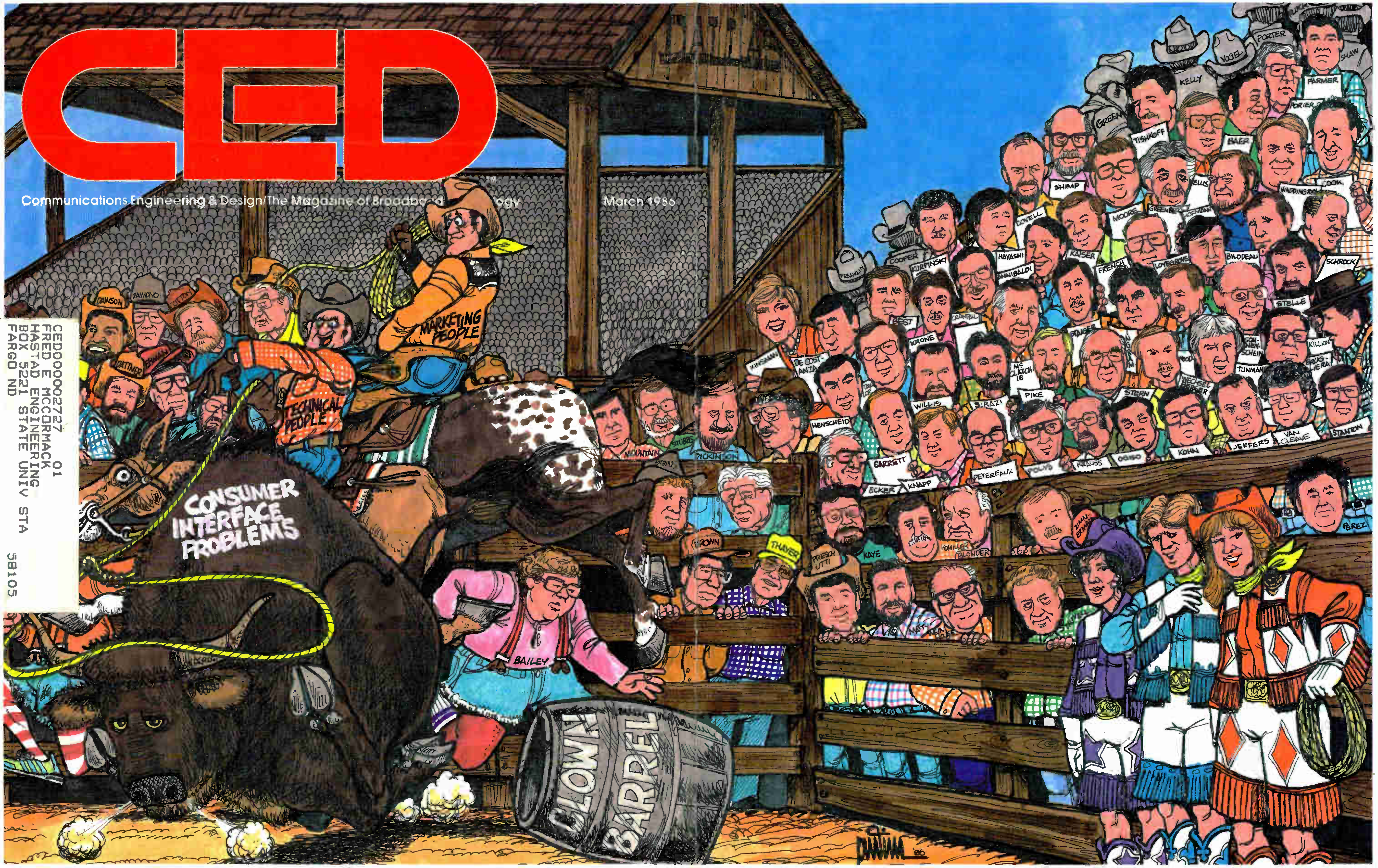
CED

Communications Engineering & Design/The Magazine of Broadband Technology

March 1986



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Scientific Atlanta

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Reader Service Number 1

CED

March 1986 Volume 12, Number 3

About the cover
CED corrals some big names in cable for our traditional NCTA cover. Original art by Rob Pudim.

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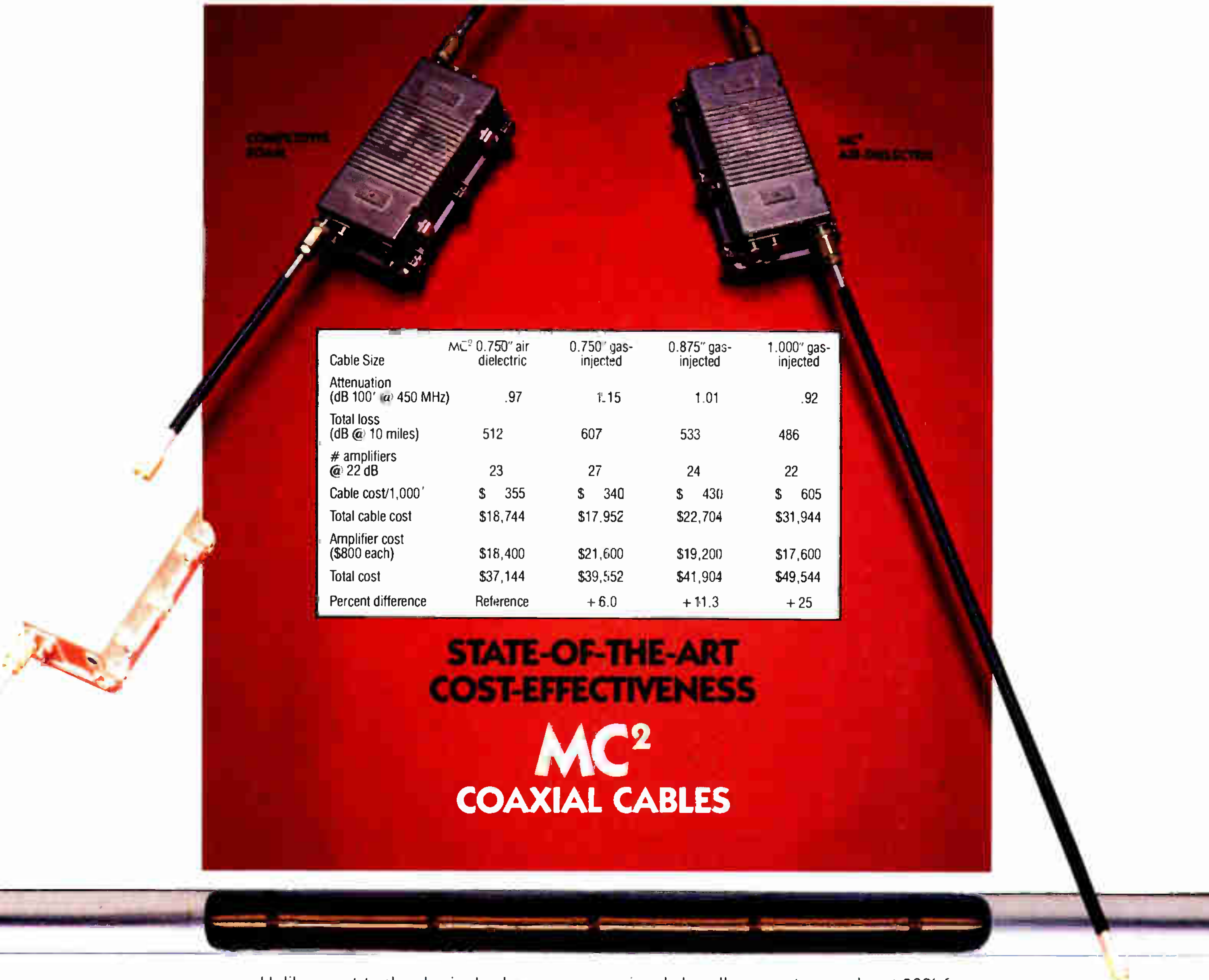

Cable Size	MC² 0.750″ air dielectric	0.750″ gas-injected	0.875″ gas-injected	1.000″ gas-injected
Attenuation (dB 100′ @ 450 MHz)	.97	1.15	1.01	.92
Total loss (dB @ 10 miles)	512	607	533	486
# amplifiers @ 22 dB	23	27	24	22
Cable cost/1,000′	$ 355	$ 340	$ 430	$ 605
Total cable cost	$18,744	$17,952	$22,704	$31,944
Amplifier cost ($800 each)	$18,400	$21,600	$19,200	$17,600
Total cost	$37,144	$39,552	$41,904	$49,544
Percent difference	Reference	+ 6.0	+ 11.3	+ 25

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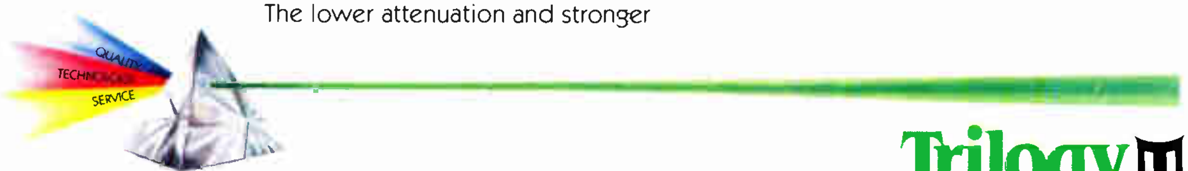

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Reader Service Number 2

Joe Van Loan: striving for excellence

Joe Van Loan is concerned about where the cable industry is headed and how it's going to get there. Suddenly operating in the face of fierce competition from VCRs and other alternate programming-delivery methods, some changes are in order. he says. And as the engineering vice president at Viacom, Van Loan is making those changes in his own ranks.

"We simply must learn to work more efficiently," Van Loan claims. "If we don't, others will; and we will not survive." What are the keys to successful operation in the face of competition? It's as basic as good service at a competitive price, according to Van Loan.

Van Loan has several specific suggestions to cable operators: "If we are overstaffed or under-utilizing our people, we must look at how to become more productive and efficient. Satisfying the customer is the ultimate goal and, often, fewer people can do that because a happy subscriber doesn't need as many service calls."

"We must take greater care to measure our people's performance—not only in quantity, but quality as well. The supervisor needs to actually go out and check on an installer's work instead of sitting at his desk all day," Van Loan insists.

Attitude isn't the only variable in the productivity equation that needs changing, though, he says. Some of the equipment being bought and sold needs to be re-examined, as well. "In the past, we were so caught up in growth that we would accept anything the manufacturers shipped us simply because there was a customer waiting. The cable industry was in the growth mode, and the manufacturers didn't have any incentive to build quality products," Van Loan asserts. "But now that things are changing, we don't want to repeat the sins of the past. There must be a renewed fervor for quality."

Ease of product use is the third variable in the success formula, and Van Loan is the first to recognize that we have some serious problems in that regard. "A VCR is hard enough to use and program without cable. With cable, it's almost impossible." And, although many companies are introducing switchers and programmable timers to help ease the confusion, Van Loan feels the optimum solution is much more long term: "The cable industry needs to come to a decision about the EIA/NCTA interface.

"A good way to go forward would be for the NCTA engineering committee to come to a conclusion, perhaps take a vote, and then, if they choose to endorse the interface, have the NCTA Board endorse it also. Public commitments from some of the major MSOs would probably go a long way in helping the cause, too," he suggested.

Although virtually all the major cities have been built, there is still room for growth in the cable industry, concludes Van Loan. "If we are going to survive with the kinds of competition we are presently facing, it's time to ask ourselves if we should be in the telephone business. First, in the local area network markets and, maybe eventually, in residential phone service as well. I am delighted to see Viacom moving in those directions, and I would like to see the industry in general thinking more along lines."

Van Loan has set some high goals for the cable industry but, like all changes, increased productivity and efficiency in cable have to start from within. What can you do today, right now, to begin?

—Lesley Dyson Camino

QUICK,...WHAT DO JERROLD, OAK, AND HAMLIN ALL HAVE IN COMMON?

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Reader Service Number 3

Proposed EIA Interim Standard IS-15

Many in the cable TV industry have long considered the ubiquitous converter to be a necessary evil. Not only do converters account for a large portion of the capital investment per subscriber, they also represent a major cause of customer complaint. In these respects, the situation has improved substantially in recent years. In 1970, a plain converter, the 26-channel Gamut 26, sold for $30—the equivalent of about $85 in 1986, after adjustment for inflation. Today, the price is less than half that, the channel capacity is much greater and cordless remote control is available. Failure rates have dropped sharply from the 20 percent to 30 percent commonly experienced several years ago to less than 5 percent.

Notwithstanding, the converter interface is still too expensive and, at best, an irritation to our customers. There must be a better way.

All of the functions of a converter (except descrambling) are, or should be, provided in the TV set. All TV sets have some kind of channel selector, and most of the new ones are capable of selecting mid-band and super-band cable TV channels. Why, then, should cable subscribers be required to pay for another set-top channel selector? Not only does it represent additional investment to be recovered through subscriber fees, but it also compromises enormously the convenience of infra-red remote control and degrades (to a limited extent) the quality of the received TV signal.

Even worse is the baseband converter in which a channel is selected, processed at IF, demodulated, then actually remodulated and the entire process repeated all over again in the TV set. This ridiculous situation exists because, until recently, TV reception technology has developed entirely in the over-the-air broadcast environment—with almost no coordination with cable TV delivery systems or the other potential uses for the TV display section.

Nearly 20 years ago, the first converters were introduced in Manhattan Borough of New York to overcome the direct pickup interference from seven VHF stations transmitting (then) from the Empire State Building. Hubert Schlafly, engineering vice president at Teleprompter, pleaded with TV set manufacturers to provide an externally accessible IF jumper so the converter could be connected directly to the receiver IF instead of through the leaky 300 ohm TV antenna terminals and another tuner.

To its credit, the receiver industry in the mid 1970s, as a consequence of the CTAC advisory committee to the FCC, researched the matter of immunity to interference from strong local co-channel signals. An EIA Bulletin was published in 1975, regarding this and other aspects of compatibility with CATV. The IF jumper was not part of the answer. The Bulletin never developed into even an Interim Standard, which would have been subject to rigorous public review. However, receiver manufacturers did begin to provide 75 ohm coaxial input ports, possibly motivated as much by desire to improve color reception off-the-air as to relieve the CATV direct pickup problem. This helped some but, because of design mistakes, many of the coaxial input ports turned out to be more or less ineffective.

Probably the most upsetting misunderstanding between the two industries was the heavily touted "cable-ready" TV set, which was actually "ready" only for non-premium cable customers. The receiver people genuinely believed they had produced the cable-compatible TV receiver we all wanted. They were incensed, and perhaps a little chagrined, when they discovered that cable operators continued to install the noxious converters even with "cable-ready" receivers.

The sad part is that neither the cable operators nor the receiver manufacturers anticipated the angry customer reaction when they discovered, after purchasing a deluxe, premium-priced TV set, that the attractive conveniences of the remote control are rendered almost useless by a cable connection. Adding to this fiasco is the frustration of cable customers who attempt in vain to connect a VCR.

Now, stereo sound adapters complicate the situation even further. The market presently is inundated with ingenious, somewhat Rube Goldberg, adapters meant to overcome the consumer's frustration. They are only band-aids, temporarily useful to hold the jury-rigged system together long enough to produce consumer electronic equipment expressly designed to serve as the receiver and display for a variety of signals in addition to over-the-air NTSC TV broadcasts.

At last, the cable industry and the consumer electronics industry, through the NCTA and EIA, have been working together in an attempt to assuage the consumer's dismay. The effort has been significantly prodded by the explosive spread of VCRs and the adoption of multi-channel TV sound.

The product of the joint effort is a proposed Baseband (Audio/Video) Interface Standard connector, analogous to the RS-232 standard interface connector for computers. This proposal is expected to be adopted soon as an Interim Standard, EIA IS-15. Television sets with IS-15 interface are likely to appear in dealer's showrooms as early as 1988.

What is the IS-15 interface? Here is how the EIA Proposal describes it:

Continued on page 40

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

Remember when 20, 12 - even 5 channels were your maximum potential? Now...

Rebuilding? Save Money With JERROLD

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

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

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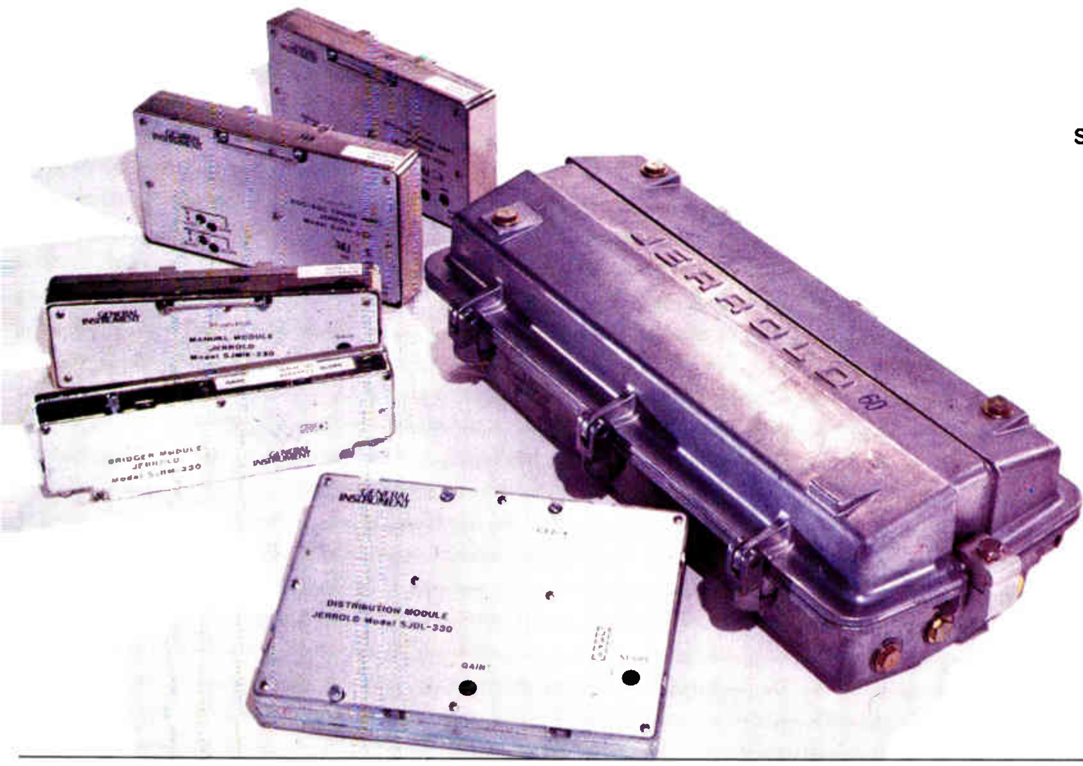


Reader Service Number 4

GENERAL INSTRUMENT

return path

CLI program response

In the February 1985 issue of *CED*, you published an article entitled "Living with 21006," by Roy Ehman. While I enjoyed the information provided and found it useful, I did not find the sample computer program as easy to understand or use. It led me to looking into alternatives. Enclosed please find two of my own versions of a Cumulative Leakage Index program—one using the BASIC language for IBM (and compatibles), the other using the Lotus 123 software. Both programs work extremely well and may be of some use to your readers.

In the BASIC language version, the remarks in lines 1 through 8 and again in lines 401 through 407 give instructions on how the program may be tailored to the user's particular needs.

In the Lotus 123 version, all fields are "protected" from accidental erasure using the "/ Worksheet Global Protection Enable" command, followed by "/ Range Unprotect" command for cells B6 through B17. This feature protects accidental damage to formulas and titles, or instructions within cells which are permanent in nature.

To use the Lotus version, the user simply loads the program from disk and then fills in the blanks called for. The CLI is calculated automatically and printed out. The enclosed printout gives the entries, including formulas, for all cells used, and the user simply needs to transcribe the entries into the correct cell locations. Column widths are: A=44, B=9, C=19 and D=9. Note that there are no data in Column C. These column widths were chosen to keep Column D "off page" and out of normal view. This column contains the actual formula cells and calculations which lead to the CLI provided in view in Column B21.

