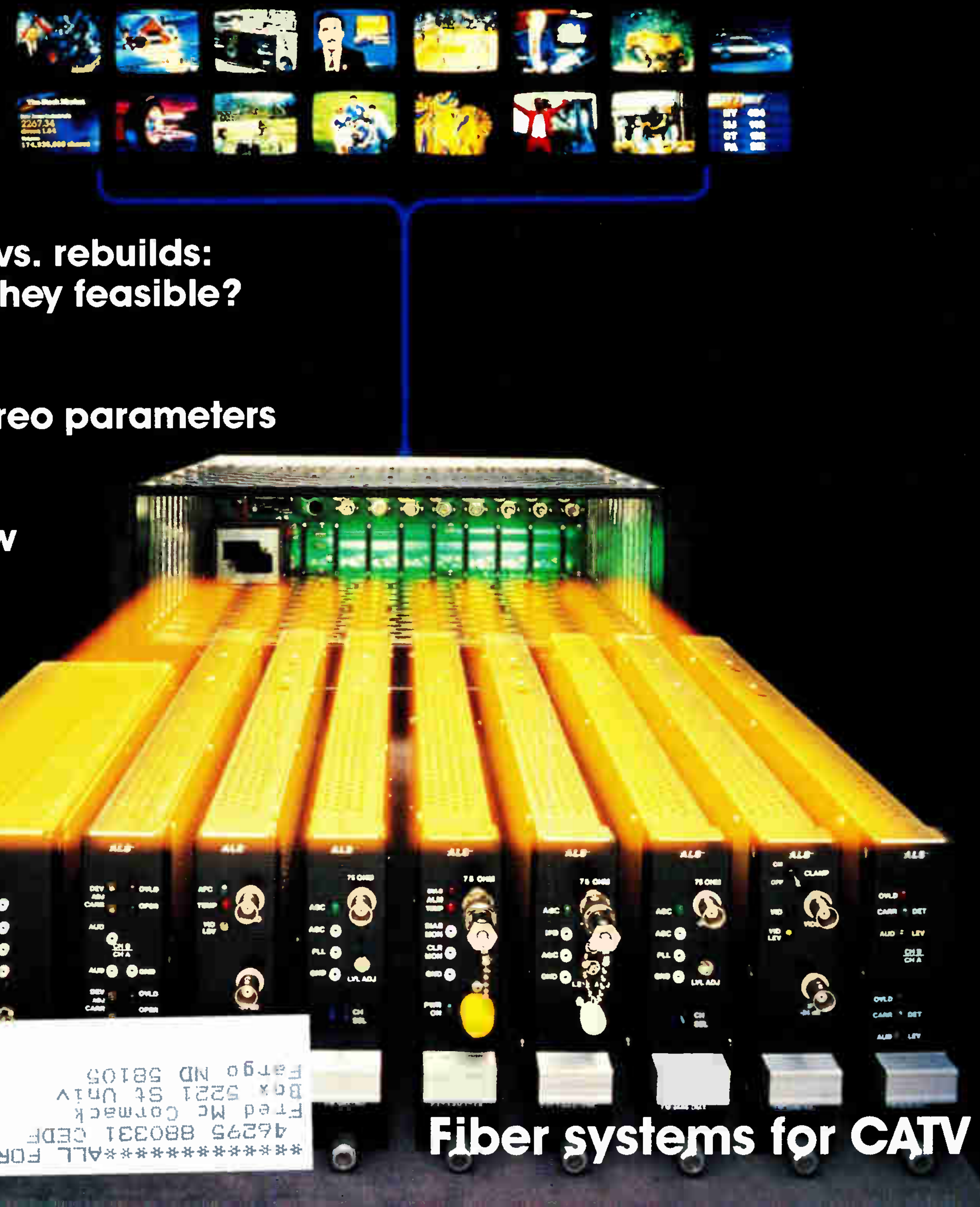
FEBRUARY 1988

COMMUNICATIONS ENGINEERING AND DESIGN
THE MAGAZINE OF BROADBAND TECHNOLOGY

CED



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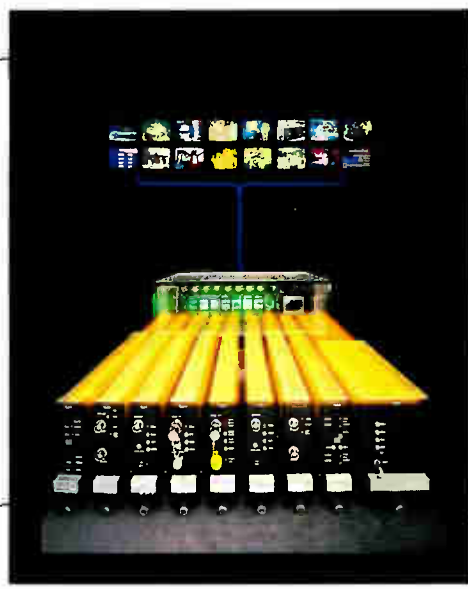
February 1988 Volume 14, Number 2

About the cover
Fiber optic systems available for implementation in CATV systems today can deliver at least 16 video channels per fiber. Photo courtesy American Lightwave Systems.



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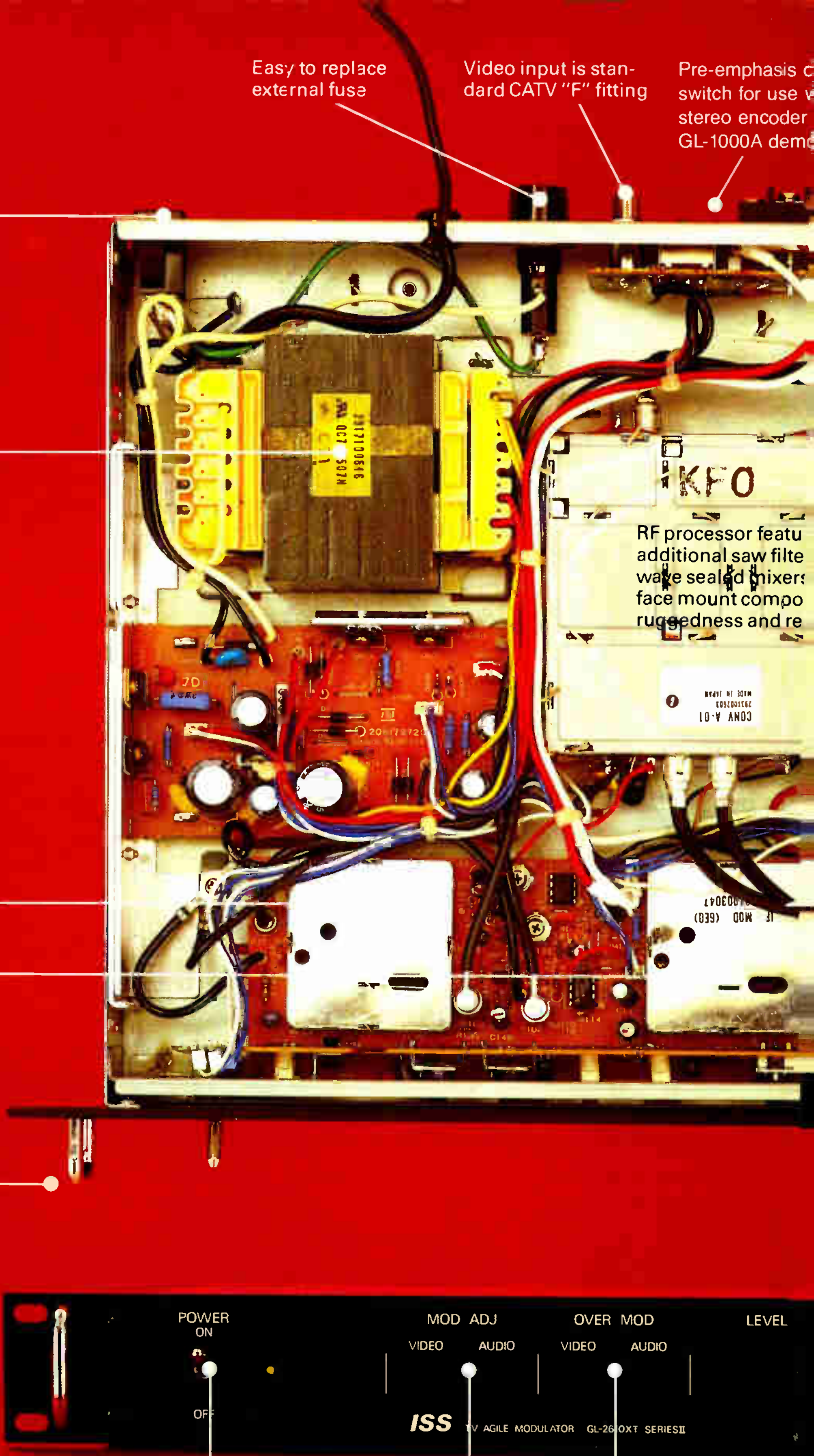

