released at the show. Tom Wheeler told attendees that the research project revealed a gloomy future in cable markets for multi-channel programmers like direct broadcast satellites and microwave-distributed pay television.

Wheeler stated that the ORC report provides "strong evidence that not only is cable the consumer's preferred choice, but whatever small share is available to the alternative distribution systems, they will be fighting among themselves, not us, to get it!"

The backdrop for this year's convention was the Las Vegas Hilton Pavilion. Attendance for the show was 14,805, down slightly from last year's 15,600. Exhibitors totaled 329 and consumed some 200,000 square feet of space, also down from 1983.

While this year's show featured less hype and exuded a more business-like atmosphere, there were noticeably less people on the floor from time to time than in previous years. Most vendors, however, seemed to be extremely happy with the actual business that was conducted.

Perhaps the reason for the show appearing to be slow, is that the industry has already wired most of the nation. Construction and franchising have been the simultaneous driving forces of the frenzy on the showroom floor in past years.

While no big blockbuster products were unveiled, there were a myriad of smaller ones. New software, new exhibitors, modems, data products, computers, screens, keyboards, stereo systems, addressable technologies and more entered the cable arena. (See "Product News," p. 77.)

The technical sessions were well-orchestrated and featured excellent speakers. The topics were current and on-target, and the quality of the actual papers delivered were equal to or better than they have usually been. But, this year the topics were different. Instead of the traditional "How Do You Balance a System," this year's technical emphasis centered on the new technologies (i.e., addressability).

For the first time, there was not just one but two papers on the theme "How one might better organize an engineering department of

SCTE announces new board members

LAS VEGAS, Nev.—Election results for board members and new executive committee members were released by the Society of Cable Television Engineers.

New members of the SCTE board of directors include: John Shaw (Wavetek Indiana) as Region IV director; David Franklin (Adelphia Communications) as Region VI director; and Rex Porter (Gilbert Engineering) as an at large director.

Re-elected to the board were Andy Devereaux (American Cablesystems) for Region VII; Jim Emerson (AM Cable/E-Com) as an at large director; and John Kurpinski (Cable Services Co.), from Region VIII director to an at large director.

Executive committee members are Jim Emerson, president; Robert Vogel (Raychem Corp.), Western vice president; Andy Devereaux, Eastern vice president; Tom Polis (RT/Katek), secretary/treasurer and past president; Stephen Cox (Unity Construction), executive vice president; and Sally Kinsman (Kinsman Design), director.

a medium- to large-size cable system." This session came complete with organizational charts, job descriptions, operating guidelines, objectives and performance criteria. A second paper on this subject was complementary but related to the personnel, the organization and the effectiveness of engineering management.

NCTA topped off the convention with its annual banquet awards, entertainment provided by Paul Anka, on the evening of June 7. Presented at the ceremonies were the Vanguard Awards, the Challenger Award, the Associates Award, the Science and Technology Award, the State/Regional Association Award, the Marketing Award and six President's Awards.

The Vanguard Awards were presented to Douglas Dittrick, president and CEO of Tribune Cable Communications; and Sally Davison, general manager of Staunton Video Corp. and president of DAVI Construction Co.

The Challenger Award was presented to John Evans, president of Arlington Cable Partners. Frank Drendel, president of M/A-COM Cable Home Group, received the Associates Award. Robert Luff, vice president of engineering, United Artists Cablesystems, received the Science and Technology Award. The State/Regional Association Award was presented to George Gardner, general manager of Cable TV Inc. Winston "Tony" Cox, president of the Home Box Office Network Group, was given the Marketing Award.

Recipients of the 1984 President's Awards were Brian Conboy, vice president of Time Inc., Brian Lamb, C-SPAN president; Richard Loftus, president of Trident Communications; Daniel Ritchie, chairman and CEO of Westinghouse Broadcasting and Cable; Robert Schmidt, president of Communications Technology Management; and Charles Walsh, partner, Fleishman and Walsh.

C-COR ships feedforward amps

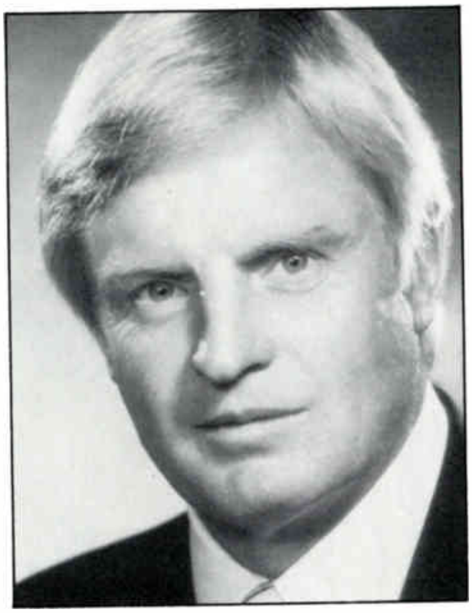
STATE COLLEGE, Pa.—C-COR Electronics Inc. announced that significant quantities of its feedforward trunk amplifiers have been shipped and installed and that order input continues to be healthy.

Acceptance of C-COR's Triple S (Sealed Signal Synchronizer) ceramic delay line (patent pending) feedforward amplifiers has required the company to increase production schedules to now manufacture one feedforward amplifier for every two conventional amplifiers.

Adams-Russell reports $1 million in Arvis sales

WALTHAM, Mass.—Adams-Russell Co. Inc. announced that its Arvis Division has booked orders for nearly $1 million for Arvis-7000 automatic commercial insertion systems during the first quarter of 1984. Clients include major MSOs and interconnects such as Colony Communications, Providence, R.I.

Introduced to the cable/broadcast market in January 1984, the top-of-the-line Arvis-7200 and the basic modular Arvis-7100 systems were designed to offer cable operators the flexibility, quality and professionalism of broadcast advertising while accommodating the intricacies of multiple presentations.


O'Brien

Times Fiber names O'Brien president/CEO

WALLINGFORD, Conn.—Lawrence DeGeorge, chairman and chief executive officer of Times Fiber Communications Inc., announced that Colin O'Brien, executive vice president and assistant to the chairman, has been named president and chief executive officer and a director of the company effective July 1, 1984.

In making the announcement, DeGeorge said, "During the time that Colin has been with Times, I have been very impressed with his performance. He has already made a number of significant contributions to the company. As I relinquish the title of chief executive officer, I am confident that Colin has the leadership qualities to achieve the company's goals and objectives in the future."

William Lynch, former president and a director of the company, retired June 30, 1984. During the past 15 years, Lynch held a number of executive positions at Insilco Corp. and, since 1977, Times Fiber Communications. He will remain available to the company in a consulting capacity.

In other news, Times Fiber announced that Storer Communications Inc. will purchase and install Mini-Hub® fiber optic cable television distribution systems for 2,000 subscribers in three of its Florida franchises. In 1982 Storer had installed Mini-Hub systems to serve 450 subscribers in North Miami. The additional units are to be installed in Storer's franchises in Hollywood, Dade/Broward and South Dade and will cost about $600,000.

Texscan announces sales, new services department

LAS VEGAS, Nev.—Texscan Corp. announced initial deliveries of its HE 42000 series headend to Olympic Cable TV in Port Orchard, Wash.; Electrical Installations in Monroe, Wash.; and Midland Cablevision in Bettendorf, Iowa.

The HE 42000 product line is compatible to NTSC, HRC and IRC frequencies plans. It features low power consumption, reduces physical space requirements, ease of maintenance, low cost and advanced performance features.

Initial deliveries of Texscan's feedforward 450 MHz trunk amplifiers to Cablenet of Chicago were also announced, and that production quantities of these state-of-the-art amplifiers are now available.

Texscan also unveiled its new "creative services" department, which will produce and distribute high-quality programming aids to owners of Texscan character generator systems.

The new department, assigned to Texscan's MSI Compuvid division in Salt Lake City, will be headed by Noble Wrather, a veteran of 30 years in advertising and publishing. Wrather has worked with MSI since 1979.

The new department will create video artwork for use in cable advertising that will be distributed in printed form and on diskette storage media to users of Texscan's various character and graphics generator lines on a single-purchase or subscription basis. Owners of certain character generator models also will be able to receive artwork by telephone using modems and the batch transfer feature of their character generator.

GE, United Artists to merge cable units

FAIRFIELD, Conn.—General Electric Co. and United Artists Communications Inc. announced that they have entered into a merger agreement under which General Electric Cablevision Corp. (GE's cable television subsidiary headquartered in Schenectady, N.Y.) will be merged into the United Artists cable television unit, United Artists Cablesystems Corp. headquartered in Westport, Conn.

Under terms of the agreement, General Electric will receive $132 million in cash plus 37 percent of the stock of United Artists Cablesystems. United Artists Communications Inc. will own the remaining 63 percent of the stock of United Artists Cablesystems Corp.

The merger is subject to approval by the boards of directors of General Electric and United Artists and their cable subsidiaries, as well as appropriate government and other approvals.

When closing of the transaction occurs later in 1984, it is expected that United Artists Cablesystems will serve approximately 700,000 primary subscribers and provide approximately 550,000 units of pay cable ser-

vice in 15 states. The combined company will become the 11th largest multiple system operator in the country and will operate major cable systems including those in Northern New Jersey with 130,000 basic subscribers; Grand Rapids, Mich., with 80,000 subscribers; and Westchester County, N.Y., and Peoria, Ill., each with about 50,000 basic subscribers.

Regency receives $8.5 million in orders

EAST SYRACUSE, N.Y.—Regency Cable Products (formerly Octagon-Scientific Inc.), a subsidiary of Regency Electronics Inc., recently received new orders in excess of $8.5 million. Orders for new systems include Continental Cablevision, Adelphia and Jones Intercable. Additional orders for existing systems include Continental Cablevision, Times Mirror, Adelphia, Jones Intercable, Heritage, Wometco and US Cable. The majority of shipments are scheduled for completion by December 1984.

Joseph Boone, president and CEO of Regency Electronics, stated, "The (recent) order activity has been very encouraging. Coupled with the new product introductions our cable business seems to be recovering from the recent industry shruggishness."

Wegener to supply SSS with down converters

TULSA, Okla.—Star Ship Stereo, the first premium pay audio service, has signed with Wegener Communications Inc. for the purchase of 100,000 block converters. "The 100,000 converters represent the minimum number of converters to be committed to the field within the next 12 months," stated Phyllis Vetters, SSS vice president.

Star Ship Stereo will lease the block converters to cable systems who, in turn, will distribute them to subscribing homes. In addition to leasing the block converters, SSS will provide the necessary headend equipment for the new audio service, which features 10 wide ranging stereo formats.

GI finalizes TOCOM acquisition

LAS VEGAS, Nev.—General Instrument Corp. and TOCOM Inc. announced prior to the NCTA show that TOCOM had become a wholly owned subsidiary of GI effective May 31.

Shareholders holding more than two-thirds of TOCOM's outstanding stock, the required majority, voted to approve the merger at TOCOM's annual meeting in Dallas on May 30.

With the consummation of the transaction, approximately 8 million outstanding shares of TOCOM stock have been converted into shares of GI stock. Each share of TOCOM stock was converted into .117647 of a share of General Instrument common stock. A total of approximately 930,000 shares of GI stock were issued to TOCOM shareholders.

TOCOM becomes part of the Broadband Communications Group of General Instrument and will maintain operations at its Dallas-based headquarters.

In other developments, General Instrument announced that its Jerrold Division is developing digital audio and video processing technologies for use in its addressable CATV converter line.

GI and Dolby Laboratories recently signed an agreement in which General Instrument will license Dolby's new digital audio technology for use in its satellite descrambler and cable TV products.

Toshiba and ATC announce venture

DENVER—Toshiba Corp. and American Television and Communications Corp. have agreed to form a joint venture to sell and distribute Toshiba products to the cable television industry.

The new company will be headquartered in Denver. Chief executive officer of the new firm will be John Rigsby, currently ATC vice president for video product development. Dr. Katsuhiko Miyoshi, project executive of Toshiba's North American CATV Project, will be executive vice president.

Toshiba and ATC are forming the venture to promote the new Distributed Subscriber Terminal (DST) and other products to the entire cable television industry.

Anixter to distribute Sonecor equipment

CHICAGO, Ill.—Anixter Communications announced that it has been awarded a three-year contract to distribute customer premises equipment for the Sonecor Systems division of Southern New England Telephone Co.

Anixter will be materials manager for Sonecor and perform a full range of distribution services using Anixter's Optimum program and its on line, real-time order entry and inventory control system. Anixter will provide next day delivery to customers, primarily from a new service center it is establishing in Cheshier, Conn.

Sonecor Systems is engaged in the deregulated equipment marketing of communications, data processing and office automation products.

Zenith receives new Z-View orders

LAS VEGAS, Nev.—Zenith Electronics Corp. received initial orders from two multiple system operators for its new Z-View two-way interactive cable television technology.

TeleCable Corp. has begun installing Z-View in two Texas locations, and Group W Cable is installing the interactive system in a Chicago suburb.

Specific details were not disclosed, but James Faust, president of Zenith's Cable Products Division, said he expects that the orders for Z-TAC/Z-View equipment—including a previously announced agreement with Rogers Cablesystems Inc.—could total more than $25 million.

E-Com system used in meter reading test

ROWLEY, Mass.—The municipally owned electric utility here will begin testing remote, automatic meter reading under a matching grant from the American Public Power Association (APPA). At the heart of the one-year trial program will be the TRU-NET 500 interactive CATV system manufactured by the E-Com Products Division of AM Cable TV Industries Inc. of Quakertown, Pa.

Scheduled to begin this month, the test will be used by the APPA to set future standards for the power industry, according to Dennis Annelli, vice president of business development for AM Cable TV. The test will be conducted by using 100 CATV subscribers in cooperaton with American Cablesystems, which serves the Rowley area.

"This contract is significant for AM Cable TV because the APPA represents 1,750 municipally owned electric utilities nationwide that service 33 million customers," Annelli said.

In addition to the automatic monthly meter readings, the TRU-NET 500 system also will provide demand and time-of-day, or peak period, readings from a single register, optically encoded meter. According to Rowley's APPA consultant, Robert Lottero of Northern Technology, "The use of single register meter for time-of-day readings offers the utility a savings of $125 per meter when compared to the cost of a dual-register unit."

RTK and CCG complete merger

LAS VEGAS, Nev.—At last month's National Cable Television Association convention, Communications Construction Group announced its merger with RT/Katek Inc. through an exchange of stock. The new company has been named RT/Katek Communications Group.

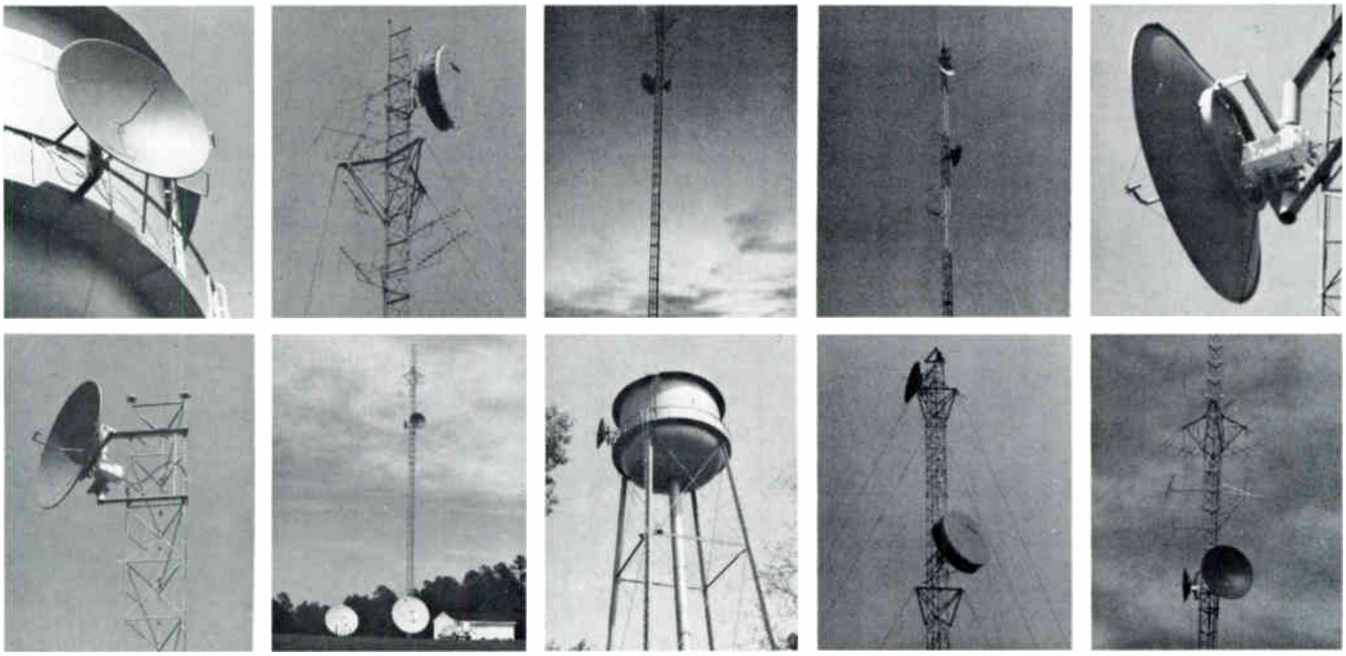
"Our merger with CCG completes our plan to consolidate several turnkey service organizations into a single corporate group," said RTK Chairman Robert Bilodeau. "Though all Divisions will be supported by the RTK umbrella," Bilodeau added, "each will continue to operate as an autonomous unit."

RTK now offers full plant and MDU construction management services, residential and commercial installation services and converter repair services.

Both CCG President George Tamasi and Executive Vice President Tom Polis were also elected to the RTK board of directors.

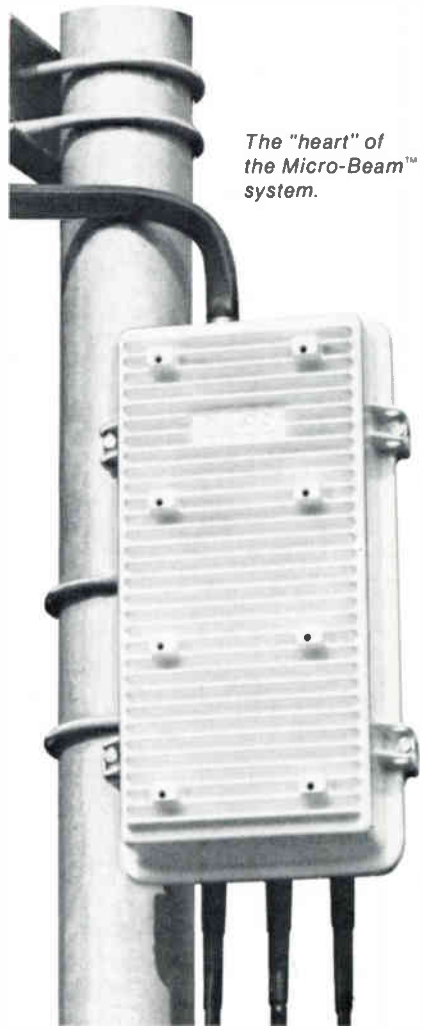
The new Communications Construction Division is presently building systems for Media General in Fairfax, Va., Tribune-United Cable in Montgomery County, Md., Comcast in Michigan and American Cable in Pompano Beach, Fla.

If you thought microwaves were too rich for your system...look again!



Micro-Beam™—Performance proven in over a year of trouble-free, revenue producing operation at 9 different sites.

Look at MICROBEAM™



The "heart" of the Micro-Beam™ system.

Micro-Beam™ (patent pending) is a new flexible and cost-efficient CARS Band signal delivery system ideally suited for CATV plant expansion.

Micro-Beam™ transmission allows the cable operator to skip on by long cascades. Start with a fresh signal anywhere in the system. Go beyond the limits of subscriber density, geographic, or man-made barriers—without expensive heated/air-conditioned transmitter buildings.

Using just one Micro-Beam™ transmitter (mounted behind the antenna) you can send as many as 52 channels up to 14.5 miles away! And now, with our new Micro-Beam Plus™ systems, you can transmit a full 52 channels up to 10.5 miles, in two different directions. All for less than half the cost of conventional microwave systems.

Micro-Beam™ gives you multi-channel microwave transmission of your entire service from a single outdoor unit which can be located practically anywhere in your plant.

How many new runs are you planning? Take a look at how much it's going to cost you. Then take a look at Micro-Beam™. For more details call, or write:

channel master satellite systems

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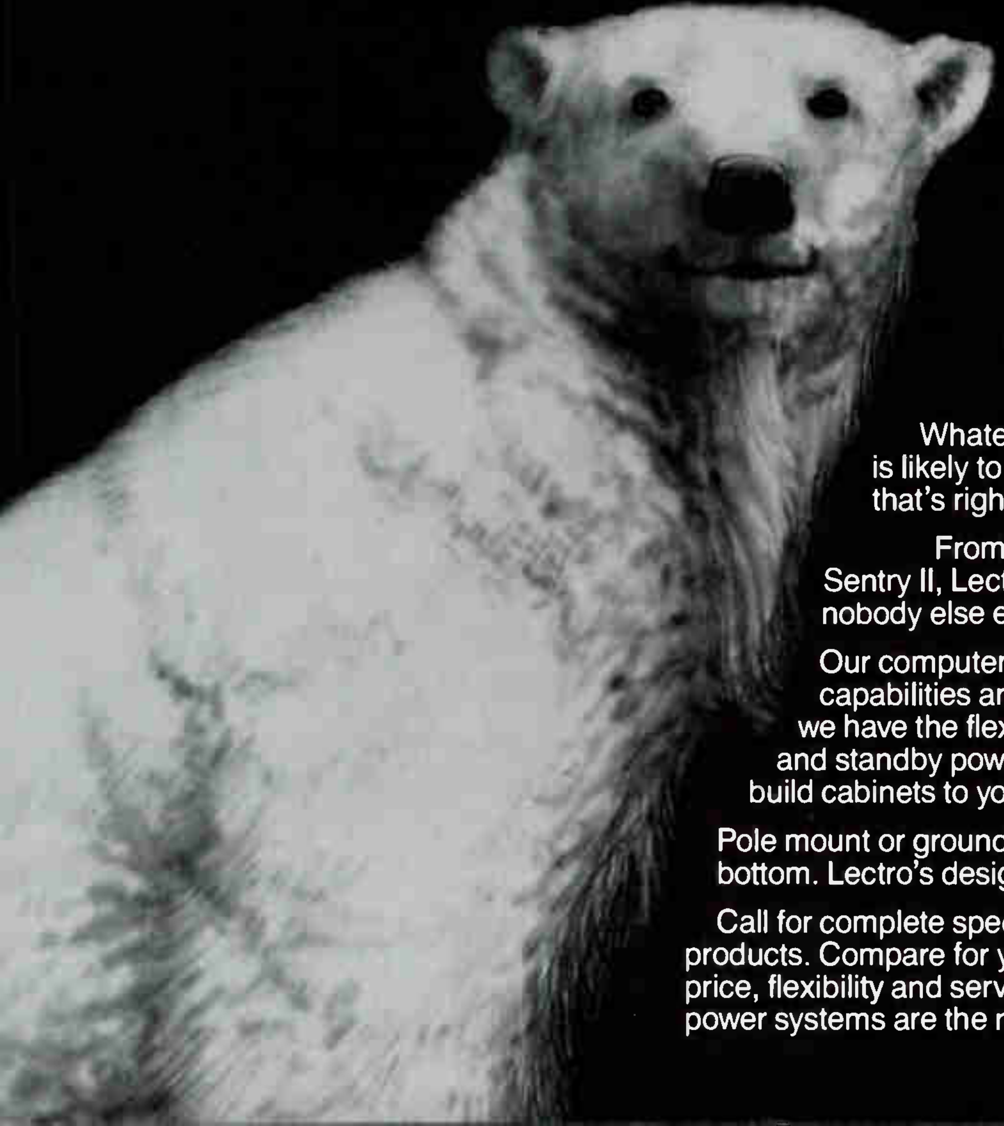
LECTRO POWER SYSTEMS BEAT THE OTHERS COLD.



Whatever requirements your cable system is likely to face, Lectro has the power system that's right for you.

From Mini Brutes to Add-Ons to the new Sentry II, Lectro offers over 50 different models—nobody else even comes close.

Our computer-aided design and manufacturing capabilities are the most advanced in the industry. So we have the flexibility to meet a wider range of standard and standby power needs—including our ability to custom build cabinets to your specifications.

Pole mount or ground mount. Batteries on top or on the bottom. Lectro's design is the most flexible on the market.

Call for complete specs on our whole family of power supply products. Compare for yourself and you'll agree, for quality, price, flexibility and serviceability—Lectro standard and standby power systems are the natural choice.

SENTRY II
Features:
- Total modular construction, customized to your needs.
- Automatic switchover when either module is unplugged.
- Auto restart overload protection.
- Constant voltage taper charger.
- Under-voltage protection.
- Top or bottom battery position, optional.
- Accommodates group 31 batteries.
- Ground or pole mount.
- Status indicator lights.
- Metered battery voltage & output current.
- MOV surge protection, standard.
- Optional heavy-duty surge protection available.
- Optional daily battery exercise charge available.

MINI BRUTE
Features:
- 89.4% operating efficiency (tops in the industry).
- Fan cooled for extended life.
- 5% load regulation.
- 1% line regulation.
- Modular design.
- Positive disconnect for added safety.
- MOV surge protection standard.
- Time delay and current limit options available.
- 7″W x 8″D x 15½″H
- Wt.—37 lbs.

ADD-ON STAND-BY UNIT
Features:
- 60 Volts output or optional 30 volt.
- 720 Watts.
- 2 Hr. 20 min. operating time at full load.
- Compatible with any standard make Ferro supply.
- Dual battery operation.
- 5% load regulation between 3 & 5 amps.
- Automatic low voltage shut down.
- Plug-in connectors for simple installation.
- Built in fan for longer life, standard.
- 13″W x 8″D x 33″L
- Wt.—38 lbs. (without batteries).

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What the groundhog sees that you can't—Part 2

By Anthony J. DeNigris
President, Nationwide CATV Services Inc

Last month's article explored the need to thoroughly analyze soil conditions, existing utilities and the degree of restoration that may be encompassed before making a determination as to which method of underground cable installation to implement. Regardless of the method selected to put cable in the ground—and coupling this with the installation of conduit, pedestals or vaults, and boring, as well as the restoration factor—the complete process of "doing it all" and making it work is extremely complex. Each of the aforementioned facets, and the manner in which they are handled, requires a knowledge of the obvious (and not so obvious) do's and don'ts, and a good degree of common sense.

Trenching

When one decides to go in and trench an area for cable placement, the first point to consider is how to handle the restoration. Naturally, the objective should be to leave the property in the same condition as it was beforehand; however, this can only be done if the proper steps are taken.

For example, consider a condition such as "golf course-like" lawns. In this situation it should be quite obvious that a sod cutter be utilized. Also, it should be noted that if the grass is rolled up and left in that condition too long prior to replacement on the completed trench, there exists the likelihood it will die due to lack of sunlight and moisture. To prevent the moisture problem, sod should be removed in as thick a layer as is practical. Also, I would advise against any type of trenching in high-integrity areas during the blistering summer months, because sod can burn out in only a single afternoon.

It also should be remembered that the layer of loam that is left after the sod is removed, in most cases, gets turned over and intermingled with whatever type of dirt is below the topsoil, usually fill. When this occurs, if the soil on top of the trench prior to replacing the sod is not loam or topsoil, then the sod layer that is replaced will not bond to the trench, especially if the original sod was removed in a thin layer. By taking proper action in sod removal, you can avoid the problems involved in reseeding trenched areas to match the existing grass.

When it comes to the actual trenching, the depth and width of the trench will determine to what degree an operator must go to prevent possible damage to existing underground utilities, sprinklers and drainage systems. Surveys must be required in advance for utility markout. An effort must be made to determine if sprinkler systems or drainage routing are located in the proposed trench path. One also must be aware that the possibility exists for other unknowns, such as wiring for lamp posts or existing master antenna systems.

There are some obvious points to trenching that also must be considered. First, never open up more trench than you can place cable in a given day—the danger for pedestrians to stumble is great. Second, don't trench when a heavy rainfall is expected—the trench will fill with mud and the existing mound of removed soil adjacent to the open trench will wash away. Third, if you encounter a lot of rocks and jagged stones, they must not be used when backfilling the trench; clean fill must be substituted. Fourth, when considering trenching in moist or soggy ground conditions, one must be aware of the possibility of the tires on the machinery chewing up the ground, and therefore the operation should be avoided until the ground dries out. This list can go on and on. It is up to every system operator to truly contemplate his particular conditions and make adjustments for these conditions.

The right way to do something in one geographic area can differ vastly from another; which means: the do's for you might be the don'ts for someone else. One final point about trenching—you have to be aware that as ground freezes, rocks and other debris in the ground are subject to shifting, even if by a slight degree. Should cables be lying in a trench adjacent to such debris or rocks, the hazard exists for abrasion of the cable and, ultimately, with the cable being cut at some time in the future.

Vibratory plowing

Sometimes called vibrating, other times called plowing, the biggest point to remember here is that you cannot see what the plow blade is going to cut through next! All of the precautions and preliminary steps that were mentioned under trenching must be adhered to when one considers plowing cable—and then some.

It is true that restoration is not an immediate problem with this method; however, this is only true when the machine is moving along smoothly and the blade encounters no obstructions. Should an obstacle present itself in the path of a plow blade, the machine will encounter resistence and possibly shake and bounce, causing the wheels to skid on grass and/or the plow blade to bounce up and out. This results in spot restoration problems—and unseen damage to the cable. Plow manufacturers like to tell us that their equipment will break through anything and not to worry. This is not always the case, however. But if it should go through anything, such as a chunk of concrete (in a backfilled area), guess what we have just laid our cable between.

At this point we don't know if we did something that might have damaged the cable; nor do we know what the effect might be down the road—remember the shifting ground noted earlier! Problems can also exist when using a plow if the operator does not feed the cable smoothly and uniformly into the chute. Cables can get "kinked" easily from operator neglect.

Conduit and duct

A big oversight occurs in many trenching situations where no conduit is allowed for. In certain conditions an operator who allows cable to be put in the ground without the protection and future security that conduit offers—that is, properly placed conduit—is leaving the door open for an unexpected and uncalled-for expense in the future.

The key here is properly placed conduit. It's easy to throw PVC into the ground and run a cable through it and it's also easy to figure out what size conduit to use (initially). But what gets overlooked most of the time is that it is a lot harder to pull cable through conduits that have existing cables in them. And therefore, the initial size of conduit selected should be larger with this in mind.

The other major factor that must be considered is the radius of any particular bend in that conduit. I have seen cases where this was not figured properly, and due to the radius being too tight, either the cable could not be pulled in or the cable ripped through the inside radius of what is called a conduit sweep. This is because a cable pulling through a sweep exerts pressure against the inside radius and technically wears its way through until it jams. Should this happen, the cost to open the trench and replace conduit will be astronomical.

More on underground construction will be discussed in the third and final segment next month.

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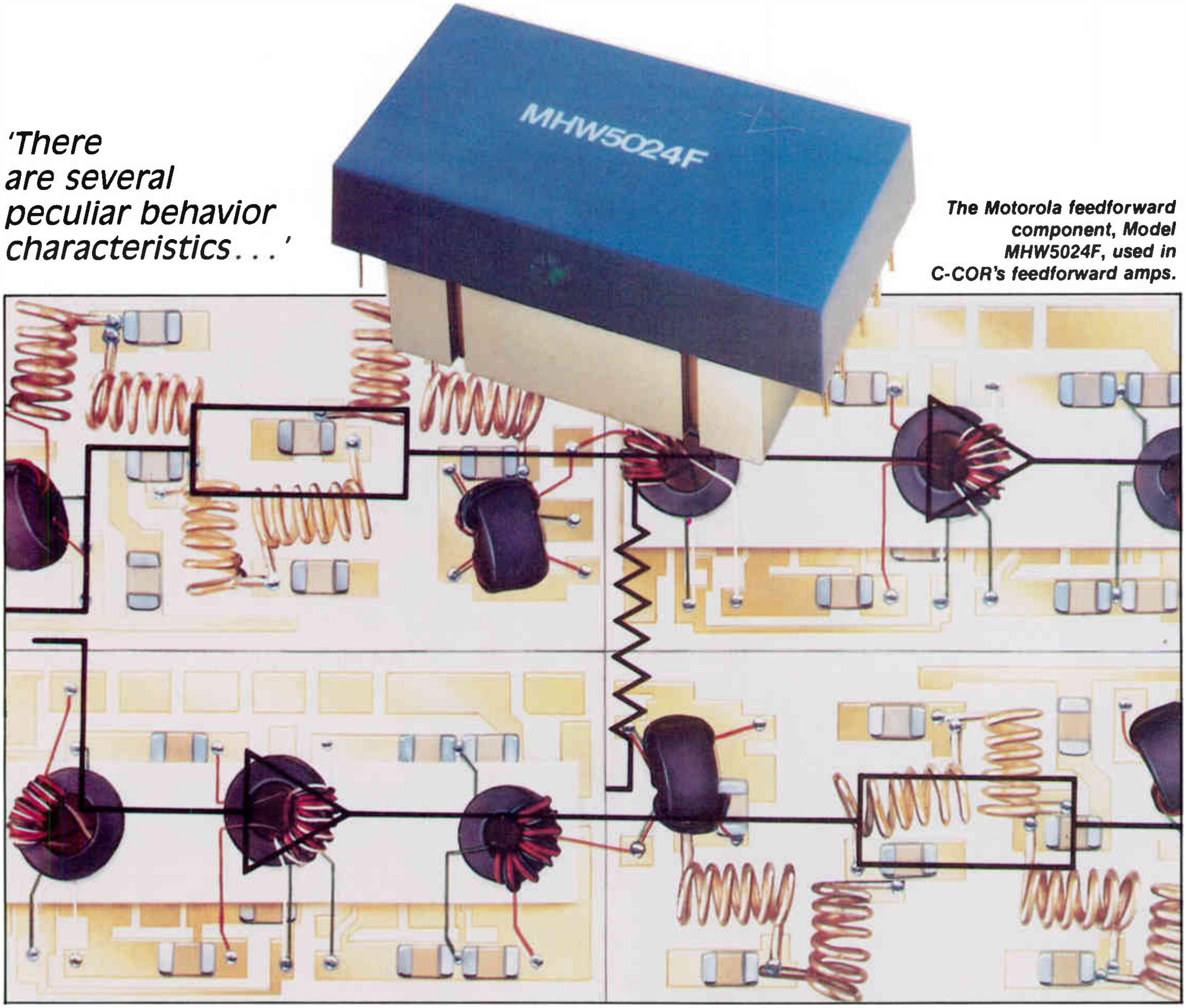


The Motorola feedforward component, Model MHW5024F, used in C-COR's feedforward amps.

Fundamentals of feedforward circuits

By Joseph P. Preschutti and Colin J. Horton
C-COR Electronics Inc

Now that equipment suppliers are offering a variety of feedforward, parallel hybrid and standard amplifiers for distribution system applications, making the correct choice of equipment for new and rebuild systems projects is more difficult than ever. This series of articles will provide a comprehensive explanation of feedforward circuit operation, system design applications and maintenance considerations. Furthermore, the limitations of the feedforward circuit performance will be defined.

The first article deals with the basic characteristics of the feedforward circuit, describing the advantages as well as the limitations of feedforward circuits. There are several peculiar behavior characteristics of feedforward that are unique. These new characteristics can change the "rules of thumb" generally used by the system designer. The behavior of composite triple beat, cross-modulation, noise, flatness, cascade performance calculations and other considerations are presented. The second article will discuss several applications of feedforward trunks, bridgers and line extenders. The third article will address maintenance, test and repair considerations for feedforward systems.

What is feedfoward?

Feedforward is a distortion reduction technique. Since cancellation circuits are used twice in the feedforward circuit, understanding the characteristics and limitations of cancellation provides the basis for analyzing the characteristics and limitations of a feedforward circuit. The internal operation of the feedforward circuit is discussed in this section.

Figure 1 is a functional block diagram of a feedforward amplifier. Two push-pull cascode hybrid integrated RF amplifiers are required, the first is the main amplifier, the second is the error amplifier. There are two cancellation loops, the first isolates noise and distortion generated by the main amplifier and the second produces the distortion cancellation phenomena.