In transcribing the entries from the printout, the user should ignore the "U" at the beginning of cells B6 through B17. This "U" is printed to simply denote which cells are unprotected. [Note: In the sample printout provided, column B21 (the CLI) reflects "ERR" because a formula is within this cell and no data has been entered. This is normal and will disappear when data are entered, and has no effect on the program performance.]

```
Plant size in miles: 170
Total miles driven: 75
# of leaks found at 50 uV/M:    25
# of leaks found at 100 uV/M:    5
# of leaks found at 150 uV/M:    0
# of leaks found at 200 uV/M:    0
CLI is: 54.0654
```

```
1 REM * * THIS PROGRAM MAY BE MODIFIED TO SUIT ANY VALUES OF LEAKAGE READING
2 REM * * LEVELS BY CHANGING THE VALUES IN LINE 110 THRU 180. LIKEWISE,
3 REM * * THE NUMBER OF DIFFERENT LEVELS MAY ALSO BE MODIFIED. IF THE NR.
4 REM * * OF LEVELS IS MODIFIED, THEN LINES 300 THRU 330 MAY ALSO HAVE TO BE
5 REM * * CHANGED ACCORDINGLY AS WELL AS A CHANGE IN LINE 400. WHILE THIS
6 REM * * PROGRAM IS DESIGNED TO DRIVE A PRINTER, IT MAY ALSO BE MODIFIED TO
7 REM * * RUN WITHOUT ONE, BY SIMPLY CHANGING ALL LINES CONTAINING "LPRINT"
8 REM * * TO READ "PRINT"

10 CLS
20 LPRINT TAB(20) "McCAW CABLEVISION, CLOVIS NM"
30 LPRINT TAB(22) "CUMULATIVE LEAKAGE INDEX"
40 LPRINT TAB(22) "BY BOB BAKER—JAN 1986"
50 PRINT
60 PRINT
70 INPUT "PLANT SIZE IN MILES"; PS
80 LPRINT "PLANT SIZE IN MILES: "; PS
90 INPUT "TOTAL MILES DRIVEN"; MD
100 LPRINT "TOTAL MILES DRIVEN: "; MD
110 INPUT "NR. OF LEAKS FOUND AT 50 uV/M"; L1
120 LPRINT "NR. OF LEAKS FOUND AT 50 uV/M: "; L1
130 INPUT "NR. OF LEAKS FOUND AT 100 uV/M"; L2
140 LPRINT "NR. OF LEAKS FOUND AT 100 uV/M: "; L2
150 INPUT "NR. OF LEAKS FOUND AT 150 uV/M"; L3
160 LPRINT "NR. OF LEAKS FOUND AT 150 uV/M: "; L3
170 INPUT "NR. OF LEAKS FOUND AT 200 uV/M"; L4
180 LPRINT "NR. OF LEAKS FOUND AT 200 uV/M :"; L4
300 S1 = L1*50*50
310 S2 = L2*100*100
320 S3 = L3*150*150
330 S4 = L4*200*200
400 CLI = 10*(.4342945*(LOG((PS/MD)*(S1 + S2 + S3 = S4))))
401 REM * * THE ABOVE FORMULA ASSUMES THAT THE BASIC LANGUAGE CALCULATES
402 REM * * LOGARITHMS TO THE NATURAL BASE, AND THEREFORE CONVERTS THEM
403 REM * * TO A COMMON LOG BY ADDING THE CONVERSION FACTOR OF "0.4342945"
404 REM * * TO THE BEGINNING OF THE FORMULA. IF YOUR BASIC LANGUAGE
405 REM * * ALREADY CALCULATES LOGS TO THE BASE 10 (COMMON LOGS), THEN
406 REM * * SIMPLY OMIT THIS FACTOR AND REWRITE THE FORMULA TO READ
407 REM * * CLI = 10*(LOG((PS/MD)*(S1 + S2 + S3 = S4)))
410 LPRINT "CLI IS:";CLI
420 IF CLI > 64 THEN LPRINT "CLI EXCEEDS FCC LIMIT OF 64"
430 END
```

```
Enter the plant size in miles:     [     ]
Enter the total miles driven:      [     ]
Enter the # of leaks
found at 50 uV/M:                  [     ]
Enter the # of leaks
found at 100 uV/M:                 [     ]
Enter the # of leaks
found at 150 uV/M:                 [     ]
Enter the # of leaks
found at 200 uV/M:                 [     ]
Enter the # of leaks
found at 250 uV/M:                 [     ]
Enter the # of leaks
found at 300 uV/M:                 [     ]
Enter the # of leaks
found at 350 uV/M:                 [     ]
Enter the # of leaks
found at 400 uV/M:                 [     ]
Enter the # of leaks
```

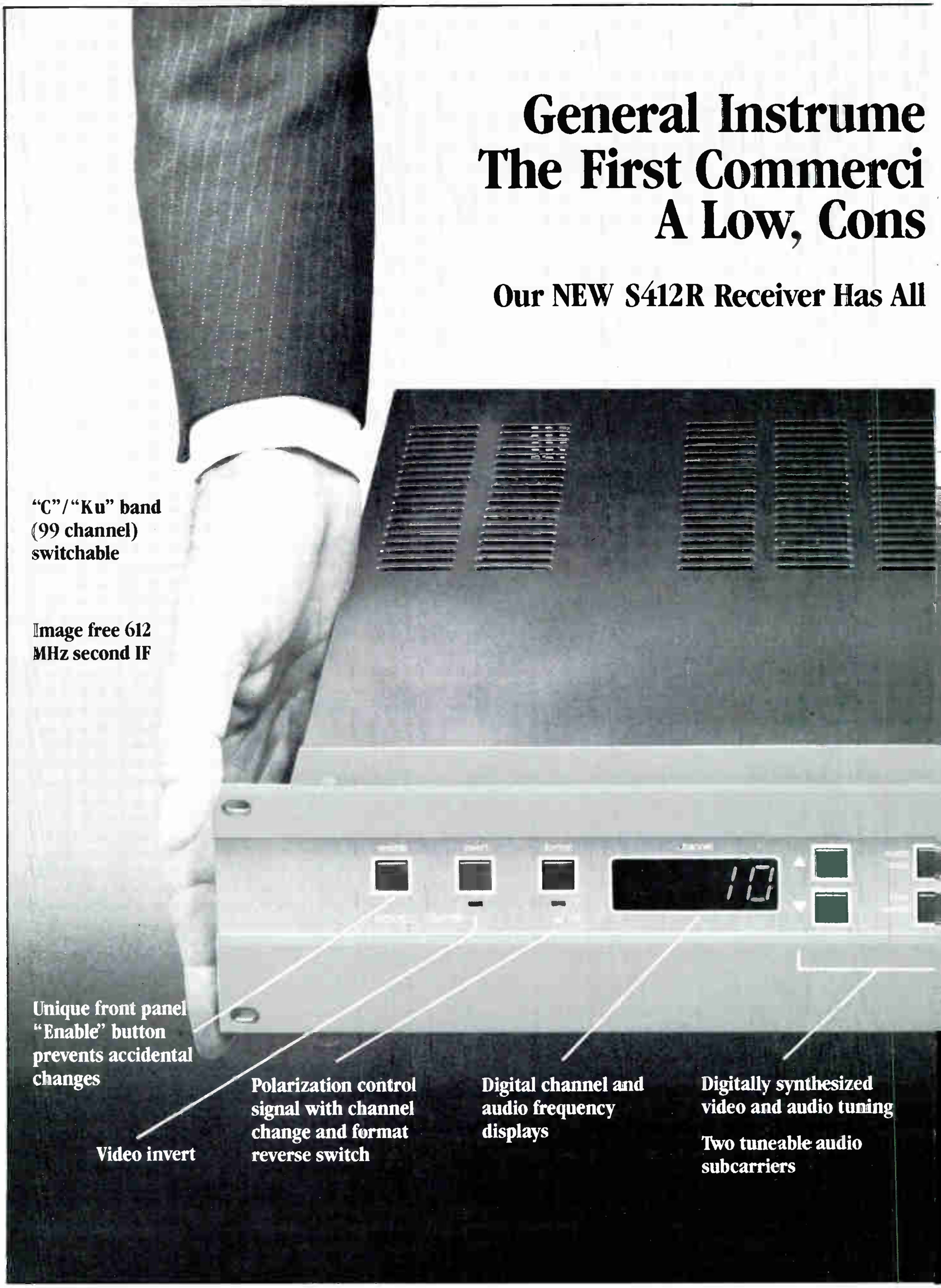
The enclosed printout gives the entries, including formulas, for all cells used.

found at 450 uV/M: [ ]
Enter the # of leaks
found at 500 uV/M: [ ]

CUMULATIVE LEAKAGE INDEX IS: ERR
(Maximum FCC CLI is 64)

A1: ^McCAW CABLEVISION, CLOVIS NM
A2: ^CUMULATIVE LEAKAGE INDEX CALCULATIONS
A3: ^by Bob Baker & Lotus 123, Jan 86
A4: \ =
B4: \ =
C4: \ =
A6: 'Enter the plant size in miles:
B6: U '[ ]
A7: 'Enter the total miles driven:
B7: U '[ ]
D7: +B6/B7
A8: 'Enter the Nr. of leaks found at 50 uV/M:
B8: U '[ ]
D8: +B8*50*50
A9: 'Enter the Nr. of leaks found at 100 uV/M:
B9: U '[ ]
D9: +B9*100*100
A10: 'Enter the Nr. of leaks found at 150 uV/M:
B10: U '[ ]
D10: +B10*150*150
A11: 'Enter the Nr. of leaks found at 200 uV/M:
B11: U '[ ]
D11: +B11*200*200
A12: 'Enter the Nr. of leaks found at 250 uV/M:
B12: U '[ ]
D12: +B12*250*250
A13: 'Enter the Nr. of leaks found at 300 uV/M:
B13: U '[ ]
D13: +B13*300*300
A14: 'Enter the Nr. of leaks found at 350 uV/M:
B14: U '[ ]
D14: +B14*350*350
A15: 'Enter the Nr. of leaks found at 400 uV/M:
B15: U '[ ]
D15: +B15*400*400
A16: 'Enter the Nr. of leaks found at 450 uV/M:
B16: U '[ ]
D16: +B16*450*450
A17: 'Enter the Nr. of leaks found at 500 uV/M:
B17: U '[ ]
D17: +B17*500*500
D19: @SUM(D8..D17)
D20: @LOG(D7*D19)
A21: 'CUMULATIVE LEAKAGE INDEX IS:
B21: 10*D20
A22: ' (MAX FCC CLI IS 64)

Robert E. Baker,
Plant Manager,
McCaw Cablevision,
Clovis, N.M.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The First Commerci
A Low, Cons
Our NEW S412R Receiver Has All
"C"/"Ku" band (99 channel) switchable
Image free 612 MHz second IF
Unique front panel "Enable" button prevents accidental changes
Video invert
Polarization control signal with channel change and format reverse switch
Digital channel and audio frequency displays
Digitally synthesized video and audio tuning
Two tuneable audio subcarriers


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Threshold extension circuitry without bandwidth compression
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Reader Service Number 6

Computer III and cable's future

Perhaps the skipper of a luxury ocean liner, languorously plying the North Atlantic waters on well-defined routes, doesn't need vision. Short of hitting an iceberg, little can go wrong.

On the other hand, suppose you're the captain of a small, wooden vessel filled with hungry sailors on a long voyage, without benefit of charts, seeking America.

The issue, of course, is vision and temperament. Years ago, when the cable industry left port, it was inexperienced. You've got your sea legs now, no question. You can take the vessel where it must go. But so can lots of other crews.

Still, you're a big luxury liner, and nobody will blame you for wanting to cruise awhile and just avoid hitting those icebergs.

But I wonder: are you still looking for America? Others may be.

Perhaps I'm looking too far into the fog, but some recent FCC proceedings keep me wondering. Since the FCC's 1980 "Computer II" decision, telcos have been allowed to offer computer equipment and "enhanced" services like protocol conversion or data storage only through separate, arms-length subsidiaries. The intent: to prevent cross-subsidization of non-regulated businesses by the regulated businesses.

As things stand now, the telcos must separate their regulated and unregulated businesses. But some of the RBOCs are clamoring to get back into the equipment manufacturing and long-distance business—activities barred by the AT&T divestiture agreement. And virtually all the RBOCs are lobbying for regulatory relief at the state and federal levels.

Without question, local Bell operating companies want to become information companies like AT&T or IBM—able to send and process information of all types. Nobody, it seems, wants to offer plain old telephone service as a primary business anymore.

User bypass of the local telephone network is the big worry, but cellular telephone systems and shared tenant services (buildings that provide telephone and communication services in addition to heat, water and light) are other businesses RBOCs would like to be in. And Nynex, Bell Atlantic and Pacific Telesis have opened retail computer stores. BellSouth has formed FiberLAN, a company that installs fiber optic local area networks.

At the moment, the AT&T divestiture agreement bars the RBOCs from offering information services—as distinct from communication services. But sometime this spring, the commission will rule on "Computer III," a possible landmark case that could lift some of the current restrictions on non-regulated AT&T and RBOC activities. There's some possible overlap between the FCC's rules and those stipulated by the Justice Department's divestiture rules, so further action might be necessary.

So what's the big deal? The skirmishing over CI3 is just the camel's nose under the tent. Speaking at a recent Communications Networks Conference, FCC Chairman Mark Fowler called for total deregulation of all telcos, providing that access to local switching centers was provided.

"The public utility model does not always apply—and, perhaps, should never have applied lock, stock and barrel—to the entire field of telecommunications," Fowler said.

Here's Fowler's deal. Local switching centers are opened to competition, whether this is a physically co-located switch or a "comparably efficient interconnection." In return, all entry and rate regulations are dropped.

Sweeping, simple, controversial. And certainly a precedent for other cases that might come along.

Bear in mind that what is being proposed here is an open systems architecture: multiple access to telephone switching centers by competing vendors. No more administratively created monopoly. No franchise.

Keep in mind also the comparable moves to open systems architecture in the data communications and CATV worlds. In data, it's the Manufacturing Automation Protocol and Corporation for Open Systems. MAP is a standard for components and software relating to factory automation. Frustrated by the high cost of customizing interfaces for the myriad of devices hooked to its internal communication networks, General Motors put together a powerful group of buyers. The objective: vendor independence. GM wants the freedom to attach many different types of devices, made by differing companies, to its internal networks.

And it looks like GM will get its way. Likewise, the COS is a new group, including IBM, that plans to support standards-making procedures for data communications set by the International Standards Organization. The 22-member COS includes major computer and communications equipment manufacturers.

Even in cable, we're beginning to move towards open systems, spurred by converter capital costs and the availability of cable-ready tuners. The Electronic Industries Association's new baseband interface standard, for example, is another step on the road to open systems.

Granted, not many in CATV are the slightest bit worried about the telcos sniffing around for CATV's business. Maybe some of us are trying too hard to see through the fog.

Maybe.

In any case, we intend to follow this and related cases. And to make things easier for you, we've got a new look, beginning with the issue you hold in your hands. It's nothing major, simply a polishing and refinement of what we've been doing all along. But, as a whole, you should now find the material in *CED* easier to digest.

The objective throughout—from cover copy to classifieds—is accessibility. Hopefully, you'll discover, without knowing exactly why, that the pages are more inviting, easier to read and follow.

We'd welcome your comments. Send your letters to the editor, *CED*, P.O. Box 5208 T.A., Denver, Colo. 80217. Or give me a call at (303) 860-0111.

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Second-order distortion in push-pull amplifiers

Push-pull really does work, as William Lambert demonstrated in this timeless article, written back in 1970. If you've always wanted to know how, here's your chance.

Techniques previously presented to the cable television industry for carrying multichannel television signals include the octave system, the split-band system, the push-pull system and the two-cable system. Some of the advantages of a system designed with push-pull equipment can be described as: 1) full spectrum availability, 2) increased output capability, 3) low group delay distortion (advantage over split-band), 4) ready availability of two classes of service and 5) use of a converter required only for premium service.

Perhaps the only disadvantage attributed to a push-pull system would be the apparent complexity of the equipment design. However, if the problem areas are defined at the outset of the design effort, proper attention then can be given to details so that well-designed, reliable equipment is readily attainable for yielding the desired system performance.

Second-order distortion in broadband amplifiers is not new. The distortion has always been there, and the beats and second-harmonic components resulting from the second-order nonlinearity of the amplifier have always been with us. However, until the advent of midband channel usage, this type of distortion has never been of any concern. But when it becomes necessary to use parts of the spectrum that are not octavely related, it becomes necessary to minimize second-order distortion in the amplifiers.

How does second-order distortion show up in a TV picture? No simple answer is possible since the degree to which the beat is objectionable is a function of many things. For instance, a second-order beat that falls below the visual carrier is much less objectionable than one that falls above the visual carrier but below the aural subcarrier. Also, the actual frequency of the beat itself is a factor for if the beat frequency is harmonically related to the horizontal line frequency, the beat pattern will show up as vertical lines on the screen—the number of lines being determined by the harmonic relation to the horizontal sweep rate. If the interfering beat is an odd multiple of half the line rate, the beat loses itself in the interlace and is not visible. Any combination in between will show up as diagonal lines.

In order to design a system using push-pull amplifiers, a design limit of second-order distortion is needed. How much beat will a viewer tolerate? In an attempt to answer this question, we have made many subjective tests. It was found that a second-order beat (generated from modulated carriers) down at least 60 dB from the visual carrier level was barely perceptible to most people. The most critical condition occurs when the picture includes a large area of constant tone or hue—such as the background seen on a typical panel show.

In performing the tests, channels 2 and 13 and a carrier at 157.25 MHz were passed through amplifiers with channel 13 being observed on a color TV set. The sum beat of the video carriers in channels 2 and G falls into channel 13, 1.25 MHz above its video carrier. The example above is one of a sum beat with the three channels given. There also are other second-order distortion components, namely, difference beats, an example of which would be 13-G, the beat falling into channel 2; and 13-2, the beat falling into G. In the case of the difference beats into 2 and G, the interference is 1.25 MHz below video carrier. This will provide no visible distortion whatever.

Also present at the output of the amplifier was the second harmonic of each of the above channels. These were not considered, in that the second harmonic is inherently 6 dB down from the sum and difference beats[1][2].

Many other conditions attach to any subjective testing. However, it suffices to say that, as a result of subjective tests, it was found that if the sum or difference beat, generated from CW carriers, delivered to the TV set was in no case worse than -60 dB, the interference (from modulated carriers) on the screen would not be perceptible to most people. It should be pointed out, however, that if the second-order distortion is allowed to increase by only 6 dB, the visible interference becomes quite objectionable. Except as noted, the carriers used in all the tests were

By William Lambert, Vice President/General Manager, Jerrold Distribution Systems Division

Cable Classics

Push-pull amplifiers now are taken for granted as building blocks in modern cable systems. Indeed, we take for granted the use of channel plans in which second order distortion (sum and different beats and second harmonic) does occur and can affect system operation. In cable, push-pull amplifiers first were introduced to permit the transportation and test of multichannel television signals—meaning mid-band and super-band channels in addition to the 12 standard broadcast channels.

This paper by Bill Lambert, originally published in 1970, addresses some of the questions of designers and users of push-pull amplifiers.

What second order beat level will a viewer tolerate? What is the second order performance required of each amplifier in a cascade? What is the performance of the individual amplifier stages in a push-pull amplifier? How much push-pull is required to cancel second order distortion sufficiently to achieve the required signal amplifier performance? How sensitive is second order performance of an amplifier to gain and phase tolerances of circuit components?

This article explores these questions, provides a mathematical treatment and plots curves showing the results.

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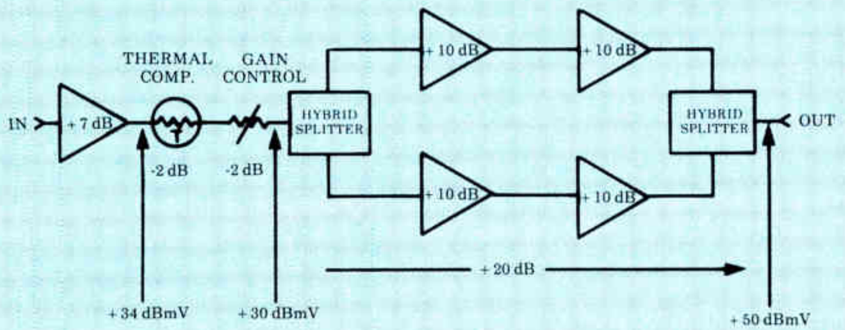
It is necessary to know how the second-order "builds up" in a system of cascaded amplifiers.

FIGURE 1

Block diagram of model SMM-P push-pull amplifier with manual gain control



modulated with normal video signals.

From these tests it was determined that a signal with second-order distortion components of -60 dB (as generated from CW carriers) was the minimum that we wanted to deliver to the customer's TV set.

How much push-pull

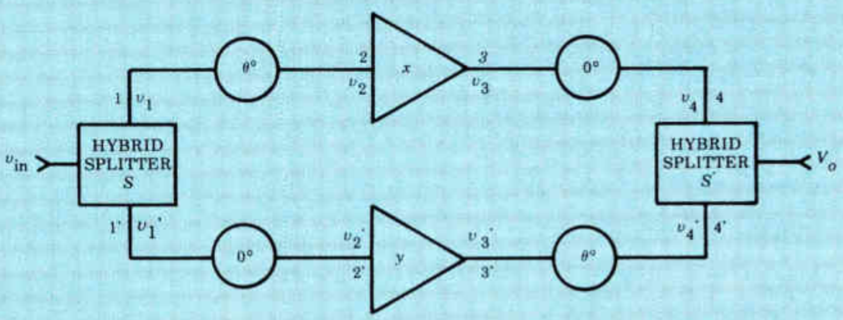
Having ascertained that the worst second-order distortion that can be tolerated in the system is 60 dB down, the question must be asked: What second-order performance is required from each amplifier and how much push-pull is required to obtain this performance? In order to answer this question properly, it is necessary to know how the second-order "builds up" in a system of cascaded amplifiers.

From extensive tests performed in the field and in the laboratory, it was determined that holding the second-order beat in each trunk amplifier be-

The feed amplifiers also must be designed with individual amplifier performance of -66 dB second-order distortion at their rated output.

FIGURE 2

Block diagram of push-pull amplifier



low -66 dB at a rated output of +50 dBmV resulted in a trunk cascade in which the second-order distortion was no worse than -66 dB at the end of the cascade and at normal system operating levels (about +32 dBmV).[3]

Similarly, the feed amplifiers also must be designed with individual amplifier performance of -66 dB second-order distortion at their rated output. When this is done, any combination of trunk and feeder will provide second-order distortion that is at least -60 dB down to any tap in the system. It must be emphasized that the second-order buildup in a short cascade (two or three amplifiers, typically found on feeders) is such that, if the second-order distortion of the distribution amplifiers is not at least 66 dB down at their rated output, it is impossible to deliver signals to a TV set anywhere in the system with a second-order distortion specification of -60 dB.

In this way we arrive at a second-order performance requirement in each amplifier of -66 dB at +50 dBmV. The details of amplifier design follow from this requirement. Figure 1 is a block diagram of an arrangement found adequate in this respect. Three stages are used, a single-ended input amplifier followed by two stages in push-pull. The single-ended stage has 7 dB of gain. The gain control and thermal compen-

If proper care is taken in designing the push-pull stage, it is possible to achieve at least 20 dB of improvement.

FIGURE 3

Push-pull amplifier Gain A_1 versus y amplifier gain a_{1y}

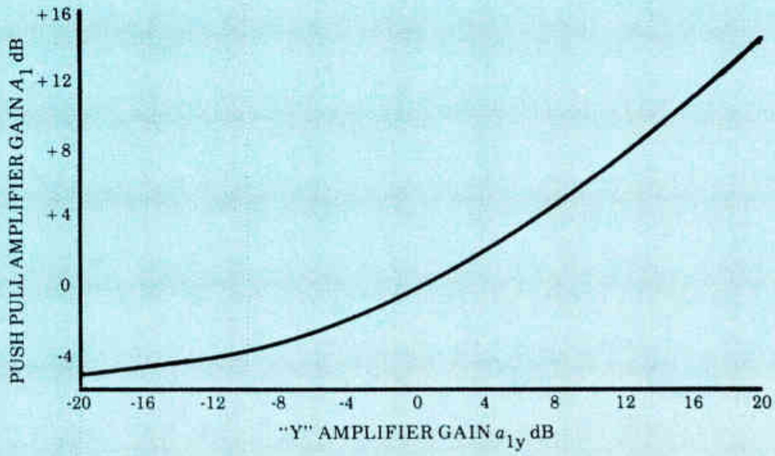
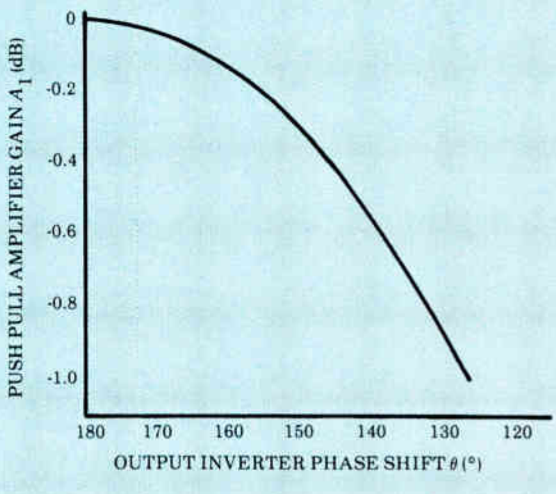


FIGURE 4

Push-pull amplifier Gain A_1 versus inverter phase shift for equal individual amplifier gain $a_{1x} = a_{1y}$ and $\phi = 180°$



sation circuits introduce 4 dB of loss and the push-pull stages provide 20 dB of gain. Thus, the entire amplifier has an overall gain of 23 dB.