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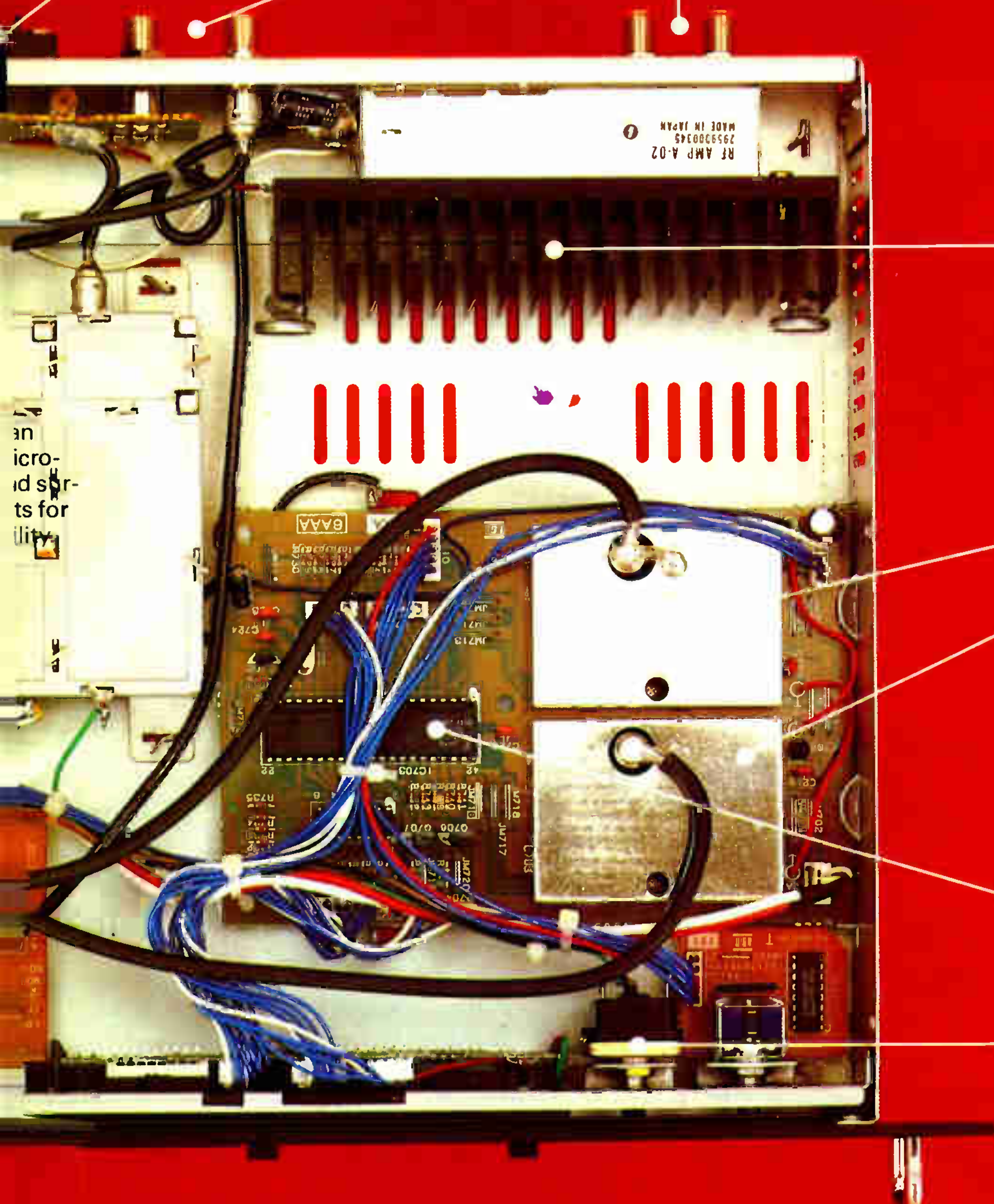

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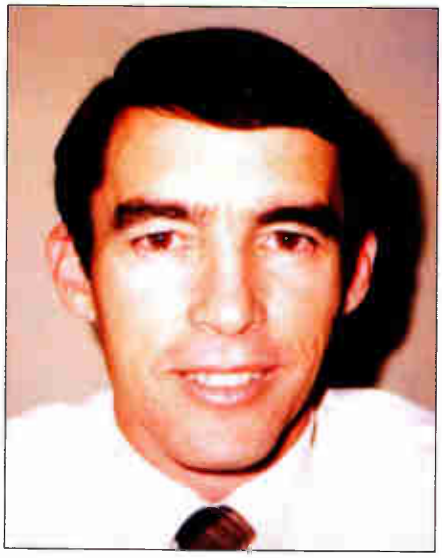

Bert Henscheid

New spirit for head of R&D at Texscan

With more than 20 years of experience in cable television product engineering, Bert Henscheid has been a part of the good times that saw the industry grow by leaps and bounds. Conversely, by being an employee of Texscan, he's weathered the lean times of the past two years. And through it all, he's remained a respected voice in the engineering community, committed to providing quality products.

In Henscheid's capacity as vice president of research and development at Texscan, where most of his efforts are aimed at exploring advanced product ideas, it's partly Bert's job to make sure the company steers clear of situations like the one that put the manufacturer in Chapter 11 just three years ago.

"We were growing rapidly—sales were up," recalls Henscheid. But then the industrywide slowdown occurred and Texscan was trapped. "It was kinda painful after growing so rapidly to rapidly decelerate," he remembers. But as of Dec. 10, 1987, Texscan is no longer in the shadow of Chapter 11 bankruptcy and life is getting back to normal in El Paso.

Henscheid started his career in aerospace after graduating from Arizona State University with a bachelor of science degree in engineering in 1962. He worked for North American Aviation (which later became Rockwell) on the early Apollo missions before moving to Phoenix with Kaiser Aerospace and Electronics.

As a junior engineer at Kaiser, Henscheid's work was aimed at designing ground support equipment for the military until 1965, when Kaiser entered the cable TV business as a distribution equipment manufacturer.

In 1972, Kaiser sold out to Hughes Aircraft and the Thetacom division was born. Henscheid was kept on board as a senior engineer and spent a large portion of that time working on extended bandwidth products. In fact, he guided much of the developmental work on the first 400 MHz product line—a fact he remains proud of today.

"That was fun being involved in that program," he says. "The jump from 300 MHz equipment to 400 MHz was a rather significant and spectacular move." To date, Texscan is now behind other vendors (it hasn't developed 550 MHz gear yet) but that may not be the case for long. "We were surprised that (550 MHz equipment) got so popular," says Henscheid. "I thought the bandwidth race was over at 450 MHz. In one way I hope it's over at 550 MHz, but as long as new technology comes along, it keeps engineers like us busy."

In 1976, Hughes sold the division to Texscan and Bert was named chief engineer. In 1977, more than four years of studying at night school resulted in a master's degree for Henscheid and a year later he was promoted to director of engineering. He then added the title of vice president in 1979. Finally, in 1986, he was put in charge of the research and development efforts. His charge now is to provide the industry with the products it needs while bringing Texscan back to the forefront.

In fact, the El Paso-based firm is looking beyond the United States borders to do just that. A full marketing division operates out of London and business "has been picking up," says Henscheid.

Now that Texscan's financial predicament has been overcome, a new optimistic spirit has taken over. As VP of R&D, Henscheid is looking forward to introducing new products to the Texscan lineup. Currently, two lines of distribution electronics—the T-Series (the old Thetacom products) and the Pathmaker (acquired from GTE Sylvania during a buy-out about four years ago)— are offered. But Henscheid said his department plans to introduce some feedforward products, 600 MHz taps and passives, ALSC circuitry, more efficient power supplies and new equipment for the LAN and multipoint distribution system markets. He is also exploring the possibility of supplying equipment for use in fiber optic systems.