• *First loop cancellation:* The first loop isolates the noise and distortion created by the main amplifier. This technique is shown in Figure 2, with the signal flow indicated by the dotted lines. A signal (S) is applied to the input of the circuit and is sent in two directions by DC1. At the output of the main amplifier not only is the original signal (S) present, but also the errors involved in the amplification pro-

Figure 1: Feedforward functional block diagram

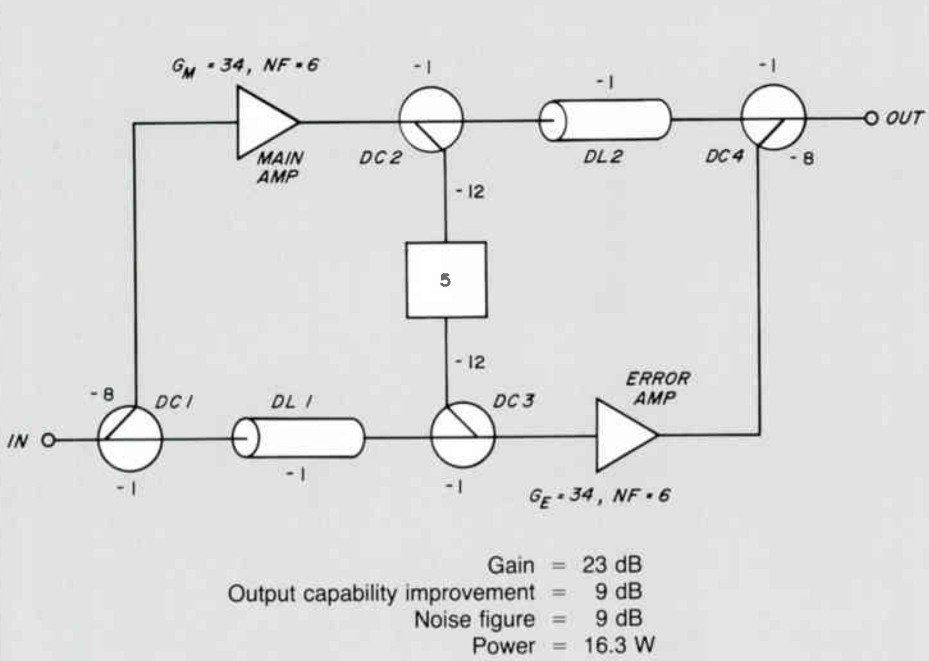
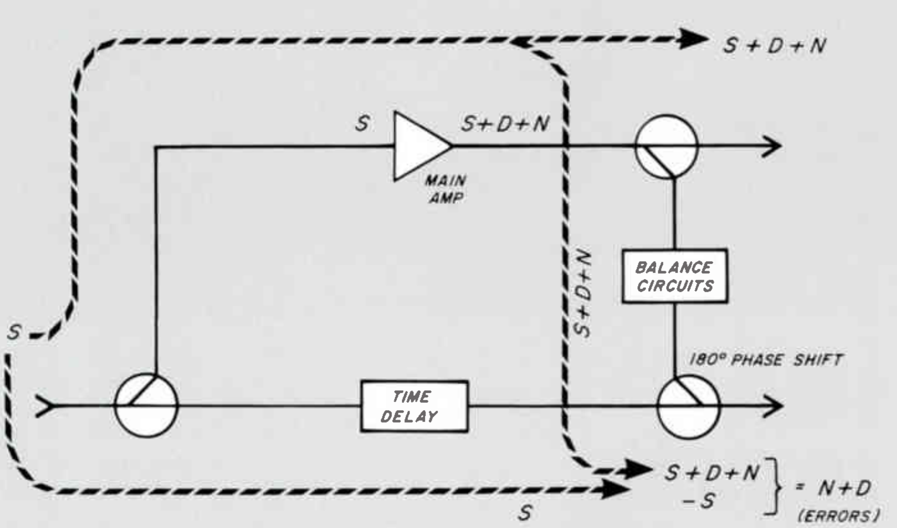


Figure 2: First loop cancellation



cess; namely, noise and distortion (indicated by N and D respectively).

Most of the output signal of the main amplifier is directed towards the output of the feedforward circuit through DC2, however, some of that signal is siphoned off and brought down to DC3 where it is combined out of phase with the original input signal. Equation 1 indicates the cancellation process if the cancellation were ideal.

Equation 1

S + D + N	– S	= D + N
Main amp output	Input signal	Errors in the amplification process

- *Second loop cancellation:* The cancellation of the second loop reduces noise and distortion. This second loop is shown in Figure 3. In this figure the N plus D term isolated by the first loop cancellation is amplified by the error amplifier and reinjected out of phase with the signal coming from the main amplifier at DC4. The end result is shown in Equation 2. If the cancellation process were ideal, then the output signal would be an exact replica of the input signal without the noise and distortion created by the main amplifier.

Cancellation

Ideally, the feedforward circuit would provide a perfect replica of the input signal without any distortion. In fact, the feedforward

Equation 2

S + D + N	– (D + N)	= S
Main amp output	Distortion and noise	Clean output signal

circuit relies on cancellation to provide distortion reduction and the limitations of cancellation define several of the limitations of the feedforward amplifier: output capability, flatness, temperature stability and long-term stability.

Cancellation involves the combination of two signals that are of equal amplitude and opposite phase. The state of the art for broadband circuits over the temperature range –40°C to +60°C is on the order of 22 to 26 dB cancellation. We will use 24 dB cancellation as a basis for the rest of the analysis presented in this article. Improvements in second order distorton of push-pull hybrid ICs and typical passive and tap output-to-output isolation specifications can be cited as good examples of this 24 dB cancellation figure.

A new phenomenon: Third order nonuniformity

Modern multichannel broadband systems are being specified with third order distortions being the main output limiting factor. This is still the case with feedforward amplifiers. However, the nature of this parameter has changed dramatically. RF hybrid ICs with a push-pull cascode circuit were the main gain blocks used in broadband distribution amplifiers prior to the use of feedforward. The third order performance of these circuits did not rely on cancellation, but rather depended on the performance of the transistor die. Because of this, the third order performance of the individual transistors, the hybrids, and therefore, the distribution amplifiers themselves was a relatively fixed value. Unit-to-unit and lot-to-lot variations in third order performance were very small. The amplifier performance then was very predictable and orderly. System performance calculations based on individual amplifier tests also were predictable, orderly and practical.

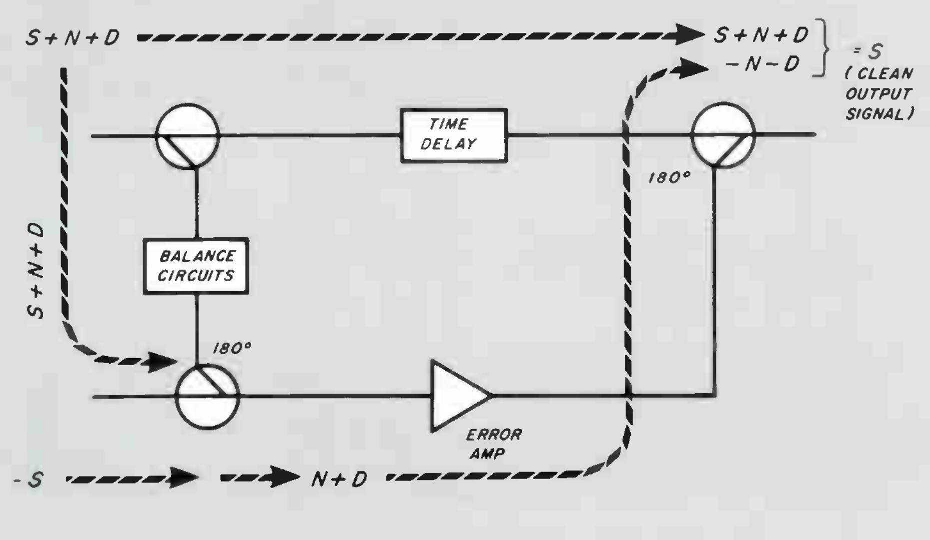
System designers relied on this uniform product to predict system performance by using empirical techniques. That is, one could measure the performance of the single trunk amplifier and then predict the performance of a cascade of these amplifiers or predict system performance based on data accumulated from amplifier performance. With feedfoward circuits, this is no longer the case. A discussion of the specification of the output capability of the feedforward amplifier follows.

- *Cancellation and distortion reduction:* The distorton of the feedforward circuit compared with the distortion performance of the main amplifier will be considered. The second loop (Figure 3) produces 24 dB cancellation. We are concerned with third order distortions being the limiting system design factor and these, if the main amplifier is operating in a well behaved mode, will derate on a two-for-one basis. That is, if the output signal level is increased by 1 dB, the carrier-to-composite triple beat ratio will be degraded by 2 dB. A 24 dB cancellation would then result in a basic 24 dB reduction in distortion. However, a 3 dB loss exists between the main amplifier output and the feedforward circuit output (see Figure 1). This loss reduces the output capability, so we should subtract 6 dB from the 24 dB reduction in distortion. The result is an 18 dB reduction in distortion with this feedforward circuit.

- *Cancellation measurements:* As was stated earlier, third order distortion performance of non-feedforward type amplifiers was uniform from unit to unit. Examine Figure 4, which is a photograph of a swept display of the cancellation of the second loop of a feedforward gain block versus frequency. This photo was taken at room temperature. Notice that the cancellation is generally better than 24 to 26 dB with the high frequency cancellation having two nulls where the distortion is substantially better than 30 dB. Also note that the cancellation is not uniform across the entire bandwidth. These cancellation characteristics will *not* be uniform from unit to unit. The nulls will be displaced in frequency from one unit to the next. In a typical production run, some units will align to better than 28 or 30 dB across the band while others may have no nulls at all and will be relatively uniform in the 24 to 26 dB range.

The result is that the third order distortion performance of several feedforward amplifiers will naturally be remarkably different from one another. Empirical tests on individual amplifiers must then be basically unreliable in and of themselves as an evaluation and specification process.

Figure 3: Second loop cancellation



Temperature stability

The cancellation shown in Figure 4 involves a delicate balance of amplitude and time delay along two different signal paths. When the temperature changes, the gain and delay of the main amplifier as well as the insertion loss and delay characteristics of the directional couplers and delay lines will change slightly with temperature. It is impractical to assume that the precise balance needed to maintain 30 or 35 dB cancellation can be maintained over the temperature range. Figure 5 shows the cancellation of the circuit in Figure 4 at

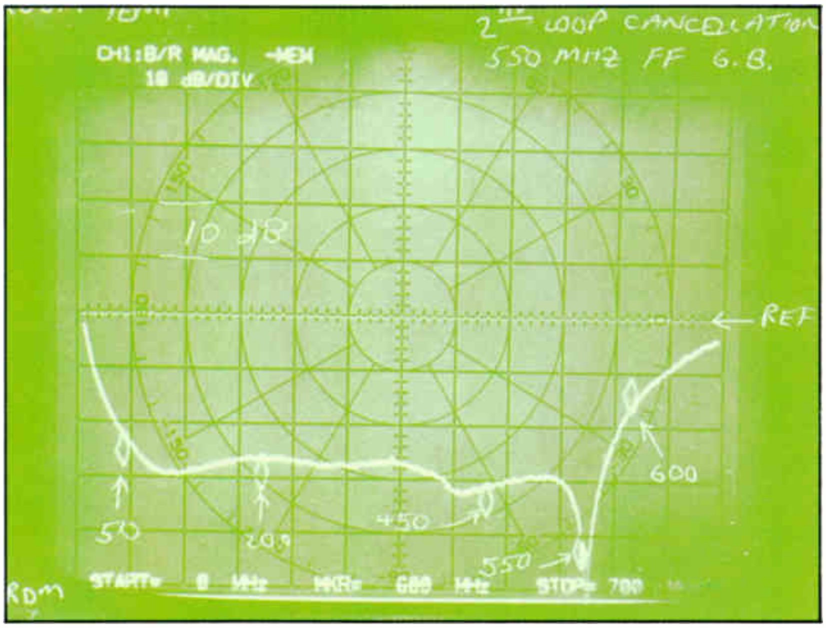


Figure 4: Cancellation at room temperature

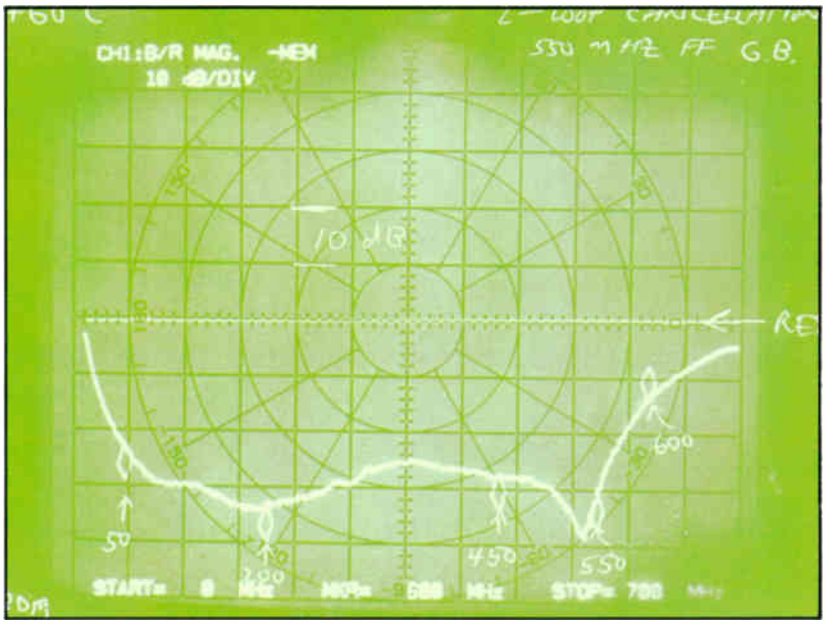


Figure 5: Cancellation at 60°C

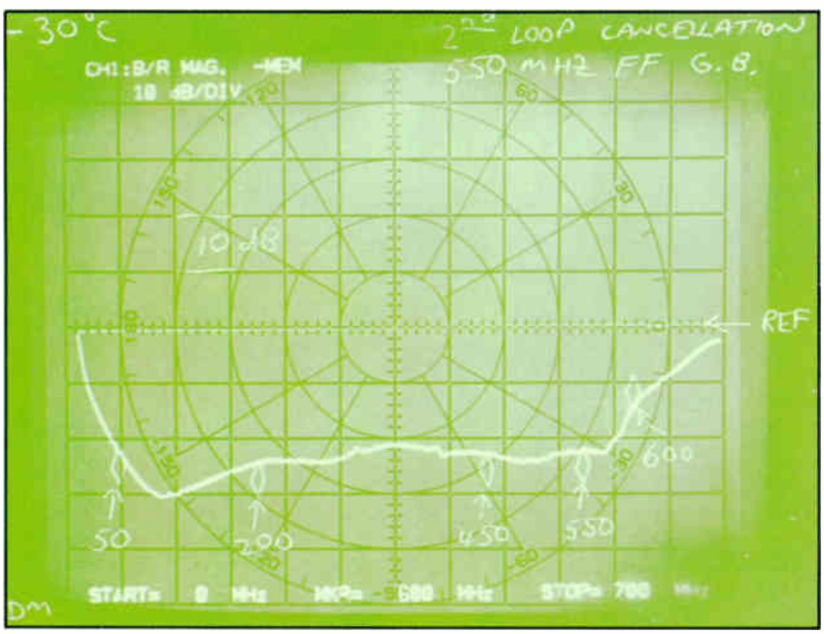


Figure 6: Cancellation at −30°C

+60°C temperature. Figure 6 shows the cancellation at −30°C.

The key point here is that the equipment manufacturer and system designer must deal with specifications based on the analysis of the limitations of the cancellation process and not rely upon empirical data taken on one or even several units. Generally speaking, 16 to 18 dB cancellation would be a poorly designed circuit, while 22 to 26 dB cancellation is a well-designed state-of-the-art circuit. However, 26 to 30 dB cancellation is impractical to achieve over the temperature range and across the entire spectrum.

Cascade test results

Cascade tests of 20 feedforward trunk stations were conducted. The amplifiers had 26 dB spacing and were operated at 36 dBmV output signal level at the highest channel with a 7 dB linear tilt between the highest and lowest channel. Without providing the details,[1] the assumption of 24 dB cancellation on the feedforward circuit plus the minimum performance specifications of the hybrids used in these amplifiers indicated an individual amplifier carrier-to-composite triple beat ratio (CCTB) performance of 89 dB. Assuming in-phase addition of CCTB, the cascade of 20 trunks would produce 20 Log N or 26 dB worse CCTB than an individual amplifier. This results in an expected CCTB of 63 dB for the cascade.

The CCTB of each amplifier was measured individually. The minimum CCTB was 92 dB, while the mean value was 95.2 dB. Cascade test results are shown in Table 1. Clearly, the minimum performance of an individual amplifier should not be used to predict cascade performance. This results in an overly pessimistic performance prediction of 63 dB for the cascade. The mean value of 95.2 dB could be used to make cascade predictions, with a calculated performance being 69.2 dB.

Table 1

	Calc.	25°C	−25°C	55°C
CCTB	63	72	70	69

Two points should be considered. First, individual minimum amplifier performance should be specified along with typical amplifier performance in a feedforward circuit if meaningful cascade performance calculations are to be attempted. Secondly, will the typical performance of the system, which clearly depends upon better than 24 dB cancellation, be maintained with time? It's our belief that some consideration to an ultimate softening of the cancellation characteristics with time and temperature ought to be considered in system designs with feedforward circuits.

Gain flatness

There are two parameters that affect the basic flatness of the feedforward gain block. One is relatively straightforward, understandable and controllable. The other is more

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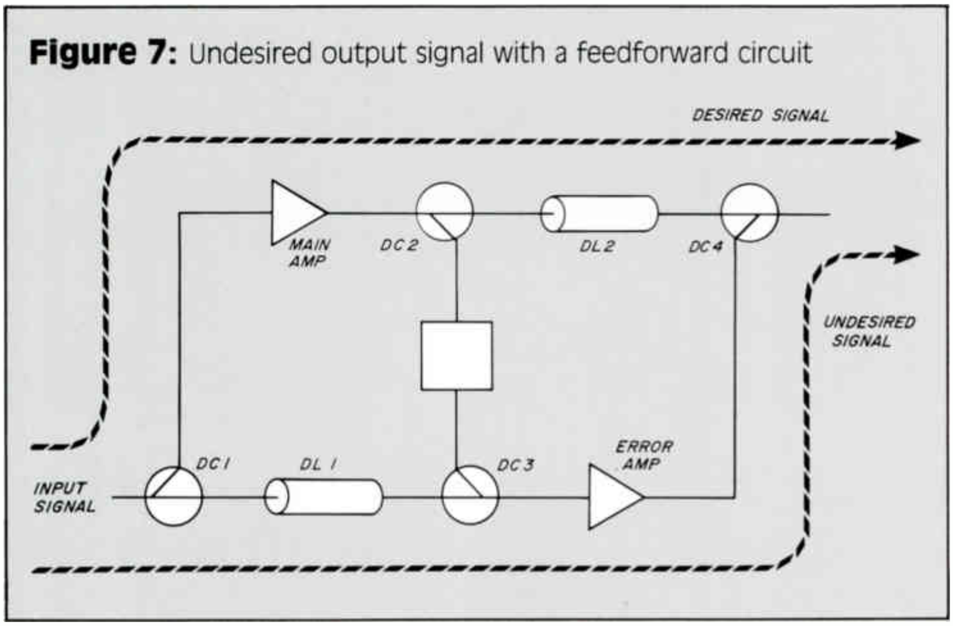
Figure 7: Undesired output signal with a feedforward circuit



subtle, insidious and out of control. The more controllable parameter is the fact that 34 dB gain hybrid ICs are used in the feedforward amplifier instead of the commonly used 18 dB gain blocks. The higher gain combined with basic limitations of the packaging technology result in reduced gain flatness in amplifiers utilizing 34 dB gain blocks. This, however, is controllable by a slight increase in the complexity of the flatness circuits provided with the trunk-line equipment.

The new and unusual phenomenon associated with a feedforward circuit is understood by looking at Figure 7. This figure shows that the output signal is in reality a combination of the desired output signal derived from the main amplifier plus an undesired output signal provided by the error amplifier. The undesired signal is below the desired signal by an amount equal to the cancellation achieved in DC3, the coupler before the error amplifier. This phenomenon does not exist in trunk stations of the non-feedforward type. This phenomenon has two effects, one concerns the equipment designer and the other concerns the system designer. The equipment designer must add further complexity to his interstage flatness circuits in a trunk station to overcome the results of the flatness degradation caused by the undesired output signal at room temperature.

The system designer must realize that the flatness of the feedforward circuit is dependent on the cancellation of the first loop and that the cancellation profile will change with temperature, thus producing a small gain change. For example, a null might exist at room temperature so that essentially no undesired signal is present at the output. At the temperature extremes, the null may disappear and the undesired signal at the output could be 24 dB below the original signal. This is still well within expected performance for cancellation. However, the change in cancellation from 35 dB to 24 dB at that particular frequency will cause a gain change of approximately 0.1 dB.

The net result is that trunk-line cascade flatness will change more with temperature with feedforward equipment than it will with non-feedforward equipment. This flatness change is due primarily to changes in cancellation of the first loop of the feedforward circuit. In a 20 amplifier cascade, a gain change caused by this phenomenon of 0.1 dB per amplifier could result in 2 dB flatness degradation different from and not normally seen on previous equipment. Very long supertrunk cascades may require seasonal balancing if these gain changes cause significant changes in cascade flatness.

Noise figure

Although the feedforward circuit has excellent properties for using it as an output amplifier on a trunk station, its use on the input or preamplifier stage of a trunk station is restricted.

The noise figure of the feedforward amplifier can be analyzed by considering the fact that the noise generated in the main amplifier is cancelled by the first loop so that the noise at the output of the feedfoward amplifier is primarily due to the noise created by the error amplifier. Noise is not usually considered to be a cancellable phenomenon, however, in this case the noise being cancelled is correlated. That is, the noise output of the main amp is contained in both signal paths and, therefore, is correlated and cancellable. The noise generated by the error amplifier is not in both signal paths, is not correlated and not cancelled.

Where does the noise come from? In Figure 1 it can be seen that the gain of the feedforward amplifier is equal to the gain of the main amplifier minus those losses incurred through DC1, DC2, DL2, and DC4 (Equation 3). A general characteristic of the feedforward circuit is that if we neglect the effect of the cancellation of the first loop, the gain from input to output through DC1, DL1, DC3, the error amplifier and DC4 also is equal to 23 dB (Equation 4). The noise at the output is due to error amplifier noise. Therefore, the noise figure of the feedforward amplifier is equal to the noise figure of the error amplifier plus those losses incurred between the feedforward circuit input and the error amplifier input. In this case the noise figure would be equal to 9 dB.

$$-DC1 + G_M - DC2 - DL2 - DC4 = \text{Gain}$$
$$-8 + 34 - 1 - 1 - 1 = 23\text{ dB main path gain} \quad (3)$$

$$-DC1 - DL1 - DC3 + G_E - DC4 = \text{Gain}$$
$$-1 - 1 - 1 + 34 - 8 = 23\text{ dB error path gain} \quad (4)$$

Generally, this feedforward circuit will always have a worse noise figure than an equivalent RF hybrid amplifier. It follows then that the use of a more complex feedforward circuit on the input or preamp of a trunk station would have to improve the distortion of the trunk station enough to overcome the deleterious effect of reducing the dynamic range by increasing the noise figure.

Gain compression

Feedforward circuitry does not improve the power handling capability of the amplifier, rather it simply reduces the distortions created by the main amplifier. Because of this, a phenomenon exists at feeder output levels that can severely limit application of feedforward circuits in bridgers and line extenders. This will be discussed in detail in the next article in this series.

Power consumption and heat

A disadvantage of the feedforward circuit over the RF hybrid counterpart is the increased power consumption and heat generated within the package. This increased power consumption requires the use of an efficient switching regulator power supply and attention to the thermal characteristics of the amplifier package. In many instances, repackaging of standard broadband product lines will be necessary to allow for switching power supplies and lower thermal resistance packages in order to maintain reliability and avoid excessive overheating of critical amplifier components.

Cross-modulation in broadband feedforward circuits

The feedforward circuit configuration provides significant improvement in the intermodulation distortion performance of a broadband amplifier. However, amplitude cross-modulation reduction at high frequencies does not necessarily occur to the same extent in a feedforward circuit. This will be shown after first discussing cross-modulation in push-pull cascode amplifiers.

The nature and behavior of cross-modulation at high frequencies in multichannel broadband amplifiers is well known and documented. Gumm[2] and Luettgenau[3] have described, documented and characterized phase cross-modulation at high frequencies. Simply stated, the predominant energy of the cross-modulation sidebands occurs as phase modulation instead of amplitude modulation of the carrier at higher frequencies.

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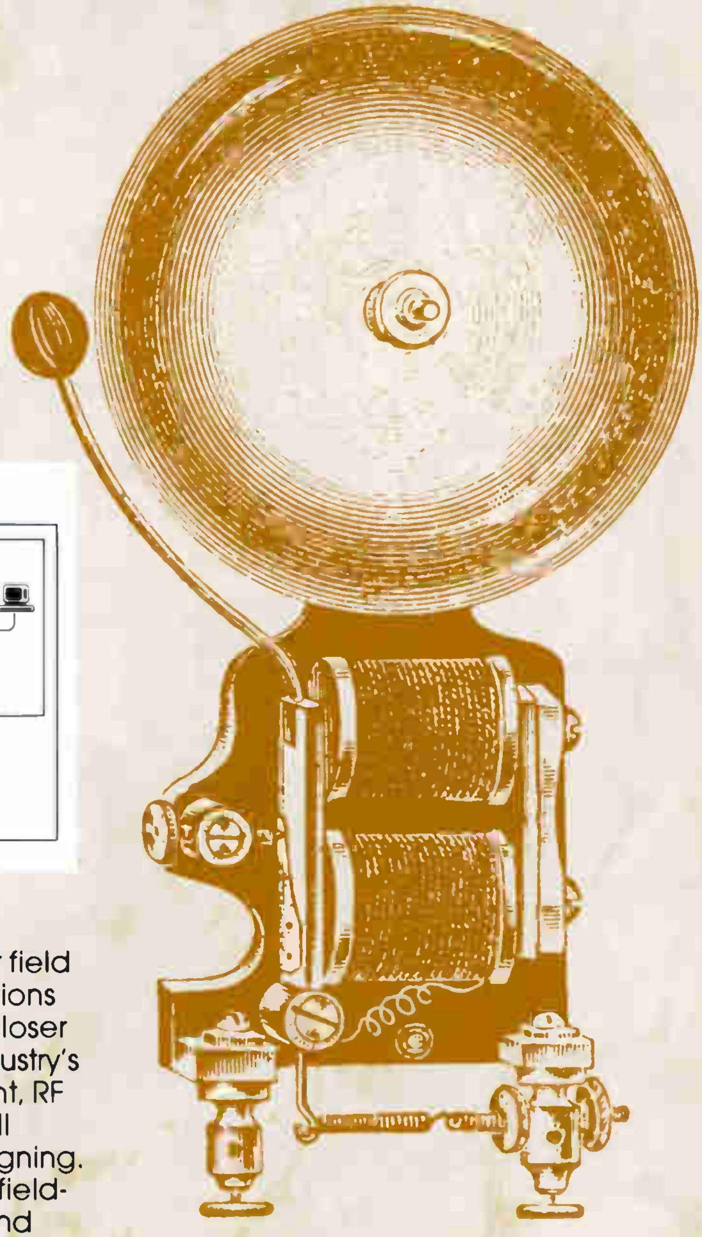

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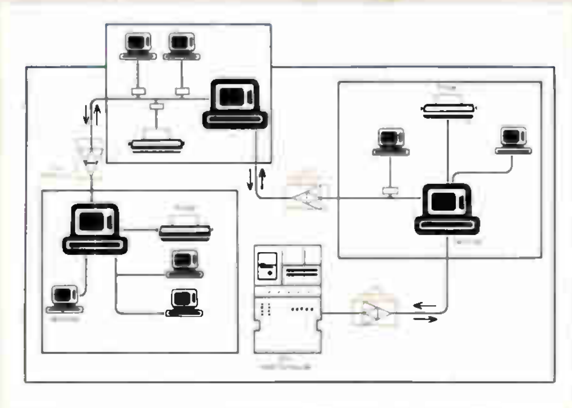

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Furthermore, the visual effect of the phase cross-modulation occurs at levels that make composite triple beat noise the limiting factor in broadband systems that carry 50 or more channels. Even in systems that use harmonically related or phase-lock carrier techniques, the triple beat mechanism is of prime importance, while cross modulation was deemed incidental.[4,5]

The cancellation phenomenon of the feedforward circuit introduces yet another degree of complexity in analyzing high frequency cross-modulation. The following analysis shows the effect of cancellation on cross-modulation sidebands and predicts the resultant effect on amplitude cross-modulation.

Jeffers[5] used the classical rotating vector representation of narrowband FM to describe the phase cross-modulation phenomenon at low levels of nonlinearity. This approach will be used to describe the effect of feedforward circuit cancellation on the cross-modulation sidebands.

Figure 8 shows a carrier vector with the double sideband cross-modulation vectors having a resultant vector whose phase is 90 degrees out of phase with the carrier vector. This represents pure narrowband FM or phase modulation. Detection of the envelope of this signal would result in no amplitude modulation.

Figure 9 shows a similar representation for the case of pure amplitude modulation. In this case the resultant vector of the sideband components is shown in phase with the carrier vector and therefore provides pure amplitude modulation, with no phase modulation.

Experiments were conducted to define the extent of this effect on push-pull cascode RF

Figure 8: Narrowband FM modulation vector

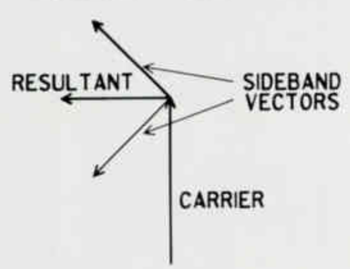


Figure 9: AM modulation vector

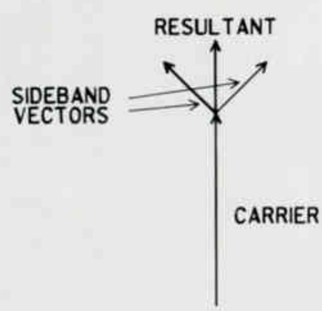
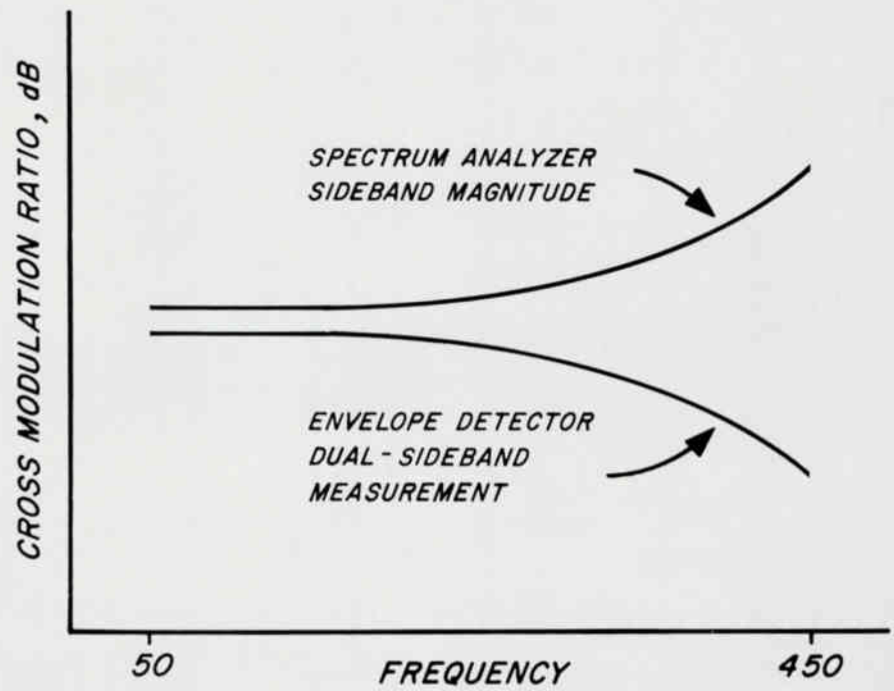


Figure 10: Cross-modulation of RF hybrid IC using two measurement techniques



hybrids. The magnitude of the phase difference between the carrier and cross-mod sideband components can be calculated by first measuring the magnitude of the cross-modulation sidebands on a spectrum analyzer and then comparing the results to the measurement of amplitude cross-modulation by standard National Cable Television Association-sanctioned techniques.

Experiments on 450 MHz, 60-channel RF hybrids indicate a typical phase angle of 80 degrees for the resultant of the sidebands at the high frequencies. This is very close to pure phase modulation as shown in Figure 8.

Figure 10 shows the general tendency of the phase modulation to produce a discrepancy between the amplitude of cross-modulation sidebands as measured on a spectrum analyzer and cross-modulation measured by NCTA methods.

This beneficial phase relationship can be destroyed by the cancellation process in a feedforward circuit. For instance, the high frequency cross-mod component generated by the main amplifier will have a phase characteristic similar to that shown in Figure 8 with characteristically low amplitude cross-mod. The cancellation process of the error loop involves the combination of the sideband with another signal of nearly equal amplitude and nearly opposite phase to provide an output signal with substantially reduced sideband magnitude. However the phase of the resultant sideband can take on any value between 0 and 360 degrees. This is shown in Figure 11.

There are several resultant vectors R1 through R8, plotted in Figure 11. Each of the possible resultant components has a magnitude 26 dB below the original distortion sideband, corresponding to a cancellation signal having a magnitude within 0.5 dB and a phase within 3 degrees of 180 degrees with respect to the original sideband. Clearly, the resultant can take on any phase value.

What then is a reasonable expectation for amplitude cross-modulation performance for feedforward circuits? The answer to this question involves first recognizing the magnitude of the original cross-modulation sideband and then analyzing the results of the cancellation process.

Hybrid vendors now specify both composite triple beat and amplitude cross-modulation on their 450 MHz parts. Typical performance numbers for both distortions with 60-channel loading at +46 dBmV output levels at all channels is 60 dB. Yet, these same devices exhibit cross-mod sideband magnitudes of typically 45 dB referenced to the sideband of a 100 percent square wave modulated signal for the same test conditions. That is, the sideband magnitude for cross-mod components is 15 dB worse than the composite triple beat. But again, this is predominantly phase modulation and not amplitude modulation. Using this information, the amplitude of the cross-mod sidebands of a feedforward circuit can now be calculated.

Referring to the previous section on cancellation and distortion reduction, which presumes 24 dB cancellation and 3 dB in output losses for the feedforward circuit, one could expect a reduction in the magnitude of the cross-mod sidebands of 18 dB relative to the performance of a single hybrid. So, if we start with a predominantly phase modulated sideband component of 45 dB and improve this by 18 dB, the result is a cross-mod sideband component 63 dB below reference. This takes care of the magnitude of the component. Now, we must look at the phase.

Figure 11 shows the phase of the resultant component after cancellation. If the resultant is either R2 or R6, the original beneficial phase relationship will be maintained. If the resultant is either R4 or R8, the opposite is true, with complete PM to AM conversion taking place. Note that this condition occurs at perfect amplitude balance of the feedforward circuit while the extreme limit of delay balance is being reached. Assuming that all points in this circuit are equally probable, the typical or average phase will intuitively be between these extremes. That is, either R1, R3, R5 or R7 on Figure 11 represents average performance.

Combining this assumption with the amplitude information of the preceding paragraphs we are left with the typical cross-modulation sidebands having a magnitude of 63 dB and a resultant whose phase relationship to the carrier is typically 45 degrees. In this case, both the amplitude modulation and phase modulation content of the sidebands are assumed to be equal with a corresponding value 3 dB below the magnitude of the resultant component. This assumption is shown graphically in Figure 12 and results in a prediction of typical amplitude cross-modulation of 66 dB for the case being considered.