Individual transistor stages of the type used in this amplifier generate beats below -55 dB at an output of +50 dBmV. The beat level, relative to the output, is reduced 1 dB for each decibel decrease in output. If the amplifier is designed as shown in Figure 1, the first-stage output level will be 16 dB below the amplifier output level. Thus, at +50 dBmV output, the first-stage level is +34 dBmV and its second-order distortion will be -71 dB. If proper care is taken in designing the push-pull stage, it is possible to achieve at least 20 dB of improvement due to push-pull. Then the second-order distortion of the push-pull section will be at least -75 dB at +50 dBmV output. Adding the second-order distortion of the push-pull stage and single-ended stage will yield a second-order beat for the total amplifier that is no worse than -66 dB at +50 dBmV.

Mathematics of push-pull

The objective here is to derive a mathematical model for push-pull amplifiers so the reduction of second-order distortion can be calculated. The push-pull amplifier performance is evaluated as a function of gain and phase balance. Figure 2 is a block diagram of a possible configuration for a push-pull amplifier. The amplifier consists of two hybrid splitters (S and S'), two phase inverters (ϕ and θ), and two amplifiers (x and y).

For purpose of this mathematical treatment, the transfer characteristics of each of the two amplifiers are described by the Taylor expansion.

$$v_o = v_{in}a_1 + \overline{v_{in}}^2 a_2 + \overline{v_{in}}^3 a_3 + \overline{v_{in}}^4 a_4 + \cdots$$

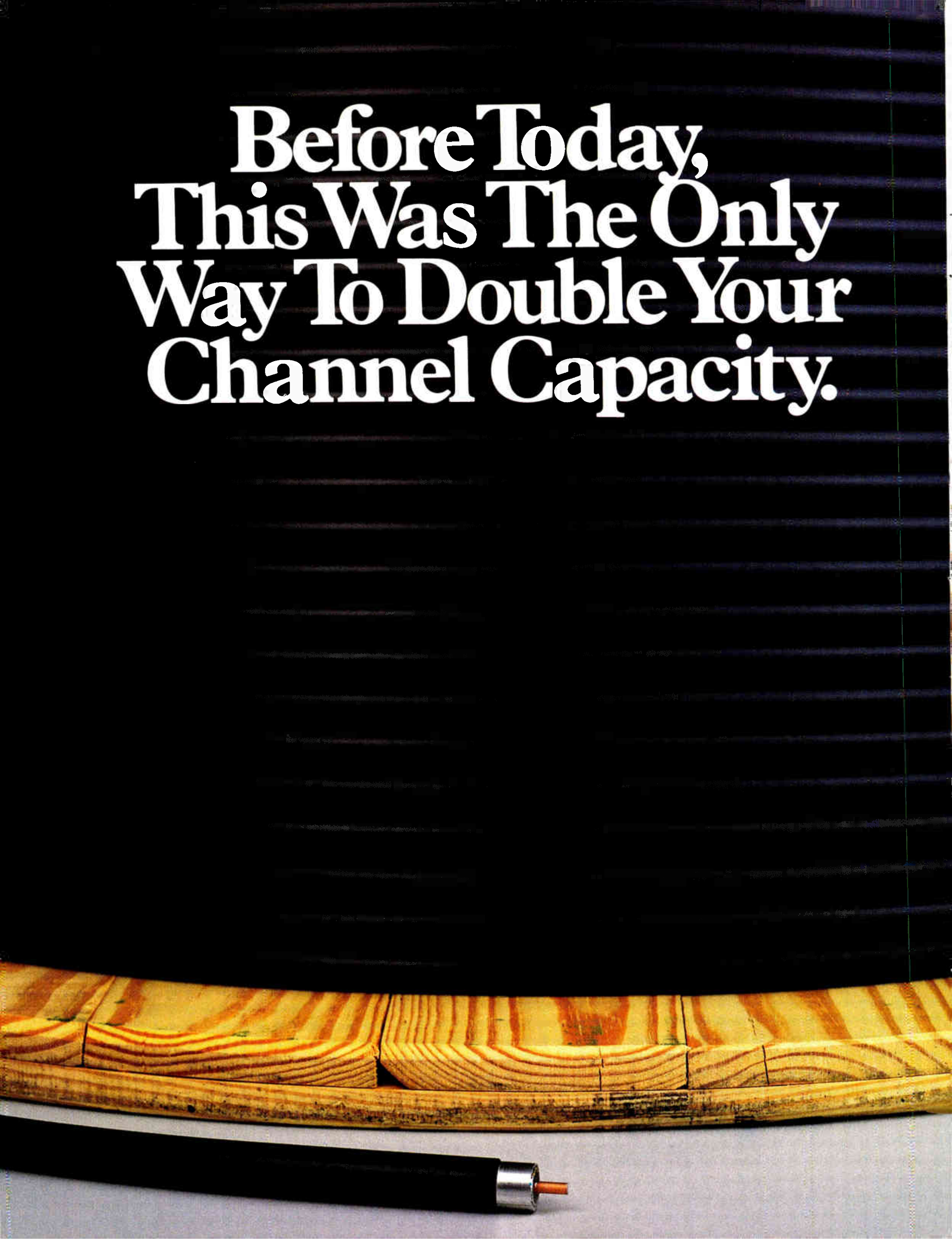
In this expression, v_o is the total output signal containing the fundamental, the second-order distortion components, the third-order distortion components, the fourth-order distortion components, etc. In our analysis, all components above third order will be ignored.

The fundamental signal at the output of the amplifier is $v_{in}a_1$. The second-order distortion components (second harmonic, sum beat and difference beat) are represented by the second term in the expression, $v_{in}^2 a_2$; the third-order distortion components (compression, X_{mod} triple beat, and IM) are represented by the third term of the Taylor expansion, $v_{in}^3 a_3$.

The input signal to the hybrid splitter S is v_{in}. At its outputs 1 and 1′ the signals are:

$$v_1 = 0.707\, v_{in}$$

$$v_{1'} = 0.707\, v_{in}$$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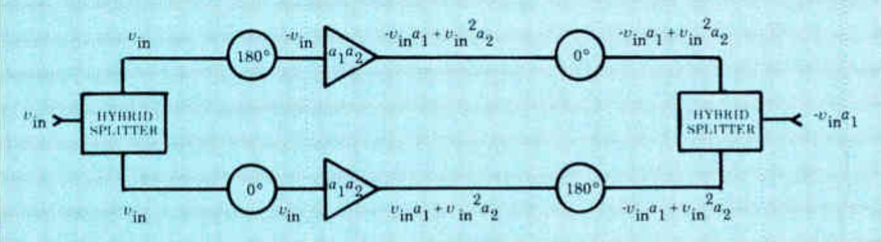
The objective is to derive a mathematical model for push-pull amplifiers so the reduction of second-order distortion can be calculated.

FIGURE 5

Block diagram of ideal push-pull amplifier



where 0.707 represents the voltage division of the 3 dB split. The phase inverter reverses the polarity of one signal. At the amplifier inputs 2 and 2′, the signals are:

$$v_2 = 0.707\, v_{in} e^{j0}$$

$$v_{2'} = 0.707\, v_{in}$$

The signals at outputs 3 and 3′ of the x and y amplifiers can be written as follows:

$$v_3 = 0.707\, v_{in} e^{j0} a_{1x} + (0.707\, v_{in} e^{j0})^2 a_{2x} + (0.707\, v_{in} e^{j0})^3 a_{3x}$$

$$v_{3'} = 0.707\, v_{in} a_{1y} + (0.707\, v_{in})^2 a_{2y} + (0.707\, v_{in})^3 a_{3y}$$

(As previously mentioned, distortion terms above third order are ignored.) The signals at the input to the summing hybrid splitter S' are written as follows:

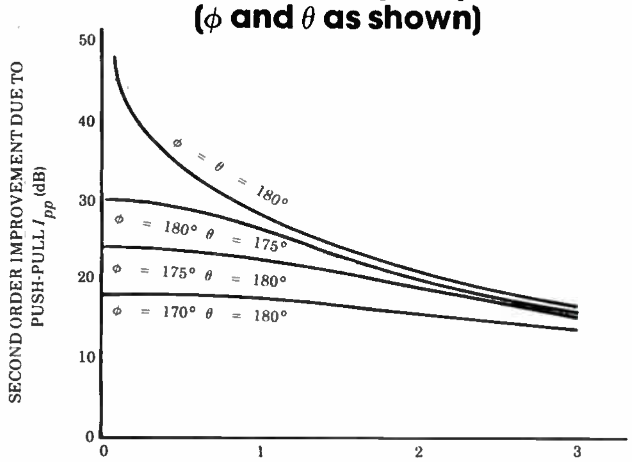
$$v_4 = 0.707\, v_{in} e^{j0} a_{1x} + (0.707\, v_{in} e^{j0})^2 a_{2x} + (0.707\, v_{in} e^{j0})^3 a_{3x}$$

$$v_{4'} = 0.707\, v_{in} e^{j\theta} a_{1y} + (0.707\, v_{in})^2 e^{j\theta} a_{2y} + (0.707\, v_{in})^3 e^{j\theta} a_{3y}$$

The push-pull amplifier performance is evaluated as a function of gain and phase balance.

FIGURE 6

Second-order reduction due to push-pull versus second-order differential between *x* and *y* amplifier (ϕ and θ as shown)



The output V_o of the push-pull amplifier is the sum of signals v_4 and $v_{4'}$ as processed by the hybrid splitter S'.

$$V_o = 0.707\, v_4 + 0.707\, v_{4'}$$

where the factor 0.707 accounts for the 3 dB split. As mentioned above, the amplifier output contains many components (the fundamental, second-order distortion components, and third-order distortion components). This is written as

$$V_o = v_{o1} + v_{o2} + v_{o3}$$

Therefore, the fundamental output of the amplifier v_{o1} is

$$v_{o1} = (\overline{0.707}^2 v_{in} e^{j\phi} a_{1x}) + (\overline{0.707}^2 v_{in} e^{j\phi} a_{1y}),$$

simplified,

$$v_{o1} = 0.5\, v_{in}(a_{1x} e^{j\phi} + a_{1y} e^{j\theta})$$

The phase balance of the two inverters also plays a part in determining the second-order performance of the push-pull amplifier.

FIGURE 7

Second-order reduction due to push-pull versus inverter phase shift in degrees (△ = 0 dB, ϕ and θ as shown)

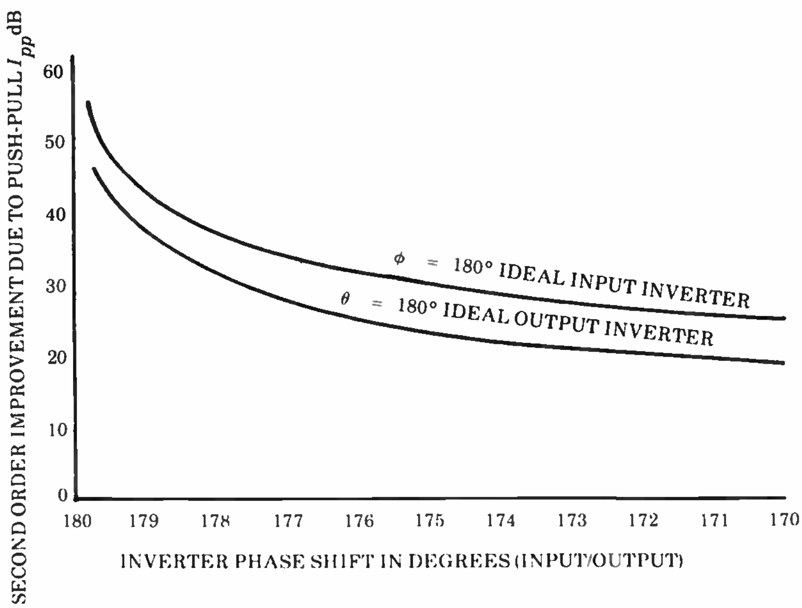
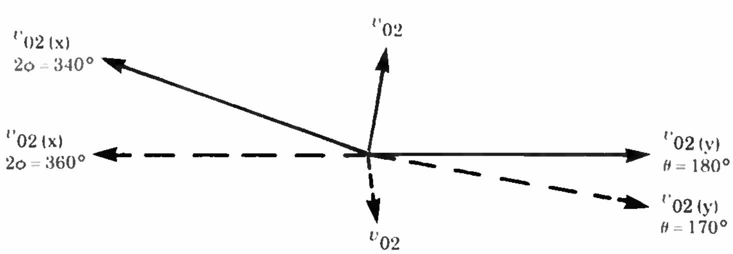


FIGURE 8

Vector diagram phase relationship of ϕ and θ



The second-order distortion component at the amplifier output is

$$v_{o2} = \overline{0.707^3}(v_{in}e^{j\phi})^2 a_{2x} + \overline{0.707^3} v_{in}^2 e^{j\theta} a_{2y}$$

or

$$v_{o2} = 0.354\, v_{in}^2 (a_{2x}e^{j2\phi} + a_{2y}e^{j\theta})$$

The third-order distortion component at the amplifier output is

$$v_{o3} = \overline{0.707^4}(v_{in}e^{j\phi})^3 a_{3x} + \overline{0.707^4} v_{in}^3 e^{j\theta} a_{3y}$$

or

$$v_{o3} = 0.25\, v_{in}^3 (a_{3x}e^{j3\phi} + a_{3y}e^{j\theta})$$

The total output of the amplifier is then seen to be

$$V_o = v_{o1} + v_{o2} + v_{o3}$$

$$V_o = 0.5\, v_{in}(a_{1x}e^{j\phi} + a_{1y}e^{j\theta}) + 0.354\, v_{in}^2(a_{2x}e^{j2\phi} + a_{2y}e^{j\theta}) + 0.25\, v_{in}^3(a_{3x}e^{j3\phi} + a_{3y}e^{j\theta})$$

Amplifier Gain: The Gain a_1 of the push-pull amplifier is given as follows:

$$\text{Gain} = a_1 = \frac{v_{o1}}{v_{in}}$$

and from the preceding

$$v_{o1} = 0.5\, v_{in}(a_{1x}e^{j\phi} + a_{1y}e^{j\theta})$$

therefore,

$$a_1 = 0.5\,(a_{1x}e^{j\phi} + a_{1y}e^{j\theta})$$

Expressing this in decibels,

$$\text{Gain} = A_1 = 20 \log a_1 = 20 \log 0.5\,(a_{1x}e^{j\theta} + a_{1y}e^{j\theta})\ \text{dB}$$

Second-Order Distortion Component: The magnitude of the second-order distortion is expressed as (from the preceding)

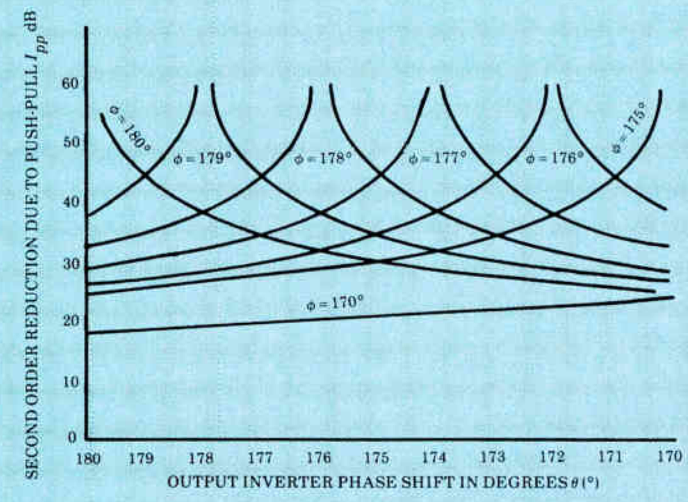
$$v_{o2} = 0.345\, v_{in}^2(a_{2x}e^{j2\phi} + a_{2y}e^{j\theta})$$

where a_{2x} and a_{2y} describe the second-order curvature of the x and the y amplifier transfer characteristics, respectively. For effective second-order cancellation in a push-pull amplifier, it is necessary that a_{2x} and a_{2y} be nearly

Gain matching is required so that an individual transistor does not operate at a higher level than its counterpart.

FIGURE 9

Second-order reduction due to push-pull versus output inverter phase shift ($\triangle = 0$ dB, ϕ as shown)



equal. This is one of many factors that determine the second-order performance of the finished amplifier.

From the above expression it can be seen that the phase balance of the two inverters also plays a part in determining the second-order performance of the push-pull amplifier.

Mathematical expressions have been derived which describe the Gain and second-order distortion of a push-pull amplifier.

The Gain of the push-pull combination has been described as

$$\text{Gain} = A_1 = 20 \log 0.5\,(a_{1x}e^{j\phi} + a_{1y}e^{j\theta})\ \text{dB}$$

from which it is seen that the Gain is a function of the gain of each of the two individual amplifiers and the phase relationship of the input and output inverters.

To study the behavior of the push-pull amplifier Gain A_1 as a function of x and y gain balance, the gain of the x amplifier, $a_{1x}e^{j\theta}$, is arbitrarily assigned the value of $1e^{j180}$. That is, the x amplifier has unity gain (0 dB) and its phase inverter (ϕ) is perfect with a value of 180°. The gain of y amplifier a_{1y} then is varied by ±20 dB from unity gain, with θ also held constant at 180°.

The results of this exercise are shown in Figure 3. Note that with ϕ and θ equal to 180° and the x and y amplifier gains nearly equal, the total Gain A_1 varies only 0.5 dB for each 1 dB change in individual amplifier gain. The possibility of gain increase by an individual amplifier of 20 dB is not likely. However, note that if one amplifier fails (y = -20 dB), the total amplifier Gain A_1 will be reduced by 6 dB.

To study the Gain behavior of the push-pull amplifier as a function of phase variation, the x and y amplifier gains were set equal to each other and ϕ was assigned the value of 180°. Then θ was varied from 180° to obtain a total amplifier Gain A_1 reduction of 1 dB. The results are shown in Figure 4. It can be seen that large phase variations are required in order to degrade A_1 by 1 dB.

Perfect Balance, Gain, and Phase: The second-order distortion was expressed as

$$v_{o2} = 0.354\,\overline{v_{in}}^2(a_{2x}e^{j2\phi} + a_{2y}e^{j\theta})$$

Best performance of the push-pull amplifier is attained when $a_{2x} = a_{2y}$, $\theta = \phi = 180°$. Under these conditions:

$$v_{o2} = 0.354\,\overline{v_{in}}^2(a_{2x}e^{j360°} + a_{2y}e^{j180°})$$

$$= 0.354\,\overline{v_{in}}^2(a_{2x} - a_{2y})$$

A block diagram showing an ideal push-pull amplifier (perfect second-order cancellation) is given in Figure 5.

Variations Due to Second-Order Component Unbalance, with θ and ϕ Constant: In order to study the behavior of a push-pull amplifier as a function of all the above-mentioned variables, the following procedure is used. Assume that the gains of the individual amplifiers are equal. Set $\phi = \theta = 180°$; then vary the amount of distortion in the two amplifiers and calculate the improvement due to push-pull. The second-order distortion ratios D_{x2} and D_{y2} of the x and y amplifiers are

$$\frac{a_{1x}}{a_{2x}} \text{ and } \frac{a_{1y}}{a_{2y}}$$

respectively. Expressing this in decibels:

$$D_{x2} = 20\log\frac{a_{1x}}{a_{2x}} \text{ and } D_{y2} = 20\log\frac{a_{1y}}{a_{2y}}$$

This distortion difference between the two amplifiers is expressed as follows:

$$\triangle = D_{x2} - D_{y2}\ \text{dB}$$

The second-order distortion ratio of the x amplifier is arbitrarily held constant, and D_{y2} is varied above and below this value. The second-order distortion ratio of the push-pull amplifier then is compared to the distortion ratio of the x amplifier for a measure of distortion reduction due to push-pull operation.

The second-order distortion of the total amplifier in decibels is

$$D_2 = 20\log\frac{v_{o1}}{v_{o2}}$$

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Reader Service Number 17

Matching for second-order distortion is required so each side of the push-pull will have equal amounts of second-order components.

and

$$I_{pp} = D_2 - D_{x2}$$

where I_{pp} is the decibel improvement due to push-pull operation.

The mathematical expressions derived above were programmed on a computer so that the various parameters of the amplifier could be varied and the resulting behavior plotted and studied.

Figure 6 shows the second-order improvement (I_{pp}) plotted against the second-order distortion differential (△) between the two amplifiers ϕ and θ as shown. With ϕ and θ both equal to 180°, it is seen that if △ is greater than 2 dB, an improvement of 20 dB is impossible. If phase errors between the input and output inverters are greater than 5°, it is seen that the second-order distortion difference between the two amplifiers must be kept under 1.5 dB in order to get at least 20 dB of improvement due to push-pull operation.