As a vendor serving the technical side of the industry, Henscheid is committed to providing high quality equipment to those in the field. "Vendors need to provide good, reliable equipment, so that's not the limiting factor" in the effort to provide better pictures, he says. All of the talk about picture quality lately is good for the industry in general, he says. "The telco threat may force the MSOs to improve their business efficiencies and performance."

Even when Texscan was down, it never lost sight of its mission. "Our commitment (to cable industry customers) never wavered," says Henscheid. "Our primary product is cable TV equipment."

Outside of the office, Henscheid is a busy man. His family still resides in Phoenix, so commuting is a weekly chore. The youngest of his three children, who is still in high school, is heavily involved in the Boy Scouts and Bert has taken an active interest in it as well. He is also a senior member of the SCTE, a member of the NCTA Engineering Committee and has been a part of numerous technical panels and authored technical articles.

But he really enjoys his work, too. "I like to work in new product development," he says. And that's good, because with competitors waiting in the wings, cable needs to do all it can do to provide improved service through new technology.

—Roger Brown

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Reader Service Number 5

Politics and HDTV

To a remarkable degree HDTV technology has achieved the ability to display video images comparable to those projected from 35 mm film on the wide screen in movie theaters, together with multi-channel sound fidelity comparable to CD recordings. There is still room for improvement; and the engineers will not rest until they reach perfection, nor should they.

Since the CCIR deadlock at Dubrovnik last year, emphasis has shifted from technical to more mundane commercial concerns. What will it cost? Who will pay for it? Close on the heels of commercial concerns are political positions and strategies, industrial as well as governmental. Which industry will benefit and which lose? Which of the several technical plans is likely to favor (or hurt) which industry, and which countries? We could be in some danger of becoming more concerned with damage control than with providing the best television pictures conceivable by the modern engineering mind.

Take broadcasting for example. If TV stations, as we now know them, are to take advantage of the new HDTV technology without loss of the audiences upon whom their revenues depend, they must have new standards directly compatible with the existing 200 million NTSC TV sets in use in the U.S.[1] If a compatible system is also to meet the exciting promise of HDTV, additional spectrum allocations appear to be essential. Broadcasting trade associations have expressed a fear, not without reason, that failure to achieve these needs promptly is likely to leave them with second-class status. "We must not allow broadcasters in this country," says NAB, "to submit to inferior technology." The FCC seems to be sympathetic, yet must deal with the considerable political clout of the land mobile services demanding the surrender of parts of the spectrum already allocated to TV.

If television broadcasting fears second class status, it is primarily the VCR they should fear most. Unlike broadcasting, whose advertising revenues depend on mass audiences, the VCR industry probably does not need NTSC compatibility to bridge the transition to one or several advanced TV standards. VCR is in the catbird seat, where it makes its money by manufacturing and marketing both the old and the new until finally the old is rejected in the market place.

Cable TV is likely to continue its dual role of distributing whatever it is that the broadcasters transmit, while at the same time distributing non-broadcast programming. Whatever form of compatible advanced television standards broadcasters adopt, cable will carry their programs. At the same time, however, cable can carry any other form of HDTV that seems likely to attract or hold subscribers, whether compatible or not.

Without a standard that is compatible with NTSC, yet capable of meeting the great expectations of non-compatible HDTV, there seems no way for broadcasters to even remain abreast.

Several options for broadcasting appear to be on the table. The most universally desirable option appears to be a 6 MHz standard that would be compatible with NTSC standards, yet produce the clear, crisp wide screen pictures promised by HDTV. Before ruling this out as unachievable, it would be well to recall Don Fink's remark that, at the time of the first NTSC in 1941, "the prospect of imposing three signals (one for each primary color) on a channel designed for one signal was so visionary that, had it been mentioned at all, it would have called forth the forbidden word in the engineer's lexicon: impossible." Nevertheless, it is the common wisdom that compatibility in a 6 MHz channel could only be achieved by compromising performance.

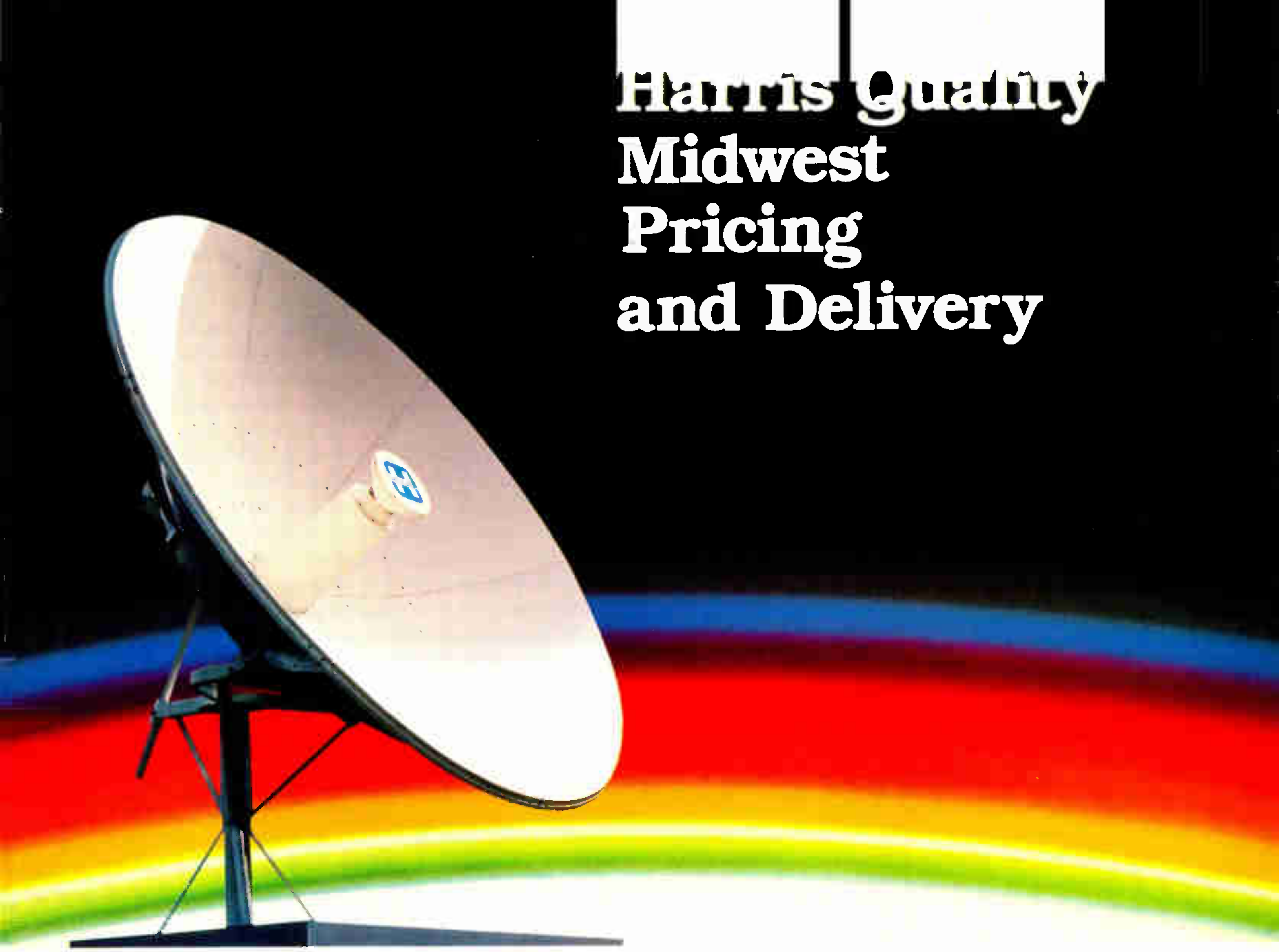
A second option is to find additional spectrum which might be allocated separately for terrestrial broadcast of non-compatible HDTV; or, in combination with traditional channel assignments, for augmenting NTSC transmissions to HDTV quality. Consideration is being given to utilizing the rather sparsely inhabited UHF spectrum for this purpose. Alternatively, the FCC has suggested sharing the 2.5 to 2.69 GHz, 12.2 to 12.7 GHz, or the 22/23 GHz bands with ITFS/MMDS, auxiliary broadcast, DBS, and a variety of point-to-point services.