Summarizing and comparing cross-modulation and composite triple beat (CTB) performance predictions for the feedforward circuit, a hybrid with 46 dBmV output at 60 channels has 60 dB CTB, 60 dB AM cross-modulation, and 45 dB cross-modulation sidebands. A feedforward circuit with the same output level will have 78 dB CTB with 66 dB AM cross-modulation. The key point is that this analysis predicts the probability of PM to AM cross-modulation conversion by the cancellation process of the feedforward circuit. Therefore, AM cross-modulation should not be specified at levels equal to CTB in a feedforward amplifier.

Experiments on individual circuits confirm the existence of this process.[6] Room temperature performance of feedforward circuits can be aligned to minimize this effect, however, the effects of time and temperature can and will produce AM cross-modulation in a balanced feedforward circuit at levels well above the CTB.

Summary

Feedforward amplifiers have attractive advantages, but specification of equipment performance and system performance must be done on an analytical basis rather than empirical basis. Critical third order distortion performance is not uniform, but is rather dependent on a cancellation phenomena which can change with frequency, temperature and time.

A 450 MHz, 60-channel composite triple beat for a feedforward gain block should be specified at no better than an 18 dB improvement over existing hybrid integrated circuit technology distortion performance.

Use of feedforward circuits for trunk station pre-amplifiers is not normally advisable due to the decrease in dynamic range associated with higher noise figures of feedforward circuits.

System designers must expect cascade flatness at temperature extremes to be measureably less than previous non-feedforward systems.

Cross-modulation performance should be specified at levels worse than the composite triple beat.

References

[1]Pavlic, John C., "Some Considerations for Applying Several Feedforward Gain Block Models to CATV Distribution Amplifiers," NCTA Technical Papers, June 1983

[2]Gumm, Linley, "Phase Effects in Cross Modulation," IEEE Transactions, Vol CATV-1, No 1, October 1976

[3]Luettgenau, G. G., "Cross Modulation in HRC Systems," NCTA Technical Papers, May 1981

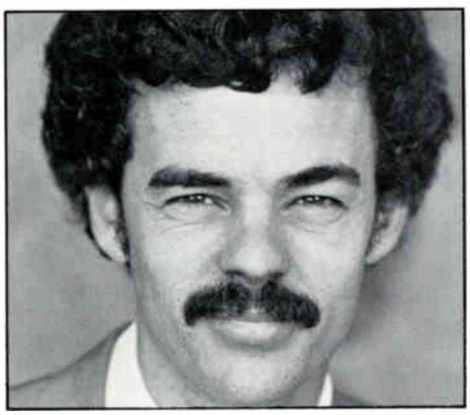
[4]Jeffers, Michael F., "Cross Modulation—An Overrated Specification," Communications Engineering Digest, October 1979

[5]Jeffers, Michael F., "Technical Considerations for Operating Systems Expanded to Fifty or More Television Channels," NCTA Technical Papers

[6]Powell, Jack, TRW Semiconductors, private correspondence

[7]Staiger, Jay G., "Advanced Hybrids for CATV Amplifiers," NCTA Technical Papers, June 1983

[8]Preschutti, Joseph P., Horton, Colin J., "Applications of Feedforward Technology in Broadband Communications Systems," CCTA Technical Papers, June 1984



Born and raised in Australia, Colin Horton received his Bachelor of Engineering in Electrical Engineering from the University of New South Wales, Sydney, Australia. While writing his thesis on the colorimetry of color television cameras, he received an internship with, and later employment from, the Australian Broadcasting Commission. As an engineer for ABC, Horton was responsible for the planning and installation of facilities for the production of television and radio broadcasts and was also responsible for the acceptance testing of communications equipment. After moving to the United States in 1978, Horton joined C-COR Electronics in State College, Pa., as manager-systems engineering.

Figure 11:
Magnitude and phase of resultant cross-modulation sideband components after 26 dB cancellation

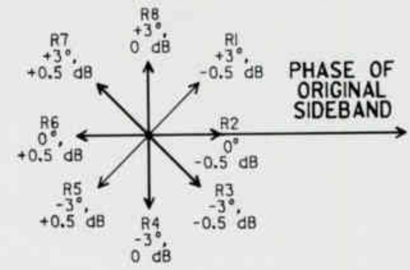
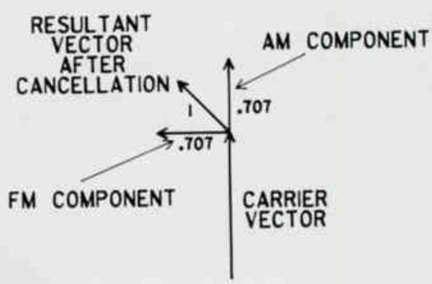


Figure 12:
Assumed typical phase relationship of the cross-modulation sideband resultants after cancellation



Joseph Preschutti joined C-COR Electronics Inc. in 1972 and has held several engineering positions prior to being named vice president-engineering in October 1983. He is responsible for directing all research and product development activities for the company. Preschutti holds a B.S. and an M.S. in Electrical Engineering from The Pennsylvania State University. He is a member of the Institute of Electrical and Electronics Engineers, a senior member of the Society of Cable Television Engineers and serves on the National Cable Television Association Engineering Committee. He has presented and published numerous technical papers.

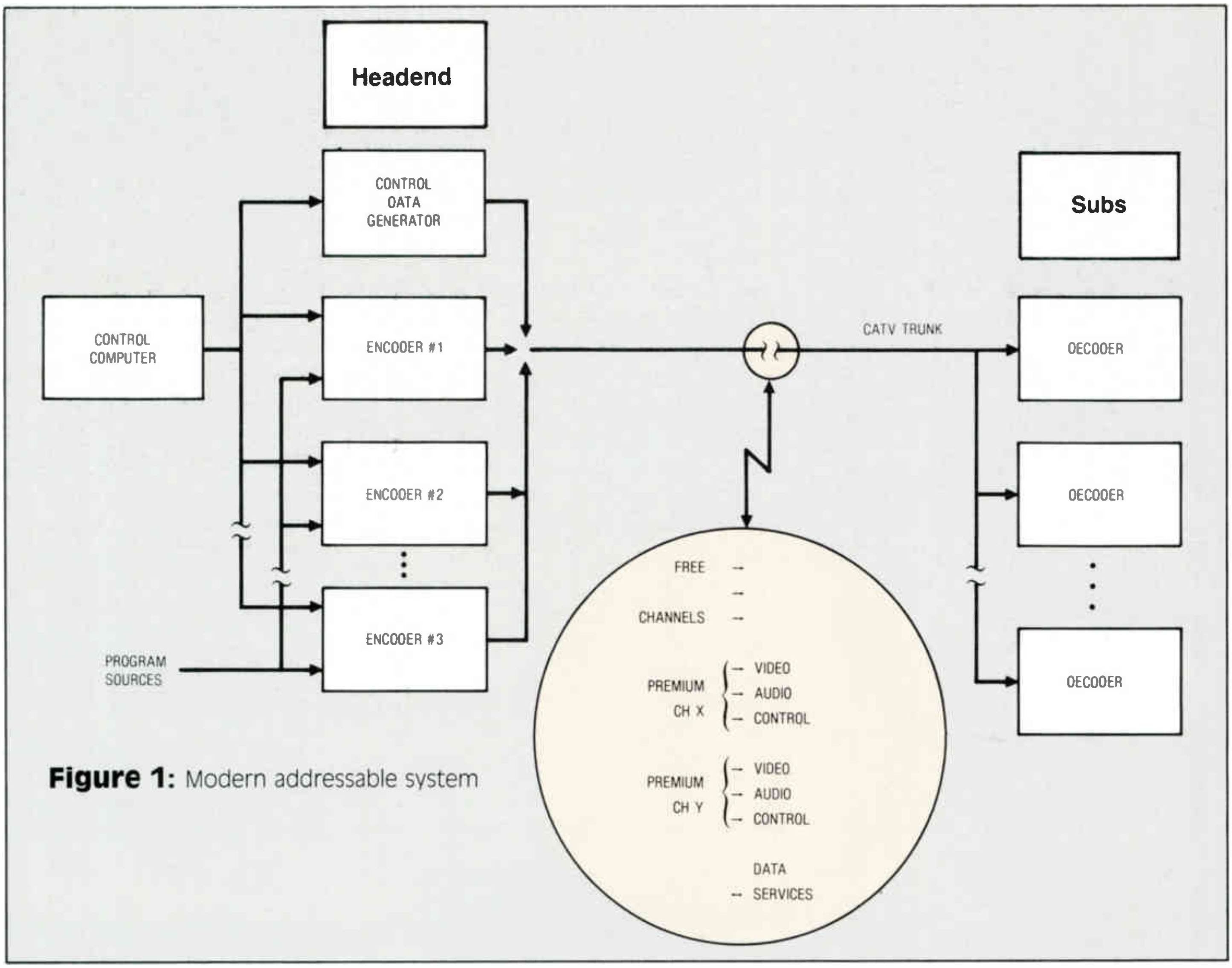


Figure 1: Modern addressable system

Encryption applications in the cable TV arena

By Anthony Wechselberger

Director, Advanced Engineering, Oak Communications Inc

The use of encryption technology in the delivery of premium television is the center of much attention today. It is also an area of misinformation where misunderstood terminology and technology are being discussed. One major area of confusion lies in the technical differences between encryption and scrambling and, particularly, hybrid utilizations of the two. In understanding some basics about cryptography, one can better appreciate these differences, and differentiate buzzwords from substance in the expanding selection of products utilizing encryption.

New requirement thresholds

Whenever there's a need in any marketplace, responses to that need will be garnered from market suppliers. The attribute approach to product demand theory tells us that demand can be manipulated by need, price, competition, or budget, as well as a whole set of attributes connected to the product's perceived value or need. This can be hyped one way or another by advertising—the "bandwagon effect"—and the like, which affects the consumer's perceptions and tastes.

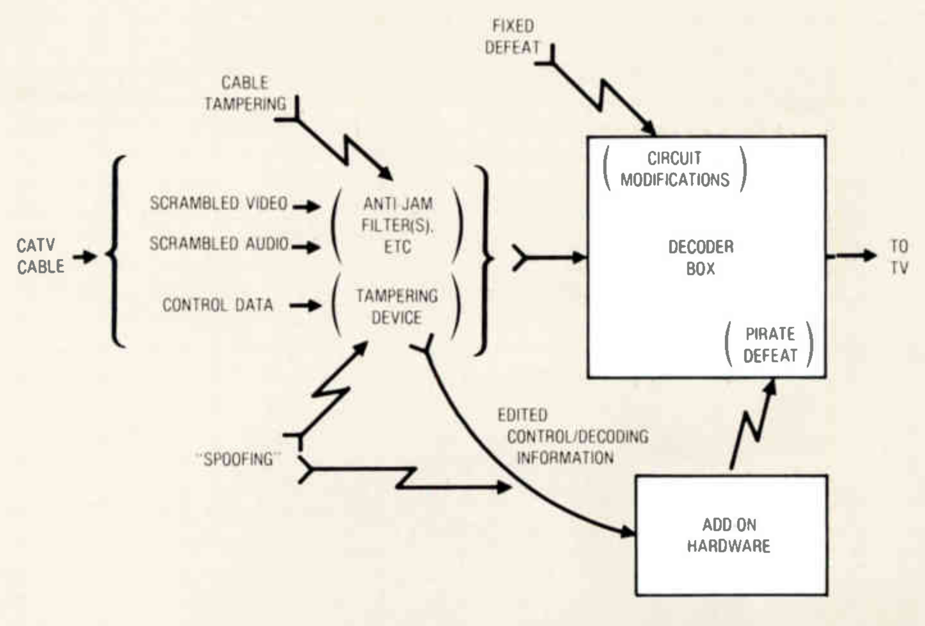
And so it is in our marketplace, the CATV market, where specmanship and buzzwords change each year in the scramble for market share. This is not a negative thing. Consumer features in converters and decoders, for example, is an area where much innovation has taken place. When the cable subscriber gives up the remote control for his $800 console TV, system suppliers are now able to give back some of those remote conveniences with the newer CATV equipment.

The demands we cable equipment suppliers react to must be responsive to both the end user and our immediate consumer, the cable operator. The operator in turn creates needs, but also responds to the palpitations of his own market, for which he purchases equipment, runs a business and distributes programming. *He must control* the consumption of his product (programming) for both short-term and long-term gains and market stability.

The process of controlling that product brings us to security, and the newest contemporary market response: encryption technology. The industry has responded to a need for better security already, although not directly. The evolution of products into the baseband arena is being aided primarily by two attributes: one real, one perceived. The "real" attribute is increased utility as a result of baseband processing. Examples are user features (such as volume control) and the freedom to do novel types of signal processing. The "perceived" attribute is security. In reality, being at baseband has little to do with the ability of a system to resist piracy. In discussing the resistance of a system to compromise, we talk about matters of degree. Equipment that one operator considers adequate may be totally unacceptable to another who sells programming in an area where high-technology industries are located. What is *done* with that signal at baseband is of concern. In a similar way, addressability is mistaken by many as an advance in security. We shall examine these misunderstandings in detail.

Encryption is a technique that offers hard security, uses relatively simple and inexpensive digital hardware, and lends itself easily and naturally to time-varying scrambling requirements. But before encryption can be applied, certain requirements must be met. Digital audio transmission, for example, can be one part of those requirements. We'll discuss several other necessary ingredients as well. By understanding some of the buzzwords, and asking a few critical questions about how the system you are evaluating is put together, *you* can tear down the rhetoric and make the tradeoffs. We first look at the main facets of a contemporary cable system.

Figure 2: Network attack scenarios



The addressable system and security

A CATV system is a communications system. In a modern addressable system there are four basic kinds of information sent (Figure 1):

- Program video
- Program audio
- Control data
- Data services

Under "data services" is lumped a variety of additive types of digital information such as teletext, videotext, downloaded software (games or computer program) and any interactive communications. While the need for security of these services certainly will become evident in time, the lack of standardization in format or modulation/transmission techniques causes us to set aside that category for this discussion.

In securing premium television delivery, the methods of handling the first three information types are within the confines of a specific addressable pay TV system. Program audio and video are generally, though not always, associated with each other. For simplicity, we consider them two constituents of a premium broadcast, as is usually the case. They are counted separately above, however, for two reasons: their broadcast formats are different and independent (VSB AM vs. FM) and the associated channel bandwidths required for each are an order of magnitude different. The relevance of these differences will be explained, but we note that premium programming has no entertainment value without both.

The third information type, "control," is whatever is used by the manufacturer (assuming an addressable system) for network control and authorization purposes. Considering the piracy issue, which includes any unauthorized access to programming, note that the control channel or channels have no relationship to the service being purchased. One of the first questions to ask then about a scrambling system is what is the function of the control/authorization channel? That is, how is it related to the scrambling approach if at all? In most systems the control channel(s) direct the decoder to decode or not to decode as a function of the channel tuned to, or the "tier" of a given program. Critical to the issue is whether any information contained in the control channel is required in the decoding process. If not, the control channel can be ignored when attempting to pirate the signal. Likewise, if the scrambling technique or decoder circuitry easily succumbs to one-time defeats, the control channel content is of no interest. Such is the case when descrambling can be accomplished by observation of the scrambled signal alone.

What about "time-varying scrambling"? Time-varying scrambling adds a dimension of change to the scrambling process such that the decoder will not properly decode at all times unless it appropriately follows the change. Is this better security? To a degree, yes, but if the attribute that changes has few or trivial differences, then no real barrier to prevent defeat of the system is actually created. Consider the pirate entrepreneur who wishes to build the "universal decoder." Most positive scrambling systems use one of several techniques of suppressing the horizontal synch pulse. ("Positive" systems are those that actively scramble the premium signal, and thus require a decoder. "Negative" systems remove the signal from the unauthorized viewer through traps or signal path switching.) Whether the system's scrambling is at RF or baseband, our pirate's universal decoder, if built to operator at baseband, can quite easily reconstruct the synch pulse and completely ignore all control channel information, time-varying or not.

Figure 2 illustrates several avenues where system attacks can take place. While simple wire changes/clipping/shorts, etc., are the deadly fears of operators, there are many ways to attempt piracy. Jamming tones can be filtered, traps that screen out pay channels can be removed, addressing data can be synthesized locally and add-on hardware in the decoder can be employed.

What is desired is a scrambling technique that: 1) renders the entertainment value of scrambled programming useless (which means hard security on at least one of the audio or video and adequate depth of scrambling on the other); 2) does not lend itself to one-time defeats (implies some sort of time-

Figure 3:
Time-varying considerations

1) Relevant parameters
- What characteristic changes?
- How often?
- How many different ways?
- How different is the system as a result of the change?

2) The security figure of merit is based on a set of ground rules
- How much information does the pirate have?
- How much intelligence and resources?
- What is his motivation?

3) Cryptography is attractive and effective
- The characteristic is simply a digital word (key)
- Easy to change
- Hardware is digital
- The "change" is immense

dependence); 3) cannot be undone by observation of the scrambled waveform; and 4) *requires* information continually downloaded from the headend, forcing contact through the control channel between headend and decoder to be maintained. Figure 3 lists several questions to be considered with respect to the time-varying nature of a scrambling system.

Criterion 4 above has two important implications. First we ensure the headend is always in control of the box by not allowing it to work if the data communications link is interrupted. Secondly, we require that in order to effect proper decoding, it's necessary for the decoder to be instructed *how* to decode, not just simply when to decode. In an addressable system, the control channel is the link between headend and decoder over which decoding instructions can be sent.

The previous discussion is gearing us toward the theme of this article, principally that, in CATV distribution security is a systems issue. The simplest method of defeat will be the path followed by the would-be pirate. The system must therefore be viewed from several angles and an adequate threshold against compromise developed for each. How much added security is afforded by random video inversion of the picture for example, if a simple-to-detect "flag" exists in the vertical interval indicating current polarity? Is any security afforded in an addressable system simply because it's addressable? Not if it's easier to address (authorize) the box yourself than it is to open the box up and tamper with circuitry. At one time such arguments were considered too far out to worry about. But premium TV is big business these days and new marketing approaches (pay-per-view, novel program packaging, etc.) afford new avenues of theft. The motivations for the program thief and the investment in revenues demand attention to these details as never before.

Encryption systems

There are two main categories of modern encryption approaches: the "classical" or "conventional" approach and the "public-key" approach. The public-key crypto system is, in theory, capable of performing all of the functions of the classical technique, but has a few special qualities in that fewer secret variables need to be passed around in the system. It also has implementational difficulties that make it less than attractive for many applications. For purposes of this article, only the classical system will be considered.

In the conventional encryption process (Figure 4) a digital bit stream (the information) is passed through an algorithm that transforms the input into a seemingly unrelated output bit stream. The transformation that is performed is a function of the "key variable," and in a conventional system the same key is used at both the transmit side where encryption is performed and the receive side where decryption is performed. A different transformation is implemented whenever the key changes. The key is a digital word of many bits (generally in the range of 24 to 64 bits), so 2^n (where n is the number of bits in the key) different transformations are possible by varying the key. In a properly designed algorithm, all keys are equally strong (i.e., resistant to "cracking") and no detectable relationship exists between the input data, output data or key variable. Each combination of key bits represents a completely different scrambling "mode" and there is no such thing as "almost having the correct key." The key must be exactly correct or no decryption is possible.

The process of encryption must, of course, be reversible. That is, applying the same key at the receiver must yield back the original message. The original, non-encrypted data is called clear or plain text, the encrypted data is called cypher text. So during transmission (i.e., between headend and decoder), only non-intelligible cypher text is available to the would-be tamperer. If the decoder doesn't have the proper key, no message or clear text will be obtainable, even if the pirate has the hardware. Further, in a properly designed system based on cryptographic security principles, we can give the pirate just about anything he wants: hardware, access to, and knowledge about the control channel, schematics, any firmware and even the crypto algorithm itself. The only doorway to information access, or in our case programming, should be through the key variable. Controlling access to the key variables is thus essential. This is called "key management," and is the basis for what ultimately makes or breaks the security of a cryptographically based system. The cryptographic or encryption algorithm, therefore, can be thought of as a lockbox. The message is encrypted or locked by the algorithm, and can only be unlocked by the same algorithm, which means the identical digital key must be used for decryption (we have yet to define exactly what is being encrypted).

Encryption implies digital

There are two fundamental ways to apply encryption. Which way is used depends on the format of the information, specifically whether it is digital or analog. "Digital encryption" can be applied only if the source data is digital, since the formal process of encrypting something is inherently a digital process. If an analog signal is to be encrypted it must first be digitally encoded. This could use an analog-to-digital converter, or some other digital coding technique such as delta modulation, for example.

The other way to apply encryption is to use a time-varying analog scrambling approach, and *control* the time-varying nature of the scrambling using encryption. "Control" is normally, or can easily be made, a digital process. This is why, as mentioned earlier, the time-varying scrambling can't be different in a trivial way. Since the tie-in (dependence) to the encryption is through the control process, if the control process isn't needed to get at the signal the encryption can be ignored. This latter cryptographically controlled technique must still be considered "scrambling," however, since the information signal itself is still in analog form.

Now that we have defined some essentials, the value of encryption will be more readily evident. For encryption simply enables a complex security problem, in which many variables (audio, video, control) must be secured, to be bottled up into just protecting a few digital keys. How this is brought about requires an appreciation for the difference between analog and digital transmission.

Standard television transmission, including all current scrambled pay TV techniques, is analog. That is, irrespective of whatever preprocessing or post-processing techniques are used, the signal is analog during its transmission phase. Even newer systems claiming to employ "digital video" are in fact transmitted analog. The fact that they may be processed digitally at the headend or receiver is purely an implementation convenience (and as yet an expensive one). The reason true digital video transmission techniques are not used is a matter of cost, both in terms of dollars and bandwidth. To digitize a color video picture requires a data rate between approximately 20 and 80 megabits (and an RF transmission bandwidth commensurate with that), depending on the coding technique and degree of compression applied. Efforts to reduce this bit stream appreciably are possible, but at extreme penalties of cost or picture fidelity.

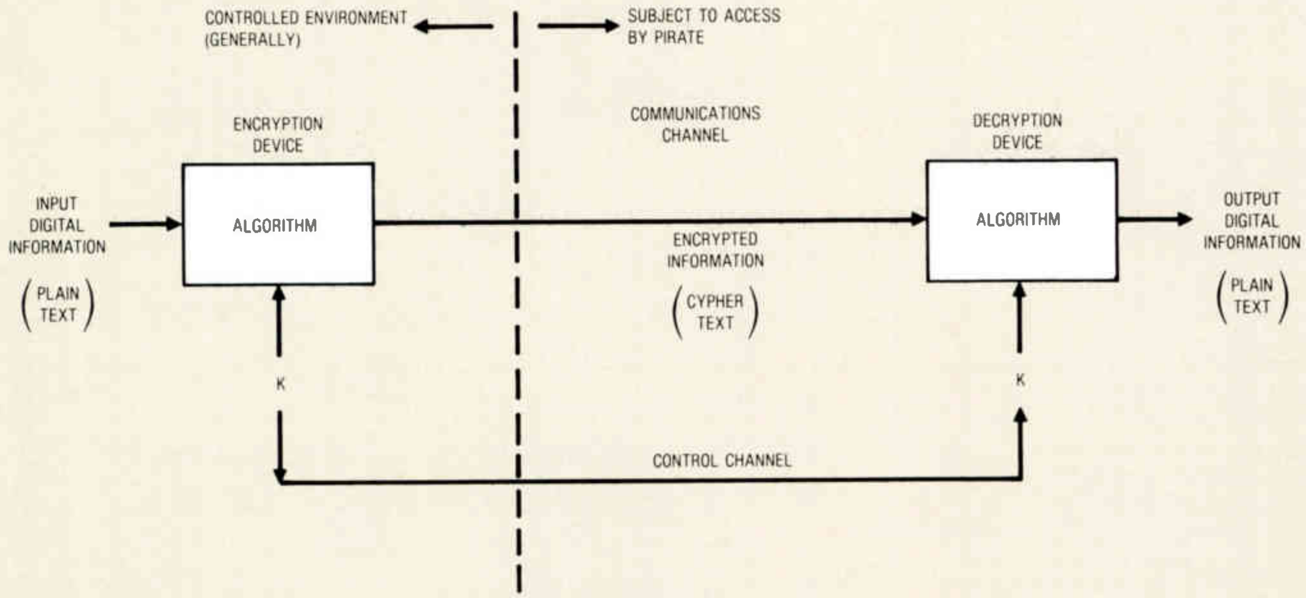
The audio portion of a television program is less prohibitively handled digitally. A bit rate between 200 and 700 kilobits is necessary for digital audio, and this data rate can be readily transmitted within the confines of a standard 6 MHz video channel (along with the video, of course). Digital audio processing is not trivial, however, and this sort of technology requires a sophisticated degree of systems engineering capability.

Once we have prepared the information itself for digital transmission, the door is open for the application of encryption. The control channel is inherently digital so it too can be "cryptographically" protected.

Key distribution

Encryption alone will not assure the security of information in any network in which it's used unless the key management problem is carefully addressed. In the broadcast scenario, the problems of key variable distribution are particularly challenging (in comparison to applications where only station-to-station situations exist). It probably has occurred to the reader by now that, if access to working hardware is given the pirate, it is little trouble to determine what digital key is being used for decryption. Recall, that previously it was stated that one-time defeats won't be allowed. Therefore, the encryption/decryption keys

Figure 4: Classical cryptographic system



must be changed from time to time. The time interval depends on the key length, the ability of the encryption algorithm to resist analysis by computer, the expected accessibility of the key and the motivation of the system's enemy.

In an addressable system the CATV control channel is the obvious choice for a key distribution path. (Alternate methods might be by courier, mail, etc.) But one can't just go broadcasting the new keys throughout the network. They must remain secret to all but authorized decoders. The solution for controlling key access is to encrypt the keys for transmission. By transmitting decryption keys in an encrypted form throughout the system, we have not really solved the key distribution problem, however, because to decrypt these keys requires yet another key. Such is the notion of "multilevel key distribution" (Figure 5). Various information exchange networks require different solutions to a multilevel approach. In the CATV environment the requirements dictate that: 1) when the keys are updated (changed), all decoders (and encoders too) must do so at the same time; 2) the system operation must ensure that all decoders have had the new keys properly delivered, decrypted and prepared prior to engaging them; and 3) only authorized decoders are able to perform (1) and (2).

In fact, many types of information passing through the control channel are candidates for encryption. Authorization or tiering data, for example, also should be considered "sensitive" information since, as pointed out earlier, it can easily be locally synthesized and fed to the decoder by simple digital hardware or any home computer. Such control channel manipulation by other than the legitimate network controller is just as dangerous a form of tampering as hardware tampering. Attempts to subvert the system by such address channel tampering is called "spoofing." Integrated within the operational framework of the system must be a totally planned out methodology for key distribution and protection against spoofing.

Spoofing can be of several forms, depending on how the pirate is attempting to fool the box. Control channel mechanisms must be in place to:

1) Prevent the insertion of illicit control data.
2) Prevent the deletion of valid control data.
3) Prevent the modification of valid control data.
4) Prevent the replay of control data.
5) Prevent box swapping between systems and geographic areas, and ensure stolen boxes are useless.

The Sigma solution

Armed with some encryption fundamentals then, we look at Oak's CATV distribution solution. Emphasized earlier was the notion that encryption is a digital process, that digital video transmission is not yet feasible but that digital audio is. By combining a time-varying analog video scrambling process in which the descrambling process is controlled through encryption, together with digital encrypted audio, we have a solid basis for an acceptably secure entertainment delivery system. The final component is an encrypted control channel for network control, key distribution and authorization of all program distribution and user features from the headend. This is the solution selected for Oak's new Cable Sigma system. To secure the time-varying nature of the system, time-varying encryption keys are employed within the encrypted control and authorization channel.

In the Sigma system "medium" security of the video and "hard" security on the audio is said to exist. These phrases relate to the relative difficulty of pirating the resulting system. With hard protection of the audio, the entertainment value of the programming is secured. In all current CATV systems, by comparison, the audio channel is in the clear, or, at best, located on an easily recovered aural subcarrier. This leaves the only barrier to piracy in such systems the video scrambling. In the system described here, the video scrambling can be very difficult to defeat, the audio is unrecoverable to the extent that the encryption cannot be broken and information in the control channel *must* be employed to gain access to the programming, since the programming itself is locked by the encryption overlay.

Additional problems having to do with error control/error propagation must be addressed when employing encryption. Encryption al-

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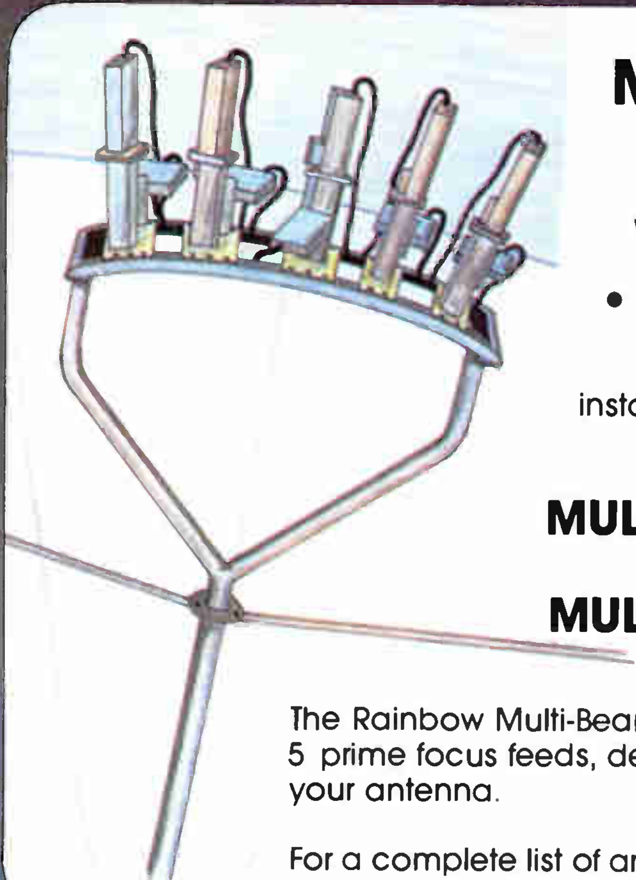

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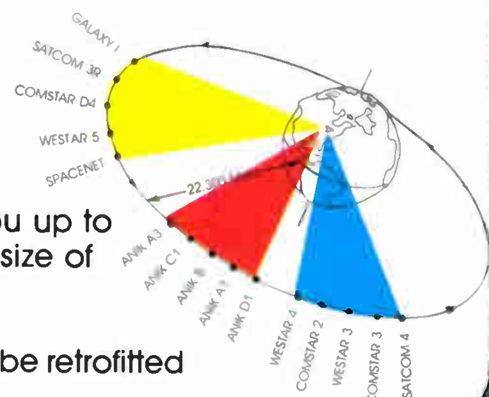

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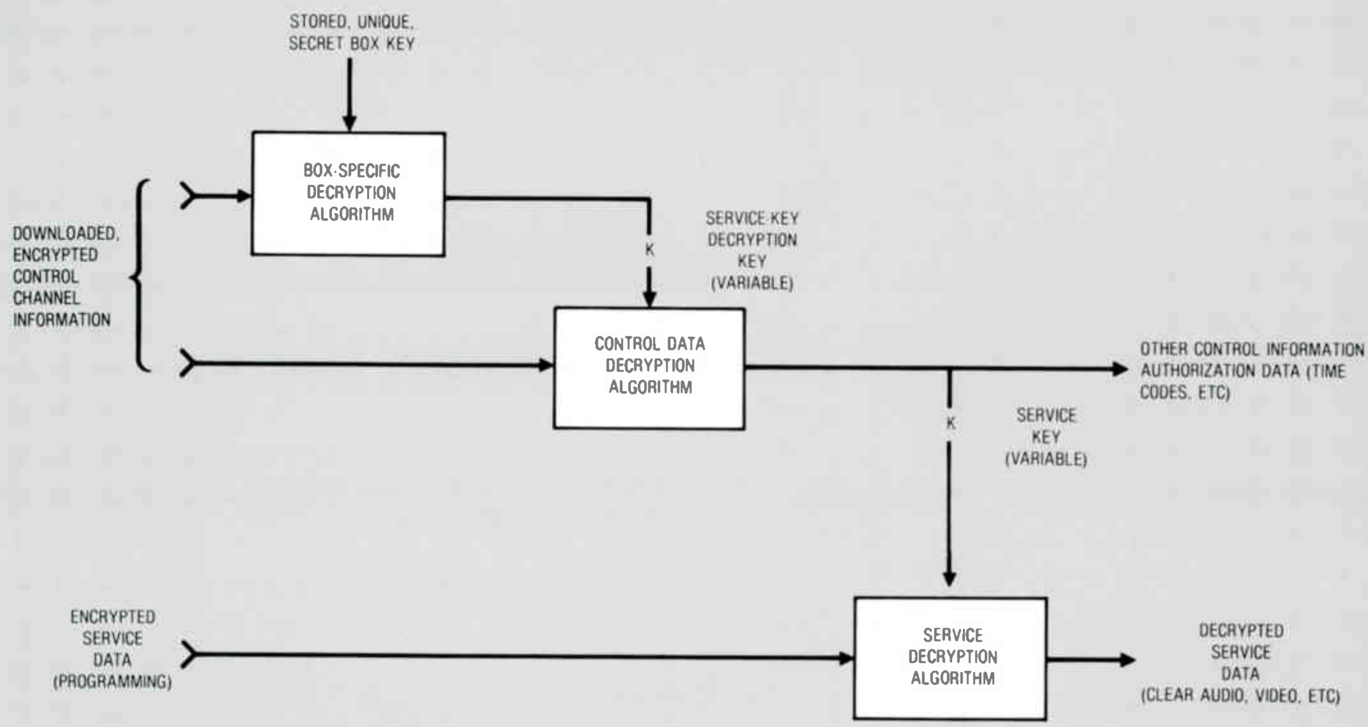
Figure 5: Multilevel key distribution



gorithms generally have the characteristic that bit errors occurring in the receiving and detection process "avalanche" or propagate during decryption. Poor or ignorant attention to detail in the system design phase of a network employing encryption can have catastrophic effects as a result of bit error consequences. The approach to error control must be considered, which includes analysis of system bit error rate and robustness against various forms of channel impairments.

In the Sigma system, scrambled video is employed, wherein complete horizontal and vertical synch pulse removal (as opposed to synch pulse suppression) is performed. Two channels of audio are digitized, encrypted and embedded in the video. The standard aural carrier is not used, but is available. Two separate control channels are used: the first, a global, FSK-modulated channel that all decoders continously monitor; the other, an in-channel VBI (vertical blanking interval) data path that is channel-specific. The former contains general authorization and system-oriented control data. The latter contains program-specific data relevant to a given channel and time. A 64-bit, field-structured, data-packet-based communications protocol has been designed around the FSK data channel. These packets deliver a continuous stream of encrypted data to decoders, both globally and box-specific, for purposes of encryption key delivery, special event programming, box installation and downloading of system parameters and box features. Special provisions exist to guard against spoofing and box swapping between systems. Protection for time-dependent variables and error control also is provided.

Different digital audio keys are utilized for each channel and the keys are varied contínously. A multilevel key distribution system is employed in which three key variables are used. These include a box-specific key that is secret and unique to each box (unknown, even to the system operator), a variable second-level key common to all legitimate subscribers, and the audio keys. Solid-state nonvolatile memory is used in the decoder to store key and authorization information (encrypted while stored). Each box also has a non-secret box address that is its addressing identification used by the headend computer to communicate to the box.

Encryption can be applied to premium CATV distribution in a way that directly makes the strength of the cryptograhic overlay a barrier to illicit program access. This is done by encrypting the signal itself, thereby forcing the pirate to address the problem of a cryptanalytic attack in order to break the system.

Digital encryption requires a digital information source, and audio was shown to be a programming component, which, when digitized and encrypted, can be effectively used to lock out unauthorized access. Finally, encryption of the authorization and control channel must be included to ensure attacks against the system control and key distribution processes are thwarted.

Anthony Wechselberger is director of advanced engineering for Oak Communications Inc. His major areas of concentration are communications, computers, digital processing and control. He joined Oak in 1980 and spent two years in the corporate advanced technology group working to develop a technology base in the cryptographic area. Research centered on synthesis of hardware- and software-based proprietary cryptographic algorithms, cryptanalysis and key distribution scenarios for the broadcast environment. Before joining Oak, he spent six years with General Dynamics Electronics Division working with data communications hardware, digital control systems, microprocessor systems and radar signal processing systems. He holds BSEE and MSEE degrees in electrical engineering.