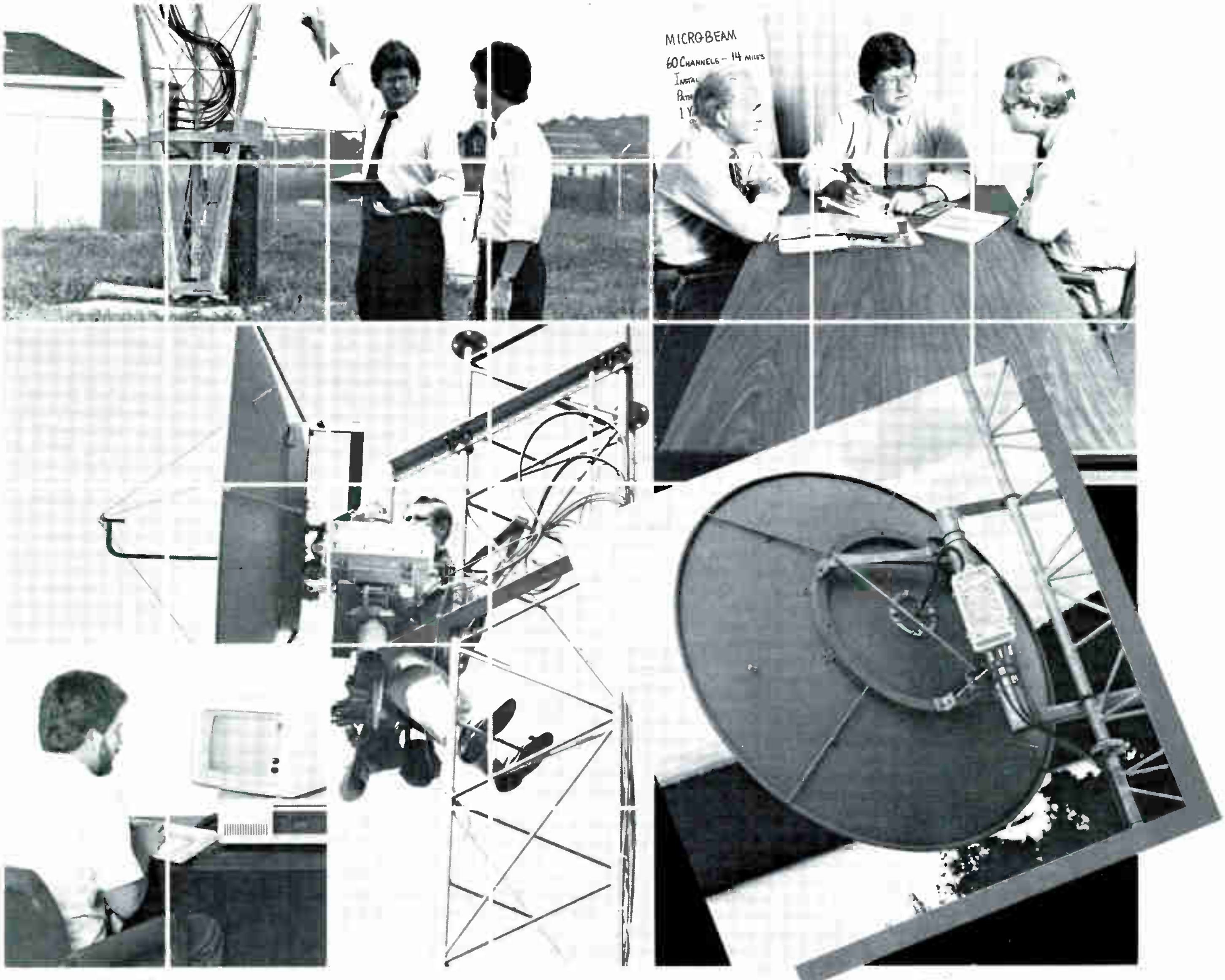
In order to keep △ to less than 2 dB, matched pair transistors are used in the push-pull circuits. In selecting transitors for this application, the matching must be done for gain and second-order distortion.

Gain matching is required so that an individual transistor does not operate at a higher level than its counterpart. Matching for second-order distortion is required so that each side of the push-pull will have equal amounts of second-order components which are necessary for good cancellation.

Variations Due to Phase Balance, with Gains Equal: Figure 7 shows the improvement due to push-pull (I_{pp}) as a function of inverter phase shift. The curves are plotted for △ of 0 dB, i.e., the second-order distortion components of the x and y amplifiers are equal. Curve $\phi = 180°$ shows the results obtained when the input inverter is held constant at 180° and the output inverter phase shift is varied as shown on the abscissa. An improvement of 20 dB is readily possible for variations in the output inverter up to 10°. Curve $\theta = 180°$ is for the output inverter held constant at 180°, and the input inverter is varied as shown. A 20 dB improvement is possible down to 171°.

The curves also point out that phase errors in the input inverter are magnified by a factor of two (6 dB) compared to phase errors in the output inverter, as clearly shown in Figure 8. This vector diagram shows the resultant second order with $\phi = 180$ and $\theta = 170$, and $\phi = 170$ and $\theta = 180$. Physically, this is explained by the action of the second term in the Taylor expansion multiplying by 2 any phase error in the input inverter.

Nulls for Various Phase Combinations, with Gains Equal: Figure 9



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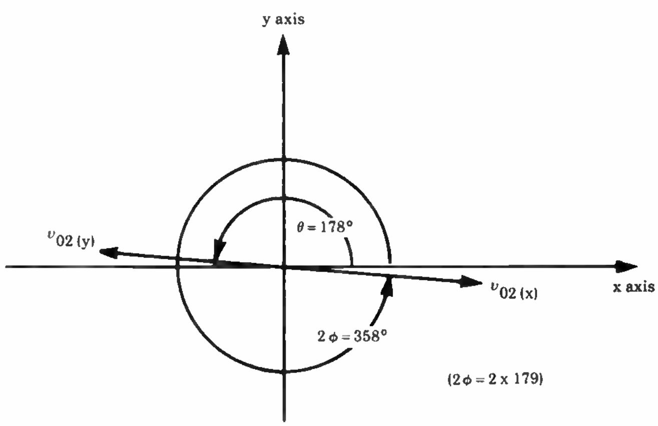
Particular attention was given to the hybrid inverter networks with regard to phase and amplitude balance.

FIGURE 10

Vector diagram phase relationship of ϕ and θ for cancellation



shows the improvement (I_{pp}) due to push-pull versus the output inverter phase shift (θ) for various values of ϕ. As can be seen from these curves, there are many combinations of ϕ and θ which yield perfect cancellation. A vector presentation of this mechanism is shown in Figure 10. From Figure 9, it is seen that for $\triangle = 0$ dB, 20 dB of second-order reduction is possible with a phase unbalance as high as 10°.

In order to achieve good push-pull performance, particular attention was given to the hybrid inverter networks with regard to phase and amplitude balance, by making these networks into separate subassemblies that were pretested before insertion into the amplifier. The inverters were designed with amplitude balance of better than 0.3 dB and phase error of less than ±1.5°.

The amplifiers themselves were designed and built as mirror images of each other. Past experience has shown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Second-order distortion ratios as low as -80 dB at +50 dBmV were readily attainable.

that when this is done, the electrical length and, therefore, the phase shift are very repeatable.

Conclusion

A mathematical model of a push-pull amplifier for use in CATV systems was formulated and curves were plotted for various combinations of variables in order to achieve an amplifier that will exhibit good second-order distortion performance. From the model it was seen that, when designing such an amplifier, minute care must be given to the phase characteristics of the inverter and amplifier stages, to gain differential between the two amplifiers and to the second-order distortion differential between the two amplifiers—so that the design objective of a -66 dB second-order distortion ratio will be readily attained.

Practical amplifiers then were designed with particular attention to gain, phase and second-order balance between the push-pull legs in the two amplifier stages. Repetitive measurements showed that second-order distortion ratios as low as -80 dB at +50 dBmV were readily attainable.

Subsequently, production line amplifiers were built which, in all cases, exhibited a second-order distortion ratio well below -66 dB at +50 dBmV, the initial design objective.

Acknowledgment

The author wishes to thank M. Jeffers, K. Simons and G. Rath for their patience in reviewing the paper. The author also wishes to thank I. Polidi for the computer programming that provided the data from which the curves were plotted.

References

1. K. A. Simons, *Technical Handbook for CATV Systems*, Hatboro, Pa., Jerrold Electronics Corp., 1968.
2. Bell Telephone Laboratories Inc., *Transmission Systems for Communications*, 3rd ed, 1964.
3. M.F. Jeffers, Jerrold Electronics Corp., Hatboro, Pa. (unpublished paper). ■

Continued from page 10

"The attached proposed standard establishes a standardized audio/video baseband interface for television receivers and VCRs. This interface is designed to be used with external decoders for CATV systems employing baseband scrambling techniques. In addition, the interface can be used as a peripheral input port accepting either NTSC video or RGB inputs."

The interface will be in the form of a 20-pin connector which can be used with video discs, VCRs, teletext decoders, DBS or MDS receivers as well as CATV and encoded SAPs (second audio programs).

IS-15 decoders can be designed to work with either RF or baseband scrambling systems. Until customers purchase receivers with IS-15, converter/descramblers still must be supplied. Some modifications in the headend encoder may be necessary to deal with a mixture of older TV sets and IS-15 peripheral decoders.

You may want to say: "Here we go again." Technology, especially with respect to converters and scrambling, has changed so rapidly and so often as to make a shambles of orderly depreciation schedules. This time, however, it looks like the two industries may have effectively cooperated in a long-range solution.

The next step would have to be incorporating the descrambler in the TV set itself. It would seem this could only be accomplished with some form of encryption, such as the DES algorithm, that would be so secure and so well standardized that it could be sold to consumers over the counter. Certainly, such an arrangement is technically feasible. However, the evolutionary processes of cost reduction and standardization seem likely to take many years—perhaps into the next century. Meanwhile, IS-15 (and its offspring) are expected to ease substantially the consumer pressures for more user-friendly consumer electronics systems.

To the delight of manufacturers, IS-15 should create a growing demand for non-converter descramblers, both addressable and programmable. Meanwhile, the need for converters and converter/descramblers gradually will decline as more and more IS-15 TV sets find their way into subscriber homes. ■

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Reader Service Number 23

Voting yes for fiber

The hardware problems are solved. It is now up to the cable companies, says consultant Gary Moore.

At the risk of sounding like a gadfly, let me argue that it is possible today to carry CATV, data and telephone services all the way to a subscriber dwelling on fiber optic cable—economically.

In fact, there are two fiber optic systems for CATV being installed, both by telephone companies. One of the BOCs currently is in the installation phase of a fiber optic CATV delivery system in Florida. Likewise, there is a small rural telephone company installing a full fiber optic system in Texas that carries CATV, telephone, data and is capable of providing any form of communications that may develop in the next 30 years.

Both systems utilize single mode fiber to deliver signals from the central office or headend to the subscriber's TV set. The architecture for both systems is tree and branch.

By Gary Moore, Telecommunications consultant

The Florida system serves a limited number of subscribers per individual fiber, while the Texas system serves 10 to 20 times more subscribers per fiber.

The Texas system utilizes fiber not just for trunking—but for delivery to the TV set or converter. It features impulse pay-per-view capabilities, data services, security and monitoring services as well as telephone services.

Currently, both systems are analog, but both are designed for conversion to full digital transmission.

Contrary to popular belief, splitters, connectors and other passive (or even active) optical hardware is available at an economical price in quantities.

Technically, the loss budget for these items is less than 1 dB. Splices with unmeasurable loss (0 dB) are quite common. While normally achieved with fusion splice, either elastomeric or fused give excellent results and are cost effective.

Today, off-the-shelf connectors have a loss of less than 1 dB. A splice (preferred by the telco) has a loss of 0.1 dB to 0.01 dB (specified) with 0 dB splices being quite common. The fiber has a loss of 0.5 dB or less per kilometer. Splitters (taps) have a typical loss of 3 dB or less.

As for architecture, tree and branch is fine. Star configurations (in the field) use too much fiber; they are not economical from either a material or a labor point of view in the average system.

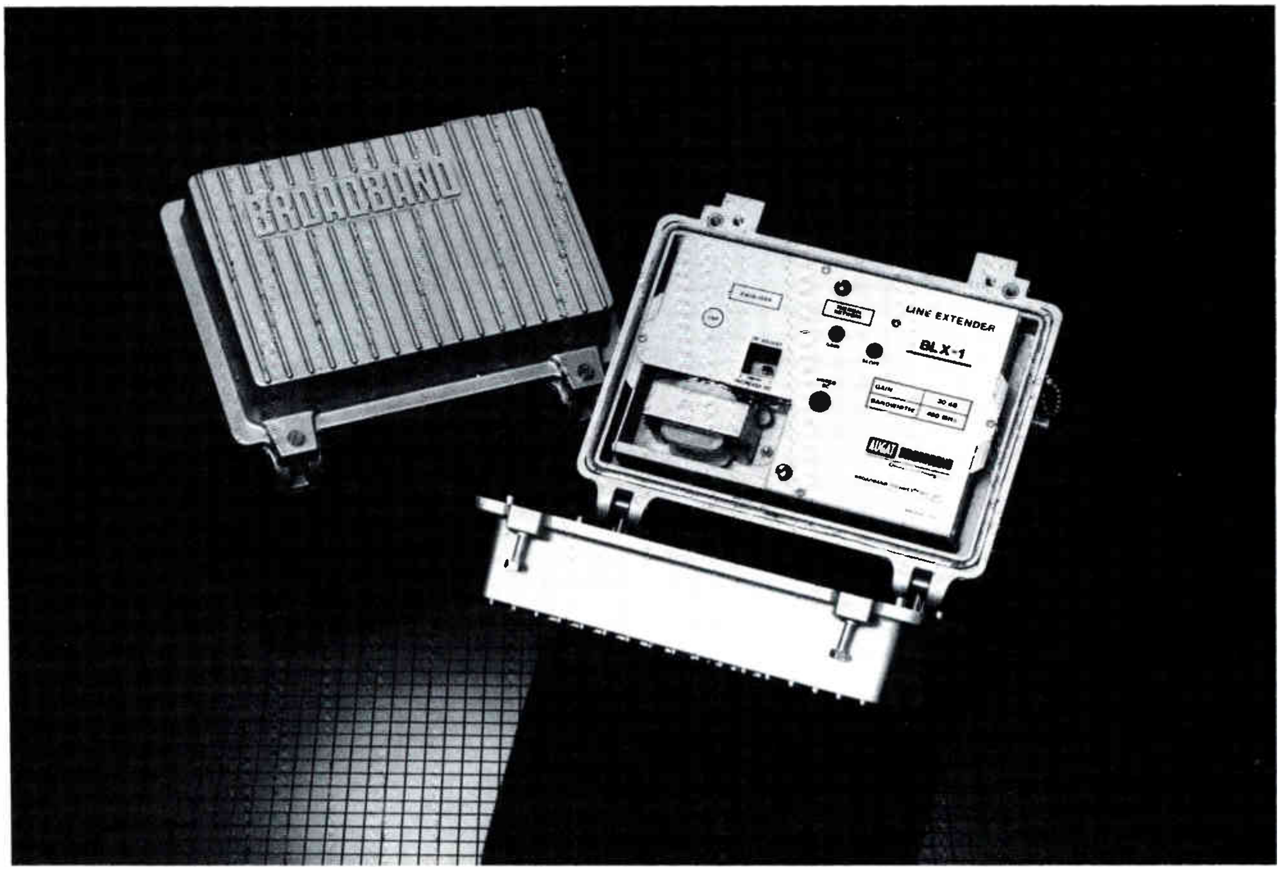
It should be explained that the "star" system most of us refer to is basically the Times Fiber Mini-hub type installation. The failure of the Times Fiber mini-hub system set fiber optics back several years in the CATV industry. This made it much less attractive to others to enter the field and develop and sell equipment capable of delivering CATV and other services to the subscriber.

The cost of fiber cable can be as cheap or cheaper on a foot-by-foot basis than copper. Based on today's materials and labor costs, it is generally less expensive (initially) to install 10 miles of fiber than 10 miles of coax. The second advantage is upkeep. Maintenance is reduced to almost zero.

Light sources and detectors have specified lifetimes in excess of 10 years (some in excess of 20 years) MTBF. The glass doesn't wear out very fast, normally.

For several years fiber optics engineers have been describing a totally digital distribution system to the subscriber. The realistic system would carry a minimum of 40 digitized CATV channels per optical frequency without costly multiplexing schemes. Also, with a minimum of 40 channels of video and stereo audio, there would be nearly 2,000 telephone or 9,600 baud data channels.

Despite the failure of Times Fiber, a few brave, far-sighted companies have persevered; and now that faith is being rewarded. There are several fiber optic



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Reader Service Number 26

Whoever has the fiber in a subscriber's location first will "own" that subscriber forevermore.

systems now obtainable that deliver data, CATV and telephone to the subscriber's dwelling.

Both installations face similar problems, in that FM transmission over fiber is the worst possible signal carrier (except possibly AM). The inherent drift from FM makes cross-talk and intermodulation much more of a problem when attempting to carry numerous channels in the same optical window (frequency).

As an intermediate step between straight FM and digital, the B-MAC system utilizing video components rather than NTSC can work on fiber. Tests utilizing B-MAC on fiber currently are being discussed within the telecommunications industry. Analog signals are the least efficient, least desirable for fiber optic transmission. Digital signals go farther and last longer. Essentially, digital can be repeated ad infinitum.

An FM signal, say eight video channels, can be repeated only three times at the most before the signal deteriorates beyond use. Every time an FM signal is repeated, all the accumulated noise is repeated and the noise is additive.

To repeat a signal three times assumes the signal you begin with at the headend is perfect. It also assumes, probably unrealistically, that the transmission electronics are in top condition as well.

It should be pointed out that in the fiber optics industry almost every proponent of fiber for CATV feels FM is the least acceptable signal. It works, but not as well as digital.

Now that digital has been mentioned, let me hasten to state that there are at least two such systems sitting in labs and working fine.

Developing a cost-effective set-top or subscriber premises converter has been a problem because of the extremely wide tuning range required for an FM signal on fiber. Yet, there have been several prototypes designed capable of going into manufacture when required. A similar converter for digital also has been developed.

Both of these converters range from a simple set-top unit with channel selection capabilities to a full addressable unit with impulse PPV, data, and telephone de-modulation as well as a built-in character generator for teletext. The most elaborate converter for digital or FM is comparable in price to the current top-of-the-line units available today.

The hardware problems are solved. It is now up to the cable companies.

In regard to consumer electronics, the major companies are ready. In fact, they are in the process of developing their own systems. There are numerous references to chickens and eggs. Most of the BOCs and other telephone companies enjoy hearing cable people battle over chickens and eggs. At the same time, they are installing fiber delivery systems to the subscriber's house.

Fiber optics provides a "total communications system." Whoever has the fiber in a subscriber's location first will "own" that subscriber forevermore. The fiber owner will provide all the communications services and needs of the subscriber.

Who is going to "own" your subscribers tomorrow?

About the author

Gary Moore is an independent consultant in telecommunications and video transmission over fiber optics. For the past three years, he has been working with a small Texas telephone company developing and designing a fiber optic delivery system. He has worked for both ABC and NBC in broadcast engineering and as a TV cameraman.

Moore is a member of the Society of Motion Picture and Television Engineers (SMPTE) and the Society of Photo-Optical and Instrumentation Engineers (SPIE) and is listed in *Who's Who in Optical Scientists and Engineers.*

Author's note

Technical specifications from manufacturer-supplied technical data. Specific items are not utilized, and averages or typical values are stated. Telephone bypass rate data taken from published industry statistics as well as individual company reports. Additional information available from the writer or from industry sources, manufacturers, etc. ■

Let your computer do the talking

Want to increase subscriber satisfaction, make CSRs happy and save money? Sounds too good to be true, but voice response technology is here.

Some cable systems now are using voice response/voice recognition systems to improve their customer service operations. Memphis Cablevision, for example, has noticed a decrease in the number of customers not home or unable to pay since installing its Melita 3000 system in October 1985. "The major reason we went with the system was reminder calls and to verify a customer being home for a repair call," says Lynn Marshall, manager of customer service. "A third application for the system is generic messages in corrections. The Melita system will call a customer, say concerning billing, tell them the bill needs a change or they haven't paid and would they please call back. We have found this method far more effective than direct mail—approximately 50 percent of those contacted return the call—and it's also more personal."

The systems also allow for live operator assistance. "Since Melita can call 300 to 400 subscribers within 30 minutes, we let it do the initial calling," says Marshall. "Then the telemarketing staff can work on collections."

Although Memphis Cablevision's initial thought was to reduce customer service time, other cable systems "were prompted to purchase voice response by going heavily into PPV," says Kit Beuret, director of public affairs, Oceanic Cablevision. Their Insta-View system from Interface Technology was installed in September 1984. It's being used for:

- PPV, the primary function
- order entry for addition of new premium services
- switching services
- current account balance
- reauthorization of an addressable converter

"Every time a customer calls through Insta-View, we save customer service time," says Beuret. "It had its bugs, modifications have been made, but it works great—fabulous since installation." Oceanic now is contemplating use of Insta-View by field personnel. Confirmation of work orders and installation/authorization of converters are two possibilities being looked at. According to Beuret, the advantages are lower error rates and less waiting time for installers.

One problem area with PPV application is call capacity. The Insta-View system can handle a maximum of 200 PPV calls in the last five minutes before program airing. "So two or three times last year, the system was overloaded and callers had to wait," says Ann Burr, vice president of operations, Oceanic Cablevision.

Viacom's interest was "increasing our level of customer service without increasing cost," says Don Grammar, management information systems supervisor for the company. Still in the testing stage, Viacom is using Dialogic's TeleClerk system for confirmation of installations, service calls, marketing surveys, information services and overflow situations. Since outages cause a bombardment of calls for repair, the overload goes to TeleClerk, and it explains the area and reason of outage and asks the subscriber to wait. After the system is back up, TeleClerk can call the affected subscribers to confirm that service has been restored.

According to Grammar, Viacom presently is using CableData's PEP for PPV and has no intention of using TeleClerk for that purpose. "The reason we went with TeleClerk," says Grammer, "is they're based in town, and they were the only company interested in leasing or renting a machine for testing."

Voice response also saves time on inbound calls from field personnel. Since many systems have inbound capabilities, the number of calls handled by dispatch can be cut. Media General has been using the Periphonics system for approximately a year for completion of trouble calls—converter swaps and installations. "Time definitely has been saved," says Bob McBride, vice president of business operations with Media General. And how do field personnel respond to a machine? "Most of them like the system, now," says McBride. "The hardest thing was to break an old habit. Some installers still prefer a warm voice to a machine."

Actually, the only difference between the "warm" voice and the machine is the ability to converse about the weather. Most voice response systems have a digitized voice, not synthesized such as a tape recording. With digitized voice, the computer combines pre-recorded words, phrases and sentences and stores them in computer memory. The effect is an actual human-sounding voice that "speaks" to the caller in a clear, pleasant voice. It often is difficult to distinguish between voice response and a real person.

Most systems are programmed to immediately disconnect and redial on no-answers, busys, hang-ups and operator intercepts. If the transaction is being recorded, the cassette will be rewound and started again to eliminate long pauses on playbacks. All these activities usually are included in reports available with the systems. Media General's Periphonics system gives a log-type report. According to McBride, the report is identical to one a dispatcher would keep stating who called, why, when and so on. The information goes straight from the phone into their host computer.

"We use voice response to save manpower," says Steve Clemons, customer service supervisor with Qube Cable. "For every truck we don't roll, we save $40." Their Melita system has been installed for two-and-a-half years. "We use it for work orders, scheduling the trucks, confirming and verifying appointments and potential discon-

In order to effectively demonstrate voice response and voice recognition systems, some companies offer a voice demonstration number. If interested in hearing an actual system, contact any of the numbers listed below.

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In Tenn. (615) 790-3005
Interface Technology..(800) 325-1559
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Reader Service Number 29

We have found voice response far more effective than direct mail—and it's more personal.

nects," says Clemons. "For disconnects, the system makes the call and asks the subscriber to contact a CSR before we disconnect. Approximately 10 percent to 20 percent actually call back to talk it out."