A third option, with little apparent appeal to terrestrial broadcasters in the U.S., is to adopt the HDTV standards for satellite transmission in DBS service, since new Ku-band receivers would be required anyway. Terrestrial broadcasters would still be governed by NTSC standards, perhaps with improvements or enhancement.

The 50/60 Hz conflict also appears to be a matter of compatibility, rather than national pride. If the 60 Hz field rate were adopted world-wide, all European home TVs and VCRs would require field rate conversion; if the 50 Hz field rate were adopted, all North and South American and Japanese home TVs and VCRs would require field rate conversion. Although field rate conversion may not be prohibitively expensive for cable headends, the impact on hundreds of millions of individual consumers is politically unacceptable, either way.

There seems no doubt that the VCR will lead the way to advanced TV, through Super-VHS and Enhanced Definition Beta. By the early 1990s or sooner, there is a reasonable expectation that TV receivers and VCRs could be available in the stores, designed to operate to the NHK wide-screen HDTV (Muse) non-compatible standards. The push for MAC based standards (multiplexed analog components) will come in part from American sources, such

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



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For cable TV, non-compatibility is not life-threatening, as it is for broadcasting.

as Scientific-Atlanta (B-MAC) and North American Phillips.

Comparative technical considerations and cost projections will be important factors, but the ultimate course of HDTV standards is likely to be influenced primarily by market power and political muscle, especially for broadcasting. This is clearly indicated by the membership of the FCC's Advisory Committee on Advanced Television Services. Not one of the members is recognized as an expert in HDTV technology. Rather, they are the corporate heads or top officials of the leading commercial television interests. Technical experts were designated, almost as an afterthought, to be the working sub-committee chairmen and vice-chairmen. Except for Joe Flaherty, who has had a long-time leadership role in the technological considerations of HDTV, even these appointments are seen as engineering representatives of politically important commercial interests rather than as leading experts in their own right in the development of HDTV technology.

For cable TV, non-compatibility is not life-threatening, as it is for broadcasting. Our participation in the Advisory Committee work probably should be generally supportive of broadcasting interests in that regard. We ought to encourage the development and marketing of multi-standard TV receivers and VCRs, with separate input ports for luminance and chrominance, comb filters, and other improved NTSC features as well as the capability of receiving non-compatible, wide screen, advanced TV signals. We should maintain the option of carrying non-compatible HDTV and various NTSC augmentation signals, although this should not be mandated as "must-carry." We should probably be wary of uncontrolled proliferation of mutually non-compatible standards that could fragment the TV and VCR market. But even if such a situation did occur, cable could rationalize it by headend standards conversion.

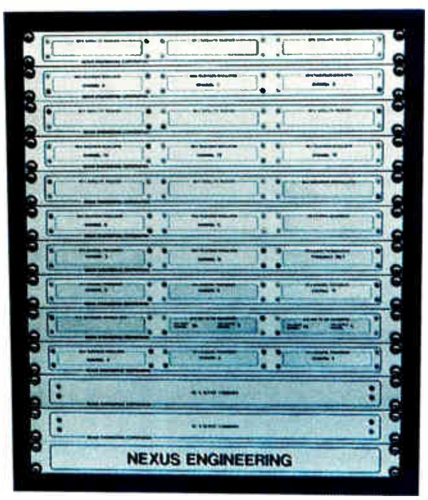
Naturally, we would prefer advanced TV signal formats that are sufficiently robust to survive transmission over cable TV networks "without material degradation in quality." However, on this issue we need to learn much more than we now know about the effect of coaxial distribution networks on signal formats that differ substantially from NTSC. This is the task on which the NCTA Engineering Sub-committee on HDTV has embarked, under the leadership of Nick Hamilton-Piercy.

Finally, whatever we do to improve the quality of pictures delivered to our customers will serve also as insurance in the coming contest with the broadband fiber digital networks (B-ISDN) promised by our friendly telephone companies. ■

[1]TV Digest *Factbook* 1987 edition No. 55. p. B-190.

Reader Service Number 7

Why is NEXUS the worldwide leader in satellite fed cable television headends for small communities?



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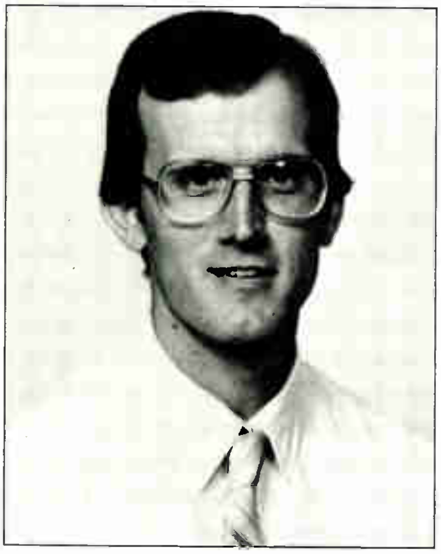

Video S/N...confusing? historically maybe, but not today

Historically, there have been several different, but technically correct, techniques to measure video signal-to-noise ratio (S/N), and each tended give you a slightly different answer. While these various techniques are now very nearly in agreement with one another, I thought it would be interesting to explore how it used to be. The historical complication of the term "video S/N ratio" can be attributed to three primary factors: the definition of "signal;" whether or not noise "weighting" was used in the measurement, and if so, which noise "weighting" network was used.

The definition of the video signal, in a S/N measurement, seems fairly straightforward. After all, in any baseband video S/N measurement, the "signal" is its peak-to-peak voltage, while the noise is an RMS voltage. But peak-to-peak as measured from where to where? The old EIA definition of signal (RS-250A) extended from sync tip to reference white level, or 140 IRE peak-to-peak, (1 volt peak-to-peak in a typical video interface). The International Radio Consultative Committee, CCIR (as well as NTC Report #7), on the other hand, defined the video signal as the "active" luminance portion of the video signal which extends from "blanking" (not sync) to reference white. Therefore, the CCIR (and NTC-7) defined the signal as a 100 IRE peak-to-peak (0.71 volts peak-to-peak) waveform in a standard video interface.

Immediately, then, there was an apparent 2.9 dB difference (20 log .71), between the two techniques when measuring exactly the same signal, with the CCIR definition causing a poorer number by 2.9 dB! Ah, but here is where the plot thickens. Enter noise "weighting."

Noise weighting is an often-used technique in video S/N measurements which reduces the amplitude of the high frequency noise components of the video waveform prior to the RMS noise measurement. This is done through the introduction of a weighting network prior to the RMS voltmeter of the noise measurement system.

The purpose of this weighting network, which is in essence a very carefully defined low-pass filter, is to simulate in the measurement the eyes' apparent inability to perceive high frequency noise in a video signal. Since the eye cannot easily see such high frequency noise anyway, the weighting network is used to remove the noise from the measurement, thereby improving the measured S/N ratio. However, the addition of such a network complicates the issue because there happens to be more than one weighting network which can be used in the measurement. Again, the CCIR and the EIA had different recommendations.

The CCIR weighting network has a response which is flat out to about 600 kHz. It then begins to decrease monotonically to about -8 dB at 2 MHz, and to about -12 dB at 3.58 MHz. The EIA weighting network, on the other hand, was flat to about 400 kHz, decreasing to about -4.6 dB at 2 MHz, dipping to about -7.3 dB at 3 MHz, and then "peaking-up" again to about -5.5 dB at 3.58 MHz. Therefore, the EIA weighting reduced the higher frequency noise less than the CCIR weighting did. So, with EIA RS-250A weighting, you would expect high frequency noise to have more of an impact in reducing the S/N ratio, when compared to a CCIR network. In fact, with all else equal, there was a 2.6 dB difference in measured S/N ratio between the two types of weighting networks, with the EIA network producing the poorer ratio.

It's interesting to note, that since there was a 2.9 dB discrepancy in one direction between the CCIR and EIA definition of S/N due to the definition of signal, there was a 2.6 dB discrepancy in the opposite direction due to the difference in weighting networks, the actual difference in measured S/N ratio wasn't any more than 0.3 dB between the two techniques. If, on the other hand, no weighting networks were used, the only difference was the definition of signal, a 2.9 dB difference.