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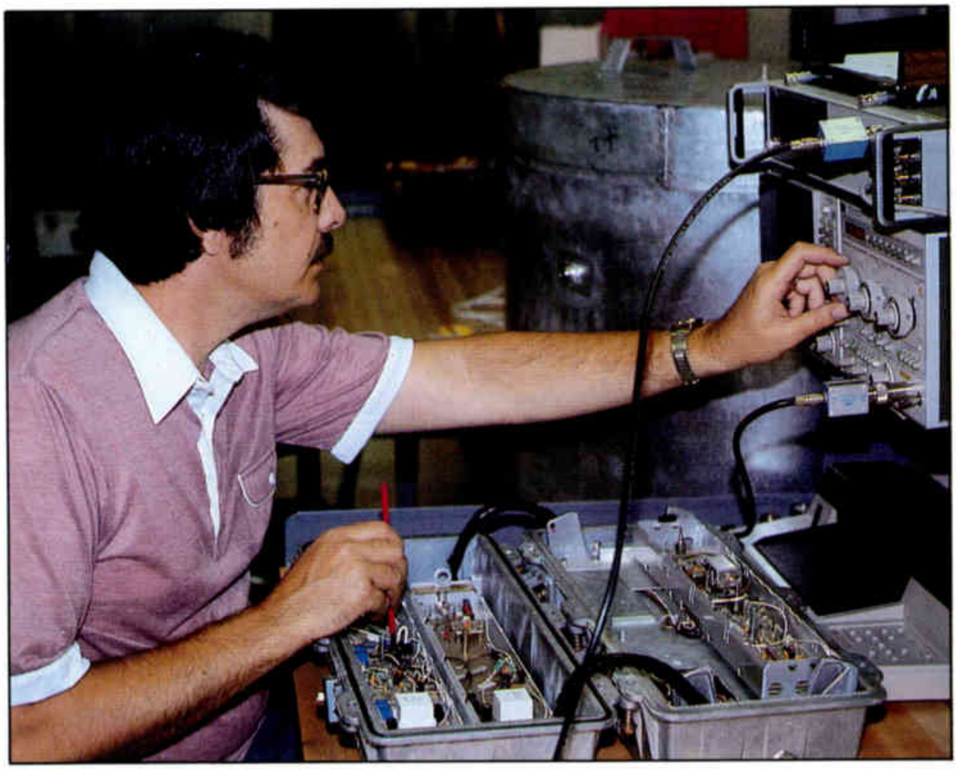

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By Laurence E. Baker
United Artists Cablesystems Corp.

Nowhere in the CATV industry is there a source for product evaluation data, a "CATV Consumer Magazine" so to speak. Whenever a system operator wishes to determine the in-depth qualities or comparative features of certain types of equipment, he or she usually has to resort to a "word-of-mouth" evaluation. By this I mean locating someone having experience with that particular unit and obtaining their impressions and advice. Needless to say, such a procedure seldom results in a high confidence level. As an alternative, an evaluation laboratory offers certain advantages—mainly by providing the hands-on opportunity to actually verify equipment specifications and to determine possible shortcomings.

The advantages of an evaluation lab

A properly designed, operated and managed evaluation facility can provide the detailed data base needed in order to arrive at an optimum balance between cost and effectiveness. The primary problem when establishing an in-house evaluation laboratory is to determine the extent of your testing needs. Possible objectives to be considered are shown in Figure 1.

Equipment evaluation can range from a simple bench set-up (see if it works process) to an extensive engineering investigation to determine detailed performance characteristics. The basic limiting factor then is to determine how much time, money and effort will be invested to achieve the desired results. Keep in mind, however, that the fundamental objective is to verify as much as possible, the electrical, mechanical and subjective operating parameters of the equipment offered in today's competitive market.

Getting set up

Beginning with the evaluation lab's physical layout, provide the best possible. Plenty of workspace with comfortable heating and air conditioning is a major necessity. Overhead florescent lighting is suggested for even illumination; dark areas not only reduce worker safety but increase eye fatigue. Provide at least one telephone, preferably with a long handset cord (this allows freedom of movement to different areas in the room or to a workbench, when needed, to discuss a technical problem). A good sturdy workbench and a roll around draftsman stool are recommended. Dry, smooth flooring is a prime consideration as well as a rubber mat in front of the bench. Equip each bench with a number of AC outlets; multiple-outlet strips equipped with fuse or circuit breaker, on/off switch and power-on indicator light is a good choice.

If the laboratory is located in a windowless area, some type of emergency lighting that automatically comes on during a power failure is mandatory. The lab facility should be lockable, not only during non-working hours, but whenever personnel are away for short periods of time and equipment needs to remain powered up. Adequate storage space for lab equipment or spare parts and also for items brought in for testing is a worthwhile feature.

Another requirement that most people tend to overlook or ignore is safety practices. Safety items such as lightweight plastic glasses to be worn when soldering will help prevent accidental solder splashes in the eye. Selection and use of proper tools for a particular job is just common sense but an occasional safety reminder from management does not hurt. An emergency safety board equipped as a minimum with a first aid kit, flashlight, heavy lineman type rubber gloves and a short length of dry rope should be mandatory. Distinctively mark the board and place it in an accessible location.

Emergency telephone numbers and procedures also can be posted here along with a reminder that these items are for emergency use only and are not to be removed or used for

Figure 1:
Evaluation laboratory objectives

- **Purpose**
  1) Provide technical evaluation assistance to system manager and engineer as requested.
  2) Determine equipment performance characteristics for evaluation and possible purchase.
  3) Special projects as assigned.
- **Test areas**
  1) Electrical
  2) Mechanical
  3) Subjective
- **Test standards**
  1) Manufacturers
  2) Corporate
  3) FCC
  4) Underwriter's Lab
- **Test procedures**
  1) Swept frequency response
  2) RF shielding
  3) Return loss
  4) Corrosion susceptability
  5) Temperature cycle tests
  6) RF distortion test
  7) RF noise test
  8) Video distortion test
  9) Video noise test
- **Specialized tests**
  1) Temperature cycle test chamber
  2) RFI chamber
  3) Salt spray chamber
  4) Static electricity vulnerability
- **Field testing**
  1) FCC proofs
  2) Microwave
  3) RFI
  4) Construction practices

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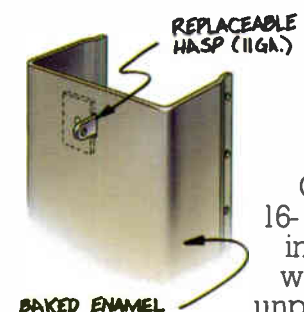

For example, CWY pedestals feature 16- and 18-gauge T2 aluminized steel construction, which tests show outlasts unpainted galvanized steel *at least five-to-one*. Plus, the rectangular design assures ease of installation and maximum use of interior space.

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Figure 2: Example subscriber taps evaluation form

Manufacturer: ____________ Model number: ____________

No. ports: ____________ Value: ____________

Date tested: ____________ Tested by: ____________

A. Electrical	5-50MHz	50-400MHz
1. Maximum useable frequency	____ dB	____ dB
2. Insertion loss (input-to-output)	____ dB	____ dB
3. Response (peak-to-valley)	____ dB	____ dB
4. Tap loss (input-to-tap)	____ dB	____ dB
5. Tap response (peak-to-valley)	____ dB	____ dB
6. Input return loss	____ dB	____ dB
7. Output return loss	____ dB	____ dB
8. Tap return loss	____ dB	____ dB
9. Isolation (output-to-tap)	____ dB	____ dB
10. Tap isolation (tap-to-tap)	____ dB	____ dB
11. RF leakage	____ dB	____ dB
12. Hum modulation	____ dB	____ dB
13. Power pass capacity	____ Amps	

B. Mechanical	Yes	No
1. Useable for aerial and underground	____	____
2. Tap plate removeable without removing connectors	____	____
3. Screws in place captive	____	____
4. Mounting space for traps	____	____
5. Drop ports air tight	____	____
6. Heat shrink space	____	____
7. Water proof	____	____

any other purpose. Whenever possible, arrange all equipment and furniture around the perimeter of the evaluation room leaving the center clear. This not only keeps tripping problems to a minimum but facilitates the movement of equipment to be tested such as large cable reels. Lastly, place an approved Class A and B fire extinguisher at or near the test facility entrance.

Personnel staffing of an evaluation facility is requisite depending upon testing needs and desires. One or possibly two people are sufficient for most testing needs. Since individual learning is an on-going process, arrange for an in-house training program. Local college courses, correspondence schools and programmed learning labs are just a few sources that can meet this need. Ideally, your evaluation staff will respond to this approach and the results will benefit all concerned.

A first-class collection of technical books and literature for a reference library are equally beneficial to lab personnel. Subscriptions to various technical and industry publications are invaluable, not only for reference but in just keeping up with the advances in technology. Equipment and sales catalogs also are important information sources. Objectivity will keep you from having an oversized collection of outdated material.

When preparing the annual operating budget, requirements of the evaluation lab should be included. Lab personnel should submit a list of equipment needs covering both new pieces of test equipment and replacement items. If this is not done, you may find yourself going backward instead of forward.

Maintain good records of testing results. Design a record system that details an evaluation from the day an item arrives for testing until you have completed the evaluation. An excellent method is to assign a project work number for each separate piece of equipment to be tested. Evaluation records should identify when the equipment arrived, who tested it, the results of the testing and final disposition. Include copies of all shipping documents and maintain all of this material in a file folder. A small filing cabinet will keep your files in order and protected. Keep account of equipment brought in for testing; a running inventory of equipment received is invaluable. This assists in keeping track of daily work scheduling and prevents equipment from being misplaced and forgotten until you are billed for it. Keep identifiable and traceable records of all equipment serial numbers, invoices and return authorization numbers.

Testing and standards

So much has been written on test procedures that it would be redundant to delve deeply into the subject here. It would also be virtually impossible because of space limitations. Although reasonably accurate test results can be determined with a small amount of test equipment and ingenuity, give a high priority to obtaining quality test equipment. Once you have done this, specific test practices and procedures should be agreed upon by all concerned.

Source material from which to develop test procedures may be found in a variety of technical publications, including those provided by the National Cable Television Association and by manufacturers of test equipment. The only limitations are those possibly dictated by in-depth evaluations requiring high cost and very specialized test equipment. Another asset is the development of a laboratory test practices and procedures manual.

Provide the following information for each different test to be performed: definition of test; brief summary of requirement and theory; step-by-step procedures to be followed; equipment needed to conduct the test; miscellaneous or general comments; and a block diagram of equipment connections. Once this has been accomplished, ensure the manual is maintained properly and does not become a collection of altered, handwritten, scrambled notes. Any time a portion of a test procedure is changed, the entire section pertaining to it should be updated.

When testing equipment, always follow one basic rule: understand and follow manufacturers equipment specifications. If an amplifier under test requires a certain dBmV input level with particular values of equalizers and pads installed, then ensure you set it up as called for. You can generally rely upon the fact that the manufacturer has spent considerable time and engineering design work to determine optimum operating results. A failure to follow this requirement will usually invalidate any specification data you may obtain from test results when doing equipment comparisons of different manufacturers.

A major fallacy in product evaluation is a blind faith in equipment calibration. As test equipment ages from time and use, internal component values change and calibration also changes. Periodic calibration checks will prevent possible embarrassment because of inaccurate test equipment.

As much as anything else, do not expect accurate test results from hurried and rushed evaluations; try to plan ahead and provide as much time as possible. For each particular category of equipment to be tested, develop a test evaluation form (see Figure 2). This greatly reduces test time and ensures that something was not overlooked. If you find yourself requiring additional special tests on a frequent basis, then update the form.

Finally, whenever you finish the electrical testing, do not forget mechanical and subjective tests. Push buttons, open and close lids, shake it, literally do anything within reason that effectively simulates an environmental test.

Above all, keep in mind that the final management decision is based upon the quality of evaluation you are supposed to do; what you said you were doing, and being technically oriented to know whether you did do it.

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How to give the silent

At last, there's an addressable cable system that protects the audio, as well as the video.

The Oak Sigma System is the first system to offer Sound-In-Sync℠ digitized audio encryption.

While other systems might scramble the video, or even encrypt the descrambling control data, *only* Sigma does all that, and encrypts the audio portion of the actual program, as well.

How Sound-In-Sync encryption works.

Unlike other systems, Sigma completely eliminates both horizontal and vertical sync pulse information from the video signal.

The encrypted digital audio data is then placed within the video at the location where the horizontal sync pulse normally would be.

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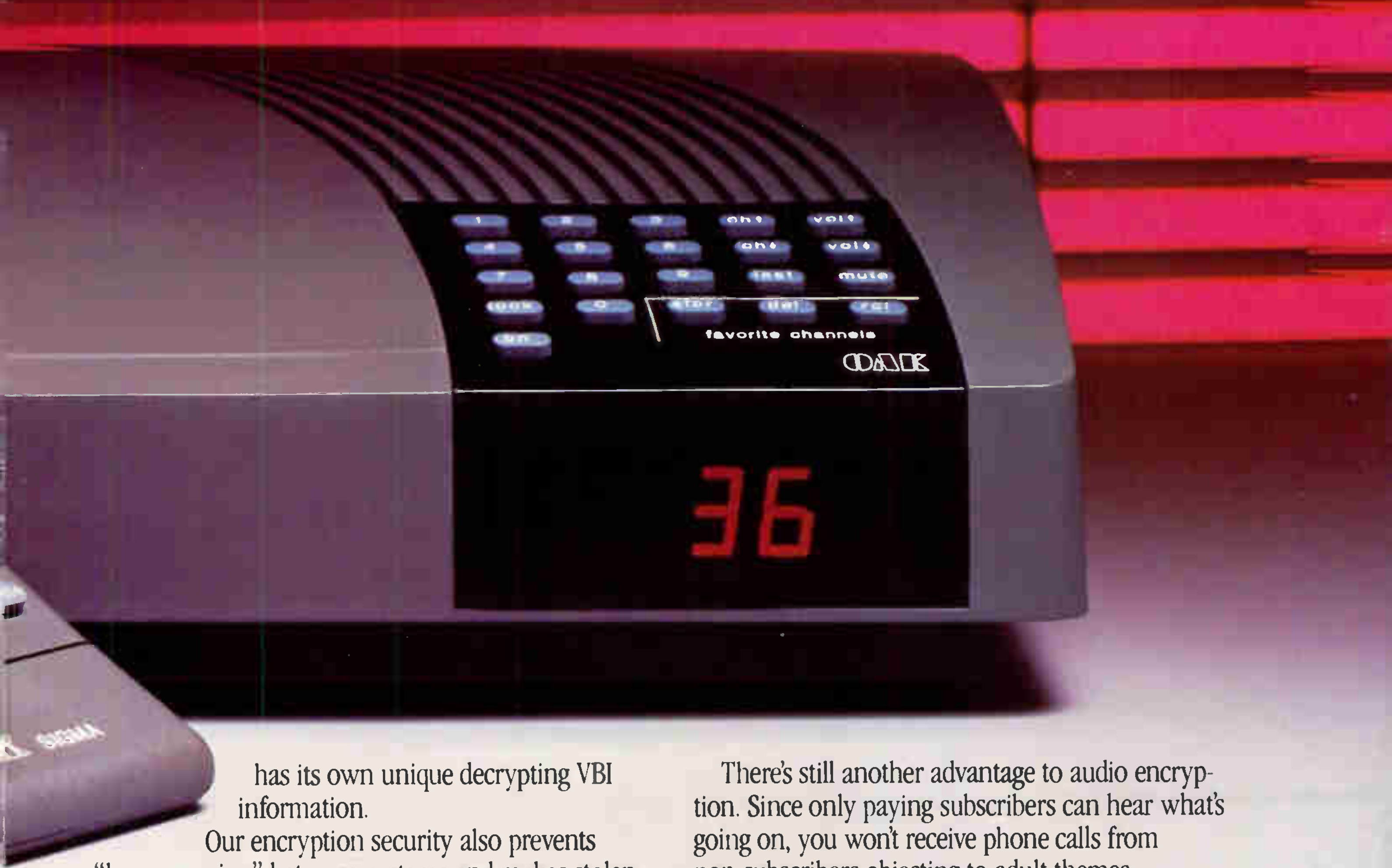
Would-be pirates are prevented from feeding false information to the decoder to defeat the system because in order to decrypt the data, the decoder must first receive authorization in the form of decryption parameters from the headend. As an added safeguard, this authorization information is also transmitted in an encrypted form.

What Sound-In-Sync encryption can do for you.

In addition to providing unprecedented signal security, Sigma's Sound-In-Sync encryption allows for user-specific pay tiering, because each scrambled channel

signal pirates treatment.



has its own unique decrypting VBI information.

Our encryption security also prevents "box swapping" between systems and makes stolen home terminal units virtually useless. Each box has its specific security code, and will only work within a given geographic area and during a specific period in time. If an attempt is made to operate the unit beyond these operator-defined parameters, the decoder will automatically shut itself off and display a self-diagnostic security violation indicator. Operators can now track and confirm service only to those subscribers authorized to receive it.

This makes Sigma ideal for pay-per-view events and other pay services. Should the decoder be tuned to an unauthorized channel, it automatically detunes itself to an operator-specified channel.

There's still another advantage to audio encryption. Since only paying subscribers can hear what's going on, you won't receive phone calls from non-subscribers objecting to adult themes.

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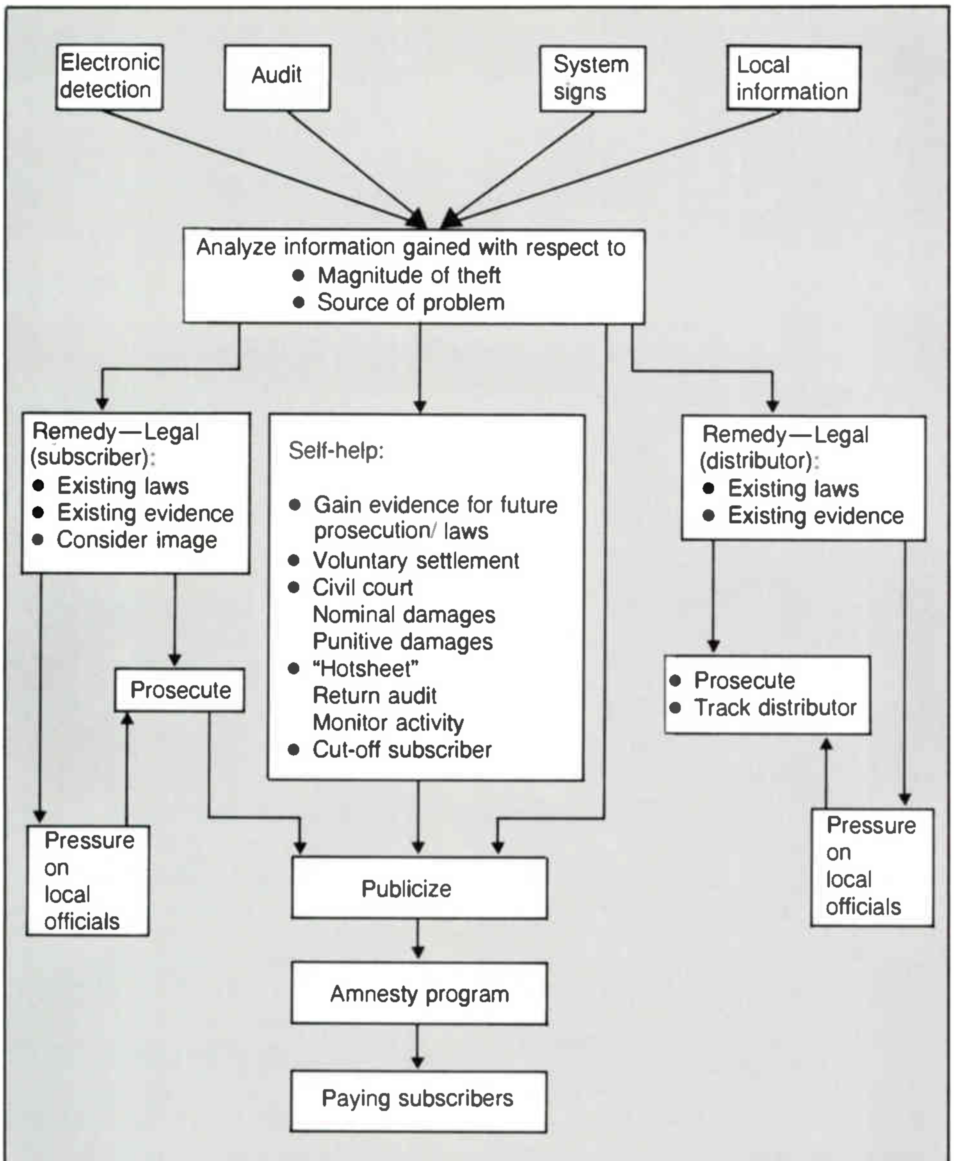


Figure 1: Current system security

A planned approach to combat theft of service

By Kenneth A. Eichelmann
Jerrold Subscriber Systems Oivision, General Instrument

Within the past year, concern for converter signal security and theft of service have catapulted to a crisis level for most cable operators. It is difficult to establish a firm revenue loss figure for the industry, but cable operators unanimously agree that millions of dollars are lost due to this pervasive problem.

Theft of service hasn't appeared overnight, but has grown as more cable operators have added pay services to their programming lineup. In turn, the temptation to steal these premium services has become very attractive.

Basically, there are three types of service thieves known to be infiltrating a cable system. The first type includes the subscriber who may or may not intentionally steal service by tampering with the electronics of his converter to the "electronic wizard" who constructs circuitry to defeat the converter. Next comes the employee, present and past, of a cable company. This group has either access and/or knowledge of the cable system and its operations. Present (and dishonest) employees can authorize subscribers to receive pay services and install converters into homes without the knowledge of management. In some cases, the subscriber doesn't even know he is stealing services.

This brings us to the third category of service thieves, the largest and most organized of them all. They are a select group of dealers and distributors ranging from a one-man show to a nationwide operation. Most system managers agree that it is the latter class that causes the most harm to the industry and that if you stop the illegal dealer/distributor, you can curtail most future theft. These distributors/dealers can supply anything from a complete hook up with a converter, to instructions and electronic kits on how to build your own descrambler.

Recognizing theft of service in a cable system is sometimes difficult. Cable operators must be sensitive to possible symptoms of this problem. Such symptoms include a sudden increase in "churn" with a large number of subscribers downgrading to basic service only, an increase in the number of service calls due to subscriber tampering with converters, traps or lines and increased advertising by any local dealer(s) offering converters or descramblers.

Awareness campaigns: Tools for success

Once a cable operator recognizes signs of theft in his system and its potential sources, he can then act to bring the problem under control. However, before any one specific method is introduced, let us first discuss steps toward ensuring success in fighting cable theft of service. Specifically, priming the community on the criminality of stealing cable services through an awareness campaign.

Awareness and education are two key factors in the successful handling of a cable system's theft of service problem. It is imperative that the public—subscribers and nonsubscribers alike—be informed that stealing services from the cable company is not something to be taken lightly. The act is a serious crime and should be treated as such. Any publicity campaign directed at the theft of service problem should emphasize that the cost of this illegal activity is borne by all subscribers, in the same way that shoplifting impacts the cost of goods to the consumer.

Tough laws on the books empower the cable operator to move vigorously against pirate distributors or illegal subscribers. An example of an anti-theft victory is the case of *Cox Cable of Cleveland v. King Electronics*. This case was the first one successfully prosecuted at the federal level, based on Section 605 of the 1934 Communications Act. To date, there have been several successful prosecutions based on this federal law, which point to its importance and the pursuit by operators to crack down on illegal distributors/dealers. In short, successful campaigns against theft of service in all its manifestations requires the strong support of the courts and legislature.

Procedures

The optimal method of identifying theft of service in a cable system is the house-by-house audit. In this manner, an operator physically inspects the system for illegal hookups, signs of tampering or other discrepancies. Several major cable operators have done extensive audit work. This method has proven profitable, allowing the conversion of illegal subscribers to legal ones. If a system's particular operation lacks the requisite staff to perform such a job, there are companies specifically in the business of conducting system audits for cable operators.

One way to employ the audit as a positive activity is to first view its potential benefits, both in terms of a quality control check and a public relations effort. Treating the audit as a service call allows the operator's staff to discuss a subscriber's service, correct any problems and check to ensure that the signals are coming in clearly.

Another method of detecting theft of service in a cable system is through the use of a return-loss test, an electronic detection method that can be implemented by operators. Basically, the test consists of transmitting a sweep frequency through the cable system circuitry and then measuring the amount of signal returned or reflected. Return-loss tests only detect whether or not a receiving device is connected to the cable inside a home. If the test shows something abnormal, this information constitutes sufficient proof of "intent to steal," and allows the cable operator to obtain a search warrant for further investigation. While audit and return-loss tests are effective methods of identifying illegal subscribers, combating distributors requires quite a different plan of action.

Prosecution and afterwards...

Without a doubt, one of the most effective methods of gaining evidence against pirate distributors and dealers is to conduct a private investigation. "Sting-type" operations have proven to be an effective means of gathering and documenting evidence to use as leverage in an eventual legal prosecution.

In order to establish a perfect case against dealers and distributors, the operator (with the assistance of legal counsel) should be thoroughly prepared. There are several reasons for this. First, any initial case in the anti-theft area needs to establish the importance and seriousness of the crime before the court. Secondly, strong and thoroughly prepared cases are necessary to ensure victory and protect against countersuits from the defendant.

Successful legal prosecutions guarantee the demise of an illegal distributor or dealer in the community and remove a large source of service theft from the system. In a situation where a few illegal subscribers are successfully brought to trial, cable operators cannot assume to have won the battle against theft of service in their system(s).

A logical next step in the anti-theft process is execution of an organized, professional advertising campaign. The object of the campaign is to inspire feelings of guilt, embarassment and, not to be overlooked, respect for the law among illegal subscribers. The intended outcome of this campaign should lead to conversion of illegal subscribers to paying customers. A strongly worded message pointing out the fact that others within a system have been successfully prosecuted for the crime of stealing cable services can produce interesting results. Cox Cable Communications comes immediately to mind. The fourth largest multiple system operator waged a very effective anti-theft campaign in San Diego, the nation's largest cable system with more than 240,000 subscribers, yielding significant subscriber conversion results.

Finally, such a campaign should allot a specific period of time for an amnesty program during which time subscribers can turn in illegal or tampered converters with "no questions asked." Several major MSOs have employed similar strategies with tremendous success. It is important to remember, however, that the ultimate goal of an amnesty program is conversion of illegal subscribers into paying customers.

Figure 1 provides an easy illustration of the complete process. According to the flow chart, it is possible to conduct these activities in several different manners. For example, operators could conduct an extensive advertising campaign without prosecuting illegal subscribers.

Internal controls and hardware solutions

In themselves, externally directed campaigns are significant, but they must be combined with a strong internal security program.

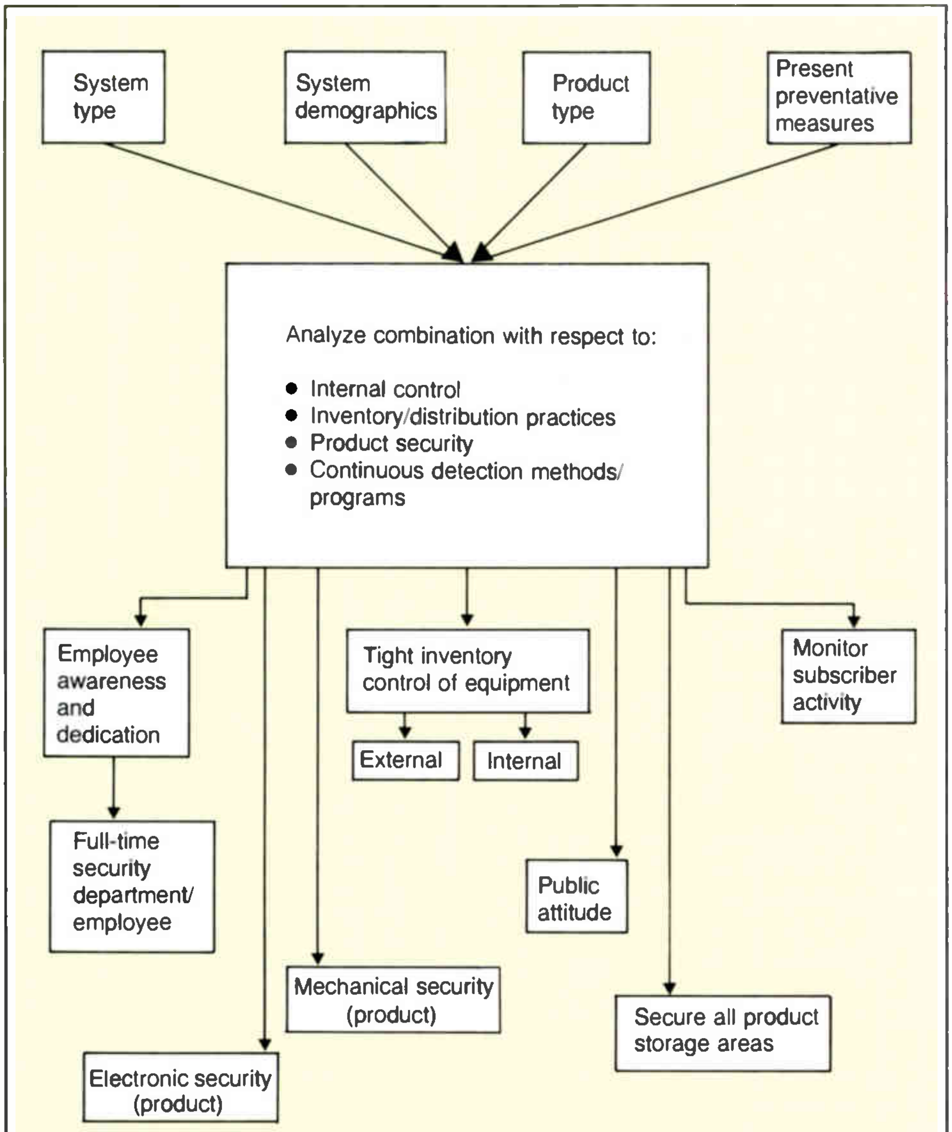


Figure 2: Future system security

This must consist of the following procedures: 1) locking converter equipment; 2) maintaining tight inventory control, including the retrieval of converters; and 3) evaluating the honesty of employees. In an addressable system, for instance, permit only a few people to turn on and off the system's converters, as well as to authorize and deauthorize reception of pay services. Employees should never know when the cable operator is conducting a security check. Together, these points are crucial to the success of any campaign.

The fight against cable service thieves and equipment pirates is not a solitary pursuit for the cable operator. Converter equipment manufacturers realize the vital need for designing and maintaining subscriber terminals with maximum signal security. Manufacturers and operators are working together to crack down on signal theft. Two ways to monitor and control this problem are tracking converter serial numbers from the original shipment location and intensive customer order screening to check for an operation's legitimacy.

As recent as two years ago, signal theft was not a major concern and, therefore, theft prevention in converter designs was not highly prioritized. Limited solutions to theft of service problems exist today. For installed and operational converters, there are several tamper-proofing solutions. For instance, warning labels that state theft of service is a crime. They can be placed on a converter in such a way that the operator knows when to suspect tampering, i.e., when the warning label is broken. Another solution is the riveting of converter trap doors, requiring special tools to open the terminal. Finally, the sensitive circuitry of the converter can be encapsulated or potted with an epoxy that is impregnable after hardening. These techniques are small, but taken together, will effectively eliminate most subscriber tampering activities.

Looking toward future anti-theft hardware solutions, cable equipment manufacturers are well aware of the need for well-designed, theft-proof converters.

One idea is to include tamper-proof circuitry as part of the RF scrambling system. This circuitry completely eliminates tampering, because the converter ceases to function when opened. If this happens the subscriber must then contact his cable operator for converter reauthorization from the addressable headend. This action, by its very nature, alerts the cable operator to a subscriber's attempt to tamper with the converter and steal pay services.

Another method is to secure the converter externally, totally preventing anyone from getting into the converter in the first place. In many ways, this design makes the type of signal scrambling used (RF or baseband) irrelevant.

In the area of scrambling, several manufacturers of RF addressable converters have added a level of security to their signal scrambling by varying the timing on the sync suppression level. This dynamic scrambling negates the effectiveness of the standard pirate box. The scrambling in baseband converters is considered inherently more secure because it can scramble at both the RF and baseband levels, in addition to scrambling the audio portion of the signal. This makes complete signal regeneration by pirate boxes very difficult and expensive.

Another approach to controlling theft of service, and one that is gaining in popularity, is the use of off-premise equipment. By removing the sensitive circuitry from a subscriber's home, both signal and equipment theft can be significantly reduced, if not eliminated.

More specifically, placing the converter/descrambler in a locked steel cabinet outside the home or in an apartment house basement, for instance, helps to prevent signal theft. As for the equipment, all expensive portions of the converter are located off-premises, further facilitating prevention of equipment theft and tampering. Instead, an inexpensive channel selector, devoid of sensitive circuitry, becomes the in-home device.

In another variation on the off-premises theme, some manufacturers use traps, taps or jammers located outside on a pole. This type of off-premises configuration requires only a plain converter for subscribers to receive cable television programming service. This method is less expensive, but does not give the operator the same level of security as an addressable converter/descrambler system.

Over the long haul, a continuing system security program should become a part of every system's operations. Figure 2 provides a conceptual design for just such a program.

The team effort

There are, indeed, many ways to fight theft of service and prevent equipment tampering. These range from cable operator activities, manufacturer programs and new converter design concepts. It is important to realize that responsibility for awareness and prevention of this problem doesn't fall onto the shoulders of any one entity. Instead, it should be an effort among all involved in the industry.

Chapter IV: The fundamentals of distortion in CATV amplifiers

This is the fourth chapter of the "Technical Handbook for CATV Systems." Each month we will feature another installment of this excellent technical tool.

By Ken Simons
Cable Television Consultant

This chapter presents an elementary introduction to the nature and effects of non-linear distortion in CATV amplifiers. Two forms of distortion are important: second order distortion which results, in extreme cases, in the compression of one peak of a sine wave and the expansion of the other; and third order distortion which results, in the extreme case, in compression (or expansion) of both peaks. It is shown that the effects of second order distortion may be analyzed by an equation involving a linear term and a term proportional to the input voltage squared, while the effects of third order distortion can be analyzed by an equation including a linear term and a term involving the input voltage cubed.

In present CATV systems, second order distortion is generally not considered because, as will be shown, it results in distortion products at frequencies which are either sums, differences, or second harmonics of the carriers present and, with the standard frequency assignments, these products fall outside of the channels used.

Thus, the limiting factor in determining permissible output levels in most CATV amplifiers is third order distortion since it results in cross-modulation between channels, and beats between carriers which fall inside the channels being used.

Introduction

Distortion in sound reproducing equipment is familiar to anyone who has heard a worn-out juke box, or an over-loaded public address system. This harsh, unpleasant sound presents the essential nature of all distortion: What comes out of the system is different from what went in! In CATV, distortion does not show up in the same way, but it is present, and it places restrictions on amplifier operation which must be understood if a system is to be intelligently planned and operated.

The amplifiers used in CATV have only one intended function: to raise the signal levels. The other things they do, the differences they generate between the outgoing signals and the incoming signals, are distortion. What forms does this distortion take? Several effects properly called distortion, such as the addition of noise to the signal, hum modulation and variations in amplifier frequency response are *not* the subject of this chapter. Here, we are concerned with only one kind of distortion: effects due to the same causes that create "harmonic distortion" in audio amplifiers.

This distortion is due entirely to non-linearity in the transfer characteristics of the transistors. Its worst aspect is cross-modulation, crossing over of the modulation from one channel to another, which causes "windshield wiper" effects in the picture. Other effects include harmonics, where an unwanted signal is generated at a frequency which is some multiple of the frequency of a wanted one; and beats where two or more wanted signals combine to generate an interfering one. These harmonics and beats can combine with the carrier on the channel in use to cause "herringbone" patterns in the picture. A study of this type of distortion will help in understanding how CATV amplifiers can be operated to avoid these problems.