Qube Cable also uses the Melita for system outages. Like Viacom's system, Qube's confirms service status and schedules a technician if needed.

Several voice response systems allow expansions on existing systems. Almost all the companies involved are willing to adapt to the cable operators' needs since each situation is different. It is possible to start with a few applications and add more later. But some cable systems would be limited on applications like converter authorization and reauthorization if their systems aren't addressable. "Addressable systems add to the beauty of voice response systems," McBride says.

Another limitation is that voice response uses touch-tone dialing. What about the subscribers with rotary dial phones? Voice response machines don't accept rotary signaling. Of course, a rotary to touch-tone conversion device, available at almost any electronics store, only costs $5 to $7. And then, the subscriber's telephone line has to be converted to accept touch-tone signals—at an increased phone cost per month.

"Forty percent of our subscriber base at Oceanic is rotary," says Burr, "so we lose out on that base."

Voice response and voice recognition technology have been available for years—but were too complex or too expensive for many applications. Declining prices for CPUs and memory have changed the picture, however.

Some voice response systems are stand-alone units, others are compatible with a host computer. The telephone lines used are direct from the telephone network or customer's PBX. Users enter their requests with touch-tone telephones, and the system responds with recorded voice messages. When used with a printer, reports of the calling activity can be generated.

Some systems, such as the Melita 3000, can be used for both incoming and outgoing applications. All four ports can be configured for outgoing calls—appointment confirmation, for example. But in the case of an outage, those same lines could be converted to incoming to handle inbound customer calls. Many systems have single telephone lines with expansions ranging from 3 to 32 lines. Phone numbers themselves can be entered manually if the universe is small, such as repair calls, loaded from a cassette if calling a specific demographic area or downloaded from an existing data base if doing a special promo and calling all subscribers.

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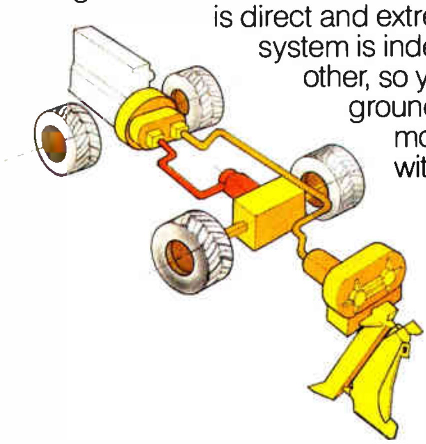

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Calling activity reports generally break out the number of busys, no-answers, machine answers, hang-ups, calls completed, calls partially completed and operator intercepts. Many systems will tailor the reports to specific needs.

Available on many outbound systems are unattended calling and performance. The system is programmed days in advance and needs no monitoring, unless requested, to perform its job. Customer service representatives are freed from mundane, repetitive calls and are better able to use their time for tasks like collections and service upgrades.

A somewhat more sophisticated approach is voice recognition, where user input is by actual spoken command, not touch-tone data. Voice mail is one present application for recognition systems.

Voice recognition can be either speaker-dependent or independent. Dependent systems are "trained" to recognize a specific user's voice pattern. In order to train the computer, the user simply speaks the intended words into a microphone one or two times. Votan's system allows for 400 people to be enrolled on a diskette, although only four can call at one time. A speaker-independent system responds to any voice pattern. However, the vocabularies generally are limited to the numbers zero through nine and the words "yes" and "no."

Of the dependent and independent systems, voice recognition can be either of two types—isolated or connected. Again, the isolated type restricts usage as each word spoken requires slight pauses between each utterance, and most customers are not trained for this. The connected speech system is applicable by allowing words or phases to be spoken as in a conversation.

Because of the many applications available, voice response systems with outbound capabilities seem to rank favorite among cable operators. Appointment confirmations, scheduling, special promotions, marketing surveys and quality control are a few of the functions that have reduced time and money in customer service. Inbound applications such as account verification, technician check-in and converter reauthorization are also important considerations but not used as widely at this time.

—*Kathy Berlin*

Correction

Last month's "Cable Classics" article, "Defining S/N" by Tom Straus, was reprinted, with permission, from the *NCTA 1974 Technical Papers*. We apologize for omitting this credit in the February issue.

people

Scientific-Atlanta Inc. appointed **John Buckett** to the position of national sales manager for the company's Broadband Communications Division. Buckett has served S-A as account manager for more than four years. Prior to joining S-A, he was a field sales representative for Watlow Electric.

Mike Parks was named president of the Cable System Services Division of First Data Resources. Parks most recently served FDR as vice president of transaction services. He replaces **Matt Gates**, who has been appointed the corporate vice president of operations. Parks' responsibilities will include overall sales and operations of FDR's Cable Division.

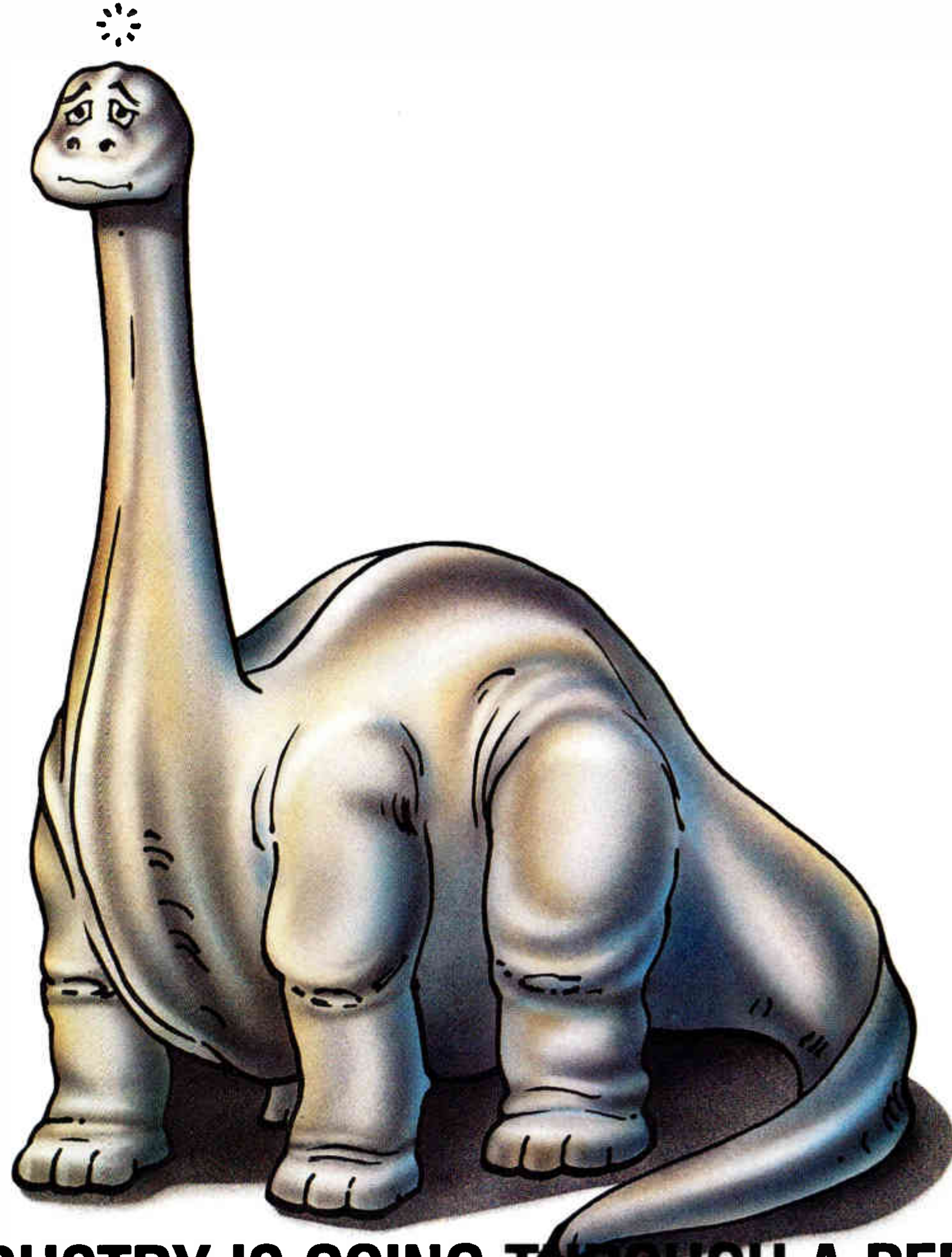
Mann Bush rejoined the Jerrold Division of General Instrument Corp. as account manager for sales activity to United Cable Television Corp. Mann returns to Jerrold after serving as an area sales manager for General Cable Corp. He had spent over 20 years at Jerrold as a sales and field engineer.

C-COR Electronics Inc. appointed **Arthur (Mick) McGuire, Jr.**, as vice president, sales and marketing. Previously, McGuire was vice president, marketing, at FirsTel Information Systems Inc. Prior thereto, he was division president and general manager with Coradian Corp.

R. Alan Communications Inc. announced the promotion of **Scott Widaman** to the position of sales manager. Widaman has served R. Alan for two years as district rep sales manager. Previously, he was the Midwest account executive for S.A.L.

Geoff Heathcote was named vice president, engineering, for Maclean Hunter Cable TV. Heathcote has been with Maclean Hunter since March 1975, most recently serving as general manager for communications engineering services. He received his M.SC. in engineering from University College in 1970.

General Instrument Corp. selected **Polly Rash** to establish and manage a full-service marketing and sales office for its Satellite Systems Division in the Washington, D.C., area. Rash currently is vice president of the Society of Satellite Professionals. She earned her master's degree in communications from Stanford University.



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Radio and microwave radiation hazards

An overview of potential frequency dangers and a review of U.S. and Soviet standards research to date.

A degree of concern has been expressed within the land-radio user community regarding the possibility of harmful biological effects of radio and microwave radiation from fixed radio base sites. State and local governments have legislated against electromagnetic radiation felt to be harmful to the general public. Federal agencies are reviewing regulations for the protection of workers. This article will explore pertinent studies among a large international body of scientific data relative to radiation biology and explore radiation limits which are compatible with scientific and technical knowledge available at the present time.

This review is limited to considerations of RF/microwave radiation from fixed base sites. There are other families of RF and microwave radiation sources which are also of possible interest to the general public.

Ionizing and non-ionizing radiation

Radio frequency radiation is electromagnetic radiation that is found at the low-frequency end of the electromagnetic spectrum. The spectrum includes extremely low frequency very long wavelength radiation at one extreme, with X-ray and gamma ray radiation at extremely high frequencies with corresponding very short wavelengths at the other extreme. Radio waves, microwave, visible light, infrared and ultra violet radiation lie between these two extremes. The range of frequencies considered applicable to the study of harmful biological effects in humans exposed to radio and microwave electromagnetic fields is approximately 300 kHz to 100 GHz.[1]

The amount of energy in a unit of electromagnetic radiation depends upon its wavelength; the shorter the wavelength (higher frequency), the greater the energy. X-rays and gamma rays with extremely small wavelengths, and corresponding high frequencies, possess relatively great amounts of energy compared to extremely low frequency radiation at the other extreme of the electromagnetic spectrum. X-radiation and gamma radiation have more than enough energy to be hazardous to humans and have a great potential for damage to human tissue. They have the energy levels to cause ionization to atoms and molecules—a process by which electrons are driven from the molecular structure, thereby producing chemical alternations that can lead to genetic damage. Electromagnetic radiation at these high frequencies and corresponding small wavelengths is known as ionizing radiation and is very hazardous to humans. Lower frequency electromagnetic radiation does not have the energy levels needed to dislodge electrons from the orbital molecular structure. This inability of the radiated energy to ionize atoms is referred to as non-ionizing radiation. Frequencies and wavelengths typically identified with radio and microwave systems are classified as non-ionizing radiation.[2]

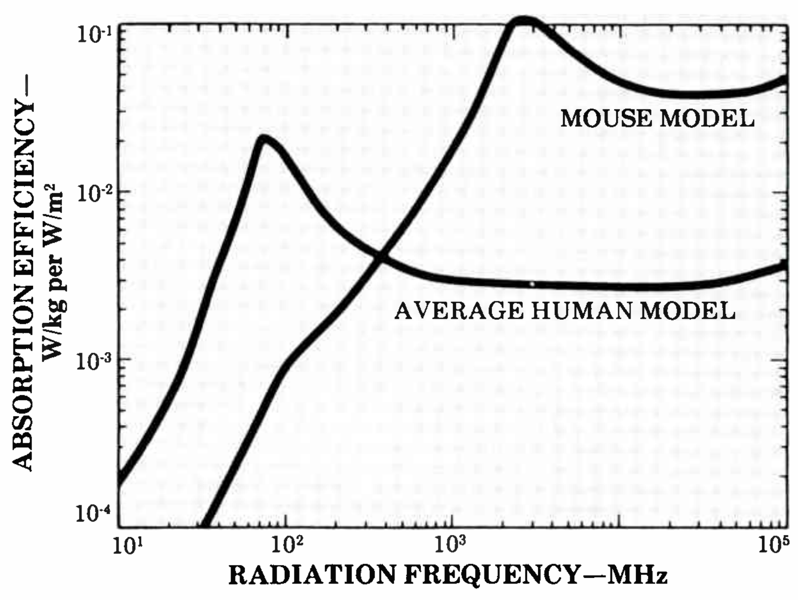
By Charles F. McMorrow, Senior Associate, Booz, Allen & Hamilton Inc.

Radiation effects on humans

Non-ionizing radiation at microwave or radio frequency wavelengths with sufficient energy to eject orbital electrons from atoms or molecules of human tissue would require an unlikely simultaneous absorption of a very large number of protons. The microwave or radio frequency intensities would have to be so high that the temperature of the absorber will be raised significantly.[3] Continued absorption of microwave power densities on the order of 100 milliwatts per square centimeter (100 mW/cm²) results in rapid tissue heating. If the exposure is long enough, irreversible tissue damage can result. For example, this type of "damage" in a microwave oven is recognized as "cooking."[4]

The major unanswered question is whether there are other mechanisms of microwave and radio frequency radia-

FIGURE 1
RF and microwave absorption efficiencies



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The average SAR is the calculated rate of energy absorbed in an organism as measured in watts per kilogram (W/kg).

tion at lower intensities that cause reversible or irreversible alterations but do not result in detectable tissue heating. Early scientific work by Soviet researchers regarding bioeffects of low-intensity microwave radiation was flawed by lack of uniformity and completeness in reporting scientific results.[5] Thus, it was not until around 1971 that the general outlines of this controversy in scientific circles became clear and biological effects of low-level radio frequency and microwave radiation received serious attention by those who would set radiation standards in the United States.

There still remain scientific questions which bear directly on the evaluation of new radiation safety standards. There is scientific criticism concerning the use of Average Specific Absorption Rate (SAR) as a method of scaling experimental animal results to humans. The average SAR is the calculated rate of energy absorbed in an organism as measured in watts per kilogram (W/kg). The National Council on Radiation Protection and Measurements calculated the average SAR for all radiation experiments where hazardous biological effects were verified and, from this, concluded that a level of 0.4 W/kg would be a factor of 10 below any of the calculated potentially hazardous SARs.[6] This was adopted as a safe SAR by the American National Standards Institute (ANSI) subcommittee C95.4. More recently, the International Radiation Protection Association published a conflicting recommendation that exposure of the general public should not exceed an SAR of 0.08 W/Kg averaged over any 6 minutes.

The mass-averaged rate of energy absorption for an average human model and a mouse model is shown in Figure 1. These data were calculated from Durney[7] et al and illustrate absorption resonance for the human model at about 80 MHz compared to 2,500 MHz for a mouse model.

There are experimental and epidemiological results from low-level non-ionizing radiation that cannot be explained in terms of thermal phenomena. These effects appear to involve field-induced reversible alternations in the central nervous system that occur at radiation intensities generally not associated with tissue heating. The interaction of microwave and radio frequency radiation with living systems results in complex modes of internal energy absorption[8] which present unique dosimetric problems and problems of assessing human physiological effects. Because of these and other political or legal uncertainties, there is, at present, no mandatory national safety standard for general population exposure to non-ionizing microwave and radio frequency radiation in the United States; and this after more than two decades of intensive research. Voluntary standards presently in use[1] are under constant revision.

Status of radiation safety standards

A widely recognized microwave and radio frequency radiation safety standard in the United States is the ANSI Standard C95.1-1982.[9] This standard is jointly issued by the Institute of Electrical and Electronics Engineers (IEEE) and is a revision of an earlier ANSI Standard C95.1-1974.

Initially, many researchers in the United States worked from the hypothesis that only thermal effects were hazardous. This led to the establishment of previous U.S. voluntary exposure standards of 10 mW/cm². However, researchers in the Soviet Union felt that their work showed hazardous biological effects from low-level radiation, and this led to much lower Soviety exposure standards: as low as 10 uW/cm² in some parts of the radio frequency/microwave spectrum. These differences are shown in Figure 2 along with recommended Chinese radiation safety standards. United States and Soviet Union cooperative research programs started in 1973 in an effort to resolve scientific skepticism regarding the Soviet techniques and the suggestion of poor language translation of

At present there is no compulsory national standard to protect employees from non-ionizing electromagnetic hazards.

earlier Soviet work in this field.

Lerner[10] offers still another insight to the difference in U.S. and Soviet safety standards criteria. He observes that in the United States, standards are set as high as is compatible with the avoidance of known and verified dangers since litigation will be settled on the basis of these standards. Costs of production in the United States also will be increased needlessly by too stringent standards, and these extra costs eventually will be absorbed by the consumer. In contrast, the Soviet Union tends to set standards very conservatively knowing that even tough standards do not add materially to the subsidized cost of production or to the consumer price. Tough Soviet standards ensure against all potential hazards. Personal liability is not an issue in the Soviet Union since liability is assumed by the State in all cases.

At present there is no compulsory national standard to protect employees from non-ionizing electromagnetic hazards in their work place in the United States. The Occupational Safety and Health Administration (OSHA) has withdrawn an earlier radiation safety guideline and, at this writing, appears unlikely to develop a new one. The National Institute of Occupational Safety and Health (NIOSH) has developed a proposed industrial radiation safety standard for occupational safety. This is similar to the ANSI C95.4-1982 Standard, and its power density limits also are shown in Figure 2. The NIOSH recommendations have not been formally released, and a revised proposal is presently under consideration.

Many State radiation safety regulations are based on the ANSI standards. California provides occupational standards[11] which include microwave frequencies between 100 MHz and 300 GHz with energy densities/field strengths limited to a far-field power density of 10 mW/cm² (the old ANSI standard). New Jersey has adopted the revised (1982) ANSI Standard without revision. Vermont and Texas have compulsory occupational radiation safety standards at the old ANSI power densitylevel of 10 mW/cm². Massachusetts passed a law in the fall of 1983 to preclude individual localities from setting their own regulations and standards within the State Department of Public Health mandates. The present Massachusetts statewide standard allows for not more than 200 uW/cm² averaged over a 30 minute exposure. (ANSI standard is now 1,000 uW/cm² averaged over a 6 minute exposure.) Several other local governments and municipalities have passed codes and ordinances which generally agree with ANSI recommendations or, in a few cases, apply more strict radiation safety levels.

The United States Environmental Protection Agency (EPA) has conducted several years of well-documented power density level measurements throughout the United States.[12] [13] At the present time, EPA is in the process of developing a federal guideline for non-ionizing radiation safety. These guidelines will be *advisory* to other federal agencies within whose jurisdiction radiation hazards are to be found. For example, the Department of Defense would be one such agency; the Federal Communications Commission, another. These guidelines are not regulations imposed on industry or the public. Regulatory agencies such as FCC and OSHA will be advised through presidential directive to start their regulatory procedures to fold the federal guidelines into their rules and regulations.

Actions of the Federal Communications Commission in addressing regulatory concerns over radio frequency and microwave radiation hazards were formalized in June 1979. A Notice of Inquiry[14] was initiated to assist the FCC in determining whether it was appropriate for the commission to take any action under existing radiation safety standards and also to provide documentation for the FCC to participate in rulemaking proceedings of other federal agencies to ensure that any standard adopted by those federal agencies adequately takes into account

The general radio frequency radiation environment in the U.S. is dominated by high-powered radio and TV broadcast transmitters.

the impact on licensees and equipment regulated by the FCC. This eventually resulted in a Notice of Proposed Rulemaking[15] in which the FCC proposed to amend Subpart I, Part 1, Chapter 1 of Title 47 of the Code of Federal Regulations, Section 1.1305 (Major Actions) to more closely comply with the National Environmental Policy Act of 1969 (NEPA) with regard to federal standards for exposure to radio frequency and microwave radiation. In a recent action, the FCC adopted radiation hazard guidelines based on ANSI Standard C95.1-1982.

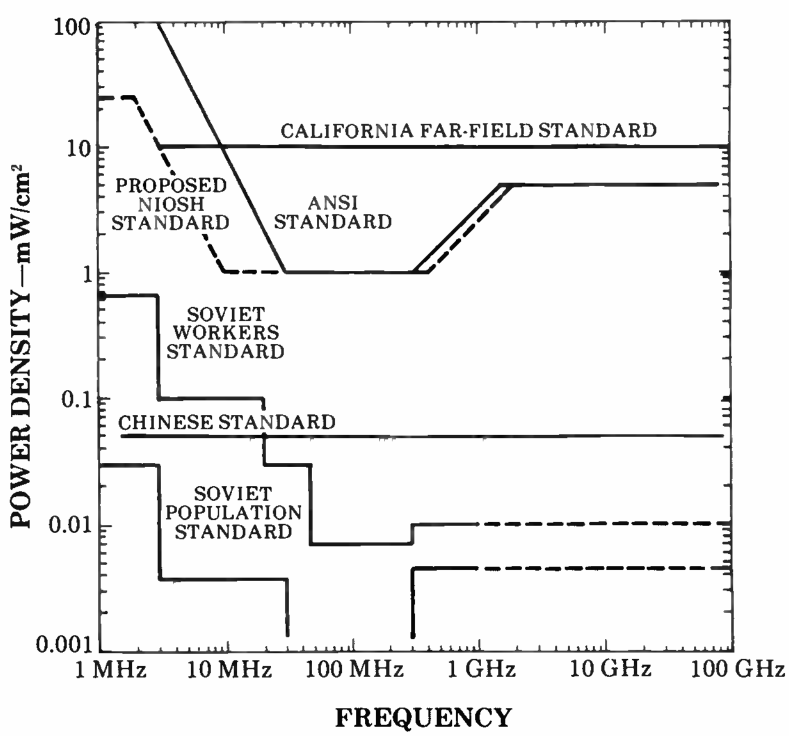
Radiation hazards

Radiation exposures discussed in the following paragraphs are limited to those related to fixed location radio frequency and microwave sites. Other general public exposures—which may include microwave ovens, the private use of mobile/portable radio equipment and exposure to military radar equipment radiation—are not within the scope of this article.