Straus[1] related these baseband signal-to-noise terms back to NCTA RF carrier-to-noise ratio terms, given an ideal demodulator. Since we in the cable industry tend to deal in C/N, I thought it would be useful to show how they were related:

Weighted S/N

$$EIA_{RS\text{-}250A} = C/N + 0.1\text{ dB}$$
$$CCIR = C/N - 0.2\text{ dB}$$

Unweighted S/N

$$EIA_{RS\text{-}250A} = C/N - 4\text{ dB}$$
$$CCIR = C/N - 6.9\text{ dB}$$

As you can see, historically, when speaking about video signal-to-noise ratio, one needed to be careful to define the technique and weighting network used. In fact, you could imagine a "hybrid" technique which used the EIA definition of signal, including sync, but used a CCIR weighting network. Believe it or not, such a technique did exist[2], but has since been changed to match other techniques.

Today we have it easy. EIA Standard RS-250B, NTC Report #7, and the CCIR recommendation are nearly in sync. And RS-250B's weighting network very nearly produces the equivalent noise weighting of the CCIR.

By Chris Bowick, Engineering Dept. Manager, Scientific-Atlanta

[1]T.M. Straus, "The Relationship between the NCTA, EIA, and CCIR Definitions of Signal-to-Noise Ratio," *IEEE Transactions on Broadcasting* Vol. BC-20, No. 3, Sept. 1974.

[2]Bell Telephone Laboratories, *Transmission Systems for Communications*, Winston Salem, 1971.

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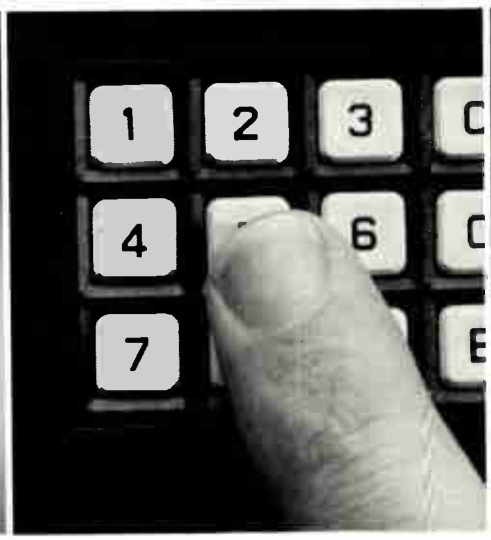

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What do managers think about success? What it is that separates them from the hundreds or perhaps thousands of competitors over the years in achieving each promotion they've enjoyed as they climbed their ladder of success?

Surely each of these people can look back and see that at every juncture of their career there were other people who could have gotten the promotion; there were other people who did good work and could have been recognized. In some cases, they may feel there were even other people who, on balance, might have been a better choice than themselves.

I can almost guarantee that in every single case, the first week or two on the new job resulted in a feeling that indeed a mistake had been made and someone else would do a better job! But as each person settles into his or her new assignment and turns to meet the challenges, the nervousness about whether or not you're the right person for the job tends to fade and soon you are completely embroiled in the efforts necessary to make a success of your new position.

By Wendell Bailey, Vice President Science and Technology, NCTA

If you asked each of these people what were the factors in their careers that made the difference, one item that I think each would mention would be training. In one form or another, either formal or On the Job (T) was a vital part of their gaining competence and confidence in their various jobs. They would also tell you that as they move into each new assignment it would be easier if every new job came with a training manual and perhaps a few courses or classes to help get you started.

Alas, the real world seldom works like that, especially for management. And management, of course, is a discipline that does not necessarily succumb very well to the exact and precise details and answers that certain technical jobs enjoy. In management you have to feel your way frequently in an imprecise area. If managers and other executives feel that training was important in achieving a level of success, then why is there so much difficulty in getting this particular group of people to part with budgeted money to provide training to the most important people in our industry. Consider how we treat this area. The one person that the cable system expects to go into every customer's home is the one person that is most often hired, given a brief orientation about company policy regarding the maintenance truck and sent off with a fist full of work orders that require him to enter the home of your most valuable asset: your customers. While the emphasis on training in this industry is growing, the scenario I have just outlined is still too often the case.

The reasons why money for training is so hard to come by is understandable. Frequently, managers of systems have goals and objectives specified by corporate headquarters that require that they juggle a certain amount of resources between multiple functions that requires them to adequately perform for the head office. Because of this, compromises are inevitably made.

The easiest compromise of all for such a manager is to delay or cancel sending employees to training sessions, seminars, symposia, lectures or other duly constituted training activities. By the same token, since the training time for a new employee tends to be non-productive time, it's very easy for managers to see the value of taking a brand new employee, putting them with established installer repairmen and sending them out for a certain period of time until they "get the hang of it."

Except for riding around with an old (three months on the job) hand and a rudimentary education about using spurs and climbing poles, the people we send into our customers' homes are the least trained for the job.

Where, for instance, does the training of how to deal with customers come from? Where is the assessment of whether or not the person we're sending into a customer's home is comfortable meeting strange people, is comfortable and competent in answering questions about the company and its policies? Where is the training for the employee who may lack sensitivity in dealing with a wide range of cultural differences in some of the multinational communities that are served by cable television?

In fact, why doesn't the typical manager look upon the job of actually going into the customer's home as being a job that must be earned after demonstrated competence, loyalty and learning by an employee. Why, for instance, is the job of entering the customer's home so often an entry-level job in our industry.

I should point out that it's not just our industry that does this. It's also true in several other service industries. That does not mean, however, that we need to do the same thing. Wouldn't it be better if each new employee, each new entry-level employee, spent time in training, then spent time doing the other jobs in the company that required interaction with your employees and his or her fellow workers? And only after they had proven they could do a job, that they had learned about the company and what it expects—as well as what it offers to its subscribers—and only in competition with other employees who wish to rise up to the most important job in the company, only then would these people be promoted

Continued on page 32

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Reader Service Number 10

Telecom's switched star cable system

An optical fiber-based switched star cable television system has been developed and is currently being installed in the borough of Westminster in London, England. The first customers were connected in July 1985. When it is completed, it will serve over 100,000 private households, commercial premises and hotel rooms.

Development work has continued and a prototype Mk 2 switched star system was demonstrated in July 1987.

Services are gathered together at the headend and transmitted over optical fibers via hubsites to wideband switch points (WSPs) close to customer's premises. From the WSPs, small-bore coaxial cables, each carrying two television channels, make the final connection to customers.

Four main types of service are provided:

- Broadcast television channels are tapped off common fibers serving several WSPs.

By Jerry Adams, executive engineer, British Telecom

Two-year-old British system debuts prototype Mk 2 switched star system.

- Video channels available on a one customer basis for video library and photovideotex services are transmitted on fibers specific to each WSP.
- Data flows for the alphanumeric videotex service and control of the network is also routed over specific fibers but in data message-based formats.
- The FM stereo radio is carried on specific fibers in PCM format to achieve the required signal-to-noise ratio.