Distortionless amplification

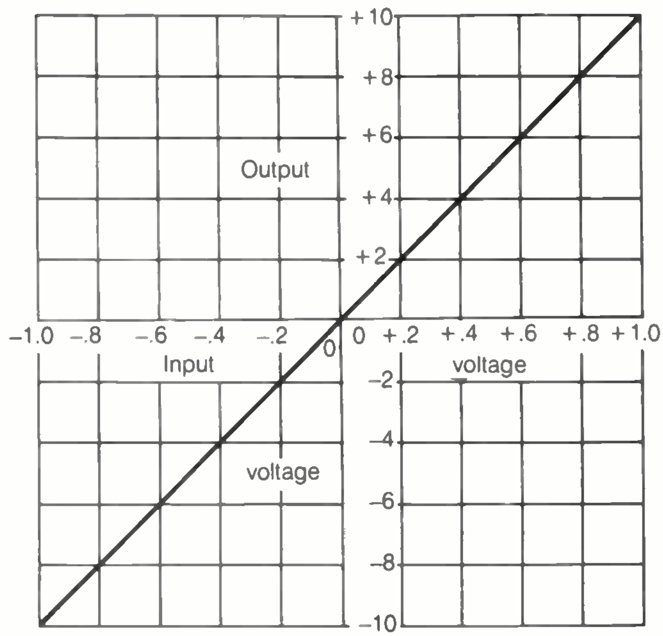
Perhaps the simplest way to describe amplifier distortion is to say what it is *not*. A distortionless amplifier would be one which increased the amplitude (voltage swing) of the input signal without changing its waveform. Suppose, for example, an amplifier could be built so that the output voltage, at each instant, was exactly 10 times the input voltage. A graph showing the output voltage plotted against the input voltage would be a straight line, as illustrated in Figure 22. Such a graph is called the "transfer characteristic" or "input-output curve," for the amplifier. A transfer characteristic which is a straight line is called a "linear transfer characteristic."

Mathematically, the performance of this amplifier would be described by the equation: $e_{out} = 10\, e_{in}$; where e_{out} is the instantaneous output voltage, and e_{in} is the instantaneous input voltage. Calculating for particular voltages would give a table:

e_{in}	e_{out} (= 10 e_{in})	e_{in}	e_{out} (= 10 e_{in})
0	0	0	0
−0.2	−2	+0.2	+2
−0.4	−4	+0.4	+4
−0.6	−6	+0.6	+6
−0.8	−8	+0.8	+8
−1.0	−10	+1.0	+10

This is the table from which the characteristic of Figure 22 is plotted.

Figure 22: A linear transfer characteristic



The way in which such a linear transfer characteristic results in an undistorted output is shown in Figure 23. A plot of the sinusoidal input voltage against time is illustrated [Figure 23(a)]. If, at each point along the time scale, instantaneous input voltage is projected downward to the transfer characteristic [Figure 23(b)], the corresponding output voltage is found. Projecting this to the right, and plotting against the same time scale, constructs graphically the waveform of the output voltage [Figure 23(c)]. For example, when the input is 0.75 volts and decreasing (point "A"), the output is 7.5 volts and decreasing (point "B"). Since the output voltage at any time is simply 10 times the input voltage, the output duplicates the input waveform.

Distortionless amplification does not require that the input be a pure sinusoidal voltage. It is achieved when the waveform of the output voltage precisely duplicates that of the input, regardless of what that waveform may be. Figure 24, for example, presents a diagram similar to Figure 23 except with a pyramidal input, showing how an identically shaped pyramidal output results.

Figure 23: Distortionless amplification

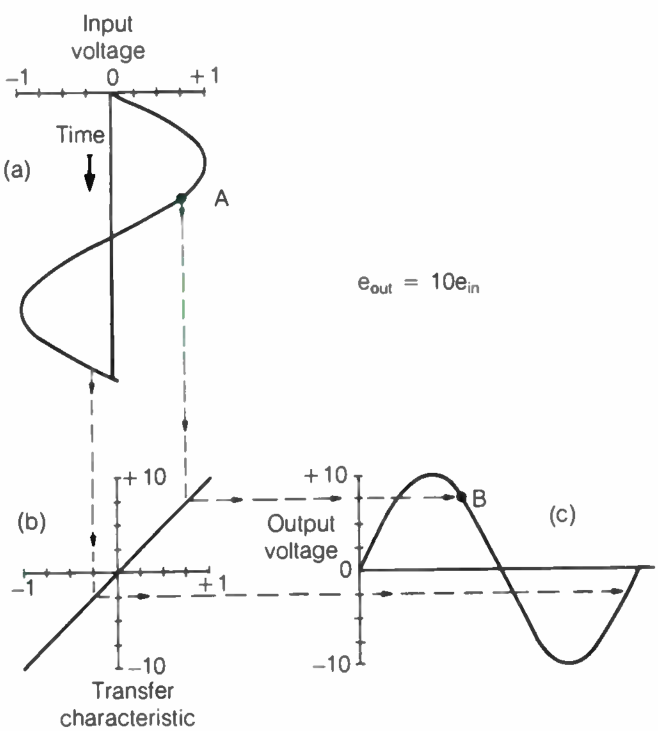


Figure 24: Distortionless amplification

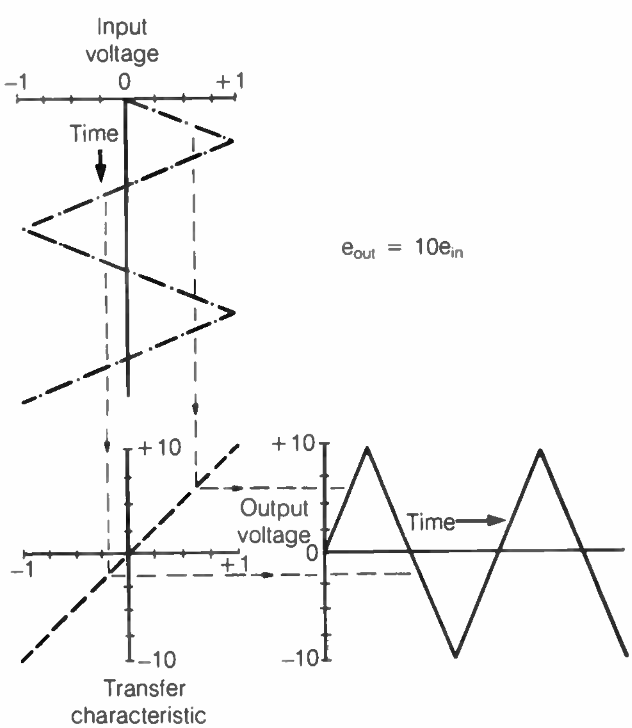


Figure 25: A non-linear transfer characteristic

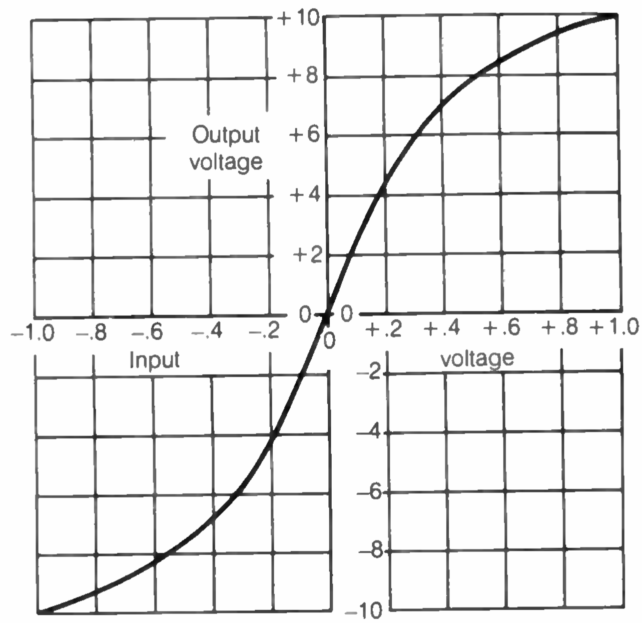
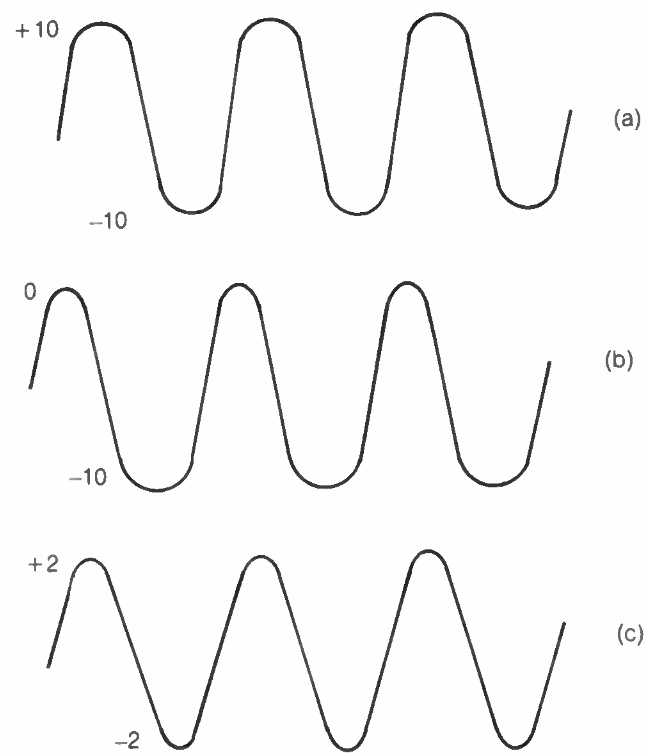


Figure 26:
Output voltage waveforms, non-linear characteristic



Amplification with distortion

Unfortunately, amplifiers that can be built using real-life transistors do not have a linear relationship between the input voltage and output voltage. Figure 25 illustrates a non-linear transfer characteristic which might be found in a real amplifier. As the input voltage swings either way from 0, the output changes along a curve which produces less and less change in output voltage as the input swings further and further from 0. If, in Figure 25, the output would continue to increase almost linearly, as it does between 0 and 4 V, it would reach about 20 V for a 1-V input instead of 10 V as shown.

When a varying voltage is applied to an amplifier with a characteristic of this sort, the output voltage has a different waveform than the input voltage. Consider the examples shown in Figure 26. Figure 26(a) illustrates the output voltage waveform obtained when a sinusoidal voltage with a voltage swing between +1 and –1 volt is applied to the amplifier whose characteristic is illustrated in Figure 25. Since the transfer characteristic is symmetrical, both peaks of the output voltage are flattened by the non-linearity, giving the waveform illustrated.

A 1.0 volt peak-to-peak sinusoidal voltage applied to the input of the same amplifier and biased at –0.5 volts so that it varies between 0 and

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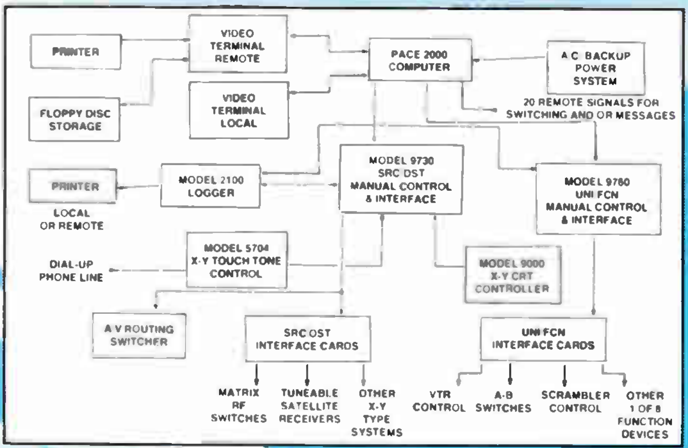

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–1 volt produces an output varying between 0 and –10 volts with the waveform illustrated in Figure 26(b). The lower peak is flattened because the transfer characteristic bends over at –1 volt input; the upper peak is faithfully reproduced because the characteristic is very nearly a straight line near 0.

Reducing the amplitude of the input voltage to 0.2 volts peak-to-peak and biasing it at 0 so that it varies between +0.1 and –0.1 volt gives the output voltage shown in Figure 26(c). Because the signal varies along a nearly linear part of the characteristic, this is almost an undistorted reproduction of the sinusoidal input.

It should be clear from these examples that the nature as well as the degree of distortion is dependent not only on the shape of the transfer characteristic of the amplifier but also on the amplitude of the input signal and on the operating point (bias). Two very different and significant kinds of distortion are illustrated: one where the peaks are flattened symmetrically [Figure 26(a)] and the other where only one peak is flattened [Figure 26(b)]. In what follows these two cases will be explored more thoroughly.

Second order distortion

In the section on distortionless amplification, it was shown that a linear transfer characteristic could be expressed in very simple mathematical terms. The equation "$e_{out} = 10\ e_{in}$" says very clearly that the amplifier in question has a gain of 10 times and no distortion. Since all practical amplifiers cause distortion, a sensible question is: "Can the transfer characteristic of a practical amplifier be expressed in some simple mathematical way which will allow analysis of the distortion generated? The answer is that the transfer characteristic of a practical amplifier can be approximated by a simple mathematical expression and the subject of what follows is how this is done.

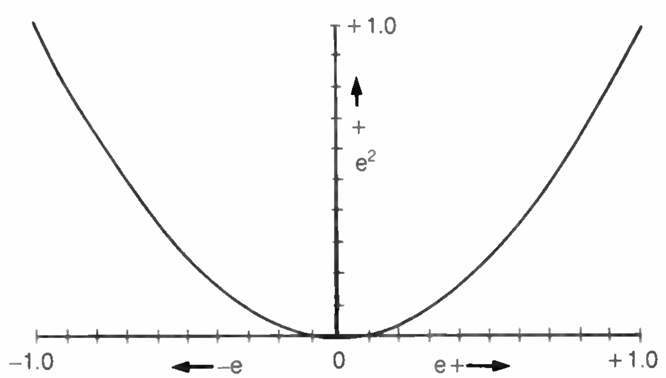
First, consider an amplifier which generates the kind of distortion illustrated in Figure 26(b). The transfer characteristic causing this kind of distortion can be approximated by an equation having the form "(e_{out}) equals (some number × e_{in}) plus (some other number × e_{in}^2)."

The following may help to understand how this works. Consider first the curve that results when e^2 is plotted against e; the numbers are tabulated below.

e	e^2	e	e^2
–1.0	+1.0	+1.0	+1.0
–0.8	+0.64	+0.8	+0.64
–0.6	+0.36	+0.6	+0.36
–0.4	+0.16	+0.4	+0.16
–0.2	+0.04	+0.2	+0.04
0	0	0	0

The corresponding curve is plotted in Figure 27. Notice that it is symmetrical around the vertical axis, curving up smoothly for both positive and negative magnitudes of e.

Figure 27: e^2 plotted against e



Next, consider an example of what happens when such a curve is added to a linear transfer characteristic. The output voltage is separated into two parts:

for the linear part: $e_1 = 10\ e_{in}$
for the "squared" part: $e_2 = 5\ e_{in}^2$
and for the total: $e_{out} = e_1 + e_2$
$= 10\ e_{in} + 5\ e_{in}^2$

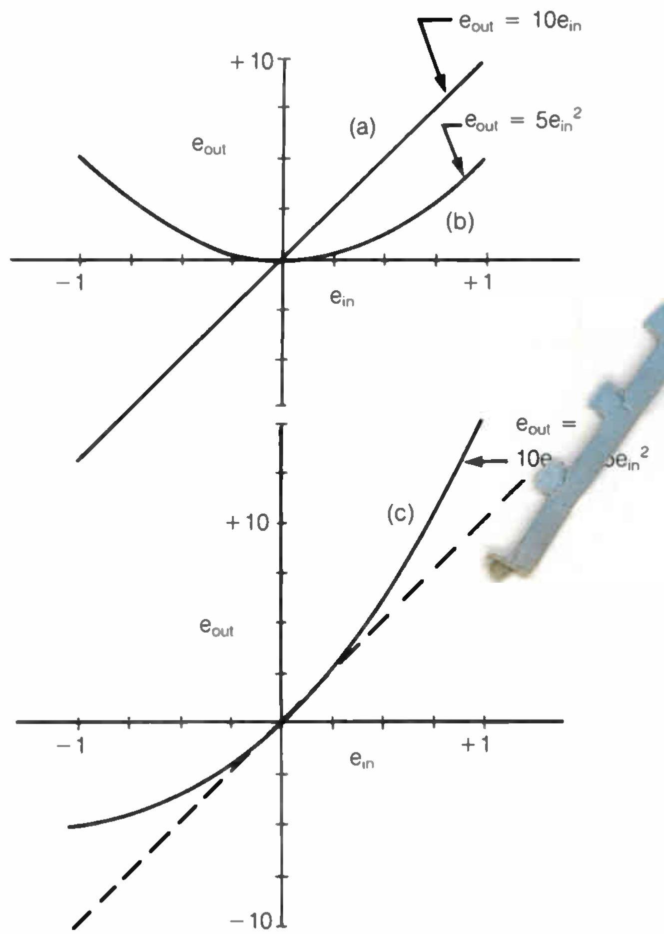
The transfer characteristic described by an equation having a linear term (one involving "e") and a "squared" term (one involving "e^2") is known as a "square-law" transfer characteristic.

The numbers are tabulated below:

e_{in}	$10\ e_{in}$	e_{in}^2	$5\ e_{in}^2$	$10\ e_{in} + 5\ e_{in}^2$
–1.0	–10	+1.0	+5.0	– 5.0
–0.8	– 8	+0.64	+3.2	– 4.8
–0.6	– 6	+0.36	+1.8	– 4.2
–0.4	– 4	+0.16	+0.8	– 3.2
–0.2	– 2	+0.04	+0.2	– 1.8
0	0	0	0	0
+0.2	+ 2	+0.04	+0.2	+ 2.2
+0.4	+ 4	+0.16	+0.8	+ 4.8
+0.6	+ 6	+0.36	+1.8	+ 7.8
+0.8	+ 8	+0.64	+3.2	+11.2
+1.0	+10	+1.00	+5.0	+15.0

Figure 28 shows the two curves plotted separately (a and b) and the total (c). Notice the similarity between this total curve (the plot of a

Figure 28: Square-law transfer characteristic



simple mathematical equation) and the lower half of a particular non-linear transfer characteristic (Figure 25).

Figure 29 illustrates graphically how the introduction of a sinusoidal voltage into an amplifier having a square-law transfer characteristic results in an output of the one-peak-stretched, one-peak-flattened variety. Since this kind of distortion results from the addition to the linear characteristic of a quantity involving e^2, it is called "second order" distortion. In these terms it is said that Figure 29 shows that "a square-law transfer characteristic (or a characteristic having second order curvature) causes second order distortion of the output." Observe that not only is the upper peak of the output voltage stretched by the action of the second order distortion and the lower peak flattened, but also the entire curve is shifted upward so that its average is above 0.

It has been shown that one way to study the effects of second order distortion mathematically is to use a square-law equation. There is a second approach which is also very useful. This involves the addition of DC and AC component voltages to produce a distorted total. Before this is presented it might be well to review the meaning of the three terms "DC," "AC" and "component."

'AC' and 'DC'

The idea of "DC" is familiar. A DC (direct current) voltage is typified by the voltage between the terminals of an ideal battery [Figure 30(a)].

It does not vary either in magnitude or polarity. The plot of a DC voltage is a straight line parallel to the time axis [Figure 30(b)].

"AC" is almost equally familiar. To qualify as AC (alternating current) a characteristic must vary above and below zero in such a way that its average is zero. A periodic AC voltage is one that goes through identical cycles of change over and over again, and its average over any one cycle is zero. Another way of saying this is: "The area enclosed by the plot is the same on the positive half-cycles as that on the negative ones."

Figures 31(a), (b) and (c) all represent periodic AC voltages, since in each case the variation is repeated in identical cycles and the average is zero. To see how the average is zero, imagine a DC voltmeter reading each of these voltages. Assuming the change to be faster than the needle can follow, it would be pushed equally in both directions, so would read zero.

Figure 29: Second order distortion

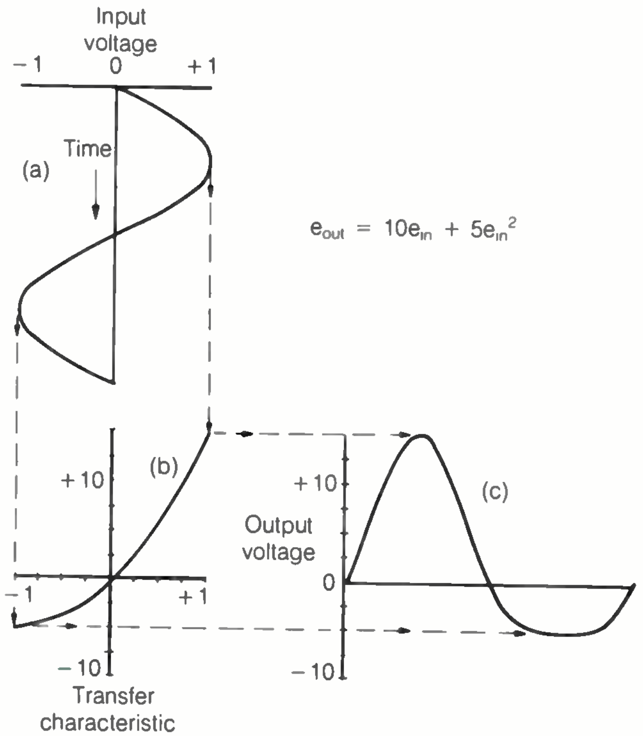


Figure 30: DC voltage

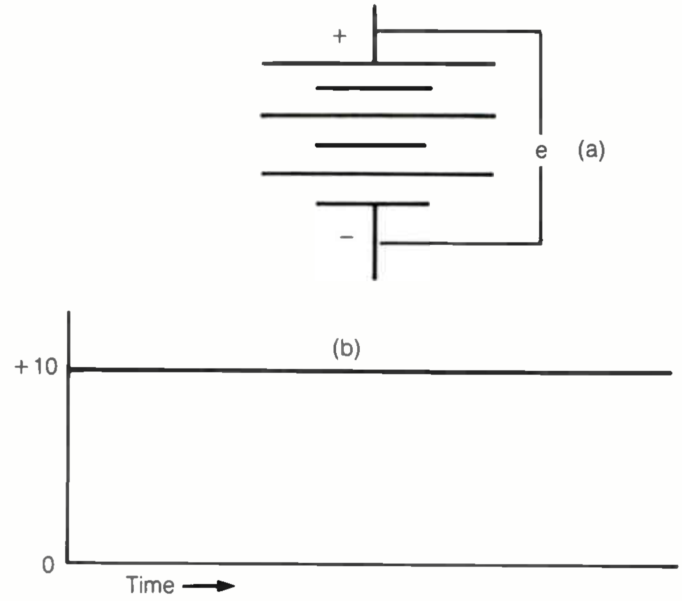


Figure 31:
Three AC voltages with different waveforms

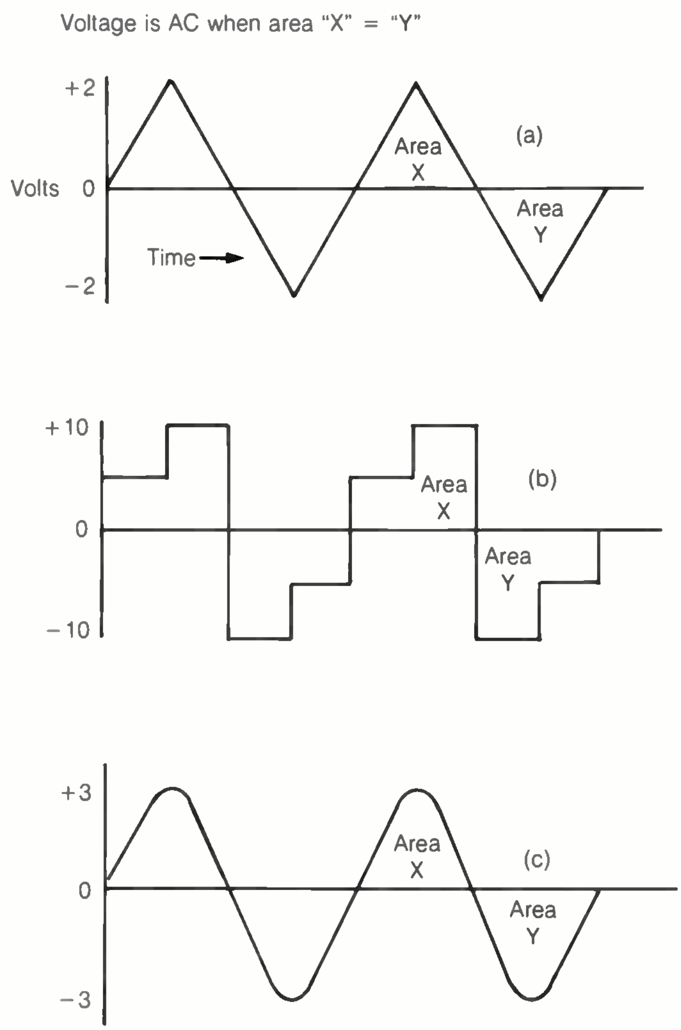
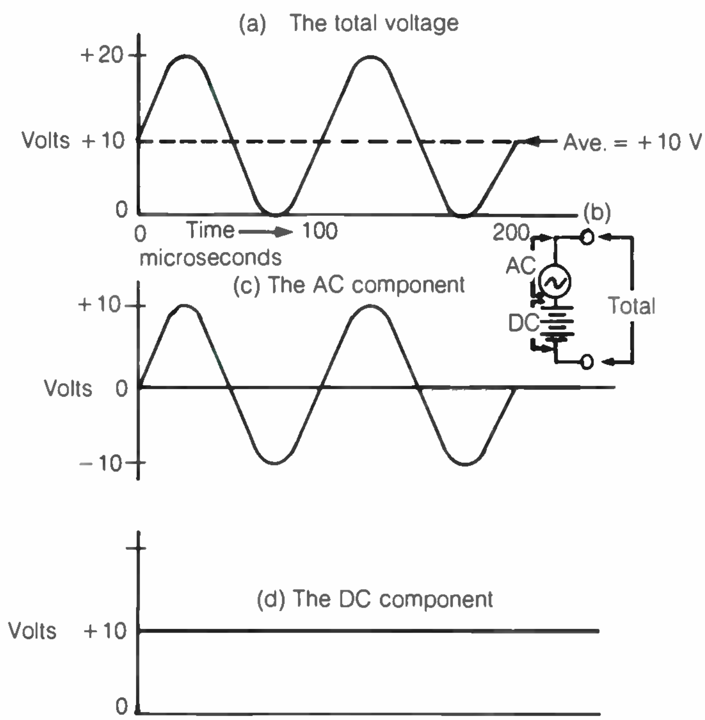


Figure 32: A voltage with AC and DC components



AC and DC components

How then is a voltage described which varies periodically but in such a way that its average is not zero? Figure 32(a), for example, illustrates a voltage which has a sinusoidal waveform, and an average of +10 volts. It is conveniently described in terms of its parts or "components." This waveform could be obtained by connecting a 10-volt battery in series with an AC source generating a 10-volt peak sinusoidal AC voltage [Figure 32(b)]. Although it is actually generated in some other way (it might, for example, occur at the collector of a transistor amplifier), it is still convenient to describe it in terms of these components. In these terms it is called a "composite AC and DC voltage, its AC component being a 10-volt peak voltage with sinusoidal waveform, and its DC component +10 volts." By breaking this complex voltage into two simpler components, it is made easier to talk about and to measure. The DC component voltage can be measured with a DC voltmeter, and the AC component with an AC voltmeter.

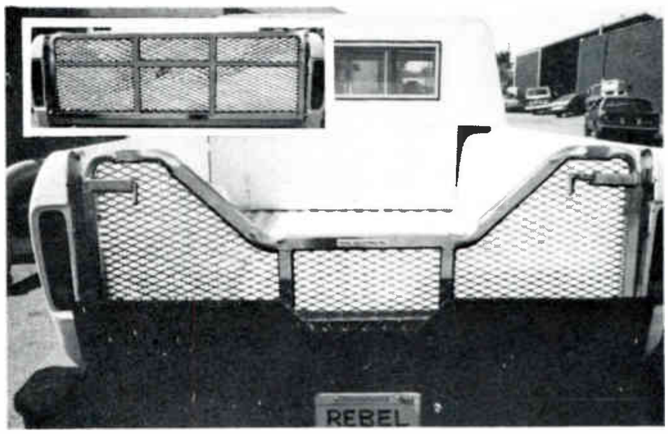
The spectrum of a composite voltage

When a periodic varying voltage contains several components like this, it can be conveniently analyzed by plotting its "spectrum." A spectrum is simply a graph which plots, in the vertical direction, the peak voltage or amplitude of each component and, in the horizontal direction, the frequency at which each of these components exists. Its importance rests on the fact that "spectrum analyzers" are available which plot these diagrams automatically, providing tremendously useful tools for distortion analysis.

The spectrum of a sinusoidal voltage is a single spike showing the amplitude and frequency of that voltage. Figure 33 shows the spectrum of the composite voltage whose waveform is plotted in Figure 32(a). The spectrum contains the same information as the time plot. It says that this voltage consists of two components, a DC component of 10 volts (represented by the 10-volt spike at 0 frequency) and a sinusoidal component of 10 volts peak amplitude at a frequency of 10 kHz (represented by the 10-volt spike at 10 kHz).

A voltage with two AC components

This technique of representing a varying voltage as the sum of several components has very wide application. Figure 34 illustrates a second situation where it is useful. Figure 34(a) shows a composite



voltage which quite obviously contains a high-frequency variation (causing the rapid oscillation) and a low-frequency one (causing the slow oscillation). It is the sum of two equal sinusoidal voltages; one having a frequency of 100 kHz (one cycle in 10 microseconds) shown in Figure 34(c); the other higher frequency component, Figure 34(d), complete 10 cycles in 10 microseconds so its frequency is 10 times higher, or 1 MHz.

Figure 35 shows the spectrum of this composite voltage. The spectrum indicates two 5-volt sinusoidal components, one at 0.1 and one at 1.0 MHz.

Second order distortion by addition of components

The use of sinusoidal components to represent a non-sinusoidal varying voltage has its most important application in the study of distortion. Earlier we discussed the distortion produced when a sinusoidal input is applied to an amplifier with second order distortion.

The waveform resulting from this distortion is plotted in Figure 29(c). An identically distorted waveform can be formed by adding sinusoidal components (or, conversely such a waveform can be separated into sinusoidal components). Figure 36 illustrates the process.

This diagram shows how a distorted output can be generated by adding three components: the *fundamental* component, a sinusoidal voltage having a frequency of 1 MHz (one cycle in 1 microsecond) in this example; the *second harmonic* component, a sinusoidal voltage having twice this frequency, 2 MHz (two cycles in 1 microsecond); and a positive *DC component*.

Notice first that the total voltage has a waveform identical to that shown in Figure 29(c) (the one produced when a sinusoidal voltage is passed through an amplifier with a square-law characteristic). Now see how the three components add in Figure 36: At 0 time on the diagram, the fundamental component is 0, the second harmonic is at its negative peak (−2.5 volts) and the DC component is at +2.5 volts. Adding the three gives the total voltage which is 0. At 0.25 microseconds the fundamental has gone through one-quarter cycle to its positive maximum (+10 volts), the second harmonic component has gone through

Figure 33: Spectrum of a composite voltage

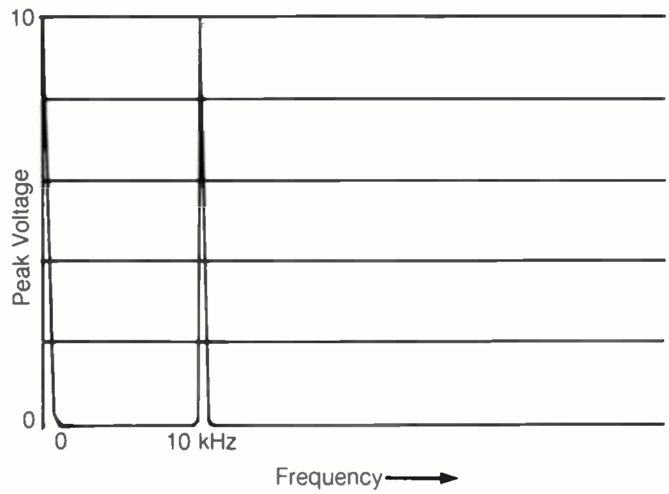


Figure 34:
A voltage with two sinusoidal components

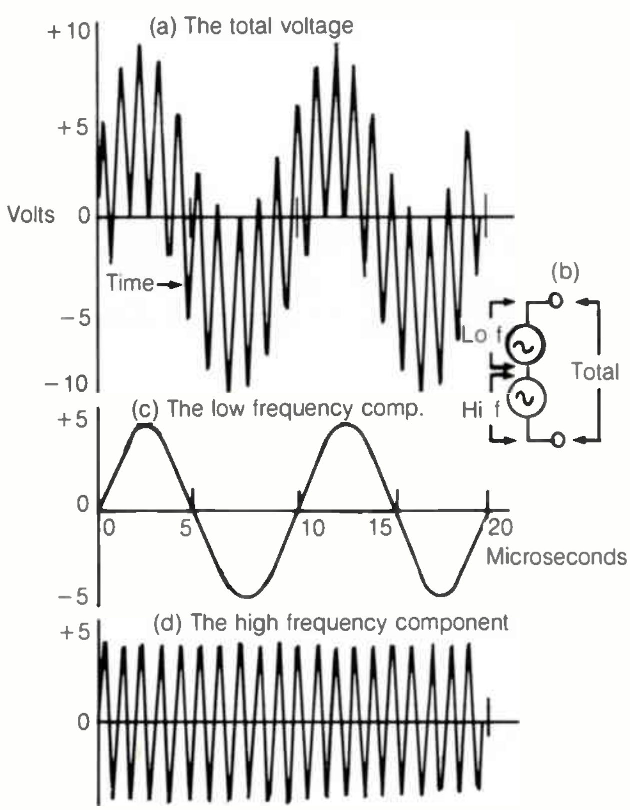


Figure 35:
Spectrum of voltage with two AC components

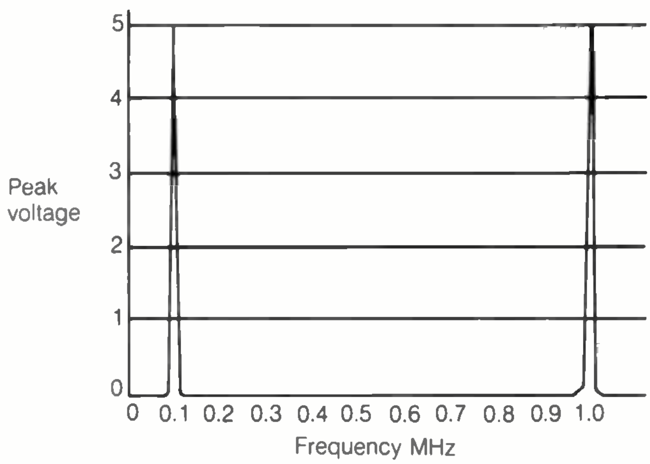


Figure 36: Addition of second order components

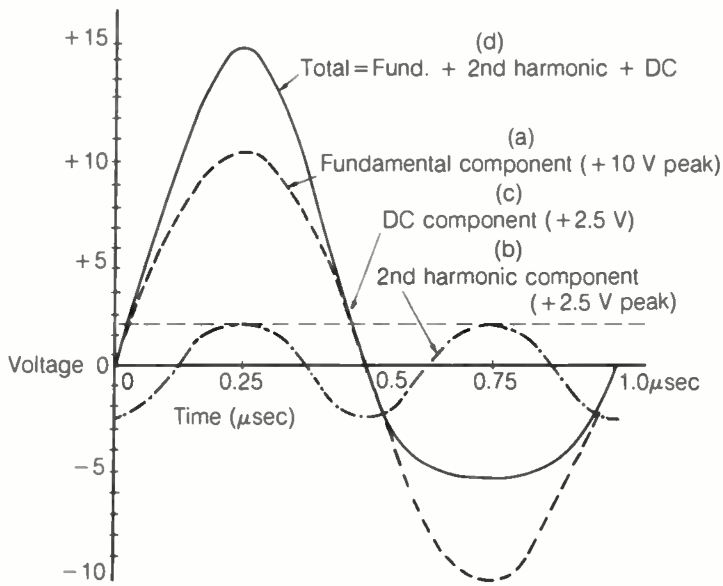
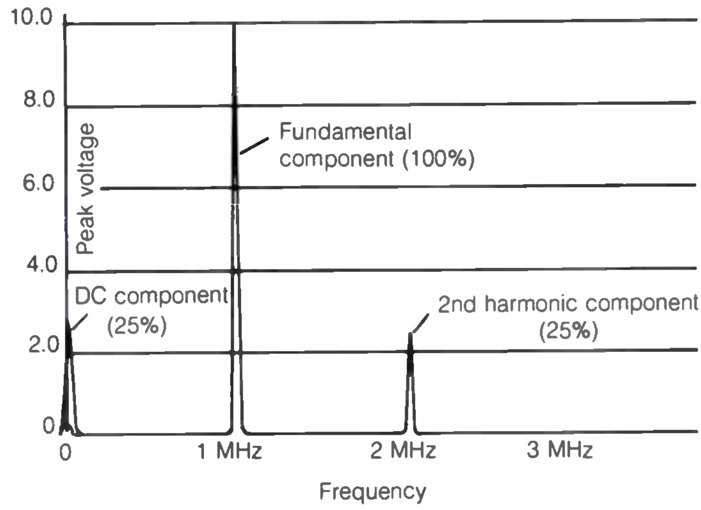


Figure 37:
Spectrum analysis showing second order distortion



one-half cycle to its positive maximum (+2.5 volts) so the three add to produce the stretched peak of the total (+15 = 2.5 + 2.5 + 10). At 0.75 microseconds the second harmonic and the DC are at +2.5 volts so they subtract from the −10 volt peak of the fundamental to flatten the peak of the total (−5 = −10 + 2.5 + 2.5).