The general radio frequency radiation environment in the United States is dominated by high-powered radio and television broadcast transmitters. EPA has made measurements of radiation power densities at 486 different locations in 15 cities. This represents a population of over 44 million people. The results of these studies led to the conclusion that 95 percent of the population is exposed to a radiated power density less than 0.1 uW/cm^2 [16]. This result does not include contributions from AM broadcast transmissions because the energy absorption by humans at AM broadcast frequencies (0.535 to 1.605 MHz) is orders of magnitude less than at FM broadcast and TV frequencies.[17]

Power density measurements made

FIGURE 2
Major radiation safety standards



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The microwave antenna is a relatively complex device having three main fields of energy directly in front of the paraboloidal dish.

on Mount Wilson, in southern California, are of particular interest. There are 27 high-powered broadcast transmitters at this location, 12 FM radio stations and 15 VHF/UHF TV stations. The combined contribution of the TV transmitters to the total radiation environment was about 26 uW/cm² [18]. These intensities are plotted in Figure 3 together with the limits of major non-ionizing radiation safety standards. Maximum radiation levels in very small areas near conducting objects at the base of the Mount Wilson towers range from 1 mW/cm² to 7 mW/cm². Other EPA measures at a high-powered UHF-TV broadcasting facility with a combined visual and aural effective radiated power (ERP) of about 5.6 megawatts resulted in a power density of about 2.7 uW/cm² at ground level half a mile from the transmitter site.

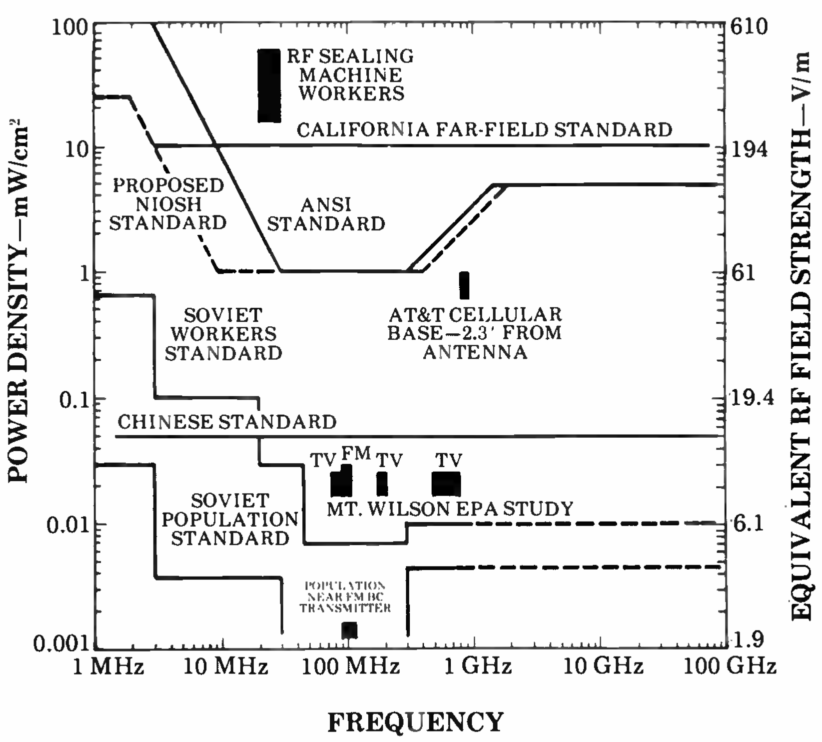
Contast these levels of power density with those from land-mobile base stations at VHF/UHF. GTE has reported measured maximum far-field power densities in the order of 0.04 uW/cm² per carrier for a VHF paging and mobile telephone service consisting of four transmitters with an effective radiated power of 350 watts per transmitter.

Power density measurements from tall buildings located close to high-powered FM and TV broadcast antennas are also of interest. EPA measurements of power density on the 102nd floor observation windows of the Empire State Building in New York total 32.5 uW/cm² [19]. The roof of the Sears Building in Chicago is exposed to a power density of 230 uW/cm², while the unshielded portion of the roof of the One Biscayne Tower in Miami is exposed to a power density of about 148 uW/cm².

The special case of cellular radio base station radiation at 850 MHz needs to be considered. AT&T reported[20] results involving RF radiation levels in the vicinity of an omni-directional cellular radio antenna serving 96 transmitters each having an ERP of 10 watts. Measured power densities near the base of the antenna did not exceed 1,000 uW/cm² at any distance beyond 2.3 feet from the antenna support. This power density level also is shown in Figure 3 along with existing radiation safety standards. Maximum power densities in the center of the main antenna beam of the cellular base station were below 1,000 uW/cm² at all points beyond 40 feet from the radiating elements of the antenna.

FIGURE 3

Typical power density levels compared to major radiation standards



Microwave considerations

Point-to-point microwave used in land-mobile radio system configurations is a low-powered source of electromagnetic radiation. Transmitter powers are typically 5 watts or less with maximum power densities of about 700 uW/cm² in the near-field of the antenna dish and less than 1 uW/cm² at ground level. At ground level directly below the main beam of a typical microwave antenna, power densities in the order of 0.01 uW/cm² have been measured.

The microwave antenna is a relatively complex device having three main fields of energy directly in front of the paraboloidal dish. The Fresnel or near-field is viewed as a cylindrical pattern extending out from the antenna a distance determined inversely by wavelength: the shorter the wavelength, the greater the distance. The Fraunhofer or far-field region is at a distance from the antenna where power density begins to decrease in proportion to the inverse square of the distance from the antenna. A transition zone is the distance between near-field and far-field and has very complex power density distributions.

A point of maximum power density exists along the main axis of the microwave beam within the near-field zone. In a typical point-to-point microwave, this area of maximum power seldom

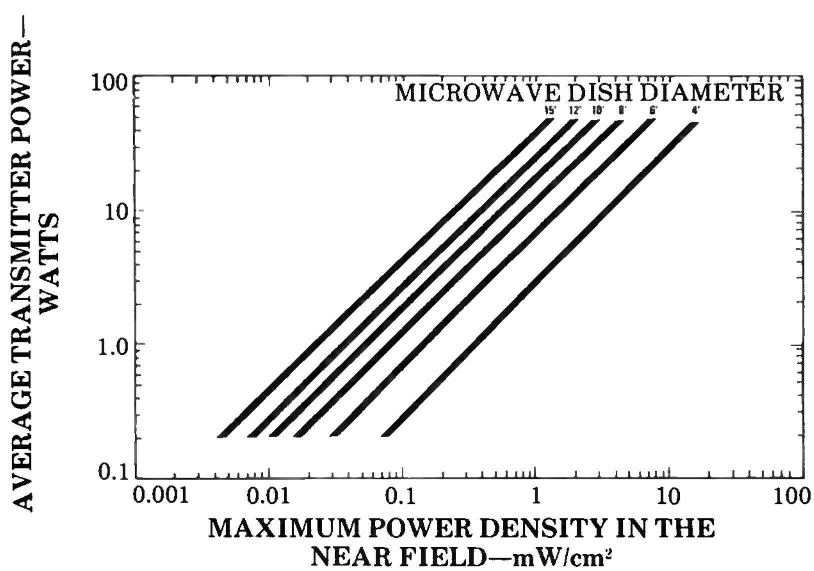
Maximum power density is a function of average microwave transmitter power and antenna size.

exceeds the limits of radiation safety. Maximum power density is a function of average microwave transmitter power and antenna size. Power density levels for a range of transmitter power and paraboloidal antenna dish diameters referenced in Part 94 of the FCC Rules and Regulations are shown in Figure 4. Distance from the antenna to the point of maximum power density along the axis of the antenna is a function of microwave frequency and antenna aperture. First order approximation of this distance is shown in Figure 5 for a range of microwave frequencies and paraboloidal antenna dish diameters. The area of maximum power density is about halfway between the antenna and the approximate intersection of the far-field along the axis of the antenna beam[21]. The power density at the rim of the antenna (or the surface of the near-field cylinder) is about 10 dB down from the maximum, or about one-tenth of the maximum power density shown in Figure 2.

It is clear from the literature, and from these approximate calculations, that point-to-point land-mobile radio microwave offers little radiation hazard to the general public. However, those who work on microwave antenna installations should be made aware of possible occupational hazards.

FIGURE 4

Maximum power densities for power and antenna dish diameter



Radar radiation hazards

The power density in the main beam of pulse modulated radar system or continuous wave sources may exceed 10 mW/cm^2. Persons who live or work near high power radar sources near airports or military bases may be exposed to sidelobe or secondary radiation from systems having stationary or slow-moving antennas. Calculations show exposures of 10 to 100 uW/cm^2 at distances up to one-half mile from some of these systems. Beam motion and antenna elevation angle make it likely that power densities will be 50 uW/cm^2 or less at distances greater than one-half mile or at least in locations accessible to the public.[22]

Radar manufacturers[15] indicate power density levels in the beam of a "typical" radar system as ranging from over 70 mW/cm^2 in the near-field at 27 meters (88.6 ft.) to less than 1 uW/cm^2 in the far-field at 10,000 meters (6.2 mi.). A high-powered radar system has been measured at slightly over 300 mW/cm^2 in the near-field at 50 meters (164 ft.) down to less than 10 uW/cm^2 in the far-field at 10,000 meters (6.2 mi.). According to EPA, most U.S. radars produce rotational time-averaged power densities of less than 10 uW/cm^2 at ground level in the far-field region of the antenna.

Radiation safety guides

A radiation safety guide for frequencies between 1 MHz and 100 GHz is shown in Figure 6. This guide is based on the present ANSI C95.1-1982 standard for safety levels with respect to human exposure. The specific absorption rate (SAR) of 0.4 W/kg recommended by ANSI is the criterion for this safety guide. These criteria presently are under revision by ANSI C95.1 and probably will be made more severe in subsequent editions of the standard.

Hazards to human tissue are time dependent. ANSI calculations of SAR are established by calculating the average specific absorption rates over a 6 minute period. The safe level of 0.4 W/kg absorption averaged over a 6 minute period is at present fully supported in the current scientific literature.[23]

Questions remain regarding the scaling of SAR from laboratory animals to the human body. Mumford[21] addressed this issue; calling upon the work of Ely et al.[24] These results are plotted in Figure 7 and, although they represent very early work, they do provide insight to human biological reaction to higher levels of power density as a function of time. In general, the work supports the 6 minute averaging criteria specified by ANSI.

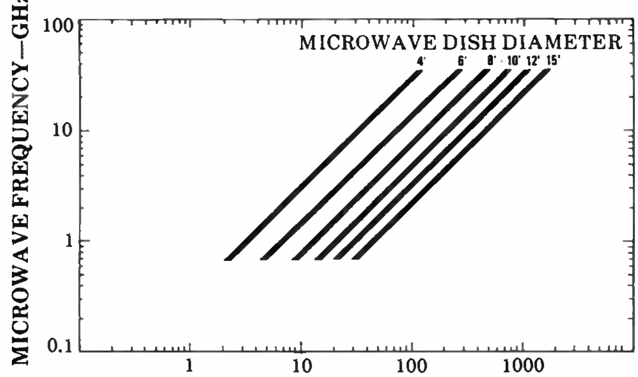
Conclusions

From a review of data available in the international scientific and engineering community, it can be concluded that electromagnetic radiation from radio frequency and microwave sources on fixed base site locations in the land-mobile radio practice in the United States does not constitute a hazard to the health of the general public. If any danger to health exists, it exists as an occupational hazard to those personnel who work directly on high-powered FM or TV antenna systems

Point-to-point land-mobile radio microwave offers little radiation hazard to the general public.

FIGURE 5

Distance to point of maximum power density



DISTANCE FROM MICROWAVE ANTENNA TO POINT OF MAXIMUM POWER DENSITY—FEET

and, to a lesser extent, to those employed in tower work on point-to-point microwave systems.

At present there is no mandatory general public national radiation safety standard in the United States. Radiation safety standards are continuously reviewed and revised in the United States and in the international community. Federal regulatory agencies who license radio/microwave systems, who promulgate national occupational safety standards and those who have mandated concerns for environmental protection issues are, as yet, unable to specify unified standards for RF and microwave radiation protection.

References

1. ANSI C95.1-1982, American National Standard Institute, New York, N.Y., July 30, 1982.
2. "Questions and Answers about

Non-unity gain amplifier math model

The amplifier math model currently used in CATV system calculations depends on the "unity gain" concept. This concept requires that the noise figure, gain and loss between amplifiers be the same for each of the amplifiers in a cascade. In single-cable local area networks (LANs) and many CATV systems, the various amplifiers have different operating characteristics; and unity gain is not applicable. A modified CATV math model is presented which is independent of the previous amplifier characteristics. A simplified model is presented, and both models are numerically compared to the conventional models. The model has been used successfully to calculate the noise accumulation characteristics of a cascade of such devices as trunk amplifiers, line extenders, preamps, spectrum analyzers and frequency translators.

The standard noise factor (linear units) analysis is presented, and these results are the basis of validity for the modified model. Then the standard CATV model is derived from the noise factor analysis with the appropriate approximations. The modified model is presented and numerically compared to the noise factor analysis. Finally, the simplified modified model is derived from the modified model. Since CATV and LAN designers use logarithmic units, equations are presented in logarithmic form when possible.

The notation can be greatly simplified by the use of a power addition operator ⊕. When two signals combine together through a lossless combiner, the total output power is the algebraic sum of the individual power levels in watts.

P_T = Total output power in watts
P_1 = Signal 1 power in watts
P_2 = Signal 2 power in watts

$$P_T = P_1 + P_2 \qquad (1)$$

Using $P = V^2/R$ and, since R is constant, equation (1) may be expressed as

$$V_T^2 = V_1^2 + V_2^2 \qquad (2)$$

The dBmV is defined as

By Richard N. Dunbar, Contel Information Systems Inc.

Utilizing the unity gain concept whenever possible will maximize amplifier spacing, thereby minimizing the number of amplifiers needed and, thus, lower cost. Richard Dunbar provides the mathematical analysis.

$$\text{dBmV} = 20\log(V/10^{-3}) \qquad (3)$$

where

V = Signal level in volts
dBmV = Signal level in dBmV

Equation (3) may be inverted to give volts in terms of dBmV as follows

$$V = (10^{-3})\,10^{\text{dBmV}/20} \qquad (4)$$

Squaring equation (4) and substituting into equation (2) we obtain

$$(10^{-6})\,10^{\text{dBmV}_T/10} = (10^{-6})\,10^{\text{dBmV}_1/10} + (10^{-6})\,10^{\text{dBmV}_2/10} \qquad (5)$$

Multiply equation (5) by 10^6, take the log and multiply by 10 to obtain

$$\text{dBmV}_T = 10\log(10^{\text{dBmV}_1/10} + 10^{\text{dBmV}_2/10}) \qquad (6)$$

Equation (6) defines the power addition operator which is expressed as

$$\text{dBmV}_T = \text{dBmV}_1 \oplus \text{dBmV}_2 \qquad (7)$$

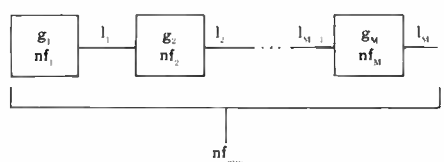
The general rule in using this operator is to perform an operation in parenthesis prior to performing other operations. Equation (7) may be used to calculate the resulting power level from combining two signals including noise signals.

Standard CATV model

The exact equation for the system noise factor nf_{sys} (a ratio) of a cascaded network of M devices is

$$nf_{sys} = nf_1 + \frac{nf_2 - 1}{g_1 l_1} + \ldots + \frac{nf_m - 1}{(g_1 g_2 \ldots g_{M-1})(l_1 l_2 \ldots l_{M-1})} \qquad (8)$$

where nf and g are the noise factors and gains, respectively, of the amplifiers (1 through M), and l is the cable loss between amplifiers as shown below.



When the cable loss equals the gain, then $g_k l_k = 1$ (where k = 1,2,...M) and equation (8) becomes

$$nf_{sys} = nf_1 + (nf_2 - 1) + \ldots + (nf_M - 1) \qquad (9)$$

If the noise factors are the same for each amplifier, then equation (9) becomes

$$nf_{sys} = M(nf - 1) + 1 \qquad (10)$$

Where $nf_1 = nf_2 = \ldots = nf_M = nf$

Converting the noise factor nf (linear) into noise figure NF (logarithmic), equation (10) becomes

$$NF_{sys} = 10\log[M(nf - 1) + 1] \qquad (11)$$

Continued on page 90

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Putting broadband LANs on the map

Local area networks have been touted as integral to the automated office of the future but, ironically, it now appears that factory automation will be a driving force in the coming five years. Indeed, 1985 might well be remembered as a watershed year for LAN technology—a year of transition. Among the changes: IBM signaled its interest in LANs by introducing a token ring system, following its earlier PC network. AT&T and DEC also emerged as new system integrators. Broadband technology got a big boost as a new standard called the Manufacturing Automation Protocol (MAP) garnered significant technical support. And network philosophy began to change. Vendor-specific systems using a single type of transmission medium, signaling and modulation technique were less favored. Instead, interest grew in open systems and multi-vendor sourcing. And increasingly, the notion of backbone nets connecting sub-nets was tested. Over time, it's likely that networks will be organized as interconnected, heterogeneous work groups.

IBM's interest has legitimized LANs and, without question, MAP will dramatically boost broadband technology in a marketplace long dominated by Ethernet signaling techniques. The federal marketplace also is important, especially for security applications.

Some analysts are predicting LAN sales growth of 30 percent per year over the rest of the decade, but it seems inevitable that a shake-out of independent vendors will commence in 1986 as the IBMs and AT&Ts make their presence felt. And while broadband vendors will not be immune to the competitive pressures, there's reason to believe that general interest in broadband technology will continue to grow. Some consulting firms, for example, predicted a decline in new baseband LAN installations during the rest of the decade, while broadband surges.

What's most interesting for the broadband communications community, though, is factory automation. A bit of history: Back in the very early 1970s, General Motors and Dow Chemical were looking for a communications system that wouldn't be affected by periodic ripping up of the factory interior. What Dow and GM wanted was pretty simple: device connection without the need for re-wiring every time a new application was added. In essence, they wanted a system that would offer a port about every 100 feet or so. Device mobility, standardized components and easy migration to the future were other desired system features.

> Factory automation changes the whole picture for local area networks using broadband technology. A protocol called MAP is responsible for the explosion.

GM, especially, was interested in factory automation since it was faced with growing competition from overseas competitors with a cost advantage in labor. And since the company preferred to use competitive bidding for all its automation gear, custom software and interfaces would be necessary so equipment from different vendors could talk to each other. Not elegant, very time-consuming and expensive. Not to mention the maze of cables required to support all the point-to-point connections. And since so many custom interfaces were needed, flexibility was sacrificed.

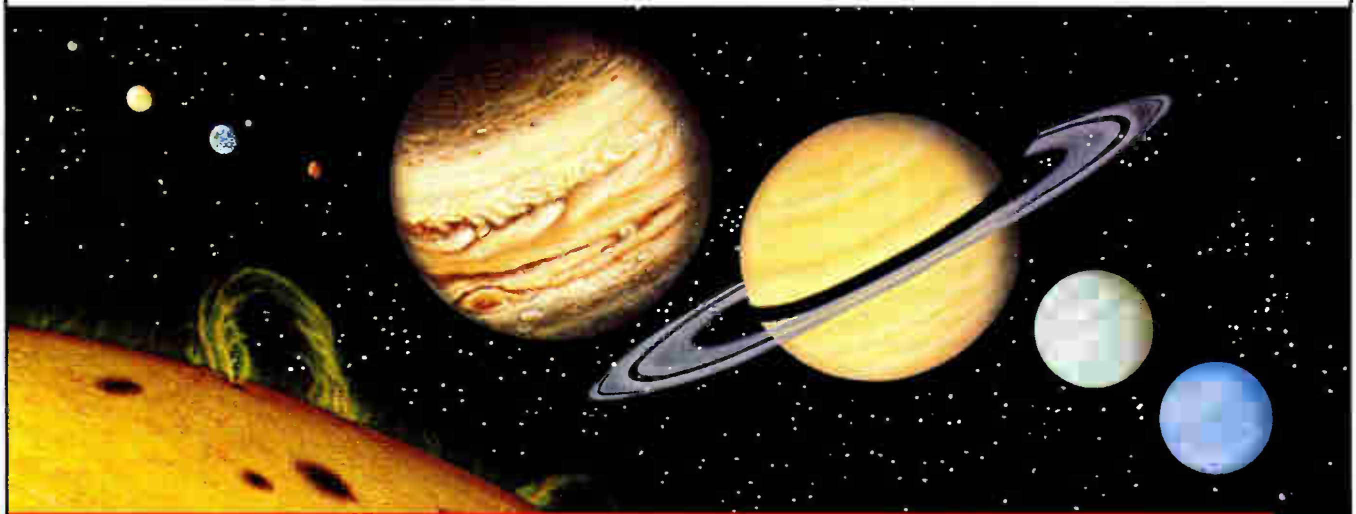
But GM isn't without leverage. It spends something on the order of a billion dollars a year on automation gear. And it tried something interesting. It put together a support group including companies like Du Pont, IBM, Kodak, Boeing, John Deere and McDonnell Douglas. The MAP task force was set up in 1980 and fairly quickly decided to follow the Open Systems Interconnecting model developed by the International Organization of Standardization. The OSI, in brief, is a seven-layer architecture for data communications. The lower layers deal with electrical and mechanical transmission standards, while the upper layers govern applications. The task force also agreed to work with other standards groups like the IEEE, ANSI and EIA.

Of particular interest to the broadband communications community is the MAP task force's choice of broadband technology, specifically the IEEE's 802.4 broadband token bus standard. Especially important in this regard is the eventual size of the factory automation market. Some analysts have estimated that by 1990, factory automation could be a $1 billion market—and MAP should have a good chunk of this business.

The reason is pretty simple. Today, GM, for example, has about 40,000 programmable devices in its plants, including 2,000 robots. By 1990, it'll have many more—perhaps 400 percent to 500 percent more. And already, over 40 percent of total product engineering design and drafting is handled by computers. That percentage should double by the end of the decade. Furthermore, GM found out in a 1981 study that as much as 50 percent of the cost for automation was directly related to communication: wiring, interfaces, software and training.