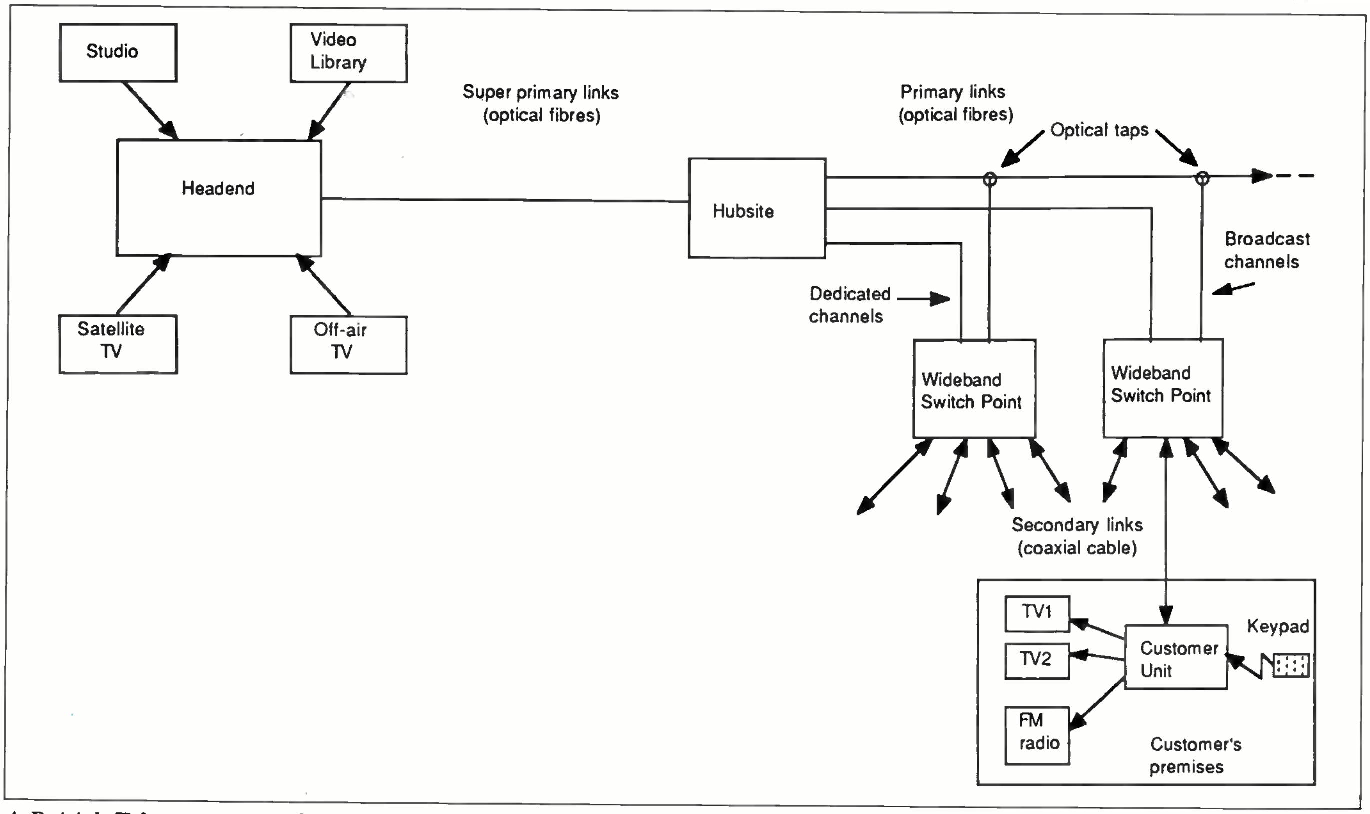
A total of 32 video channels and 16 stereo radio channels can be carried on the network plus upstream and downstream data. A significant feature is that the three different signal types, video, data and stereo radio, are carried to WSPs over the same design of optical link.

Optical transmission

The optical links were developed under contract by STC Defence Systems of Leeds, northeast England, which uses analog transmission of video channels because of the present cost advantages over digital techniques.

The standard fiber link takes four baseband video inputs of 1 V peak-to-peak. The sound, left on its normal carrier above the luminance and chrominance signals, is at a reduced level of 200 mV peak-to-peak to lessen video interference from intermodulation between sound and chrominance carriers. Each input is frequency modulated on to a carrier of 345 MHz, a high frequency chosen for good linear operation, then down-converted and placed within an intermediate frequency multiplex extending up to 200 MHz.

Frequency modulation is chosen on the grounds of transmission quality and costs; amplitude modulation is inadequate in both noise performance and susceptibility to non-linearities in the optical link. Below the four video



A British Telecom switched star system architecture.

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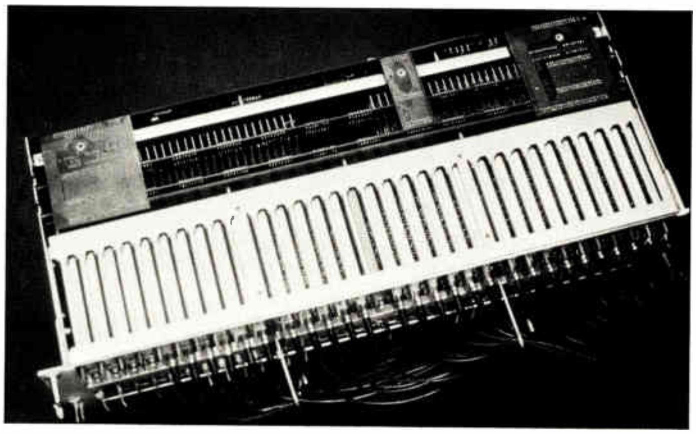
Television signals can be presented to the transmission equipment at the headend in a variety of formats.

channels there is space in the spectrum for a fifth lower quality channel for data.

The entire intermediate frequency (IF) multiplex intensity-modulates an 850 nm laser whose key characteristics are linear operation and a relatively broad optical spectrum to reduce modal noise. The optical output is launched into a 50/125 um graded index fiber with an attenuation of less than 3.5 dB/km and a bandwidth product of more than 600 MHz km giving a reach of five kilometers.

Cables with up to 160 fibers have been specially developed, requiring the development of compact joint organizers to house both the fusion joints between fibers and the optical taps on primary routes. At the optical receiver, an avalanche photodiode (APD) converts the incoming light signal back to the IF multiplex and a demodulator, employing a phase-locked loop, brings each channel down to its baseband form.



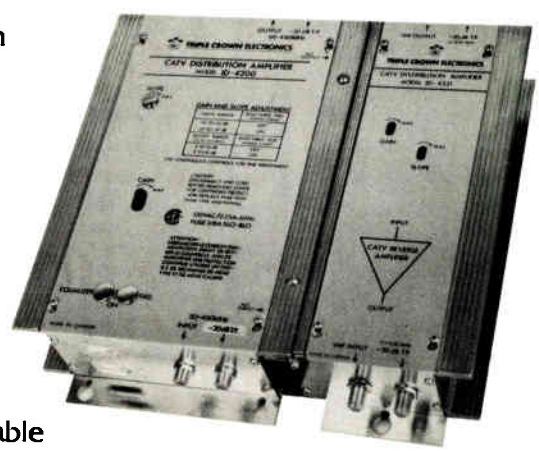
A Mk 1 switch unit, capable of serving 30 customers.

Television signals can be presented to the transmission equipment at the headend in a variety of formats, chiefly off-air at ultra high frequencies (UHF) and baseband from video tape and disc. These have to be converted to the standard baseband form required by the optical transmission equipment.

When direct broadcast by satellite (DBS) signals that use a different format are available, they could be directly inserted as a channel in the IF multiplex since they would already be frequency modulated.

The other main transmission function at the headend is fan-out of the broadcast channels in their IF multiplex format to feed all the super primary routes. The video library channels being dedicated to specific WSPs are fed directly to optical transmitters.

Data for both network control and the videotex services is routed to specific WSPs in 64 kbit/s channels in



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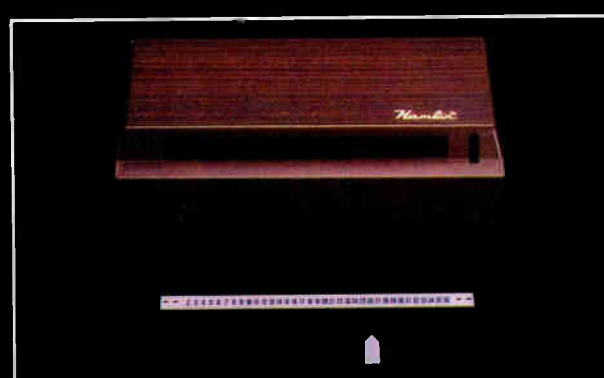

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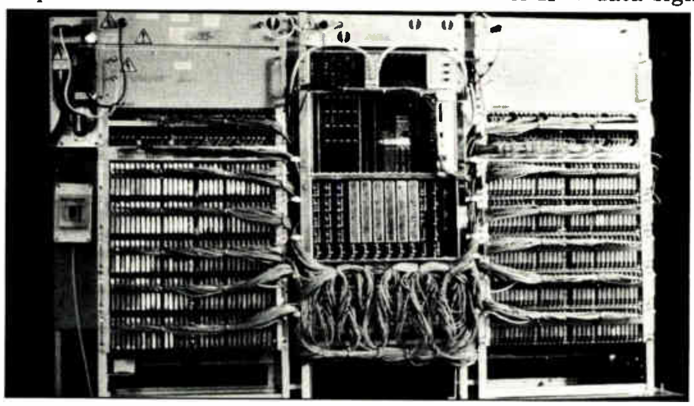
Each WSP is served by 10 optical fibers, nine downstream and one upstream.

standard 2 Mbit/s multiplexes using HDB3 line code. The level is adjusted to 1 V peak-to-peak, lowpass filtered, and then applied to one video input of the optical transmitter. A standard link therefore carries four 2 Mbit/s channels, sufficient for a hubsite serving up to 112 WSPs.