Figure 36 illustrates one case of a very important general principle: *Any non-sinusoidal periodic waveform can be produced by an appropriate combination of DC and sinusoidal components.*

The spectrum of a voltage with second order distortion

The distorted voltage of Figure 29(c) and Figure 36(d) can also be represented by the spectrum diagram shown in Figure 37. This shows the three components that make it up: a 2.5-volt DC component, a 10-volt peak 1-MHz component (the fundamental) and a 2.5-volt 2-MHz component (the second harmonic). Some points should be noted in regard to these diagrams. Each spike on a spectrum diagram *always* represents a pure sinusoidal component. If a periodic voltage is non-sinusoidal, its spectrum shows more than one component. When a DC component exists, it does not appear on the spectrum displayed by the usual spectrum analyzer. The input circuits of most analyzers respond only to the AC components.

Third order distortion

In a previous section it has been shown that the kind of non-linearity which results in the "one-peak-flattened" kind of distortion can be expressed by a simple square-law mathematical equation. In very much the same way, the kind of distortion which results in both peaks being flattened can be expressed by a cube-law equation. This equation has the form: (e_{out}) = (some number x e_{in}) − (some other number x e_{in}^3). It approximates the transfer characteristic which results in a waveform with both peaks flattened, as illustrated in Figure 26(a).

Consider the curve that results when e^3 is plotted against e. The numbers are tabulated here.

e	e^3	e	e^3
−1.0	−1.000	+1.0	+1.000
−0.8	−0.512	+0.8	+0.512
−0.6	−0.216	+0.6	+0.216
−0.4	−0.064	+0.4	+0.064
−0.2	−0.008	+0.2	+0.008
0	0	0	0

Figure 38: e^3 plotted against e

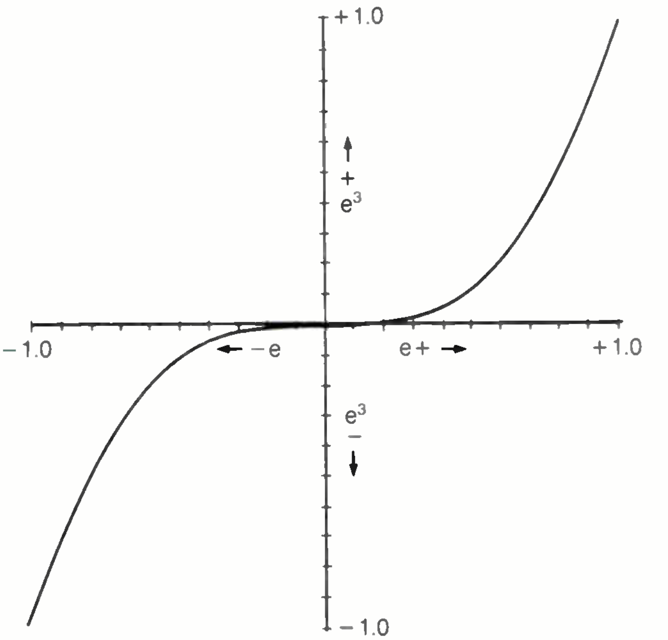
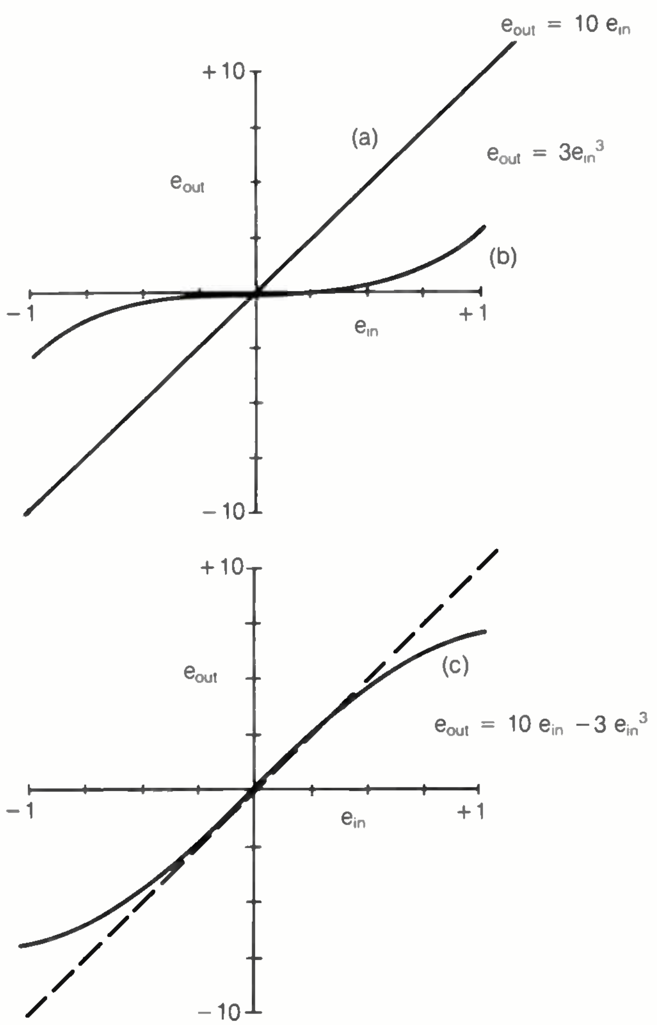


Figure 39: Cube law transfer characteristic



The corresponding curve is plotted in Figure 38. It is "skew symmetrical"; that is, the curve for negative magnitudes of e has the same shape as for positive magnitudes, but is upside down and has opposite direction.

When this curve is added to a linear transfer characteristic, it affects both extremes in the same way, since the linear part and the "cubed" part go positive together and negative together. Consider an example:

> Let the linear part of the characteristic be: $e_1 = 10\ e_{in}$ and the "cubed" part be: $e_3 = 3\ e_{in}^3$.
>
> To get a curve which flattens the peaks, the cubed part is subtracted from the linear part, so the total is:
>
> $$e_{out} = e_1 - e_3 = 10\ e_{in} - 3\ e_{in}^3$$

In this example, the cubed term is subtracted from the linear term to give a characteristic which flattens the peaks. In an amplifier with such a characteristic, the gain decreases as the input level is increased. (This is called "compression.") It is also possible to design amplifiers whose gain increases as the input level is increased. Such a characteristic is approximated by *adding* the cubed term to the linear term. In this case both peaks are stretched (this is called "expansion").

For the above example of compression the numbers are tabulated here.

e_{in}	$10\ e_{in}$	e_{in}^3	$3\ e_{in}^3$	$10\ e_{in} - 3\ e_{in}^3$
−1.0	−10	−1.000	−3.000	−7.000
−0.8	− 8	−0.512	−1.536	−6.464
−0.6	− 6	−0.216	−0.648	−5.352
−0.4	− 4	−0.064	−0.192	−3.808
−0.2	− 2	−0.008	−0.024	−1.976
0	0	0	0	0
+0.2	+ 2	+0.008	+0.024	+1.976
+0.4	+ 4	+0.064	+0.192	+3.808
+0.6	+ 6	+0.216	+0.648	+5.352
+0.8	+ 8	+0.512	+1.536	+6.464
+1.0	+10	+1.000	+3.000	+7.000

Figure 39 shows the two component curves plotted separately (a and b) and the total (c). Notice the similarity between this total curve, the plot of a simple equation, and the non-linear transfer characteristic shown in Figure 25.

Figure 40 illustrates graphically the way in which the introduction of a sinusoidal voltage into an amplifier having a "cube-law" transfer characteristic results in an output of the "both-peaks-flattened" variety. Since this kind of distortion results when a signal is passed through a transfer characteristic having an equation with a term containing e^3, it is called "third order" distortion. In these terms it is said that Figure 40 shows that "a cube-law transfer characteristic (or a characteristic having third order curvature) causes third order distortion of the output."

Third order distortion by addition of components

In the foregoing it was found possible to duplicate the effects of second order distortion by adding sinusoidal components. In a similar way, the effects of third order distortion can be obtained. Figure 41 illustrates the addition of a 10-volt peak, 1-megahertz fundamental component (a) and a 1-volt peak, 3-megahertz third harmonic component (b) to produce a distorted total (c) having the same waveform as that generated by the cube-law equation illustrated in Figure 40(c). Because of the 3:1 frequency relationship, the third harmonic voltage is

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Figure 40: Third order distortion

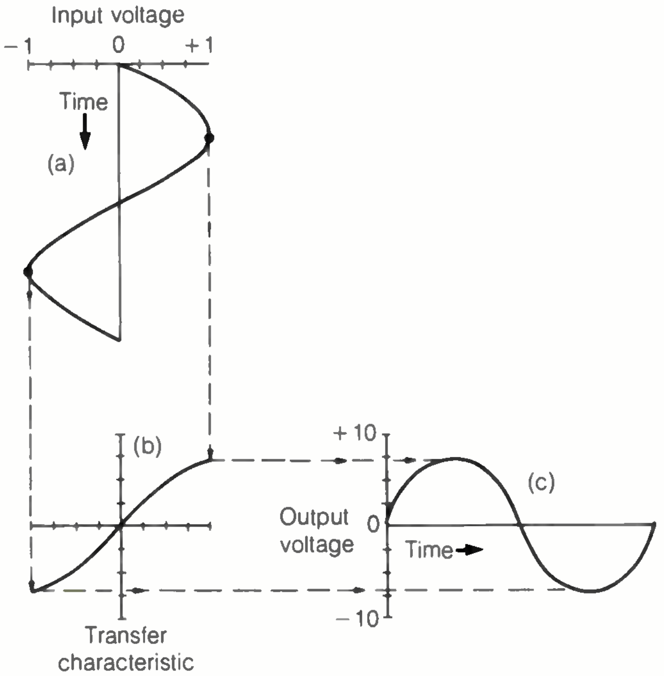
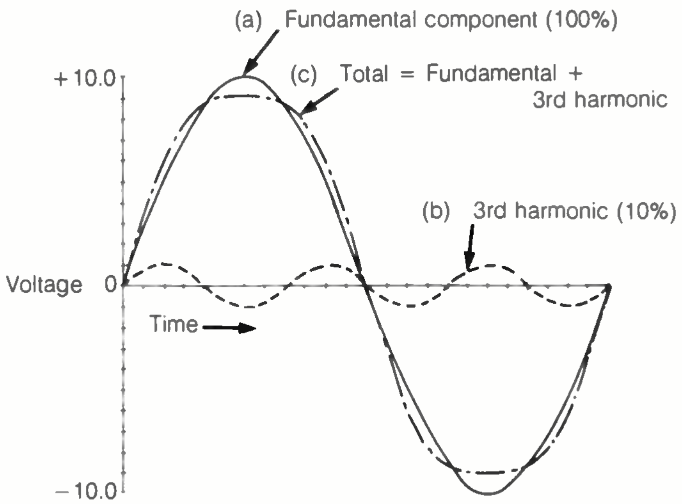


Figure 41: Addition of third order components



opposite in phase to the fundamental at its positive peak, with the result that the peak of the total is flattened and is again opposite in phase at its negative peak, so the peak of the total is also flattened at that time.

Spectrum of a voltage with third order distortion

Figure 42 illustrates the spectrum of this distorted voltage. Since the distorted waveform is duplicated by the sum of two components, the spectrum shows only these two: a 10-volt-peak fundamental component at 1 MHz and a 1-volt-peak third harmonic at 3 MHz.

The sum of two sinusoidal voltages having slightly different frequencies

Since a major objective of this chapter is to explain the distortion that occurs in broadband amplifiers when many "channels" are handled simultaneously, it is necessarily concerned with what happens in an amplifier when more than one sinusoidal voltage is introduced into it. Although the picture carrier on each channel is not a constant-amplitude sine wave (since it is modulated with the picture information), by temporarily pretending that it is, we can learn a great deal about the nature of distortion in this case.

Figure 42: Spectrum analysis showing third order distortion of a sinusoidal voltage

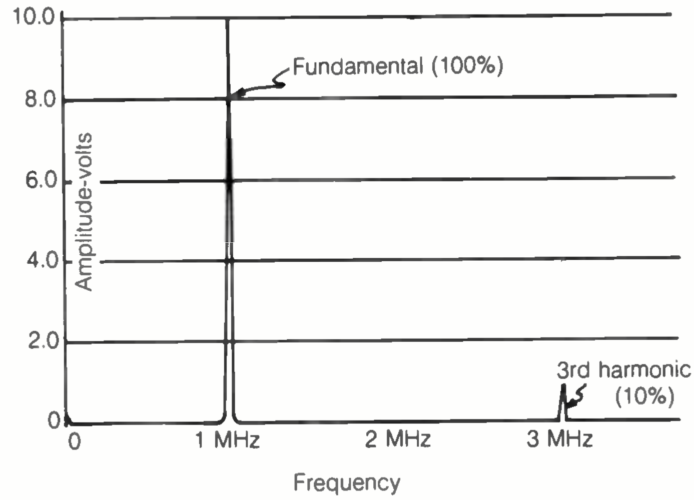
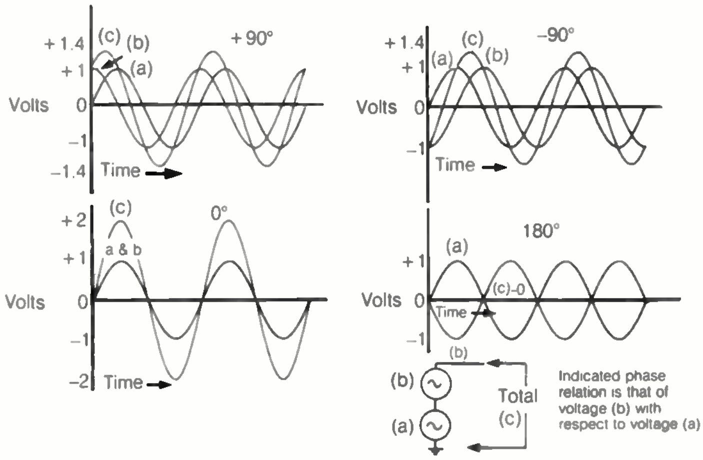


Figure 43: The addition of two sinusoidal voltages



The first question then is: What is the waveform resulting when two sine waves having slightly different frequencies are added? The two television carriers are said to have *slightly* different frequencies because in general their frequency separation is small compared with their frequencies. (In contrast to the case illustrated in Figure 34 where one frequency is 10 times the other.)

To answer this question it is helpful first to consider the way in which two sinusoidal voltages add when both have the same frequency and amplitude, but have various phase relationships. Figure 43 illustrates several cases showing each voltage separately (a and b) and the resulting total voltage (c).

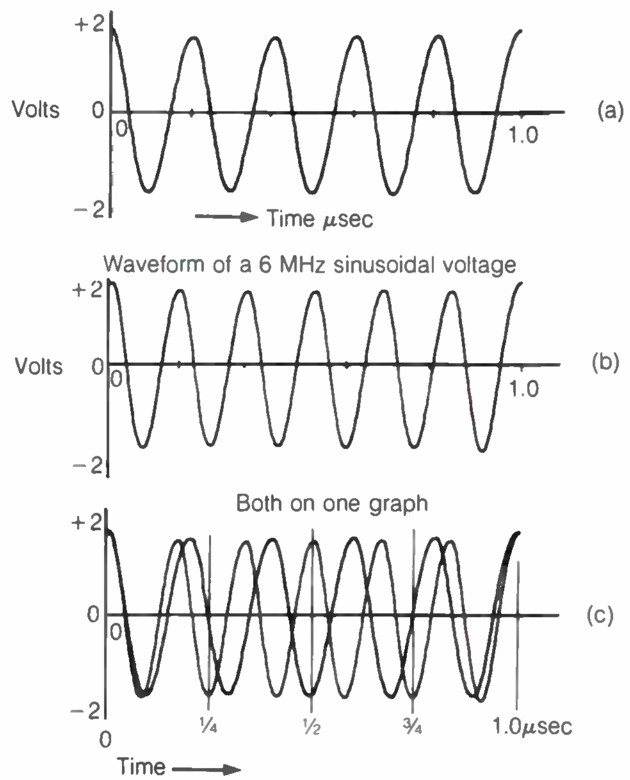
When both voltages are sinusoidal, and the frequencies are identical, and the voltages are exactly in phase, the two reach their peaks at the same instant and at that time they add directly (e.g. 1.0 + 1.0 = 2.0) so the peak voltage of the total is the sum of the two components (shown as the 0° condition).

When there is a 90° phase difference between the two, the total reaches its maximum at a time when each of the components is at 0.7 of peak, so the peak voltage of the total is reduced to 0.7 of the sum of the peak voltages of the components [e.g. + 0.7 + 0.7 = 1.4 (the +90° and −90° conditions)]. When the two voltages have opposite phase (180° out of phase), they are equal and opposite at all times, and the total is 0 (the 180° condition).

Next consider two sinusoidal voltages having slightly different frequencies. Figures 44 (a and b) illustrate the waveforms of two particular voltages. Each is sinusoidal, with a peak amplitude of 2 volts. One has a frequency of 5 MHz, a time-per-cycle of ⅕ microsecond; the other has a frequency of 6 MHz, and a time-per-cycle of ⅙ μsec. Thus, the former completes five cycles in a microsecond while the latter is completing six cycles.

Superimposing the two waveforms on each other [Figure 44(c)] shows clearly a highly significant fact: the phase relation between them is changing constantly. Initially they are in phase (both at positive peak). After ¾ microsecond the 5-MHz voltage has gone through 1¼ cycles and is 0, going negative, while the other has gone through three half-cycles and is at its negative peak. They differ in phase by 90°. After ½ microsecond the 5-MHz one is at its negative peak, while the 6-MHz one is at its positive peak, and they are 180° out of phase. As time goes on, they go through all possible phase relations, coming back to the "in phase" condition once each microsecond. It is true in general that when signals have different frequencies their phase relation changes constantly.

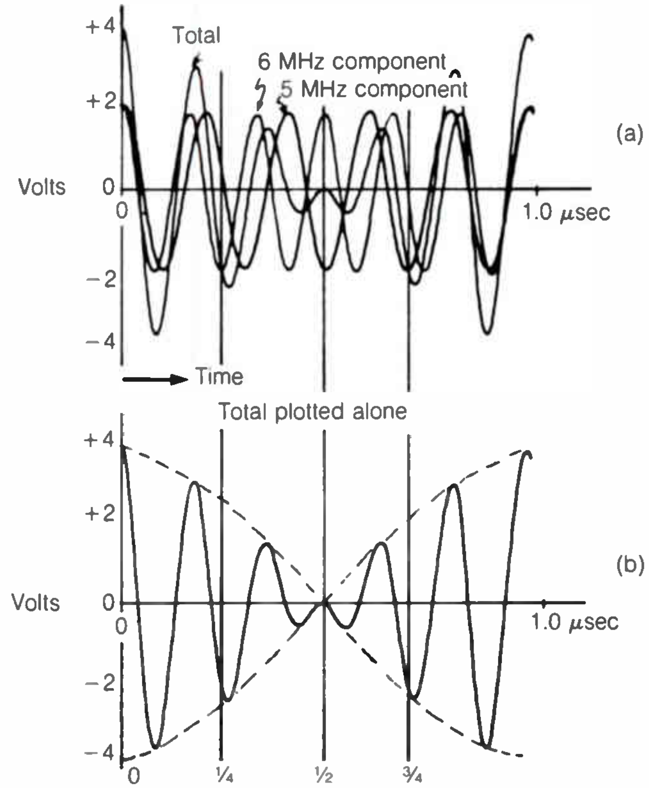
Figure 44: Waveform of a 5 MHz and of a 6 MHz sinusoidal voltage



Now what happens when these two voltages are added? The total follows the principles illustrated in Figure 43. When the two components are in phase, they add to produce a maximum peak voltage, when they are 180° out they cancel, and in between the peak amplitude changes from one condition toward the other. The resulting waveform is illustrated in Figure 45(a), showing the two component voltages and the total superimposed, and Figure 45 (b), showing the total alone. The total voltage reaches a 4-volt maximum peak initially when the two are in phase, the peaks reduce on successive cycles reaching 0 after ½ microsecond when the two components are 180° out of phase, and building up again to a 4-volt maximum peak after 1 microsecond when they come back in phase again.

Care must be exercised in using the term "peak" in reference to a varying voltage with a waveform like this. The basic meaning of the word "peak" for any periodic waveform is "the highest voltage reached at any point in the cycle." In this sense the peak voltage of this waveform is 4 volts, and it is reached once each microsecond. In another sense this voltage reaches a 4-volt positive peak at 0 on the time scale, then goes to a slightly lower (–3.5 volt) negative peak, then to a 3-volt positive peak

Figure 45:
The sum of two equal 5 MHz and 6 MHz voltages



and so on. If two lines are drawn through these peaks, as illustrated in Figure 45(b), they are said to outline the "envelope" of the waveform.

The two kinds of peak voltage can be distinguished by calling the former the "peak of the envelope" and the latter the "high-frequency" peak. In reference to Figure 45(b), it would be correct to say that the envelope peak voltage is 4 volts, and the envelope frequency is 1 MHz. It could be said further that the high frequency peak voltage varies from a maximum of 4 volts down to a minimum of zero.

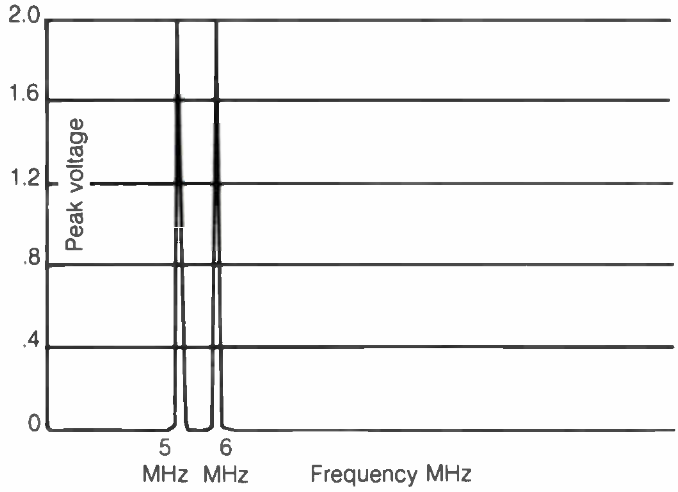
This sum of two particular sinusoidal voltages demonstrates several characteristics common to all sums of two such voltages without regard to their frequencies. One characteristic is the variation in the amplitude of the high frequency peak. For the sum of two equal voltages with *any* frequencies, the amplitude of the high frequency peak varies from maximum to 0 and back to maximum at a frequency which is the difference of the frequencies of the two components. In other words, the envelope frequency is the difference of the frequencies of the two component voltages. In this example the envelope frequency is 1 MHz, the difference between 6 MHz and 5 MHz.

Next consider the spectrum diagram of the voltage whose waveform is illustrated in Figure 45(b). This is shown in Figure 46. It shows two components, one at 5 MHz and one at 6 MHz, each having an amplitude of 2 volts. There is no component at 1 MHz, nor at any frequencies other than 5 and 6 MHz. This should not be surprising since this voltage is initially defined as the sum of two, and only two, sinusoidal components.

In discussing AC voltage it was clear that saying "the DC component is zero," does not mean "there is no voltage present." Any AC voltage averages zero, and thus has no DC component, when the area above zero and that below are equal over one cycle (see Figure 31). Similar reasoning applied to the waveform of Figure 45(b) shows how it can be true that "the amplitude of the high-frequency peaks varies at a 1-MHz rate" and yet "there is no 1-MHz component present." Since the peaks above zero have higher amplitudes at the same time as those below zero and lower amplitudes at the same time, they cancel each other and there is no average variation at the 1-MHz frequency.

The statement "this voltage has components only at 5 MHz and 6 MHz" means that the waveform shown is duplicated precisely by

Figure 46:
Spectrum of the sum of two sinusoidal voltages



adding together equal 5- and 6-MHz sinusoidal voltages. As long as this waveform is duplicated *without any distortion* no additional components are necessary to reproduce it. A general principle relating to amplifiers can be stated:

> *Only when an amplifier distorts does the output signal contain components at frequencies differing from the frequencies of the input signal components.*

Two sinusoidal input voltages with second order distortion

It has been shown that, when two sinusoidal components are fed into a distortionless amplifier, the output contains only the two original components, or in other words, the waveform of the output is the same as that of the input.

Figure 47 illustrates again the waveform and spectrum in this case, showing how the high-frequency peak voltage varies at the difference frequency (f_2–f_1) as the phase relation between the components changes.

Next consider what happens when two sinusoidal voltages are added and introduced into an amplifier with second order distortion. Figure 48(a) shows a plot of the resulting distorted waveform.

Figure 47:
The sum of two sinusoidal voltages undistorted

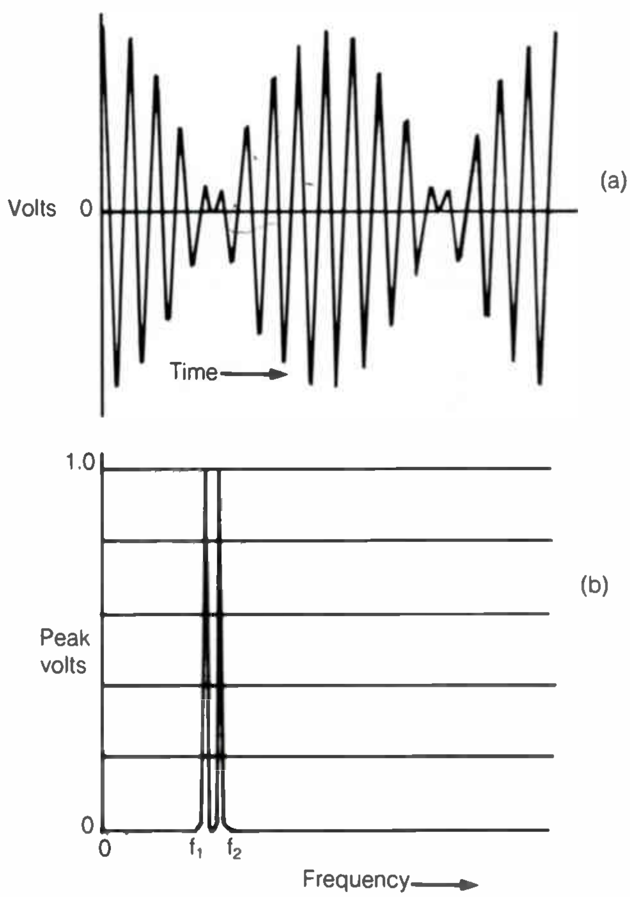
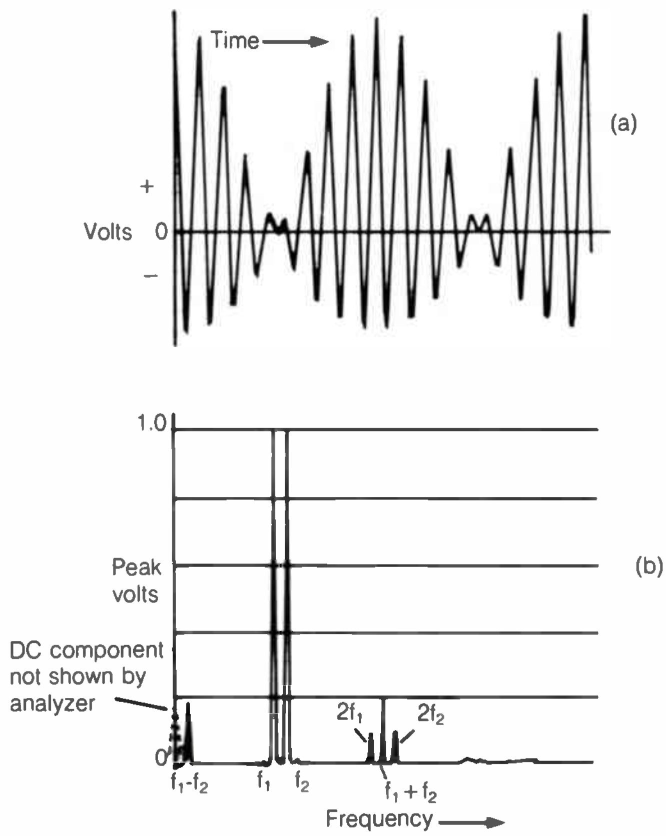


Figure 48: The sum of two sinusoidal voltages with second order distortion



Since the output waveform has a decidedly different shape from that of the input [compare Figure 48(a) and Figure 47(a)], it is clear that there must be components at frequencies other than the two original ones. Figure 48(b) illustrates the five new frequency components that are added to the output voltage by second order distortion. Since the positive peaks in the output are stretched, and the negative peaks flattened, there is a general shift in level in the positive direction, and there must be a corresponding positive DC component. Since the peaks above 0 no longer average out with the peaks below 0, there is also a component at the difference frequency (f_2–f_1). For a similar reason, there is a component at a frequency which is the sum of the frequencies of the two original signals ($f_1 + f_2$). And, of course, each of the original signals generates a second harmonic (at $2f_1$ and $2f_2$). Thus the spectrum of the output signal looks like Figure 48(b) with components at the two original frequencies as well as at the five new ones.

An important conclusion can be drawn from this one example: Whenever more than one sinusoidal voltage (that is when more than one signal) is introduced into an amplifier which has second order distortion, the output will include signals at certain frequencies differing from those of the input signals. There will be a DC component, a shift in the average collector current of the distorting stage (which does not show up in the output when AC coupling is used), a component at a frequency which is the difference of the two original frequencies, a component at a frequency which is the sum of the original frequencies, and components at twice each of the original frequencies.

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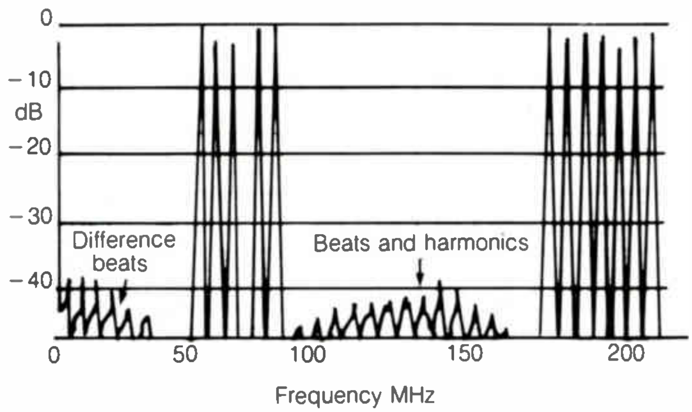
Figure 49: Spectrum of 12 CW signals with appreciable second order distortion



When the original signals are modulated with picture information, each of these spurious signals will carry the modulaton of both of the original signals from which it comes.

Why second order distortion is unimportant in present CATV systems

Anyone who has worked with CATV equipment in the past recognizes the fact that very little attention has been paid to the problem of second order distortion. The usual amplifier specification states the noise figure, gain and cross-modulation but does not mention sum or difference frequency beats or second harmonics. The reason for this is related to the standard channel frequency assignments established by the FCC. If one takes any pair of picture carrier frequencies in the standard 12-channel assignments, their sum or difference does not fall in any of those channels. Similarly, with one minor exception (channel 6 sound carrier), the second harmonics of all low band carriers fall between the two bands. Figure 49 shows the spectrum obtained when 12 CW signals on the normal picture carrier frequencies were introduced into a CATV amplifier at levels somewhat higher than normal operating level.

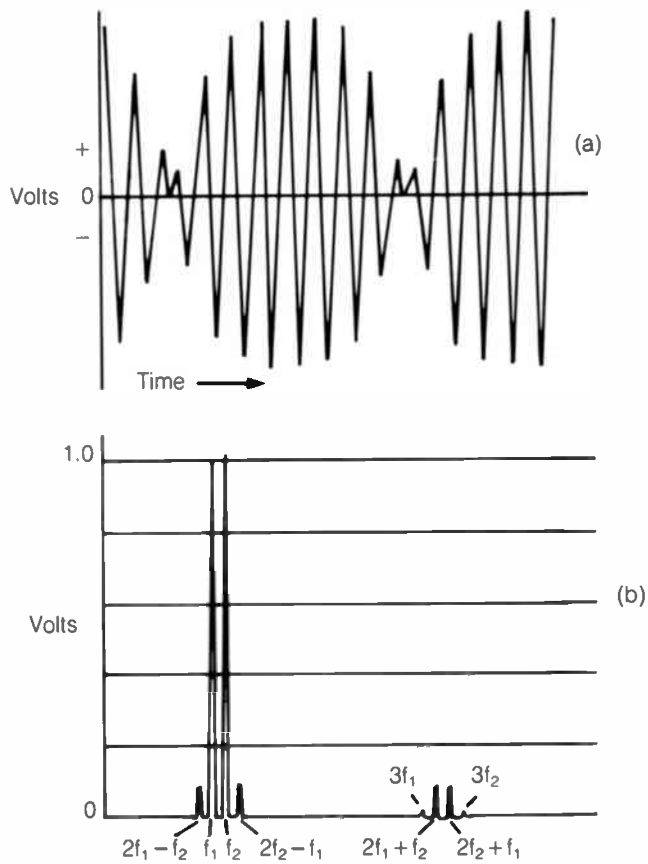
This shows how the spurious signals resulting from second order distortion fall below and between the bands, but not within the channel limits. Since this is true, second order distortion has no bad effects on an amplifier carrying up to 12 standard TV channels, and normally is not considered in this case.

Two sinusoidal input voltages with third order distortion

Figure 50(a) illustrates the appearance of the output voltage of an amplifier having third order distortion when the sum of two sinusoidal voltages [similar to that shown in Figure 47(a)] is introduced into the input. The flattening of the larger vertical peaks is clearly evident. A spectrum diagram showing the frequency components in the output is shown in Figure 50(b). In addition to the two original sinusoidal components (at f_1 and f_2) spurious signals occur at the following frequencies:

- $2f_1 - f_2$ This falls below f_1 at a spacing corresponding to the frequency difference between f_1 and f_2.
- $2f_2 - f_1$ This falls above f_2 at a spacing corresponding to the frequency difference between f_1 and f_2.
- $3f_1$ and $3f_2$ These are the third harmonics and the spacing between is three times the spacing between f_1 and f_2.
- $2f_1 + f_2$ This falls above $3f_1$ at a spacing corresponding to the frequency difference between f_1 and f_2.
- $2f_2 + f_1$ This falls below $3f_2$ at a spacing corresponding to the same difference.