And there are some important differences between plant level reliability issues and those typically found in office settings. In an office, workers are "loosely coupled." If a node goes down, other work groups are largely unaffected. If somebody tries to send a file to a print server and can't get through, he or she has to try again. It's an annoyance, but it's not a major workflow disruption. Not so on the factory floor. There, a high-speed flow of materials interconnects many different work units in sequence. Any disruption can shut down the line altogether. At the very least, an outage will ripple through the plant. So reliable communications are considerably more important in the factory setting.

MAP is GM's answer to the "islands of automation" problem. Devices within each automation cell could talk to each other because they usually were made by a single vendor. But groups of devices couldn't talk to devices in other groups. So the company was left in a situation where it had many sub-nets operating but, until now, there wasn't a way to link the sub-nets with each other or with front-office data bases. The Boeing Co., in Seattle, Wash., may have a solution. The Technical and Office Protocols, or TOP, are specifications complementary to MAP and matching its stan-



Demand for MAP products and systems, although as yet untested, should be brisk.

dards.

Work on TOP began a few years ago, and the first TOP users group meeting was held in 1985. At the physical layer, TOP uses baseband signaling corresponding to the IEEE's 802.3 baseband bus standard. TOP's importance lies in its deepening of the total approach to automation: linking the front office with process control on the factory floor.

As an automobile moves through the assembly line, information will be gathered by sensors located on just about every piece of equipment at GM, for example. In essence, almost everything that moves inside the plant will have monitoring capability. This information will be relayed to the host computer for quality control and inventory status. Based on this real-time data acquisition, workstations down the line can adjust as work proceeds.

And demand for MAP products and systems, although as yet untested, should be brisk. Some industry-watchers say all of the top 50 U.S. industrial companies have active plans for MAP; and Concord Data Systems, an early leader in MAP-based products, has something over 75 pilot projects going in 50 or so manufacturing companies.

IBM has a MAP network pilot running at its Endicott, N.Y., factory, and certainly will be evaluating whether MAP is suitable for all of the company's plants. Also being tested at Endicott are two software products IBM has developed itself: an application server and communications server. Four buildings are linked by the test network, which monitors the chemical processing line in the factory.

So far, four different versions of MAP have been developed; and most users seem to be settling on the latest version, 2.1, for a minimum of two years. But MAP isn't a settled standard yet, and changes seem likely in the future.

There is some thinking that carrierband sub-nets ought to be groups in cells that connect with the backbone broadband network. The argument is that less-expensive modems then could be used. Going with an 802.4 broadband token bus throughout would require RF modems, and they're more costly.

Then there's the question of data rates on the backbone net, which can be set at 1, 5 and 10 Mbps.

Also, there's the troublesome matter of network management specifications. It's troublesome only because the IEEE hasn't set standards here, and neither has MAP. But the IEEE 802 committee is at work on this problem, and it shouldn't be terribly difficult to solve.

Ultimately, it's expected that many of the MAP protocols will be implemented in silicon, at the chip level. Gateways and bridges to existing LAN systems also will continue to be developed. MAP-based programmable controllers and robots should begin to appear in the not-too-distant future as well.

Motorola, for example, recently released a single-chip, token bus controller that is MAP-compatible. Western Digital and Siemens also have announced plans to build their own chip. Industrial Networking Inc., a joint venture between Ungermann-Bass and General Electric, already has a product on the market. Concord Data is working on one also.

INI, in fact, has at least eight MAP products out now. Among them: a network management console, operating software, network monitor software, a headend remodulator and four different network interfaces.

Gould Inc., meanwhile, has terminated its own Modway LAN and announced its support for MAP. The company also has introduced software allowing Gould mini-computers to communicate on a MAP network, as well as a MAP gateway.

And other significant deals involving major computer vendors are being inked, indicating that many serious players in data processing and communications agree with forecasts of MAP growth. Venture Development Corp., for example, has estimated that MAP broadband nets will dominate the industrial LAN market by 1990, holding 45.3 percent of the entire market. Recently, Concord Data won two multimillion dollar contracts to supply Digital Equipment Corp. and Honeywell Information Systems with MAP products. The two deals are worth an estimated $10 million, some sources say.

This agreement follows an earlier tie-up between GM and INI, estimated to be worth about $10 million in 1986 alone. Under terms of that pact, INI is delivering modems and other gear to GM subsidiary Electronic Data Systems, for use in GM's Flint and Pontiac, Mich.; Fort Wayne and Indianapolis, Ind.; and Oshwa, Ontario, Canada, plants.

AT&T is installing test MAP networks internally and hopes to announce MAP products sometime this year. Intel, meanwhile, has announced compatible board-level software supporting the upper three layers of the OSI model.

Meanwhile, user support for the standard continues to grow. At this time, at least half of the Fortune 100 companies have announced support for MAP, and a study conducted by the MAP users group steering committee indicates that between 15 percent and 25 percent of the cost of an automation system can be saved by using MAP products.

The federal government, arguably the world's single largest user of computing technology, is soon expected to release data communications standards supporting both MAP and TOP.

Of course, not everybody is happy with MAP and, likewise, there isn't uniform concensus that MAP will succeed. McDonnell-Douglas Corp., for example, supports MAP but is very concerned about network security. Lockheed Corp. hasn't committed its support yet. "Elegant, but expensive" is how one observer characterized the MAP standard.

Also, some observers point out that if MAP standards really are implemented at the chip level, vendors won't make very much money after all—since the value-added comes from software and system architecture. And even some MAP supporters think the market will develop over a ten-year period —not, as others believe, over a five-year period.

But the growth of the MAP users group and continuing announcements of support for the standard indicate significant "money-where-your-mouth-is" confidence. In 1984, the users group had about 60 members. Today, it has about 1,600 members worldwide. Scientific-Atlanta, Fairchild Data Corp., Northern Telecom, Hewlett-Packard and Allen-Bradley Co. are

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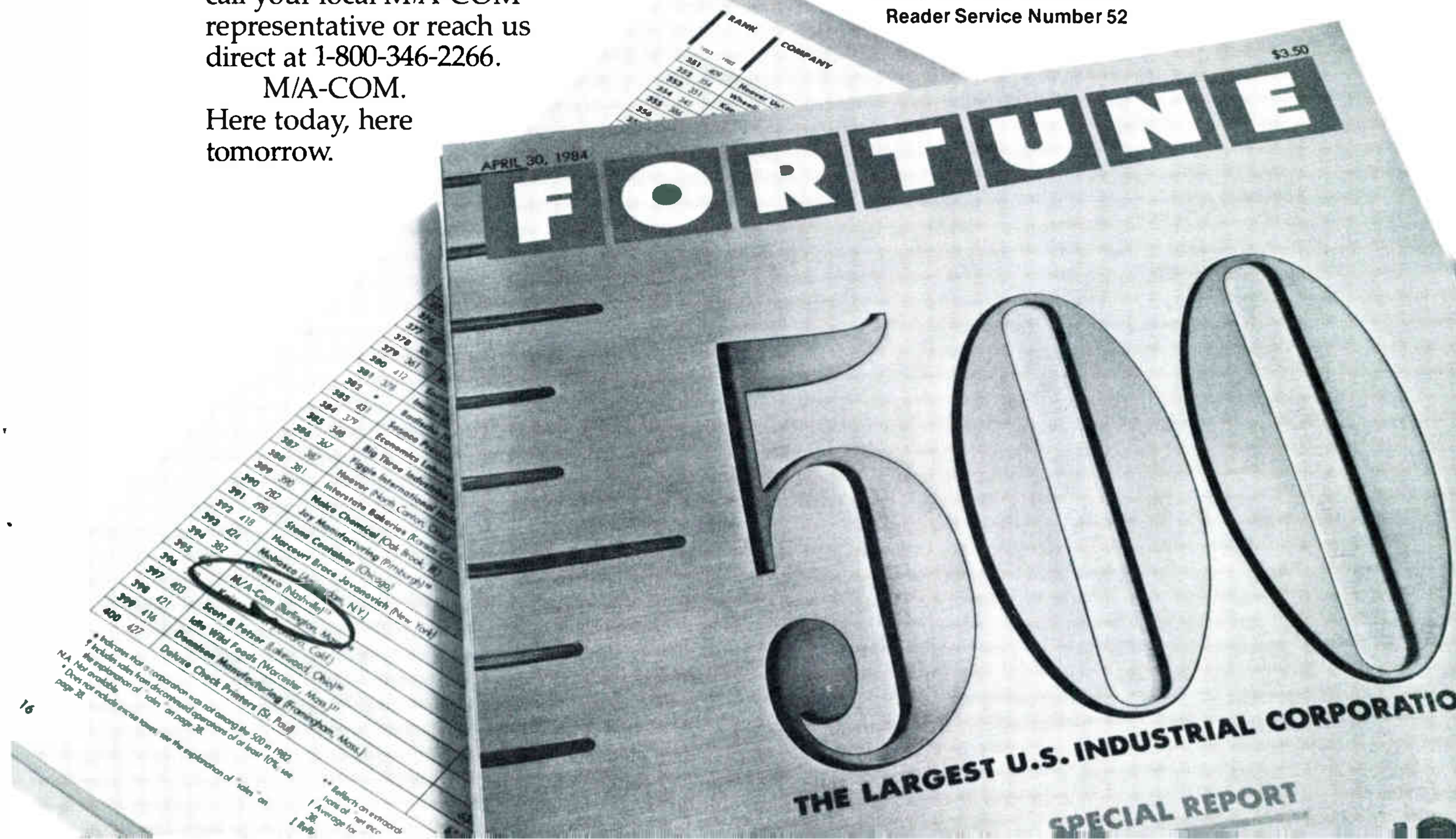


Even if a device conforms to all specifications, there's still the nagging problem of inter-device communication with equipment by other vendors.

among the suppliers supporting MAP.

Of course, designing an open system is one thing. Getting products from a variety of vendors to work together is quite another. All MAP devices are being tested for conformity to standards by the Industrial Technology Institute in Ann Arbor, Mich. Vendors also are spending quite a bit of time at the GM Technical Center in Warren, Mich. Of course, even if a device conforms to all specifications, there's still the nagging problem of inter-device communication with equipment by other vendors, even when all gear meets the specs. And, in general, it's been tough. Tougher for some than for others, but no picnic for most.

Despite the recent flurry of activity, MAP has deep roots. Hal Katz, for example, now is program director, communications technology, at Trintex, CBS-Sears-IBM videotex venture based in White Plains, N.Y. But back in the very early 1970s, he was with Bicom, a company exploring two-way CATV services to the home. Katz was experimenting with a polling network, and it didn't take off.

Bicom then talked to General Motors, which had an Oldsmobile plant in the area. In 1971, under the auspices of Interactive Systems Inc., GM began experimenting with energy management and data acquisition activities. The emphasis at that time was polling; there wasn't that much data to be gathered, and it all had to go to a central monitoring point. American Motors also began its own experiments with broadband about this time.

Bob Dickinson of AM Cable's Network Technologies division and Larry Lockwood of Tele Resources are other veterans who were active at early stages of broadband's growth as a LAN medium. Both agree MAP's important. Dickinson's group just finished some point-to-point work for GM, as a matter of fact, and he points out that "it's starting to get to the point where you've got some choices from vendors. MAP's largely responsible for that."

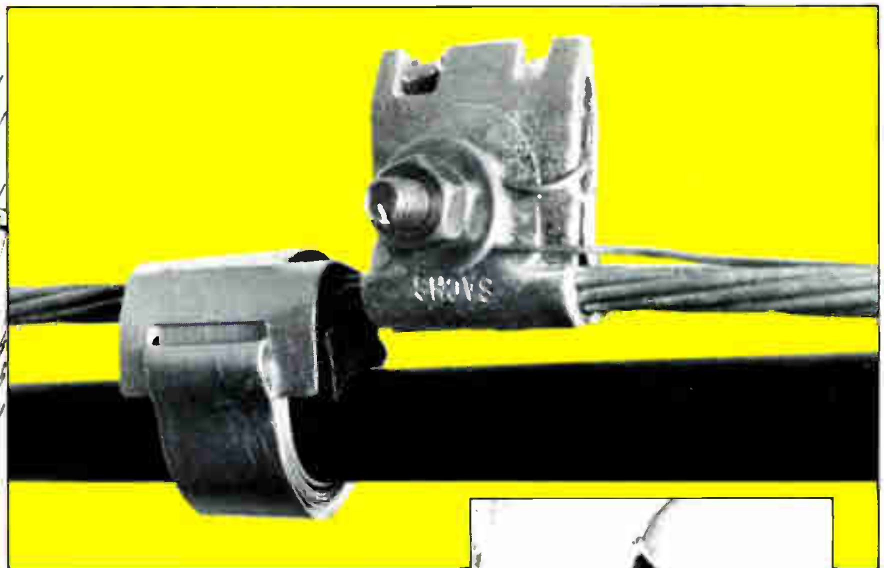
Lockwood says flatly: "MAP changes everything. Whatever the history of broadband's use as a LAN medium, that history doesn't even influence what will happen now."

Dickinson and Lockwood aren't alone in that belief. General Instrument's Vice President for LANs Jeff Roman agrees that the big growth for broadband in the next five years is factory automation.

And Scientific-Atlanta, which has been involved in 802.4 standards work since 1984, has begun to release MAP-compatible products. Among them: a new board for its 6400 modem line, supporting the 10 Mbps data rate version of MAP. A new remodulator for MAP applications, the model 6445, also is available.

—Gary Kim

Razor Blade or Support Strap...



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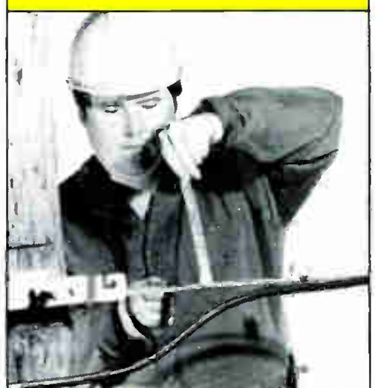
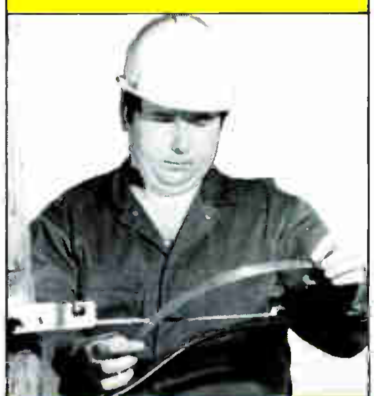


Straighten on strand.



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Reader Service Number 55

product profile

Voice response systems, like many products, range in size from a single-line, small unit to a larger 32-line unit. Their functions and capabilities can be exactly what is needed, or nowhere close. Following are some of the manufacturers and their products.

The System 606 from **Telecorp Systems Inc.** is a telecomputer that sends a recorded message over the phone, at a rate of 300 calls per hour. It automatically re-dials busy signals and no-answers and can use nine outgoing messages in the same calling session for message customization. Other features of the System 606 are unattended operating capability any time and a capacity of up to 25,000 calls per line, per day. Reports can be printed which show number of calls dialed and redialed, qualified responses, operator intercepts or bad numbers, busy signals and no-answers.

For more information, contact Telecorp Systems Inc., 5825-A Peachtree Corners East, Norcross, Ga. 30092, (404) 449-6991, (800) 334-9907.

Dialogic Communications Corp.'s, TeleClerk™ is designed to operate as a stand-alone unit or in conjunction with a host computer, Teleclerk can operate in two modes. In the telephone dial mode, TeleClerk instructs respondents to answer questions by inputting specific information via the telephone dial. In the second mode, TeleClerk can ask the caller to leave any kind of verbal message, such as name and address.

Because TeleClerk uses digital recording and playback techniques, usage of cassette tapes is eliminated as well as deterioration of fidelity. Each TeleClerk system is capable of up to five lines and has report capabilities designed for the user's needs.

For more information, contact Dialogic Communications Corp., 1106 Harpeth Industrial Court, P.O. Box 8, Franklin, Tenn. 37064, (615) 790-2882.

Available from **Microvoice Systems Corp.** is the VoiceManager, capable of automatic prescreen or transaction processing with operator support. Manual transaction processing is possible where routine or narrative information can be automated. Modular in design, the Multivoice system simultaneously can process the transactions of up to 96 users. Its microprocessors and direct memory access permit the system to operate standing alone, although it has the capability to communicate with mainframe computers to access centralized data bases.

Voice response systems range in size from a single-line, small unit to a larger 32-line unit.

Reports are available which give statistical and diagnostic data collected. Statistics collected include trunk, line and component status; event counts linked to specific transactions; remote host status; number of calls by channel, transaction group or by time of day; number of attendant referrals; average, maximum and minimum call duration; and generic error conditions such as timing out or not recognizing tones.

For more information, contact Microvoice Systems Corp., 23362 Peralta Dr., Suite 5, Laguna Hills, Calif. 92653, (714) 859-1091.

A product of **Melita Electronic Labs Inc.**, the Melita 3000 Series Telecomputer is an automatic call-in and call-out system. The Melita 3000 is expandable from a single telephone line up to four separate lines, and multiple lines can be added when required. Features include simultaneous operation for both incoming and outgoing calls, operator assisted calls for any and/or all lines; and each line is supported by a separate, individualized calling list.

Statistics provided by the Melita 3000 include busy numbers, operator intercepts, hang-ups, positive responses, answering machines, completed all questions and bad connections.

For more information, contact Melita Electronic Labs Inc., 3731 Northcrest Road, Suite 29, Atlanta, Ga. 30340, (800) DIAL-MEL, or in Ga. call (404) 457-3700.

Perception Technology offers a family of data entry/voice response systems designed around its proprietary BT-II voice response peripheral. In addition to host computer interfaces, the BT-II also operates in conjunction with a variety of PBX systems. Other members of Perception Technology's product family include the AudioText 1, the VOCOM 1 and the Call Supervisor Option (CSO).

Benefits of the data entry/voice response systems are unattended 24-hour, 7-day availability, heavy call load capacity, universal access to data base information from any touch-tone telephone, simultaneous processing of numerous transactions, minimal staff training requirements and switching routine incoming calls. Product features available include support of 8 to 256 telephone calls simultaneously, one data terminal for 32 telephone lines and negligible amount of host computer time used.

For more information, contact Perception Technology, Shawmut Park, Canton, Mass. 02021-1409, (617) 821-0320.

The Speechmaker Announcement System (SAS) from **Cognitronics Corp.** adds voice response capability. Configured as a complete stand-alone system, the SAS consists of the Cognitronics 683 Voice Response Unit, which can simultaneously handle from 1 to 12 telephone lines, an IBM(R) personal computer AT and a printer for the system's activity log reports. Large multi-line voice response units also are available.

Benefits of the system include flexibility in message vocabulary and telephone line configuration, 24-hour service, logged inquiries for system monitoring and non-volatile memory. The voice of the SAS is a digital reproduction of actual human voice. Also available from Cognitronics is an ANI-based PPV voice response system.

For more information, contact Cognitronics Corp., 25 Crescent St., Stamford, Conn. 06906, (203) 327-5307.

Available from **Interface Technology Inc.** is the TOES/350, multiple application voice response data collection and inquiry system. The TOES/350 system incorporates digitized voice response, providing the capability to instantly digitize any voice message—from tape recordings or telephone. Designed as a

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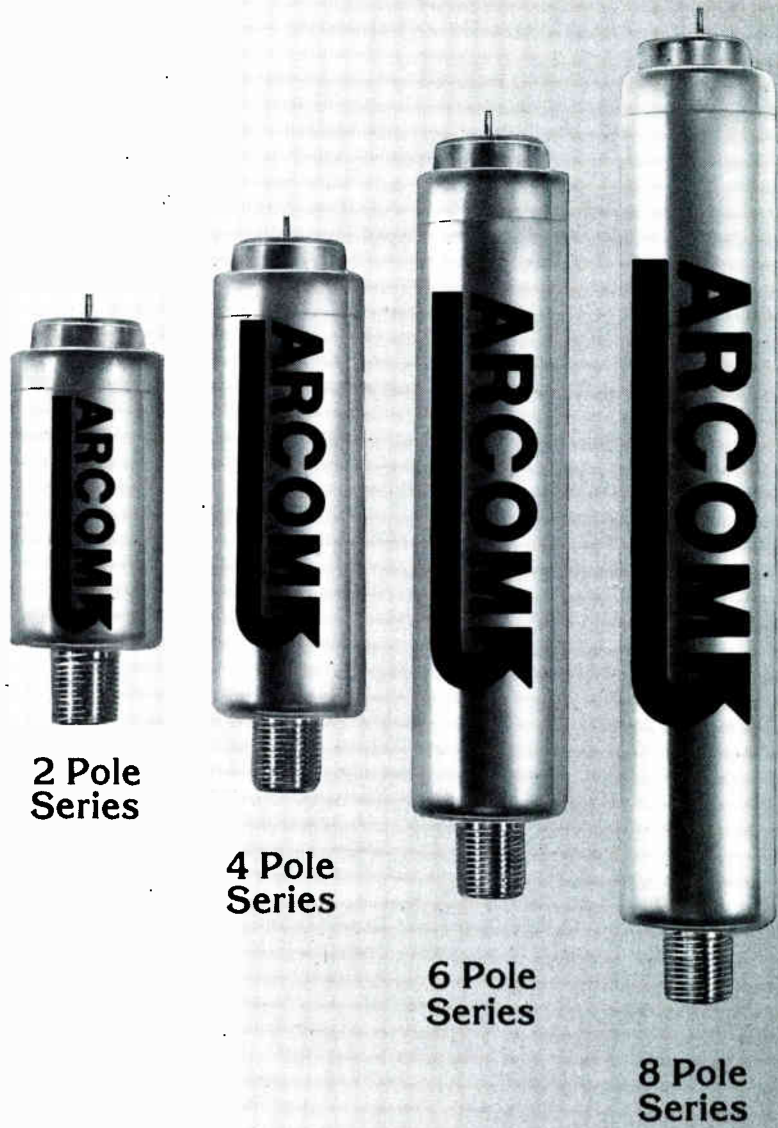

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For more information, contact Interface Technology Inc., 10500 Kahlmeyer Dr., St. Louis, Mo. 63132, (314) 426-6880, TWX (910) 765-0916.

Digital Products Corp. manufactures a new product in its series of TELSOL Automatic Telephone Robots. Tailored specifically for the cable industry, Cable Caller is capable of tasks such as scheduling service or installation, contacting deliquent customers, disconnect notification, market research, generating new customer leads and market research.

Features of Cable Caller include automated unattended operation, built-in monitor for listening while calls are in progress, compatibility with tone or pulse systems, possible mixing of local and long-distance calls, full bi-directional computer interface for automatic loading and reporting, interface ability with all standard non-multiplex telephone systems and endless loop announcement tape. When used with a printer, Cable Caller provides a printed record of its calling activity.