Straightforward transmission of the frequency modulation (FM) radio band in its normal form is not possible on the optical link because of the very high carrier-to-noise ratio required. Instead, a unique scheme has been devised whereby each channel is demodulated to its stereo multiplex form—0 to 53 KHz bandwidth—and then four channels are digitally encoded into an 8 Mbit/s multplex which is applied to one video input of the optical transmitter. Thus 16 stereo channels are carried on one fiber.

Customer data services

At the hubsite, the television signals are converted to their four-channel IF multiplex format. The broadcast channels and the FM radio multiplex are fanned out to feed optical transmitters on each primary route. The video library channels are simply repeated at this point and routed to their intended WSP.



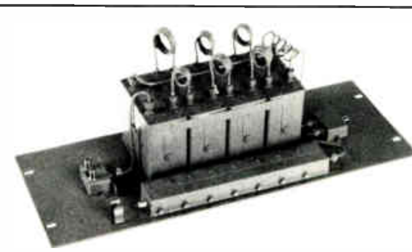
The interior of a fully equipped Mk 1 WSP 300.

The received control and videotex data signals are broken down into the individual 64 kbit/s channels and inserted into time-slot 16 of a 2 Mbit/s multiplex, which is then transmitted to the appropriate WSP as a fifth channel on one of the dedicated fibers. The other time-slots in the multiplex are available for customer data services.

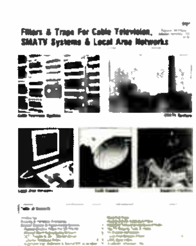
Each WSP is served by 10 optical fibers, nine downstream and one upstream. Five of the downstream ones carry broadcast television and are tapped off common fibers serving several WSPs. The other four are dedicated to the particular WSP; three carry video channels available on a per-customer basis, the fourth carries all the radio programs, control data and videotex pages. The

Channel Deletion Filter

Channel Deletion-Closed Circuit Reinsertion



MDN Batch Descrambling Network



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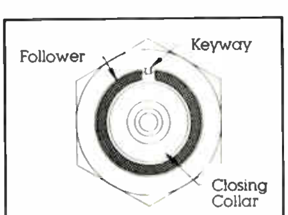

FORMER DESIGN
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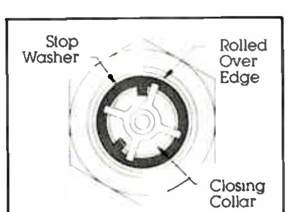

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Reader Service Number 15

The signal to the customer is launched into small bore coaxial cables by launch modules.

A customer's equipment developed under contract by Labgear Cablevision Ltd. of Cambridge, England.

upstream fiber carries data and four return video channels.

The broadcast television signals are bussed directly to the main switch units. The switch design employs a 1-in/4-out IC chip using DMOS FETs. Each switch unit serves 30 customers with two channels each and can be installed on a modular basis as demand for service from the WSP increases. Each is, to an extent, a self-contained unit with its own microprocessor, receiving and acting on control signals from the customers.

In addition to the direct inputs, main switch units have access to the video library channels and the local text generators via an auxiliary switch. In total, each switch unit has 30 inputs which are bussed to all 60 outputs, two per customer. Each output has its own 30-in/1-out switch, allowing independent selection of any input.

Sophisticated system

The digitally encoded radio channels are converted to analog form and reconstituted as a conventional FM radio band ready for distribution directly to customers. The straightforward digital coding allows this to be accomplished with a reasonably small amount of circuitry.

The WSP is more than just transmission and switching equipment. It is a sophisticated system in its own right with two levels of control, local text generation and local alarm and maintenance facilities. Given that it is usually housed in an external cabinet, special attention has gone into its engineering to achieve compact size, using dense equipment packing and efficient routing and interconnection of the many video, RF, data and optical signals within it. The WSP employs careful thermal design, with fans and a heat exchanger, to provide a controlled internal environment for the equipment housed.

The WSP has two size options, one for 150 customers with a common equipment rack and one switching rack, and one for 300 customers with two switching racks.

The signal to the customer is launched into small bore coaxial cables by launch modules which slot into the switch units in the WSP. A launch module takes two baseband video channels and amplitude modulates them on to carriers at 40 and 56 MHz in standard

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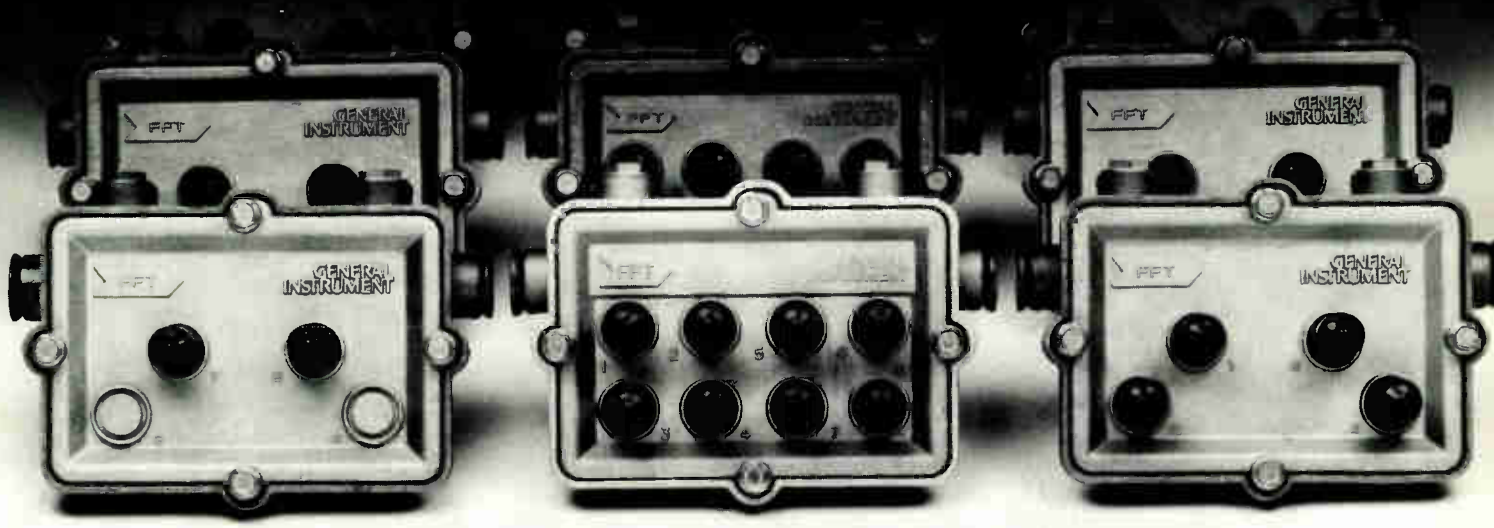

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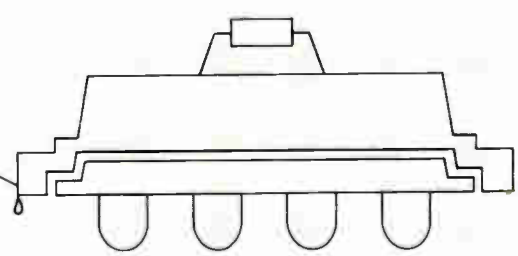

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GENERAL INSTRUMENT

Reader Service Number 16

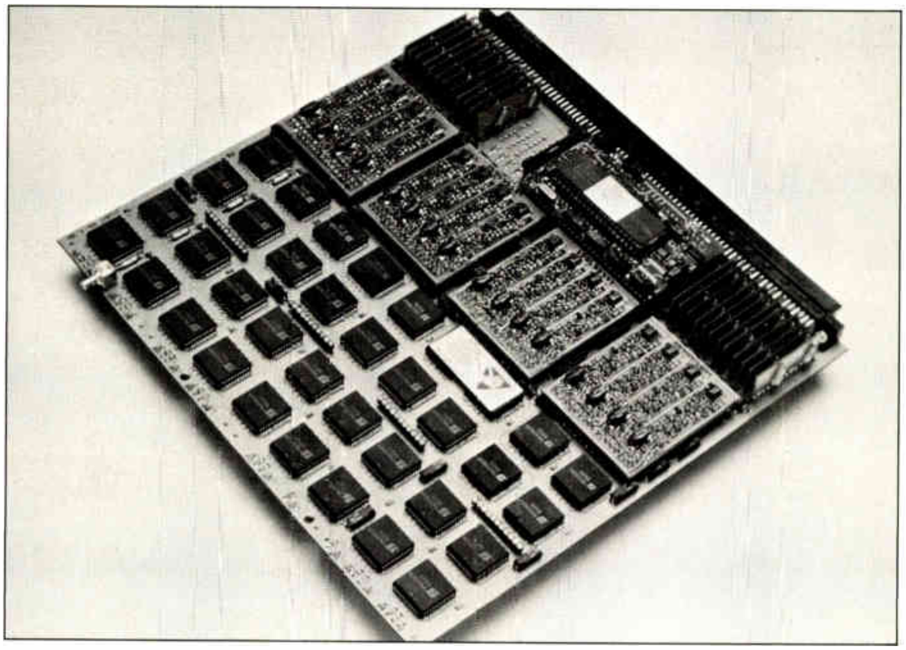
The launch module's task is to adjust relative levels, combine the signals and drive them into the 75 ohm coaxial cable.

vestigial sideband (VSB AM) format. It also accepts the FM radio in its normal frequency band, along with a 120 MHz pilot tone. These are presented to the launch module as high impedance inputs. The launch module's task is to adjust relative levels, combine the signals and drive them into the 75 ohm coaxial cable.