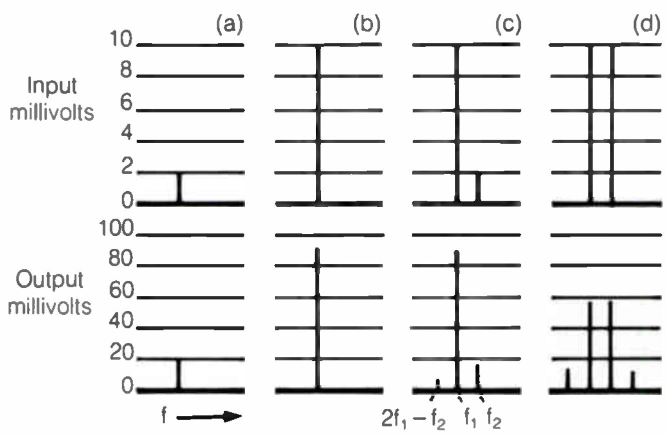
Figure 50: The sum of two sinusoidal voltages with third order distortion



Cross-modulation and compression

The spurious signals generated by third order distortion can give trouble in any multi-channel system since it is possible for them to fall within some of the channels. In present CATV systems they do not generally cause as much trouble as another effect of third order distortion, "cross-modulation." This is one of the two important aspects of third order distortion which do not result in components at new frequencies. (The other being "compression.") Each of these effects represents a change in gain at the channel frequencies rather than the generation of new frequency components. Figure 51 illustrates these effects. The upper spectrum diagrams illustrate the input signal components in an amplifier which has severe third order distortion, the lower diagrams

Figure 51: Spectra of input and output signals showing effects of third order distortion



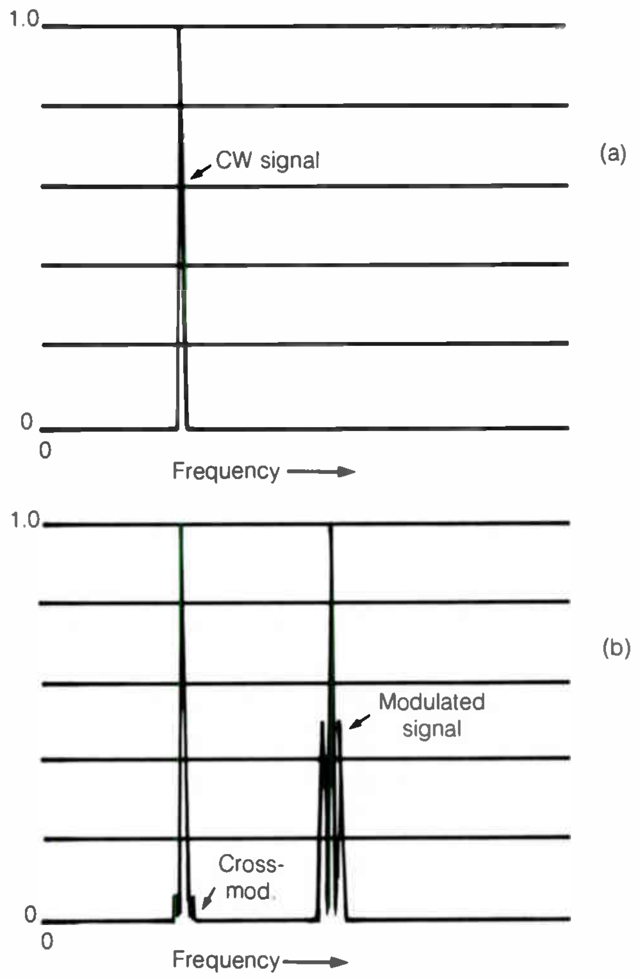
illustrate the resulting output signal components. The amplifier voltage gain, for small signal input, is 10 times. Thus, as illustrated in Figure 51(a), an input of 2 millivolts gives an output of approximately 20 millivolts.

The transfer characteristic of this amplifier can be approximated by an equation where a "cubed" term is subtracted from a "linear" term, with a shape resembling Figure 39(c). With such a characteristic the effective gain decreases as the input signal amplitude increases. Thus, as shown in Figure 51(b), increasing the input signal of this amplifier to 10 millivolts results in an output of 90 millivolts, rather than 100 millivolts which would be obtained if the gain were not reduced by the effects of third order distortion. This effect, the reduction in gain at a single frequency as the signal amplitude increases, is called *compression* and results in the distortion of the modulation envelope on any modulated signal going through such an amplifier. When this effect occurs in an amplifier carrying a single TV-modulated signal, it results in a flattening of the sync peaks which is called "sync compression."

Figure 51(c) shows what happens when a signal is introduced at low level on another frequency. Several effects can be seen: The output level on the new frequency is somewhat below the 20-millivolt point it would reach if the strong signal were not present; the strong signal output is slightly reduced by the presence of the new signal [compare with (b)], and a spurious component at $2f_1 - f_2$ can be seen.

As shown in Figure 51(d), increasing the second input signal to full amplitude results in a further reduction in gain so that both output signals at the original frequencies are below 60 millivolts and the spurious signals increase in amplitude. The most significant effect here is that the gain on each channel is reduced not only by an increase in level on that channel but also by the increase in level on the other channel. This results in a transfer of any variation, or modulation, on one carrier to any other carriers going through the same amplifier. This transfer is called cross-modulation and represents the worst effect of non-linearity in present-day CATV amplifiers.

Figure 52: Spectrum showing cross-modulation



This effect is further illustrated in Figure 52. Figure 52(a) shows the output signal obtained when a sinusoidal input is applied to an amplifier with a small amount of third order distortion. Figure 52(b) shows what happens when a second signal, fully modulated, is fed through the same amplifier, simultaneously with the original CW signal. The output includes the modulated signal (which shows up in the frequency spectrum as a carrier with smaller sidebands on each side), the output at the frequency of the original CW signal, and two spurious sideband components which show up adjacent to the CW signal frequency as a result of third order distortion. It is clear how this distortion results in a transfer of modulation from one signal to the other.

Conclusion

This chapter has attempted to describe all of the effects which result from the simplest kinds of non-linearity, second order and third order distortion, in amplifiers of the type used for CATV systems. It has shown that second order effects are generally unimportant with present-day frequency assignments and that, of all the third order effects, cross-modulation is the most important, representing the factor which limits the output level at which the amplifiers in these systems may be operated without degrading the picture quality at the receivers served by the system.

This chapter of the "Technical Handbook for CATV Systems" is being reprinted courtesy of the General Instrument Corp.'s Jerrold Division. To obtain a complete copy of the "Technical Handbook," send $10 plus $1.50 for postage and handling to: Technical Handbook Order, Customer Service Department, General Instrument/Jerrold Division, 2200 Byberry Rd., Hatboro, Pa. 19040. Jerrold customers may place orders with their customer service rep. (Make checks payable to General Instrument/Jerrold Division.)

'TVRO 101' What makes the dish tick

By Stephen Havey
Earth Station Product Planning Manager
Scientific-Atlanta Inc

While non-existent less than 10 years ago, today television receive-only (TVRO) earth station systems are in use in practically every cable system in North America, providing the wide variety of basic, pay and specialized programming on which our industry has come to depend.

The heart of any TVRO system, or at least the most visible part of it, is the earth station antenna. These range in size from 10 meters in diameter (used primarily in the earlier systems installed in the mid-70s) down to 2.8 meters. Most modern systems use 4.5- to 5-meter antennas.

Earth station antennas collect the extremely weak (typically −162 dBw) signals from one of many geosynchronous satellites and concentrate those signals enough to produce a usable signal level. The ability of the antenna to increase the signal is typically expressed as gain in dB referenced to an isotropic antenna (dBi).

More recently, manufacturers have published efficiency numbers for their antennas. While 60 to 65 percent is typical for most antennas, others may achieve 70 to 72 percent. Care should be exercised here, however, as an antenna's efficiency in terms of gain is sometimes increased at the expense of sidelobe performance, a tradeoff the cable operator can ill afford in view of 3° to 2° satellite spacing.

While the design, construction techniques and composition of earth station antennas vary widely among manufacturers, each is composed of three basic components: reflector, feed and mount.

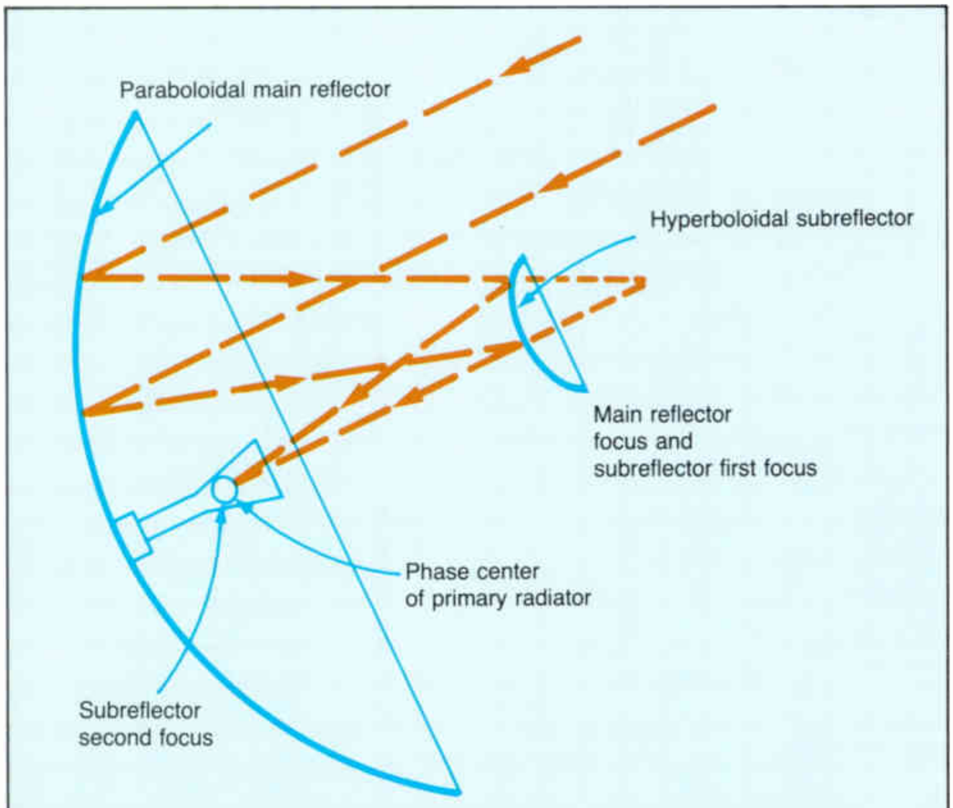


Figure 1: Cassegrain antenna geometry

Reflector

The reflector is the "dish" part of the antenna. Usually constructed of either fiberglass, aluminum or steel, the reflector is curved so that the desired signals are reflected to the focal point of the antenna regardless of where they strike the reflector's surface (see Figures 1 and 2).

Because the satellite signals will pass straight through non-metallic surfaces, antennas made of fiberglass must have a metallic coating or mesh embedded in their surface.

For single-beam antennas (those that are designed to receive signals from only one satellite), the dimensions of the reflector's curve are derived from a parabola, thus the often used name "parabolic dish."

Multibeam antennas have a curve based either solely on a sphere or, as is most often the case, a curve that is parabolic in the vertical plane and spherical in the horizontal plane. It is the spherical curve that allows the multibeam antenna to achieve uniform performance from all of its feeds even though, individually, they are not on a par with single-beam reflectors.

Multiple feeds have also been placed on single-beam reflectors, but unlike true multibeam antennas, the feeds do not produce uniform performance. The feeds mounted outboard of the center feed have distorted sidelobes and reduced gain compared to the center feed. The degradation of sidelobes and reduction in gain increases the farther these additional feeds are located from the true focal point.

While up to five feeds have been installed on some antennas, two to three is the usual number, and it is questionable as to whether they will work with 2° satellite spacing.

'. . .antennas made of fiberglass must have a metallic coating or mesh embedded in their surface'

Of primary importance in any reflector is its surface tolerance, or how closely it matches its design dimensions. The surface tolerance is critical in order to achieve not only the maximum gain (signal increase) from the antenna, but also to maintain the lowest sidelobe levels possible. It is the level of these sidelobes, or undesired gain in directions away from the desired satellite, that will determine whether or not the antenna will adequately perform with 3° or 2° satellite spacing. For the C-band frequencies (3.7-4.2 GHz) currently used in cable TVROs, a surface tolerance of 0.060 inches is a recommended minimum.

Feed

The feed is located at the focal point of the antenna and collects the signals that have been focused by the reflector. Because satellite signals are transmitted in both horizontal and vertical polarizations, an orthomode transcriber (OMT) is usually attached to the feed. It is the OMT that separates the horizontal and vertical signals and delivers each to its respective low-noise amplifier (LNA) or low-noise converter (LNC).

There are two basic types of feed in use today, Cassegrain and prime-focus. The Cassegrain feed provides more gain than a prime-focus feed and was the predominant design used in the early TVRO antennas. Figure 1 illustrates how, with a Cassegrain feed, the satellite signals are reflected first from the main reflector to the sub-reflector and then to the feed horn mounted in the center of the reflector.

Due to the open area in their large feed horns, Cassegrain systems require pressurization to prevent condensation of moisture, which adds to overall system cost.

The prime-focus feed, compared to the Cassegrain, provides approximately 0.5 dB less gain. This slight disadvantage is more than offset by the fact that prime-focus feeds cost less and do not require pressurization. Most important of all is the fact that sidelobe levels are typically 6 dB lower than a Cassegrain feed allowing better performance with 2° satellite spacing.

Figure 2 illustrates an antenna utilizing a prime-focus feed. Some manufacturers offer retrofit kits to convert earlier Cassegrain feed systems to a prime-focus feed.

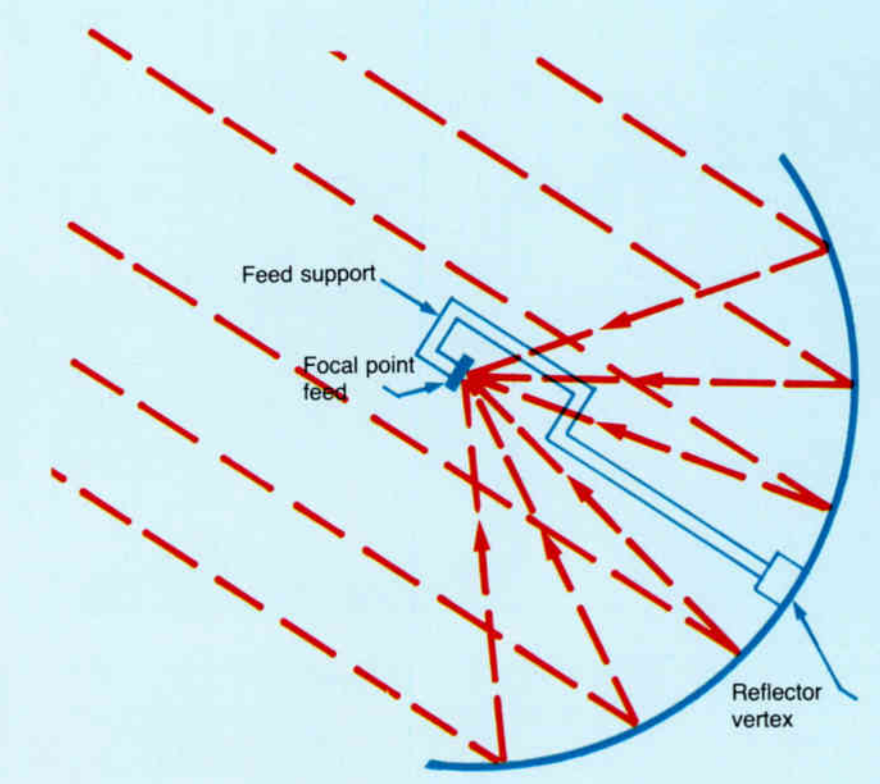


Figure 2: Prime-focus antenna geometry

Mount

The antenna mount physically supports the reflector and feed assemblies and provides the mechanical travel required to point the antenna to the desired satellites. Usually constructed of galvanized steel, the mount is generally bolted to a concrete foundation installed in the ground near a cable system's headend building.

While earlier mount designs, due to limited travel, required that this concrete foundation be oriented in a certain direction or centerline, most designs today incorporate continuous (360°) azimuth travel and thereby eliminate the need for foundation orientation.

The most common mount in use by the cable industry employs elevation-over-azimuth (EL/AZ) geometry. With this type of mount two separate adjustments, azimuth (side to side) and elevation (up/down) are required to point the antenna or to move it from one satellite to another.

Polar mounts, which require only one adjustment to move from one satellite to another, are more difficult to install initially and usually require special orientation of the foundation. For that reason they are seldom used in cable applications where frequent movement of the antenna from one satellite to another is not required.

Stephen Havey joined Scientific-Atlanta in 1977 as a field service engineer installing earth station, distribution and headend systems. He has held positions of field service supervisor, applications engineer, supervisor of applications engineering and the current title of earth station product planning manager.

TVRO, modulators

Channel Master Satellite Systems introduced a dual-feed commercial antenna system, Model 6107. This eight-section 14-foot parabolic dish is specifically designed for the professional requirements of commercial TVRO operations with performance characteristics that meet and/or exceed stringent NASA specifications. Certified in writing to perform without interference from adjacent satellites at 2° orbital spacing, the 6107 offers maximum interference rejection with excellent side lobe radiation and cross-polarization characteristics, according to the company. Dual polarization is obtained via orthomode coupling of LNAs. The mount features polar axis control for full arc coverage with a single manual or optional motorized adjustment.

Channel Master also is offering two new commercial modulators specifically designed for its professional TVRO installations. The modulators offer a choice of either 60 dBmV output (Model 6132) or 72 dBmV output (Model 6133) and deliver high quality response on all VHF and mid-band channels. The units use IF out, SAW filtering to ensure vestigial side band and adjacent channel performance, as well as proper flatness and group delay. A loop-through feature allows these modulators to be combined on one convenient common output for multiple channel applications. When proper audio and video levels are reached, the LED indicators on the front of these units light up showing that the optimum output level has been reached. These modulators can be stacked in a standard 19-inch EIA cabinet.

For more information, contact Channel Master Satellite Systems, Industry Drive, Oxford, N.C. 27565, (919) 693-3141.

Coaxial cables

A new series of air dielectric coaxial cables is available from the CATV Division of General Cable Co. The MC^2 coaxial cables have been designed for lower attenuation levels while still maintaining the needed handling performance, according to the firm.

MC^2 is available in five sizes—.440, .500, .650, .750 and 1 inch. Attenuation levels in the .750-inch MC^2 range from .97 dB/100 ft. at 68°F for 450 MHz to 1.07 dB/100 ft. at 68°F for 550 MHz.

The cables employ a composite construction in which all components are integrally bonded together. This type of construction, says General Cable, allows maximum flexibility with minimum signal loss. Each MC^2 "cell" is a hermetically sealed compartment, designed to be extremely resistant to moisture ingress and migration.

For more details, contact General Cable Co., CATV Division, P.O. Box 700, 1 Woodbridge Center, Woodbridge, N.J. 07095, (201) 636-5500.

Test equipment

Wavetek has introduced the Model 1881 system analyzer. Building on the same principles of precision testing and user-friendly operation designed into the 1880, the 1881 possesses extended frequency and amplitude capabilities for distortion analysis.

Measurements of carrier-to-noise can now be made from the headend to the last amplifier in a cascade. For those test points where signal level is low, a built-in preamplifier and filter will allow normal operations without external amplification.

Composite triple beat measurement capability also has been enhanced. This new model allows the operator to test amplifiers much closer to the point of origin, detecting intermodulation products before they become a system problem.

The extended frequency range (to 1 GHz) allows the technician to evaluate extended bandwidths of today and for future cable equipment of tomorrow. User-entered preprogrammed channels allow the operator to contour testing equipment to match system channel assignments. This, supported by CRT menu-driven instructions, allows even the novice to obtain precision in system evaluation.

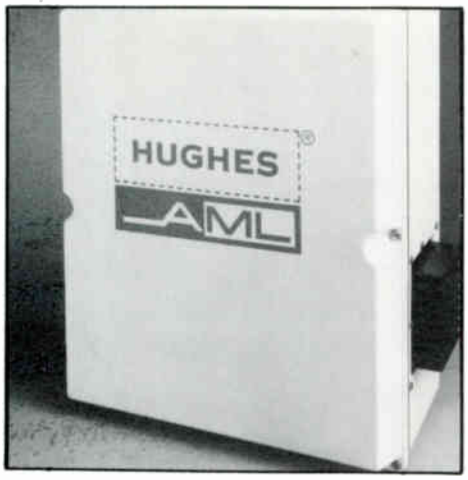
Wavetek also introduced the RT-1 remote instrument controller. This unit, in conjunction with the appropriate modem, will allow the user to remotely activate and operate the Sam III D and Sam IV series signal level meters.

Packaged in a hand-held high-impact case, the unit has an LCD display and keyboard for user friendly command entry. The RT-1 will display the commands entered, followed by the response from the Sam unit addressed. This hand-held unit provides an economical alternative to a large computer for remote testing applications. The unit is battery powered and completely field portable.

Cable leakage testing capabilities are now enhanced by the introduction of the Wavetek Model CR-6 signal leakage monitor. Technology now allows the sampling of actual system carriers as the monitor's source. This unit automatically scans the crystal controlled frequencies, for received levels. Upon detection, the Model CR-6 sounds a leakage beacon whose audible frequency is proportional to the level of signal encountered. When the leak has been isolated to a particular span, the addition of a field antenna will pinpoint the source to a fitting or crack for easy repair.

The unit is packaged in a 170mm x 71mm x 41 mm plastic case with belt clip.

For complete specs, contact Wavetek Indiana Inc., P.O. Box 190, Beech Grove, Ind. 46107, (317) 787-3332.



Microwave extender

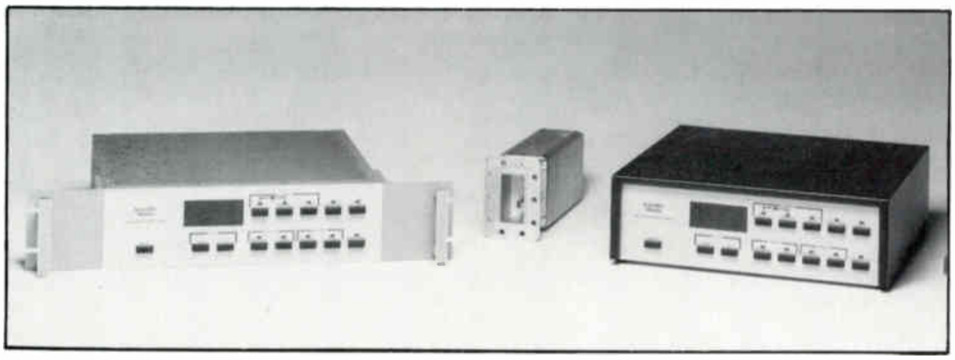
A new microwave line extender, designed to extend the range of a cable TV system where natural barriers, size of amplifier cascades or cost of cable would otherwise be prohibitive, has been introduced by Hughes Aircraft Co.'s microwave products division.

The new units are broadband multichannel transmitters using block upconversion techniques to distribute one to 60 channels of programming to small or specialized subscriber pockets. They accept VHF inputs in the 54- to 440-MHz range, and provide microwave output for distribution to cable hub sites.

Anticipated applications of the extenders include special local distribution service, crossing natural barriers, short hop repeatering, temporary restoration of multichannel service in the event of planned or emergency interruption, and as a frequency agile "hot standby" to protect regular or pay services. Both indoor and outdoor versions are available, and both are compatible with Hughes broadband AML receivers. Microwave output power levels are determined by distortion criteria and are dependent on the number of channels transmitted. Delivery is scheduled for the 4th quarter 1984.

Also available from Hughes is the Model AML-SWLNA-433 automatic bypass LNA sub-system with AGC. It consists of a low-noise GaAs FET amplifier, voltage-controlled attenuator, RF bypass switch, image rejection filter, control and status/alarm unit. It works with the AML receiver's existing AGC circuitry to control both S/N and intermodulation distortion during normal unfaded operation. The system is fail-safe in that the LNA is automatically switched out of the circuit should there be a power failure in either the LNA unit or the status/alarm unit. The LNA is also automatically switched out of the circuit should the LNA fail, as indicated by change in the LNA current above or below pre-determined limits.

For more information, contact Hughes Microwave Communications Products, P.O. Box 2999, Torrance, Calif. 90509, (213) 517-6233.



Satellite receiver

Scientific-Atlanta's low-cost Model 9530/9530A satellite receiver sets the standard for reliability and high quality performance, according to the company. This compact receiver operates with an outboard block downconverter and offers microprocessor control for both frequency and level adjustments.

The Model 9530 is a rack-mounted receiver requiring only ¾ of standard (3.5 x 12.5 inches) rack space. This compactness is achieved through the use of micro-chips, which control all receiver functions, thereby alleviating the need for independent circuits and large circuit boards. The 9530A is a table-top model affording the same compact size. The 9530A receiver is packaged with a decorative cover and surface-protecting rubber feet.

The frequency-agile Model 9530/9530A uses microprocessor controlled circuitry to select, fine tune, or scan any of 24 satellite channels. "Soft touch" push buttons located on the front panel allow input to the microprocessor. A single LED display indicates: satellite transponder number; fine tune transponder relative frequency; relative RF input level; primary audio subcarrier frequency and relative level; and secondary audio subcarrier frequency and relative level.

The above functions can be stored in two memories. The first memory retains set-up information once initial adjustments are made and will store this information even if the receiver is turned off. A second memory, activated by a "soft-touch store" pushbutton, permanently retains information even when power is removed.

For more information, contact Scientific-Atlanta, Video Communications Division, 4356 Communications Dr., Box 105027, Atlanta, Ga. 30348, (404) 925-5000.

Headend systems, TVROs, amplifiers

The Jerrold Division of General Instrument presented its complete line of 550 MHz advanced technology headend products and unveiled its line of earth station products at the recent NCTA convention.

The Jerrold Commander agile phaselock output converter, Model C4APC, features 550 MHz output and true agility for easy operator selection of 86 channels. Digital circuitry helps to ensure long-term stability, while full agility reduces the need for an extensive inventory of spare parts.

Included in Jerrold's 4.5-meter antenna line is the model C4R satellite receiver, which eliminates the need for high-cost cable from the dish to the headend using a low-noise block downconverter at the antenna. This single downconversion also eliminates duplication of expensive microwave components in each receiver.

The new Commander Ku-band satellite receiver, the C4R-12, operates at 950 to 1450 MHz input frequency, an input range that eliminates in-band and UHF interference. This input frequency is designed according to industry standards for compatibility with future 12 GHz satellite products.

Jerrold also exhibited the Commander low-cost modulator, which incorporates an RF scrambling compatible option for pay services.

The newest member of the Jerrold Starline X-Series amplifier family, the X-3000 with feedforward, also was introduced. Starline X with feedforward features inherent redundancy, provides low distortion with high gain and allows for higher headend levels and better system integration than any amplifier of its kind, according to the company.

The new Starline X-Series amplifiers were designed to help minimize initial construction costs and allow inexpensive moves up to 550 MHz. Small and medium size cable systems are covered with the conventional amplifier technology of the X-1000. Easy upgrades to 550 MHz are possible through changeout of the X-1000 active modules to either power doubling (X-1500) or feedforward (X-3000).

Jerrold also unveiled a new packaging design for indoor IntraNet, its off-premises addressable product, and introduced an outdoor version of the unit. The slimpack's design allows for easy installation in small areas such as stairwells and similar places in apartment houses and condominium units where offwall space is at a premium.

Outdoor IntraNet is specifically designed for densely populated neighborhoods. It integrates easily and economically into traditional tree and branch cable systems and provides a variety of packaging schemes—strand, pole or base mounting—for flexible installations and hassle-free maintenance throughout a system. The unit's design is capable of delivering all advanced CATV entertainment services, including impulse pay-per-view.

A new addition to the Metronet line of data communications products, the M-9000 redundant transverter switch, is an automatic switchover device used with an RF frequency transverter to provide fail-safe backup for a cable system's headend transverter. The M-9000 ensures decreased downtime and helps to deliver increased overall reliability on the communications network.

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

600 MHz 8-way tap

A new 600 MHz eight-way tap was introduced by Magnavox CATV at the 1984 NCTA show in Las Vegas. Because it is manufactured with surface mounted technology (SMT), Magnavox's new tap is very compact. The tap's 4.94- by 3.44-inch size and expanded bandwidth capability make it useful for many of the upcoming urban builds.

SMT is the surface mounting of miniaturized leadless electronic components on PC boards, facilitating the overall smaller size of the tap. These miniaturized electronics replace larger components such as capacitors and resistors. The eight-way tap fits easily into a 6-inch pedestal. The tap features an innovative seizure mechanism that can be rotated 90° without opening the tap housing. This allows the tap to be used for aerial as well as pedestal installations. The tap has an aluminum die-cast housing protected by an environmental coating that survived more than 1,000 hours of salt spray and humidity testing. The housing is pressure tested to 20 psi.

Also available from Magnavox are its advanced systems amplifier products—Parallel Power Doubling™ and feedforward.

Parallel Power Doubling utilizes two Power Doubling™ hybrids in a parallel configuration, providing increased output levels. An extremely optimum system configuration can be achieved, according to the company, using Parallel Power Doubling in the trunk and Power Doubling in the bridger and line extender modules. This configuration allows for an unusually high compression point, which in turn provides very high operating levels for the operator. Currently operating at 450 MHz, Magnavox is planning future upgrades to 550 MHz for Parallel Power Doubling trunk, bridger and line extender models. Trunk models are presently available in a nominal gain configuraton of 27 dB, operational between 22 dB and 30 dB.

Magnavox's feedforward technology can be configured into a system in ways that make it unique from other advanced systems amplifier products, according to the firm. In a feedforward trunk amplifier, the marriage of Magnavox's single-chip Power Doubling pre-amp with a single hybrid feedforward post-amp provides optimum noise and distortion performance within a system. Another extremely optimum system configuration can be achieved using Magnavox's feedforward in the trunk and Power Doubling in the bridger and line extender modules. This format allows operators to take advantage of high output capabilities without compression. Magnavox's feedforward has a low noise figure, 8.5 dB in an operational configuration, allowing for a more transparent trunk cascade. Now operating at 450 MHz, upgrades to 550 MHz for feedforward bridger and line extender models are planned. Trunk models are available in a nominal gain configuration of 27 dB, operational between 22 dB and 30 dB. Feedforward is retrofittable into existing Magnavox trunk amps and chassis dating back to the 1970s.

For more information, contact Magnavox CATV Systems Inc., 100 Fairgrounds Dr., Manlius, N.Y. 13104, (800) 448-5171 or (800) 522-7464 in New York.

Enclosures

Two new lock-boxes were introduced by Cable Security Systems—the Beast™ and the Battery Lockout™.

The Beast incorporates a non-rusting aluminized steel type-2 box for long life and no maintenance. It outlasts unpainted galvanized steel at least five to one, according to the manufacturer. A ⅛-inch thick steel shroud protects the recessed lock against tampering and is welded into the bottom right corner of each box. The box-within-a-box design with fully welded seams eliminates prying. The Beast is available in nine standard sizes and, also, can be made to custom specifications.

The Battery Lockout easily attaches to existing standby power supply cabinets to eliminate battery theft and vandalism. A solid steel, zinc-plated shroud bolts to the power supply lid and a solid steel, zinc-plated ⅜-inch locking pin is threaded to adjust to most cabinets and bolts through shelf or inside lip of the cabinet. It includes all mounting hardware and templates are available for most models.

For complete specs, contact Cable Security Systems, P.O. Box 1389, Auburn, Ala. 36831, (205) 821-0745.

Broadband RF modems

Zeta Laboratories Inc. introduced several new models to its line of frequency-agile broadband RF modems. Based on the firm's experience building low-noise frequency synthesizers for MIL-SPEC environments, the new modem family employs similar technology to produce units, Zeta says, that provide error-free data transmission, are spectrally efficient, low priced and built to withstand excessive vibration with low phase noise, eliminating a common source of bit errors. The new additions are the Model Z9 and Model Z56.

The Model Z9 provides either asynchronous or synchronous data transmission formats at rates up to 9600 BPS. It can be ordered for standard operation on transmit channels in the T7 to 2 Prime range and receive channels in the H to O range. Transmit power is adjustable from +30 to +50 dBmV with a receive signal range of −20 to +10 dBmV. Model Z9 provides a maximum bit error rate of 10^{9} over 0 to +50°C with optional performance over MIL-SPEC temperature ranges available.

The Model Z56 provides synchronous data transmission formats at 56 KBPS and with a standard RS232C, V. 35 or RS449 interface, the new modem offers speed and interface versatility making it particularly well-suited for satellite and cable system applications, according to the company. The Z56 can be ordered for standard operation on transmit channels in the T7 to 2' range and receiver channels in the H to O range. Transmit power is adjustable from +30 to +50 dBmV with a receiver signal range of −20 to +10 dBmV. In addition, Model Z56 provides a maximum bit error rate of 10^{-9} over 0 to +50°C. Operation at 65 KBPS is offered as an option.

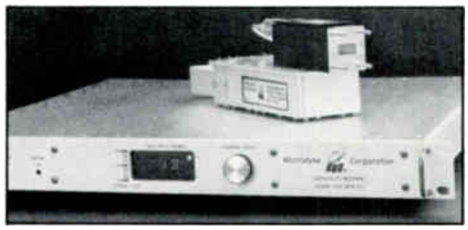
For further details, contact Zeta Laboratories Inc., 3565 Scott Blvd., Santa Clara, Calif. 95051, (408) 727-6001.

LPTV interference

Comsearch Inc. announced its new Sentry service, designed to maintain constant surveillance of all low-power television activity in order to guarantee interference-free operation to cable TV headends.

"Low-power television is a reality, with over 270 stations on the air and hundreds more to be approved in the near future. The potential for objectionable interference from an LPTV station to a cable system's off-air reception and converter channel is great. This operational threat must be detected and remedied in its early stages," said Micheal Morin, vice president of the Mass Media Services division of Comsearch.

For more information, contact: Michael Morin, Comsearch Mass Media Services, 11503 Sunrise Valley Dr., Reston, Va. 22091, (703) 620-6300.



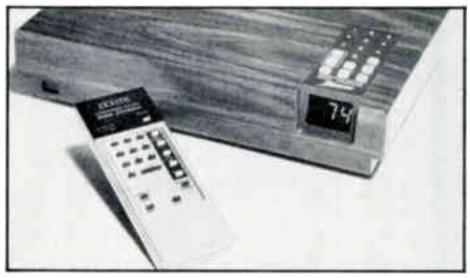
TVRO system

Microdyne introduced a new video receiving system designed for the Canadian cable television market. The system consists of the 1100 BDC-12 block downconverter, the 1100 DCR-12C Canadian satellite receiver and a 3- or 3.66-meter Ku-band antenna.

The antennas are molded in a single piece for increased rigidity and superior surface tolerances. The 1100 BDC-12 mounts directly to the antenna feed and downconverts the 11.7-12.2 GHz signals to the 270-770 MHz range. The 1100 DCR-12C receiver features a PROM controlled, frequency synthesized tuner programmed to receive the C-band (Anik D) as well as the Ku-band (Anik C-3) with the flip of a switch.

The receiver gives the operator access to both C- and Ku-band programming with one unit when used in conjunction with a C-band or Ku-band block downconverter.

For more information, contact Microdyne Corp., P.O. Box 7213, Ocala, Fla. 32672, (904) 678-4633.



Stereo, decoding units

New cable television decoding technology from Zenith Electronics Corp. will allow cable TV operators to decode simultaneously two types of pay TV scrambling in the same system.

Introduced at the National Cable Television Association Convention, Dual-Decode Z-TAC decoders incorporate the tiering and addressable capabilities common to other Zenith addressable cable products, but bring another dimension to the decoding capabilities.

The new Dual-Decode Z-TAC decoding

system was developed by Zenith research engineers for cable operators who use RF (radio frequency), but want to upgrade their systems to Z-TAC for its additional features and higher level of baseband program security.

With Dual-Decode Z-TAC, cable operators also can offer different tiers of service with differing levels of program security. Unlike other RF decoders, the suppression reference timing is generated internally to provide improved performance and reduced encoding errors.

Zenith also announced a new TV stereo adaptor for cable subscribers and a new Z-TAC baseband cable television decoder for use with stereo TV broadcasts, which are expected to begin later this year.

Combined with the new Z-TAC cable decoder, Zenith's new cable TV stereo adaptor will decode special broadcasts, allowing subscribers to enjoy programming transmitted in stereo or in a second language.