For more information, contact Digital Products Corp., 4021 N.E. Fifth Terrace, Fort Lauderdale, Fla. 33334, (305) 564-0521, outside of Fla., (800) 327-9476.

Voicetek Corp. manufactures the VTK 80 and the VTK 60 voice processing systems providing voice response and voice storage retrieval. The VTK 80 records and plays back actual words, phrases or sentences exactly as they are spoken. The vocabulary is flexible, with no fixed limit on any element. The VTK 80 supports up to 32 simultaneous voice channels, allowing access from several sources on an asynchronous basis. The system interface is a standard RS-232 control channel, operating at a wide range of data transmission.

The VTK 60 incorporates the features of the VTK 80 into a smaller unit. The VTK 60 features 2 to 8 ports instead of the 32 available with the VTK 80. Voicetek presently is working within the cable industry for application of the VTK systems with pay-per-view.

For more information, contact Voicetek Corp., 61 Chapel St., Newton, Mass. 02158, (617) 964-8820.

With a printer, reports can be generated which show a day's calling activities.

VOTAN's products include a card and software that add voice recognition and voice output capabilities to the IBM PC and compatibles, a voice terminal that provides these capabilities to a variety of micro- and mini-computers as well as IBM 3270 networks and a stand-alone multi-channel voice processing/telephone management system for applications with a large number of users.

The VTR Series of voice terminals is a system that adds complete voice I/O and telephone management capabilities to the universe of ASCII computers and terminals. The VTR 6000 is a stand-alone voice I/O sub-system with its own chassis, power supply, microphone and speaker, and connects to any computer supporting an RS-232 serial port.

The VPC 2000 Voice Card is composed of a printed circuit board that plugs into any of the long auxiliary system bus slots. Microphone, speaker and complete software and documentation to get "up and talking" are included with the VPC 2000.

For more information, contact VOTAN, 4487 Technology Dr., Fremont, Calif. 94538, (415) 490-7600.

Offered from NEC America Inc. is the NEC DP-200 Connected Speech Recognizer (CSR). The data entry system listens to spoken commands and executes the corresponding processing immediately. The DP-200 CSR is a compact version of the DP-100 system, offering upgraded functions. The NEC CSR uses Dynamic Programming (DP) allowing incoming speech and words stored in memory to become "warped" or made non-linear. The "warping" process eliminates errors caused by word segmentation and incorrect matching.

Features of the DP-200 include an expandable vocabulary size up to a maximum of 150 words in the connected mode and a maximum of 500 words for discrete mode (optional), recognition performance at noise levels up to 85 dB and an optional audio response package which can be built into the Speech Recognition Terminal (SRT).

Also available from NEC is the SR-2000, a commercial, independent speech system allowing over-the-phone access to account information. Currently used in Japan, development plans are to introduce this system to the United States. The SR-2000 system consists of a voice processor (SR-2000) and network control equipment (SR-2000-100). A variety of architectures are available on request.

For more information, contact NEC America Inc., 532 Broad Hollow Road, Melville, N.Y. 11747, (516) 753-7000.

—Kathy Berlin


JERROLD


Converter repair callbook

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4630 Pacific Hwy. East
Suite B7
Fife, Wash. 98424
206/922-9011

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Indianapolis, Ind. 46234
317/353-6668
828 Mitchell Road
Newbury Park, Calif. 91320
805/499-8702

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The model has been used successfully to calculate the noise accumulation characteristics of a cascade of various devices.

Continued from page 72

or

$$NF_{sys} = 10\log[M(10^{NF/10}-1)+1] \quad (12)$$

Equation (12) is exact and no approximations have been applied, although (unity gain) assumptions have been made. The results of equation (12) are given in Table 1, and they are used as the numerical reference in comparison with the other models.

The standard CATV model assumes $NF>>1$. Therefore, $10^{NF/10}>>1$ and, thus, $M(10^{NF/10})>>1$ since $M>1$. In this case equation (12) becomes

$$NF_{sys} = 10\log[M(10^{NF/10})] \quad (13)$$

or

$$NF_{sys} = NF + 10\log(M) \quad (14)$$

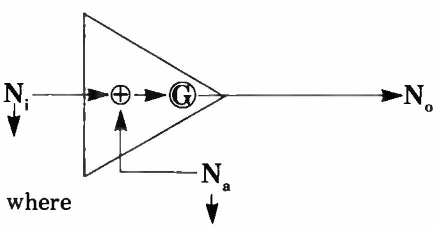
Equation (14) is the model currently used by the CATV industry and requires the restrictions of the unity gain concept with approximations.

In systems where the amplifier characteristics are different, such as trunk amplifiers connected to bridger amplifiers, the standard model is not applicable since the noise figures and/or gains are different.

A modified model is presented in the next section which is independent of the amplifier before the amplifier in question. The modified model also is used to verify the results to measurements using a preamp and spectrum analyzer.

Modified Model

The model for the general case is shown below



where

N_i = input noise level in dBmV
N_o = output noise level in dBmV
N_a = amplifier noise contribution in dBmV
G = gain of amplifier in dB
$\oplus$ = power addition

$$N_o = (N_a \oplus N_i) + G \quad (15)$$

The validity of the modified model can be checked by numeral comparison with equation (12) by applying the unity gain concept to the modified model. However, first the amplifier contribution N_a must be expressed in terms of the manufacturer's specifications, ie: the noise figure (in dB).

By the definition of noise figure NF, the output noise is given by

$$N_o = N_T + NF + G \quad (16)$$

when the input noise level is equal to the theoretical thermal noise floor N_T ($N_T = 20\log[\sqrt{kTBR}/10^{-3}]$) or, equivalently, when the input is terminated in the characteristic impedance.

In order for the modified model to comply with the fundamental definition, equation (15) must give the same result as equation (14) when $N_i = N_T$, thus

$$(N_a \oplus N_T) + G = N_T + NF + G \quad (17)$$

Canceling G from both sides and applying the definition of the power operator we have

$$10\log(10^{N_a/10} + 10^{N_T/10}) = N_T + NF \quad (18)$$

Equation (18) may be solved for N_a as follows:

$$10^{N_a/10} + 10^{N_T/10} = 10^{(N_T + NF)/10}$$

$$10^{N_a/10} + 10^{N_T/10} = 10^{N_T/10}10^{NF/10}$$

$$10^{N_a/10} = 10^{N_T/10}(10^{NF/10}-1)$$

$$N_a = N_T + 10\log(10^{NF/10}-1) \quad (19)$$

Equation (19) is substituted into equation (15) to obtain the modified model.

$$N_O = G + (N_I + [N_T + 10\log(10^{NF/10}-1)]) \quad (20)$$

The simplified version is obtained by assuming $NF>>1$, in which case $10\log(10^{NF/10}-1) \cong NF$. Thus, the simplified model is:

$$N_o = G + [N_i \oplus (N_T + NF)] \quad (21)$$

The validity of this model is confirmed numerically in Table 1 where

Table 1

Numerical comparison of models (unity gain applied)

No. of amps	Eqn (12)	Eqn (14)	Eqn (20)	Eqn (21)
1	-49.00000	-49.00000	-49.00000	-48.58607
5	-42.37242	-42.01030	-42.37242	-41.92430
10	-39.40959	-39.00000	-39.40959	-38.95679
20	-36.42321	-35.98970	-36.42321	-35.96804
40	-33.42493	-32.97940	-33.42491	-32.96854
60	-31.66803	-31.21849	-31.66801	-31.21124

No. of amps	Eqn (12)—Eqn (20)	Eqn (12)—Eqn (21)	Eqn (12)—Eqn (14)
1	0.00000	0.41393	0.00000
5	0.00000	0.44812	0.36212
10	0.00000	0.45280	0.40959
20	0.00000	0.45517	0.43351
40	0.00002	0.45639	0.44553
60	0.00002	0.45679	0.44954

Amplifier noise figure = 10 dB
Thermal noise floor = -59 dBmV
Amplifier gain = 20 dB
Cable loss = 20 dB

Eqn (12) = Noise factor model
Eqn (14) = CATV model
Eqn (20) = Modified model
Eqn (21) = Simplified modified model

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Maximizing the amplifier spacing will minimize the number of amplifiers.

the results of equations (12), (14), (20) and (21) are compared. After 60 amplifiers, the exact equations (12) and (20) differ only in the fifth decimal place.

The approximations (14) and (21) converge to within three decimal places after 60 amps; however, they both differ from the exact calculation by about 0.5 dB.

Thus, the appropriate equation may be used depending on the accuracy needed and if the unity gain concept can be applied.

Conclusion

Equation (20) represents a valid math model for calculating thermal noise levels in CATV, MATV, SMATV, LANs and other systems where the unity gain concept cannot be applied. The unity gain concept should be applied when possible since it will maximize amplifier spacing. Maximizing the amplifier spacing will minimize the number of amplifiers, which can maximize performance while minimizing cost.

Bandwidth considerations are accounted for in the theoretical thermal noise floor, N_T. If calculations are performed using a noise floor of -59 dBmV (that of a 4.5 MHz channel), the resulting (Gaussian) noise levels also will correspond to a 4.5 MHz bandwidth. Once the noise level is calculated, the signal to noise ratio is simply the signal level minus the noise level (both are referenced to a 4.5 MHz channel).

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2. Edward Cooper, "Broadband Network Technology," ©1984 by Sytek Inc.
3. Ken Simons, *Technical Handbook for CATV Systems*, ©1968 by Jerrold Electronics Corp.

About the author

Richard N. Dunbar received his B.S. in physics with a minor in mathematics in 1979 from Virginia Polytechnic Institute and is a member of ΣΠΣ Physics Honor Society.

In 1980 he was employed by Telcom Inc. as a systems design engineer to design broadband microwave communication systems. In 1982 he was employed by Contel Information Systems to design broadband coaxial cable communications systems (LANs) using CATV technology. He received his M.S. in Electrical Engineering (communications) in 1984 from Virginia Polytechnic Institute.

Dunbar also has performed frequency allocation studies on the basis of noise and distortion for the House of Representatives H.I.S. LAN. ■

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CWY Electronics introduces a new 48-inch high equipment rack for descrambler headend expansion. The RR48 rack provides 45.5 inches of rail space with 26 rail spaces. Panel rails are drilled and tapped for 10-32 screws on EIA/RETMA rack spacing of 0.5″-1.25″. The RR48 model is constructed of 11-gauge formed steel with a standard ASA 61 gray baked enamel finish.

For more information, contact CWY Electronics, P.O. Box 4519, Lafayette, Ind. 47903, (317) 448-1611 or (800) 428-7596.

In-band addressing for the Sigma product line will be announced at the NCTA show. **Oak Communications** also will be showing Sigma Phase II, featuring a smaller footprint. Phase II is fully compatible with existing Sigma systems. The company also will show its primary/secondary decoder set-up; an EIA-compatible version of the Sigma decoder; a new, hand-held VCR timer for the TC-56 decoder and a remote for the TC-56 and KDM-400 converter/decoders.

For more information contact Tony Wechselberger, Oak Communications, 16935 W. Bernardo Dr., Rancho Bernardo, Calif. 92127, (619) 451-1500.

Four new cable preparation tools, designed for use in confined areas, are now available from **Klein Tools**.

For more information, contact Klein Tools, at 7200 McCormick Blvd., Chicago, Ill. 60645-2791, (312) 677-9500.

RMS Electronics announces its 5-600 MHz Ultra-Tap series of two- and four-way interchangeable directional taps. Ultra-Tap is available with either die-cast, machine threaded or screw machine brass "F" ports. The bending strength of the die-cast, machine threaded "F" ports on models UT-600 2 (two-way) and UT-6004 (four-way) are equivalent to that of brass ports.

For more information, contact RMS Electronics Inc., 50 Antin Place, Bronx, N.Y. 10462, (212) 892-6700, collect in N.Y. state, (800) 223-8312.

LRC Electronics high pass filter

LRC Electronics, Inc., introduces a self-terminating coaxial cable connector. The connector is designed for the automatic termination of a 75 ohm coaxial transmission line in a coaxial cable system when a cable/connector interface is interrupted. The components of the connector are completely contained in the housing, and the compact design is compatible with RG 59 and RG6U connectors for both PVC and plenum cables.

Also available from LRC is a compact high pass filter with one-piece construction. Reduced in size, the design allows for elimination of ingress and egress problems with the one-piece construction.

For more information, contact, LRC Electronics Inc., 901 South Ave., Box 111, Horseheads, N.Y. 14845, (607) 739-3844.

Complete Systems C-35 digital cable tester

Complete Systems, Inc. introduces the C-35 Digital Cable tester. Based on the concept of time domain reflectometery, the C-35 cable tester is designed to serve as a diagnostic tool for CATV cable problems. In digital mode, the device will locate and identify cable shorts, opens, and confirm length and continuity. Attaching an oscilloscope for analog mode, the C-35 can step down the cable and locate kinks and partially crushed cable. The C-35 has pretuned settings for 50 and 75 ohm cable with capability to handle all CATV cable types regardless of dialectric.

For more information, contact Complete Systems, Inc., 3206 Wildmere Place, Herndon, Va. 22071, (703) 620-5372.

Riser-Bond Instruments offers a digital time domain reflectometer, cable fault locator with a new adjustable sensitivity control. The new Model 2901B with variable sensitivity is adjustable from 20 dB RL to 40 dB RL. The 2901B will enable the user to find smaller problems, measure longer cables and look through some multiple faults.

For more information, contact Riser-Bond Instruments, 505 16th St., Box 188, Aurora, Neb. 68818, (402) 694-5201.

New from **International Satellite Systems (ISS)** is the second generation GL-2610 agile modulator. The GL-2610 has a frequency stability of ±5 kHz as well as selected channels with offset frequencies of +12.5 or 25 kHz. In addition, the GL-2610 covers all fre-

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quencies through hyperband.

For more information, contact International Satellite Systems, 1004 Del Norte, Menlo Park, Calif. 94025, (415) 853-0833.

Viewsonics introduced a comprehensive line of filters and traps. The line includes high pass filters with up to 65 dB suppression, diplex filters with up to 60 dB isolation between high/low, FM traps and band pass filters and low pass filters. Each is available in a variety of mechanical configurations. Custom design also is available.

For more information, contact Viewsonics, Box 36, Jericho, N.Y. 11753, 800/645-7600 or 516/921-7080.

DX Communications Inc. introduces the Model DSB-800, an all-in-one receiver and antenna positioner. The DSB-800 can be pre-programmed to automatically select dish positioning, satellite types and numbers, channels, polarization information, stereo modes, frequencies and C- or Ku-band reception.Other features include block downconversion, descrambler-ready and infra-red full-function remote control.

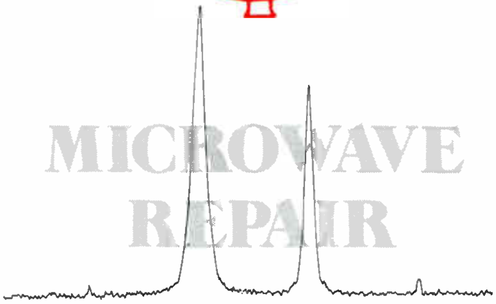
DX Communications also offers the Model DSA-644 commercial satellite receiver. The receiver features dual block downconversion, 30 MHz IF bandwidth, a SAW-filtered second IF unclamped video and composite BB outputs, a clamp/unclamp video switch, 24-channel detent tuning, 8 dB threshold and a video test point on the front panel.

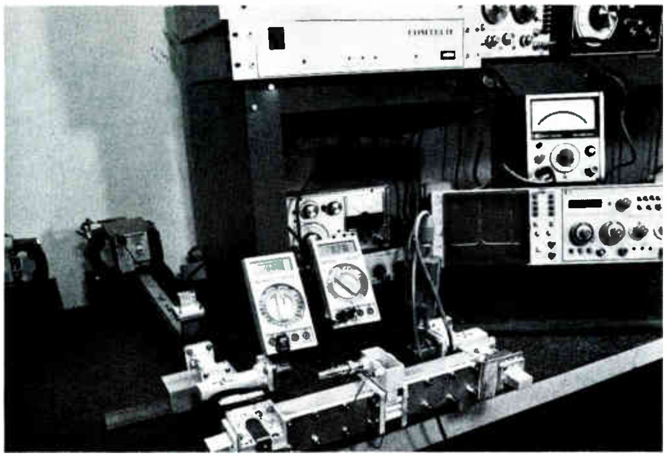
DX Communications expands its product line further with the new DSM-110, a satellite TV frequency agile modulator. Designed to interface with all DX commercial receivers, the DSM-100 offers front-panel-select channels for VHF, Midband and Superband, adjacent-channel operation, IF loop through, +45 dBmV output and low spurious output.

For more information, contact DX Communications Inc., Commercial Products Division, 10 Skyline Dr., Hawthorne, N.Y. 10532, (914) 347-4040.

Tektronix 2700 series spectrum analyzer

Tektronic Inc. announces the 2754 and 2754P spectrum analyzers, designed specifically for the system environment. Both analyzers have center and marker frequency accuracy of 1 x 10^{-5},





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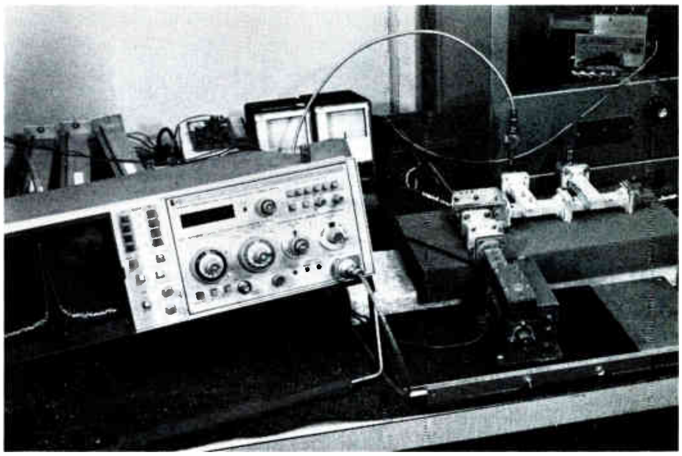

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Tektronic also offers the 2755 and 2755P spectrum analyzers, designed for the engineering lab and manufacturing test environment. The 2755 and 2755P have center and marker frequency accuracy of 1 x 10^{-5}, a frequency range of 50 kHz to 21 GHz in coax and up to 325 GHz using TEK's waveguide mixers. The analyzers have built-in signal processing that identifies CW and pulse/impulse signals.

For more information, contact Tektronix Inc., Marketing Communications Dept., P.O. Box 1700, Beaverton, Ore. 97005, (800) 547-1512, in Ore., (800) 452-1877.

Pico Home Satellite's new PAC-1000 programmable actuator/controller is a microprocessor-controlled antenna drive system. The PAC-1000 automatically programs up to 24 satellite positions and polarity selections. It also can be programmed for automatic format changes and to correct skew angles.

Pico also introduces the Pico TEN, a 10′ diameter circular mesh antenna. The Pico TEN is constructed of lightweight aluminum and powder-coated steel with dakrom and stainless hardware.

For more information, contact Pico Home Satellite, Product Information Dept., 103 Commerce Blvd., Liverpool, N.Y. 13088, (800) 336-3363.

Pico PAC-1000 antenna drive system

Anixter Communications will introduce new products from Jerrold, Raychem and Regal at the NCTA Convention, March 15-18, in Dallas. The model VCU, a **Jerrold** VCR control unit, is designed to simplify the interconnection between cables, converters, VCRs and televisions in a subscriber's home. The unit operates in the 50-450 MHz band.

From **Regal** is an eight-way multitap featuring 1½ dB increment spacing in the 7 dB through 35 dB range. The tap is available for both CATV and broadband/LAN applications.

The EZF-6 connector from **Raychem** fits all RG6 cable. The connector reduces RF leakage and moisture penetration and has a pull-out strength for temperatures -40° Celcius through +60° Celcius.

For more information, contact Anixter Communications Inc., 4711 Golf Road, One Concourse Plaza, Skokie, Ill. 60076, (312) 677-2600.

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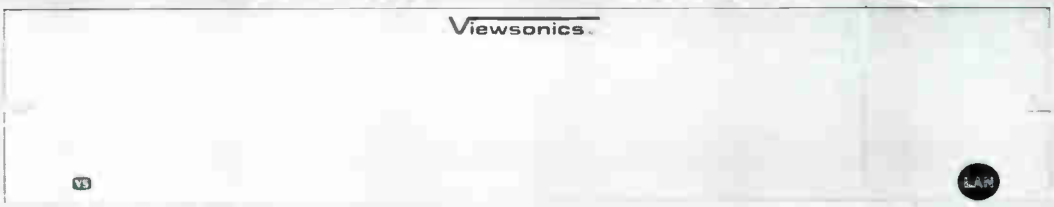

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Gary Kim
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In an industry flooded with trade publications, it is exciting to learn that cable operators are reading and responding to the massive amount of information we continually offer them. So was the case with the January issue of CED.

Your publication ran an article on the VCR interface issue which included a small paragraph on Pioneer's VCR switcher. As soon as the article appeared, I was overwhelmed with the calls from the audience I was trying to reach; Cable operators/engineers. Because CED was the only publication offering information on our switcher, I can only conclude the interest was generated solely from CED.

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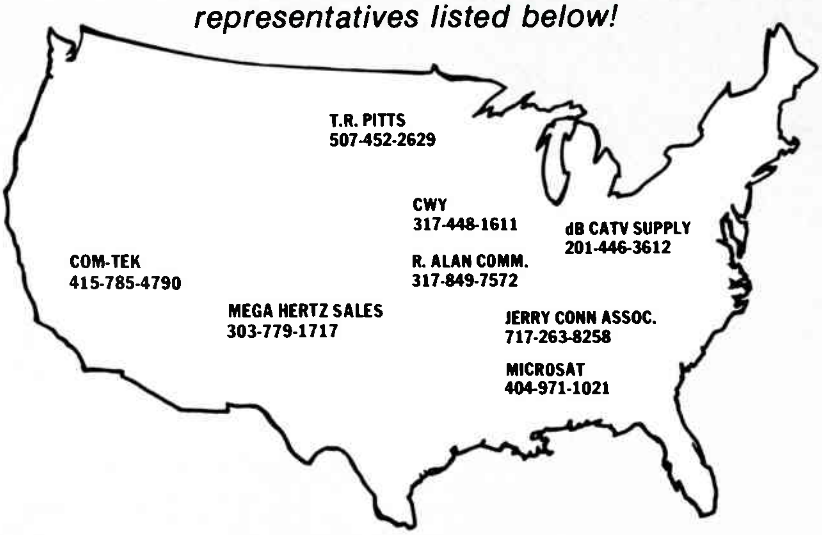

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