The stereo adaptor can be attached to the back of a color TV set or on the wall behind the TV set. It can be connected simply by the subscriber to the Z-TAC cable TV decoder through Zenith's Redi-Plug feature.

Unlike other addressable baseband cable decoders, the new generation of Z-TAC hardware available later this year will pass a TV stereo signal through to the new adaptor or a specially equipped color TV set.

For complete specs, contact Zenith Electronics Corp., 1000 Milwaukee Ave., Glenview, Ill. 60025, (312) 391-8181.

Test equipment, passive devices

Texscan Corp. introduced a number of new products at the NCTA show.

The Installer 600 signal level meter is packaged in high impact ABS plastic, comes complete with a custom padded weatherproof carrying case and is lightweight and totally portable. Covering from 5 to 600 MHz, the Installer 600 has an accuracy of ±0.75 dB to 450 MHz and ±1.0 dB to 600 MHz. Included are audio monitoring with front panel volume control and an internal NiCd battery with charger.

A new lightweight, hand-held leakage receiver, the "Beephound," has a single frequency, 88 to 128 MHz range. Crystal controlled, this unit provides 0.5 microvolt (12 dB Sinad) sensitivity. Its internal NiCd battery gives eight hours of continuous operation. The Beephound's squelch control is tone activated to eliminate false alarming. Weighing only 13 oz., the unit has a belt clip or can be hand held and incorporates a flexible antenna that can be removed for vehicle antenna connection.

The Model 9552 system sweep receiver is an updated version of its predecessor, the 9551. With a 5 to 450 MHz range, all of the original features have been retained. New features of the 9552 are: 62 dB input attenuator; log calibrated display with digital storage—1 or 2 dB/cm (0.25 dB resolution); carrying case, removable covers, rear access to battery, detented handle, textured finish; color-coordinated, laminate finish front panel; sealed, hinged panel cover; and gel cell battery with accessory charger/DC supply for bench applications.

A new RF sweep generator, Model VS-60C, utilizes an improved cabinet housing with removable covers, textured finish and optional carrying handles or rack mount brackets. The front panel groups controls into function catagories for ease of operation and a new power supply has been incorporated. The VS-60C covers from 1 to 1000 MHz.

Two new test probes—Model T9TP-20 for trunk applications and Model T9LP-20 for line extender applications—also were introduced. They are self-seizing and offer ±0.5 dB accuracy from 5 to 500 MHz and flatness across the bandwidth of ±0.25 dB.

In addition to test equipment, Texscan introduced a variety of other products: a new line extender designed expressly to permit the co-location of institutional and entertainment system configurations that features three forward gain and five reverse gain versions; a new stand-alone descrambler, Model 4025, that is the first of a new series of Texscan products using an advanced dynamic RF sync suppression system and incorporates a keylock switching circuit; a new converter, Model 6060, which is a one-way addressable, baseband descrambling, set-top unit designed for NTSC standard operation in a 60-channel cable system; a new 600 MHz line of directional taps and distribution passive devices including two-way, four-way and eight-way directional taps, directional couplers in 2 dB steps from 8 to 16 dB, as well as two-way and three-way line splitters and an expanded frequency power combiner; a new, high-resolution character generator, the CDD-45, which advances the Compuvid Data Display product line it acquired with the purchase of Computer Video Systems late last year; the SpectraTex line of graphics generator products based on the North American Presentation Level Protocol videotex standard; and its new random access videocassette commercial insertion controller, the ComSerter 92, Model CSR-92.

For specific details, contact Texscan Corp., 3102 N. 29th Ave., Phoenix, Ariz. 85017, (602) 252-5021.

Digital audio

The Sony Corp. demonstrated its newly developed cable digital audio/data transmission system (CADA®) at the recent NCTA convention. The system is designed to expand the applications of existing CATV services.

CADA represents a synthesis of the traditionally discrete technologies of digital audio, text and graphics, resulting in a wide range of valued communication applications.

The CADA system enables the CATV operator to offer a wider menu of services including ultra-high fidelity stereo audio programs, computer and game software, information and emergency service announcements and hard copy text and graphics.

Sony's CADA system allows the transmission of digital data of 7.4 MBps using a bandwidth of 6 MHz, equivalent to one arbitrary TV channel, and requires no alteration in order to connect with current CATV networks. Unlike the conventional cable transmission in which information is transmitted in analog form, CADA transmits information digitally with virtually no sound distortion or quality deterioration. Because of digital signal processing, noise and interference from transmission lines and relay devices is negligible.

Sony Corp. expects to commercially launch the CADA system in Japan this summer where a local governmental agency will install receivers in over 1,500 residences to serve as an emergency broadcast warning/information system.

For more information, contact Sony Corp. of America, Sony Drive, Park Ridge, N.J. 07656, (201) 930-6432.

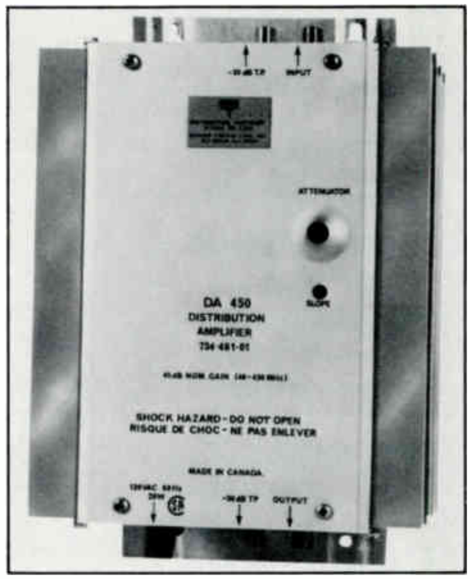
Cable data terminal

CableBus Systems Corp. announced a new home terminal modem for cable-based security monitoring.

The CDT-6/4 is a cable data terminal capable of sensing six active-high or active-low inputs. The unit is designed to allow direct hardwiring to most alarm panels without using costly interfaces. Each input is uniquely identifiable by the central computer, with three inputs being latched and three inputs unlatched. The four output switches are open collector capable of sinking 100 ma loads. Special firmware in the output control allows verification of each output status change.

The new RF specifications include 52 dBmV of output power and increased sensitivity. The unit uses the CableBus narrowband design and guaranteed stick-proof transmitters. The CDT-6/4 is capable of being used in systems with existing CableBus MICRO-2 equipment by adding an easily installed firmware upgrade.

For complete details, contact CableBus Systems Corp., 7869 S.W. Nimbus Ave., Beaverton, Ore. 97005, (503) 643-3329.



Amps, modulators

Blonder-Tongue Laboratories Inc. introduced two new 58-channel (40-450 MHz) push-pull, high output level distribution amplifiers. The DA-450-45 (stock no. 4240) has a flat operating gain of 45 dB minimum, which can be reduced to 28 dB with a variable attenuator. The DA-450-30 has a gain range of 30 to 13 dB. Both DA-450s are ideal for large apartment complexes where high level distribution of signals is required. A solid die-cast, extruded aluminum case assures exceptional heat-sinking and reliable ground connections. The slope control is a continuously adjustable equalizer that compensates for up to 7 dB cable at 450 MHz. Optional plug-in equalizers and attenuators are available for additional cable compensation. Other features include an internally mounted main fuse that snaps into a holder for easy replacement and true 75 ohm –30 dB backmatched test points at the input and output.

The new MVM (stock no. 5922) is an all solid state heterodyne video modulator that provides a modulated visual RF carrier output on any single VHF (2-13), midband (A-I) or superband (J-W) channel. The MVM can be used to put color video on any unused channel of a closed circuit MATV or SMATV system. The heterodyne conversion system of the MVM is designed for vestigial sideband selectivity in adjacent channel color systems. The MVM features a field replaceable heterodyne converter board, which permits qualified service personnel to quickly and easily change channels in the field. Desoldering, soldering or special tools are not required to accomplish channel conversions.

Blonder-Tongue also announced the availability of its new MAM (stock no. 5921) audio modulator. The MAM is an all solid state heterodyne audio modulator that provides an unmodulated visual and a modulated aural RF carrier on any single VHF (2-13), midband (A-I) or superband (J-W) channel. In addition, a monaural FM band version with increased audio deviation and a suppressed visual carrier is available. The MAM can be used to put sound on any unused channel of a closed circuit MATV or SMATV system. The MAM features a field replaceable heterodyne converter board. Channels may be changed by simply removing and replacing a complete channel module.

For complete specs, contact Blonder-Tongue, 1 Jake Brown Rd., Old Bridge, N.J. 08857, (201) 679-4000.

Stereo modulator

Leaming Industries' FMT615M wideband stereo modulator possesses the retrofitable capability of operating in the true stereo or synthesized stereo mode simply by moving a shorting bar. This ambient audio system can be used to put any mono program source onto the cable system's FM band in synthesized stereo, from local AM radio stations to international short wave broadcasts. The modulator also operates in the true stereo mode, enabling local origination of stereo programs. It further provides for simulcasting of stereo TV audio from decoders of scrambled satellite services, as well as off-air stereo TV audio.

Complete information is available by contacting Leaming Industries, 180 McCormick Ave., Costa Mesa, Calif. 92626, (714) 979-4511.

Microwave radios

Avantek Inc., introduced two new third-generation digital microwave radios providing 384 and 576 voice channel capacity in the 6 GHz frequency range for operational fixed services or common carriers. Both radios have been type accepted under FCC rules parts 21 and 94. Operating in the 6525 to 6825 MHz public safety, industrial and land transportation band and in the 5925 to 6425 MHz common-carrier band, the DR6A-384 offers a capacity of 16 DS-1 (1.544 Mbps) or 4 DS-2 (6.312 Mbps) lines, while the DR6B-576 offers a capacity of 24 DS-1 or 6 DS-2 (6.312 Mbps) lines. The radios may be optionally equipped with up to 16 and 24 300 Hz to 3.3 kHz, or eight and 12 300 Hz to 7 kHz service channels, respectively.

Both the DR6A-384 and DR6B-576 are available configured as a terminal, non-drop repeater or drop-and-insert repeater. In the terminal configuration, they will interface with D1, D2, D3 or D4 (mode 3) type subscriber T-carrier voice terminals; with SM-T, WB1, WB2, WB3 or WM1 data terminals or with M12 multiplexers.

For complete information, contact Tom Rich at Avantek Telecommunications Division, 481 Cottonwood Dr., Milpitas, Calif. 95035-7492, (408) 943-4447.

Modulator, demodulator

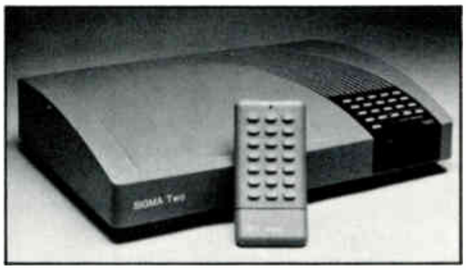
The FM supertrunk modulator (Model 8100) and demodulator (Model 8200) combination from Phasecom Corp. provides excellent very long range video signal transmission while maintaining a sufficiently high signal-to-noise ratio, according to the company.

A PLL stabilized VCO at 512 MHz allows the Model 8100 to generate ultralinear FM modulation, enabling the demodulator to faithfully reproduce the signal. Input circuitry includes a video processing unit, an audio processing unit (which soft limits the audio input signal), AGC (provides a wide dynamic input range) and modulation control (allows adaptation to specific S/N improvement requirements). A front-panel output level control governs the output amplifier's output level (45 dBmV to 60 dBmV). Front panel displays include central channel frequency, channel bandwidth, video signal indicator and an audio scale.

A PLL-type FM demodulator, occupying only a small fraction of the bandwidth in the UHF range, enables the Model 8200 to produce excellent output quality. A PLL-type FM demodulator best meets system channel selectivity and linearity requirements without requiring RF hard-limiting. The input converter is composed of a low-intermodulation converter driven by a PLL-synthesized UHF local oscillator and a low-noise preamplifier with a high dynamic input range (made possible by

AGC). Central channel frequency, channel bandwidth, and IF and video signal present indicators are featured on the front panel.

For more details, contact Phasecom Corp., 6365 Arizona Circle, Los Angeles, Calif. 90045, (213) 641-3501.



Addressable terminal

Oak Communications Inc. introduced its Sigma Two addressable home terminal, the second offering in Oak's Sigma line of subscriber cable television control products.

The Sigma Two converter is designed for multiple system operators (MSOs) who desire baseband video scrambling and remote volume control at a lower price.

Like the Sigma One converter/decorder introduced in December 1983, the Sigma Two utilizes advanced baseband scrambling to secure the video signal. It also includes an optional module, which makes the Sigma Two terminal compatible with Oak's TotalControl™ system.

Sigma's advanced baseband video scrambling completely eliminates the horizontal and vertical synchronization pulses from the video signal, according to the company. The scrambling technique includes random video inversion on scene change. This combination of features makes it highly resistant to unauthorized interception and decoding.

Sigma Two subscriber features include variable-rate channel scanning, last-channel recall and favorite-channel memory. Parental control is a standard feature and allows parents to lock out channels.

For more information, contact Doug Howe, Oak Communications Inc., 16935 West Bernardo Dr., Rancho Bernardo, Calif. 92127, (619) 485-9880.

Directional taps

RMS Electronics Inc. announced two new products, the model CA-2014FGB, a non-power passing, four-way directional tap with built-in grounding block, and the Model CA-2018FGB, a non-power passing eight-way directional tap with built-in grounding block.

These taps are nickel plated, non-corrosive for indoor/outdoor use and have machine-threaded terminals. They come complete with hex-head and slotted 1¼-inch mounting screws. The impedance is 75 ohms at all ports.

For further information, contact RMS Electronics, 50 Antin Pl., Bronx, N.Y. 10462, (800) 223-8312.

Signal source

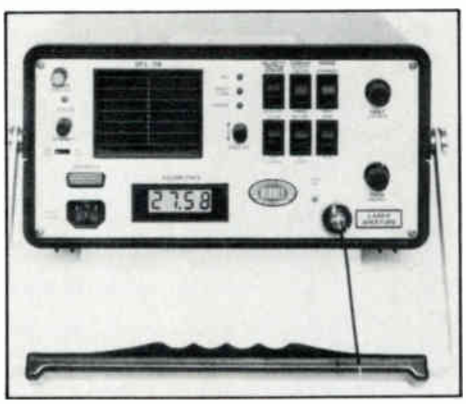
The Sniffer II signal source from ComSonics represents a complete redesign of both packaging and circuitry with design changes implemented according to suggestions made by customers and employees.

A front panel RF output level adjustment was added to allow final system carrier level setting without requiring external attenuators. The only other front panel items are a power switch and a LED power-on lamp operated from the unit's DC power supply, which also indicates proper power supply operation. The remaining operating connections are located on the rear panel.

Improved shielding integrity of the signal source housing as measured with the Sniffer detector and near field probe has reduced signal leakage to nearly undetectable levels. This was accomplished by locating the entire RF circuitry section in an additional metal enclosure inside the main housing. All other power supply, audio, squelch tone encoding and timing circuitry is located on a separate printed wiring board that provides RF filtering for the AC power lines.

To maximize Sniffer detector sensitivity, a different type of AM modulation was incorporated. Sniffer I signal source units used negative modulation, the same technique used in video modulators. Sniffer II signal source units use an AM modulation method known as symmetrical modulation, commonly found in RF signal generators. This process significantly increases sideband power level resulting in a detector sensitivity increase of 6 dB.

For more details, contact ComSonics Inc., P.O. Box 1106, Harrisonburg, Va. 22801, (800) 336-9681.



Fiberoptic test set

A new long-range, portable, lightweight OTDR featuring a 30-kilometer range on single-mode fiber and slightly less range on multi-mode fiber is now available from Biddle Instruments. The set operates from internal rechargeable batteries or any AC source and measures splice and fiber losses with a dynamic range of over 120 dB.

Additional features include: simplified controls, photon counting electronics for improved detection and signal processing and the use of a rugged, field-proven cable connector. Connection of bare fiber is quickly and easily performed because polishing and troublesome alignment procedures are not usually necessary with this connector. Testing time is reduced by the use of a rugged, jeweled output port. Preterminated fibers may be connected to optional "pig-tail" adapter cables for further reductions in testing time. The OTDR weighs only 16½ pounds, with batteries, and includes a fiber termination kit, Polaroid® camera with viewing hood and heavy-duty padded carrying case.

For complete information, contact Biddle Instruments, Blue Bell, Pa. 19422, (215) 646-9200.

Data, ad systems

Tele-Engineering Corp.'s Lantec 8400™ data communication equipment for coaxial cable systems utilizes self starting, token passing, random access addressing, which permits the communication between any number of modem terminals. The unit's design conforms to the international standard of CCITT X.25 and to the latest IEEE standards 802.4 for token passing bus access method.

It can accommodate transmission on standard sub-low residential CATV systems as well as on institutional mid-split or high-split systems, local area networks and wideband area networks. On sub-low residential networks, the 8400 works on channels A-2 or A-1 in the forward direction, on T7, T8, T9 or T10 in the return direction. On mid-split systems the return frequencies are maintained as T7-T10 and the forward frequencies of channels 7, I or H. On high-split systems, the return frequencies are maintained as T7-T10 and the forward frequencies are changed to channel M (234 MHz) through channel P (252 MHz).

Lantec 8400™ operates in any 1.5 MHz band within the above mentioned TV channel assignments. This means that four independent systems can operate in a single 6 MHz TV channel assignment.

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Also available from Tele-Engineering is the COBIAS™ advertising management system. COBIAS (central office-based information access system) provides cable television advertising operations with a cost-effective management tool for automated billing, verification, mailing list management, spot sales monitoring, sales activity monitoring, scheduling, accounts receivable, receivables ageing and receivables allocation. The systems permit easy file maintenance and quick retrieval of information on advertisers, prospective clients, markets, networks, and sales representatives. All basic files are accessible from the primary menu allowing for fast access and display of any file record. Standard access time for all records is under two seconds.

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Tamburro

Harold Tamburro has joined **AM Cable TV Industries Inc.** as vice president of finance. He previously served as vice president and general manager of MAI Communications of Barrington, N.J. Prior to that he was controller and director of administraton for the Jerrold Division of General Instrument. Contact: P.O. Box 505, Quakertown, Pa. 18951, (215) 536-1354.

Comtech Data Corp., a wholly owned subsidiary of Comtech Inc., announced the promotion of several key management individuals at the corporation's Scottsdale, Ariz., facility. **Robert Fitting** has been promoted to president of Comtech Data, moving up from senior vice president. Fitting replaces **Milton Deever** who has been transferred to the New York office of Comtech Inc. as senior vice president and chief operating officer. **Louis Harper Jr.** has been promoted to the position of assistant general manager of the company. Harper is also senior vice president of product operations. His previous position was vice president, digital transmission products. **Allen Scharf** has been promoted to senior vice president of business development and long-range planning. Scharf joined Comtech Data in 1982 as vice president, analog transmission products. Contact: 350 N. Hayden Rd., Scottsdale, Ariz. 85257, (602) 949-1155.

Bob Vogel has joined the Telecommunications Division of **Raychem Corp.** as an applications engineer in the cable TV department. In his new position, Vogel will be responsible for customer training and engineering. He was previously manager of engineering services, Western division, for Showtime. Contact: 300 Constitution Dr., Menlo Park, Calif. 94025, (415) 361-3333.

Scientific-Atlanta Inc. announced the election of two senior executives to vice president positions. **Samuel Davis** has been named vice president and group executive-Instrumentation. Davis has served in several engineering and management positions since joining Scientific-Atlanta in 1973, most recently as group executive of the Instrumentation Group. **James Hart Jr.** was named vice president and group executive-Broadband Communications. Hart has worked as a staff engineer, marketing manager and product line manager in the company's cable communications divisions since joining the firm in 1966. He was most recently group executive of the Broadband Communications Group. Contact: 1 Technology Parkway, Box 105600, Atlanta, Ga. 30348, (404) 441-4000.

General Instrument Corp. has promoted **Norman Lange** to vice president and general manager of the Jerrold Distribution Systems Division. He replaces Ken Coleman who recently resigned. Lange joined General Instrument in August 1982 as corporate vice president of marketing with staff responsibility for marketing and field sales. In February 1983 he was named acting vice president and general manager of the newly formed Sales and Service Division. Contact: 2200 Byberry Rd., Hatboro, Pa. 19040, (215) 674-4800.

Stuart Dance has been appointed vice president, marketing and sales for **Magnavox CATV Systems Inc.** Prior to joining Magnavox, Dance was vice president of sales and marketing at C-COR Electronics. Contact: 100 Fairgrounds Dr., Manlius, N.Y. 13104, (315) 682-9105.

July

July 10-12: Jerrold technical seminar, Williamsport, Pa. Contact Kathy Stangl, (215) 674-4800.

July 10-12: Cable '84, **Online Conferences Ltd.**, Wembley Conference Centre, London. Contact Online in England, 01-868-4466.

July 11-13: Magnavox CATV training seminar, Portland, Ore. Contact Laurie Mancini, (800) 448-5171; in New York, (800) 522-7464.

July 12-14: Montana Cable Television Association annual convention, Big Sky, Mont. Contact Tom Glendenning, (406) 586-1837.

July 15-19: Community Antenna Television Association annual convention, CCOS-84, Tan-Tar-A Resort, Lake of the Ozarks, Osage Beach, Mo. Contact Celeste Nelson, (405) 947-7664.

July 16-18: Magnavox CATV training seminar, Portland, Ore. Contact Laurie Mancini, (800) 448-5171; in New York, (800) 522-7464.

July 17: Southern California Cable Association meeting, Los Angeles Airport Hilton. Contact (213) 684-7024.

July 17-19: C-COR Electronics technical seminar, Albany, N.Y. Contact Deb Cree, (814) 238-2461.

July 23-25: The Department of Engineering and Applied Science of the **University of Wisconsin-Extension** tutorial on "Community Antenna Television Service: Equipment Availability, System Design, Terminology," Madison, Wis. Contact Engineering Registration, (800) 262-6243 or (608) 262-1299.

July 23-25: PC/SMATV workshop, **National Satellite Cable Association** and **Eagan & Associates**, Washington. Contact Larry Hannon, (904) 237-6106.

July 23-27: Annual conference on computer graphics and interactive techniques, ACM SIGGRAPH '84, **Association for Computing Machinery's Special Interest Group on Computer Graphics**, Minneapolis. Contact: (312) 644-6610.

July 30-Aug. 1: New England Cable Television Association annual convention, Sturbridge, Village, Sturbridge, Mass. Contact (617) 843-3418.

August

Aug. 8-10: Magnavox CATV training seminar, Chicago. Contact Laurie Mancini, (800) 448-5171; in New York, (800) 522-7464.

Aug. 13-15: Magnavox CATV training seminar, Chicago. Contact Laurie Mancini, (800) 448-5171; in New York, (800) 522-7464.

Aug. 15: SCTE Rocky Mountain Meeting Group meeting on data communications, Denver area. Contact Sally Kinsman, (303) 696-0380.

Aug. 21: Southern California Cable Association meeting, Los Angeles Airport Hilton Hotel. Contact (213) 684-7024.

Aug. 21-23: Jerrold technical seminar, Denver. Contact Kathy Stangl, (215) 674-4800.

Aug. 21-23: C-COR Electronics technical seminar, Ontario, Canada. Contact Deb Cree, (814) 238-2461.

Planning ahead

Sept. 6-8: Southern Cable Television Association annual convention, Eastern Show, Georgia World Congress Center, Atlanta.

Oct. 16-18: Mid-America CATV Association annual convention, Hilton Plaza Inn, Kansas City, Mo.

Oct. 30-Nov. 1: Atlantic Show, Atlantic City (N.J.) Convention Center.

Dec. 5-7: California Cable Television Association annual convention, Western Show, Anaheim (Calif.) Convention Center.

March 4-6: Society of Cable Television Engineers annual convention, Cable-Tec Expo '85, Sheraton Washington Hotel, Washington, D.C.

AD INDEX

Assess needs before investing the cash

By Dave Willis
Director of Engineering, Tele-Communications Inc

Every day a great many cable TV operators face the questions related to the acquisition of CATV material. The decision of what specific item to buy is predicated on at least four factors: application, specification, vendor and price. Other factors such as availability can also affect the selection process.

Most major cable operators put a great deal of money and effort into product research and evaluation. The logical result of these efforts would be uniform selection of product. Obviously, no such uniformity exists and this lack of uniformity is occasioned by application requirements, priorities, proximities and other diverse factors. There are multiple versions of specific products that are technically equivalent and could be interchanged. It is also a fact that not all products are created equal.

The small operator cannot devote the time and resouces to make in-depth evaluations. How then, can he make good decisions in this area? What are some of the techniques that can be used?

- Application requirements are an individual system decision. One of the pitfalls for the small operator is to assume that because an MSO adopts a certain product or program, that it is automatically right for him. Far from true. The small operator should be extremely pragmatic when considering new products or when pondering a new equipment program. There are no two cable systems that are exactly alike politically, technically or economically. The small operator should assess, as objectively as possible, the realities of his specific system. What are the programming needs? What steps must be taken to meet these needs? Do the economic factors augur for or against change? Is change, in fact, the way to go at all? What are the long-term implications? When you have a clear perception as to where you're going your path is far easier.
- Selection of the right vendor is one of the basic decisions. The newcomer to the industry's family of vendors has a rough road ahead of him. Every product line from every manufacturer has had its problems. Few of these problems are disasters but all have an adverse economic impact on the operator. Desireable vendors are those that support their clients through these problems and "make it right." These also tend to be the vendors that publish accurate product specifications and meet those specifications consistently.
- Without investing a lot of money in exotic test equipment, an operator still can verify many of the common specifications found in CATV products. For instance, insertion losses, through path losses, gains and tilts can all be verified using a signal level meter. You should always verify whether any given set of specifications are "nominal" or guaranteed. If the manufacturer is not confident enough of his manufacturing techniques and his quality control to guarantee the performance specifications then you can have no confidence in the product.
- The small operator is at a disadvantage in price negotiations since he does not command a really high purchasing volume. My recommendation is to have at least two suppliers that you consider viable. You may give one all your business for price consideration but you should always have a back-up supplier with current pricing established waiting in the wings. Your purchasing volume may be relatively small by itself but the total volume of independent system purchasing is a very high dollar amount. The vendor doesn't exist that can afford to write off this market segment.

Another useful approach to assessing products is to contact users. If a vendor is reluctant to provide such contacts your decision is made for you. If he is eager to provide specific user names and phone numbers, use them. You don't have to call each and every one, but a two- or three-user sample normally can give you a feeling for the product desireability.

Prior to placing these calls, make a list of all the specifics you feel you need to know. Most references are happy to share their information with you.

Among the ways of ascertaining the quality and applicability of various products, there is a vast store of performance information to be gathered from fellow operators. This information will again yield diverse preferences and again these preferences can be totally valid due to the specifics of each operation. Trade publications frequently publish equipment comparison summaries. They do not select and recommend products but give a complete set of the specifications and your comparison will yield the best product for your specific priorities and application.

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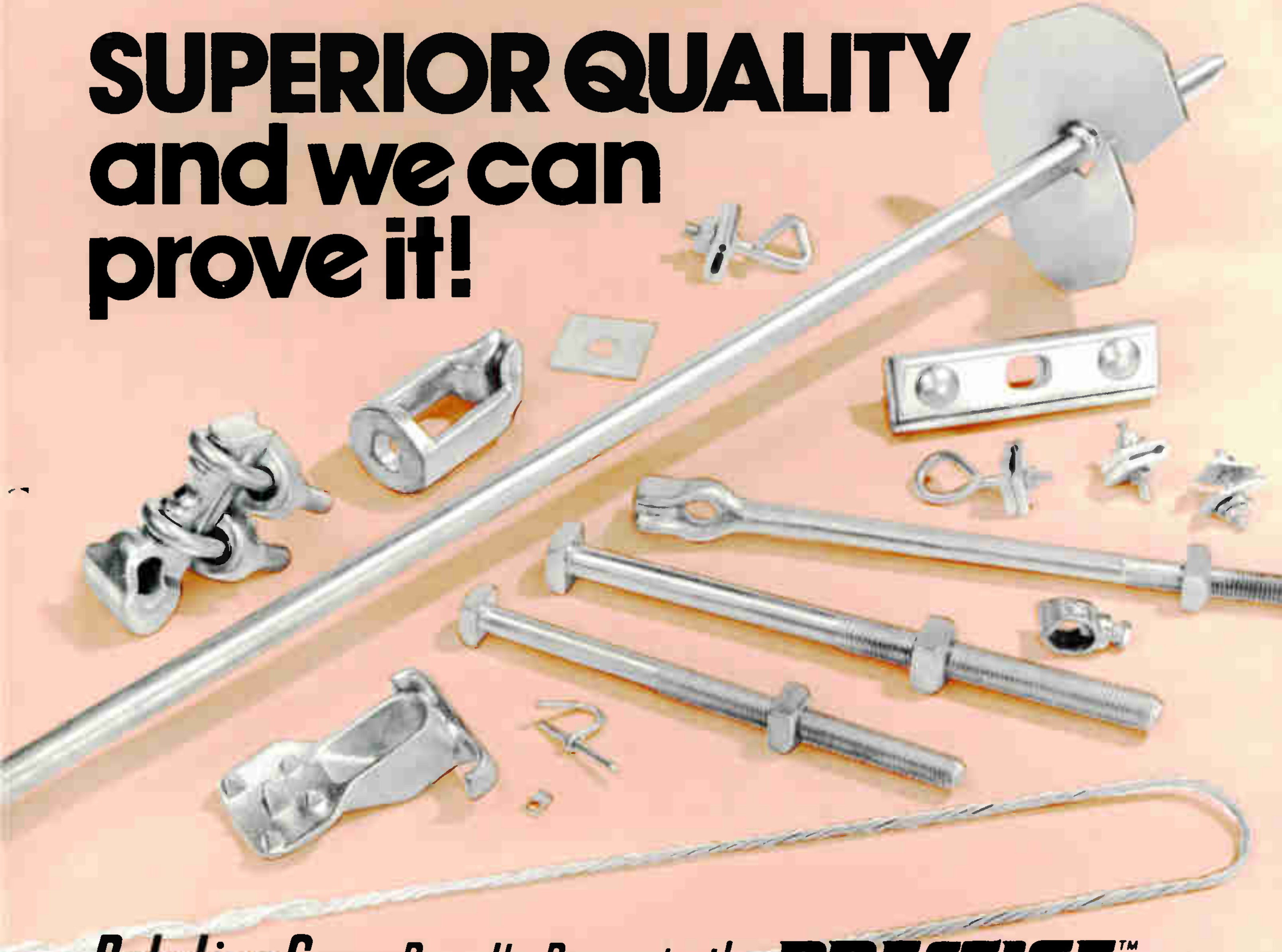

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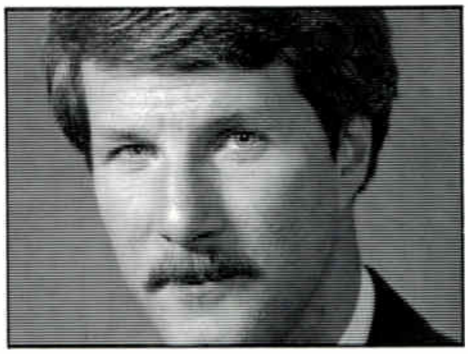
Why everyone should have CPR and first aid training



By Bob Luff
Vice President, Engineering, United Artists Cablesystems Corp

"I think I'm . . . heart attack," were the faint words barely heard from a fellow attendee sitting in the front row of the Construction Practices session at the Society of Cable Television Engineers' Conference and Cable-Tec Expo. What happened during the 15-minute catastrophe is a blemish on the whole industry.

The following events are as true as I can remember them and are recounted here not to embarrass anyone (myself included), but to show how apathetic and ill-prepared our industry has become about fellow employee medical emergency preparedness. I hope this account will inspire a desperately needed industrywide focus on employee cardiopulmonary resuscitation (CPR) and first aid training.

'I think I'm . . . heart attack'

After those faint words for help, everyone just continued on with what they were doing. Maybe it was initial disbelief. Or, maybe some did not hear the heart attack victim's whispered call for help—although I was sitting several rows back and heard his words quite clearly. From the back he looked about mid-30s and was still sitting upright in his chair, but now with one arm slightly raised to seek attention from his unresponsive classmates.

"I think I'm having a heart attack," he again weakly whispered. Everyone still remained in their places, I suppose still in a state of disbelief. But as an intense hush rolled across the room, the mood began to quickly pass from disbelief to belief. Yet no one came to his aid.

No first aid confidence

The problem was, no one in the room had enough CPR or even basic first aid training to confidently know what to do in an apparent heart attack situation.

Of all groups, one would expect our construction crews and supervisors to be the industry's most trained and experienced employees in basic first aid. Even if there were doubts or concerns as to just what aid to administer, there was no excuse whatsoever for not spontaneously taking care of the most primitive basics—sending for medical help and making the patient comfortable.

The session moderator was the first to hesitantly move toward the stricken attendee. The moderator asked, as I recall, "I beg your pardon?" And once more, the victim said in a shallow voice, "I think I am having a heart attack."

Further delays in providing assistance

At this point, a few of us left our seats and cautiously approached the victim. But, none of us did anything constructive; we all just stood around the panicked victim in a circle for several more minutes, internally debating about what to do and wishing someone had enough first aid training to do something.

A major problem, to us, which should be mentioned, was that the victim was still conscious, sitting upright, and able to talk. In hindsight, he was in no shape to direct us through his crisis, but that is what we were expecting since he could speak. We may have been responsive if the victim had turned blue and slumped forward, unconscious. But it was not, as I recall, until the victim himself answered "Yes" to our question of sending for help that someone left the room to do so.

Until this point in time, what was actually done to aid the patient for perhaps as much as five minutes of this potentially life and death situation, was *nothing*. The first minute or two was spent looking at each other waiting for *someone else* to do something. The remaining time was spent chatting with the victim.

Uncertainty in even the basics

Once aid finally had been sent for, we seemed to be more willing to provide at least some useful assistance. Although many errors were committed, someone suggested that he should lay down flat, which he did with questionable assistance from us. Then discussions broke out as to whether his head or feet should be elevated or whether he should remain flat. No one knew the answer, so we left him flat. His head seemed uncomfortable, so we did roll up a tablecloth into a makeshift pillow. About this point, we thought it might be a good idea to loosen his tie and collar button.

He said his heart was "beating a mile a minute." I placed my hand on his chest and upon feeling the frightening pulse and intensity, I jerked my hand away and exclaimed, "My God." This obviously further upset the patient. Needless to say in hindsight, I do not know how I could have been so insensitive. The patient complained of being cold, so we used several more tablecloths to make a blanket to cover him from the neck down.

Help finally arrives

The person sent to seek help went to the SCTE registrtion area where Steve Cox, SCTE's new executive director, was on duty. Steve immediately called the front desk and gave them the details including the location of the victim. Steve then rushed to aid us.

Steve had had extensive medical training in the service, and his control and confidence of the situation was as much a relief to the patient as it was to all of us in the room. He immediately assured the patient that help was on the way, and to just relax. He checked the patient's vital signs, asked various pertinent questions, again reassured him that it did not look serious to him, and told him to try to remain as relaxed as possible. Steve then made minor adjustments to our makeshift pillow, and sponged off the patient's perspiring forehead with a dampened cloth napkin.

A few minutes later, the hotel security police arrived and it was obvious that they too were well trained in CPR and first aid. I think all of us were feeling very bad that we had done so little initially for the patient, due to our lack of proper training.

The security police were able to relay precise patient conditions to a rescue squad with their hand-held two-way radios. And, in just a few more short minutes, they arrived with stretchers, oxygen, and all the other needed items.

While everyone else, including the victim, was doing their job flawlessly, I'm afraid we were still bungling around. You see, the rescue squad rushed the patient to the hospital and none of us even offered to go with him. We did not offer to go to his room and pack a few personal items to take to him. We did not offer to call his wife or family. We did not even get his name.

I did learn that the patient lived through the heart attack, and us.

I do not know how well I have been able to capture the intense feeling of frustration I felt, helplessly standing by during this life and death situation of a fellow human being. It was an experience I would not wish on anyone.

A medical emergency can strike you or one of your employees at any time and at any place. Are you confident about your employees' basic first aid training if such a disaster occurs? Usually it only takes a call to your local Red Cross or fire department to set up an excellent CPR and first aid training program. Such programs must be repeated periodically to be effective, as we learned in this real life drama. The life you save may be your own.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