These secondary link cables are terminated in coaxial connectors mounted on a patch panel in the WSP. To provide service to a customer a patch cord connects the next available launch module to the appropriate secondary cable. WSPs are assembled, tested, and delivered to site by Fulcrum Communications Ltd. of London, a wholly owned subsidiary of British Telecom (BT).

System development

The customer's equipment was developed under contract by Labgear Cablevision Ltd. of Cambridge, eastern



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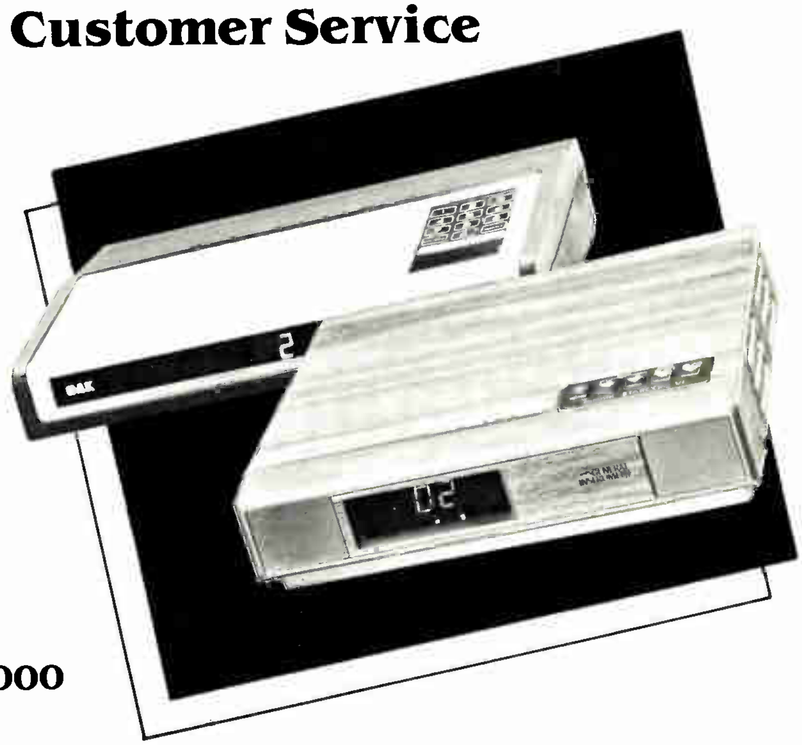

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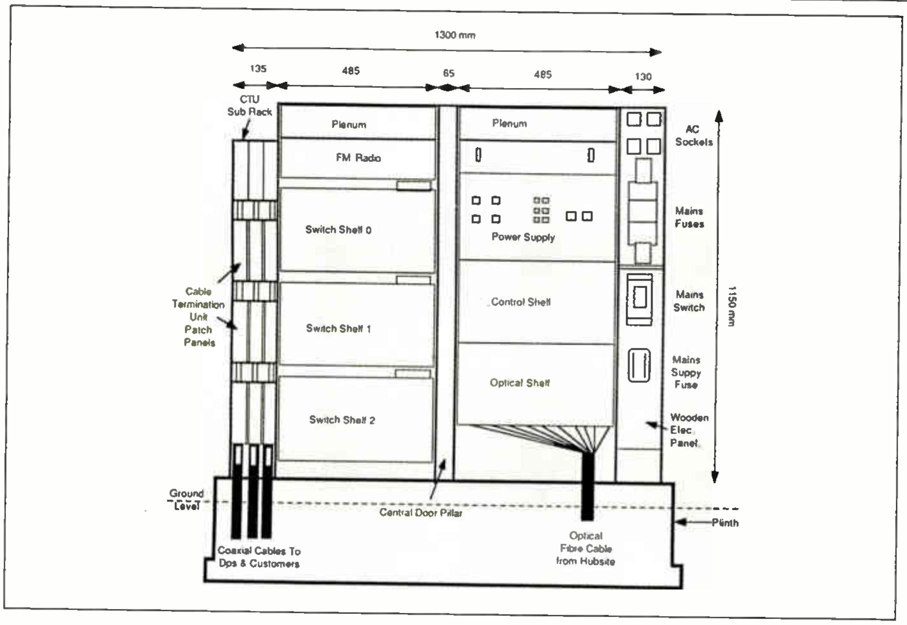
Further development of the BT switched star system has concentrated on the WSP since this is the most expensive component.



A layout of Mk 2 WSP.

England, which also produced the launch modules. It consists of four units: the customer unit, a small adaptor which plugs into the back of the television set, an infrared receiver and a hand-held remote keypad.

The wall mounted customer unit upconverts the two incoming VHF television channels to UHF using a local oscillator. It feeds two television sets—or one television and one video recorder—and an FM tuner via coaxial cable. A processor in the customer unit sends customer keystrokes on to the WSP when polled.

Further development of the BT switched star system has concentrated on the WSP since this is the most expensive component of the network and, being street-sited, potentially the most difficult to maintain. However, work on single mode optical links operating at 1300 nm and on shared secondary links has also been carried out, as well as studies on providing a greater choice of customer equipment, including a remote control full alphanumeric keypad.

Since the Mk 1 design, a new optimized IC has been developed by Siliconix Ltd. of Newbury, west of London, with a four times increase in the level of integration (1-in/16-out). A new unit, switching 48 video inputs to 16 outputs, has been developed using this device and realized on one card with the use of surface mount technology. This switch card gives a substantial reduction in costs and an improvement in performance—worst channel-to-channel crosstalk on card of better than 55 dB—as well as increasing the number of nominal video channels available on the system to 48. Each card serves eight customers with two channels each, allowing provision to be in eight-customer rather than 30-customer increments.

Mainly on the strength of this card, a 30 percent reduction in cabinet size has been achieved for the Mk 2 WSP. In addition, the WSP layout has been completely redesigned to improve "maintainability." The new configuration is symmetrical about a central door pillar and allows full access to all equipment racks, shelves and interconnections through the cabinet front doors. The only backplanes used are shelf mounted

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New launch modules have been developed that enable four video channels to be carried on each secondary link coaxial cable.

and all interconnections are by new front-mounted shielded integrated connector cables. There is a new cable termination unit which makes for a simplified patching arrangement.

Shared secondary links

New launch modules have been developed that enable four video channels to be carried on each secondary link coaxial cable. This enables one cable to serve two customers via a remote diplexer. The launch modules are realized as plug-in daughter boards on the switch card rather than as separate slot-in cards as in the Mk 1 switch unit.

The Mk 2 WSP is fully compatible with the Mk 1 system described earlier and it is intended to be used to complete the installation of the Westminster franchise. The Mk 2 switched star system, which in addition to the Mk 2 WSP employs single mode fibers, shared secondary links and a more powerful WSP processor, is available for use in any future cable television franchise. ■

Continued from page 18

to the job of customer service.

This, no doubt, would add cost to the function of serving customers. I would argue, however, that it would also decrease the expense of serving customers. Programs like this are not original with me. In fact, the very scenario that I just outlined for you is one that was mentioned to me many years ago by the head of an MSO.

The problem, as this person pointed out to me, is frequently that the corporate structure which dictates autonomy on the local level is frequently ineffective in enforcing policies regarding how local employees deal with customer service. A system manager is left to fend for himself when it comes to utilizing resources to achieve personnel aims. It is frequently thought that keeping the system generally up and the signals generally good and spending the least amount of money to do so will result in the proper balance of return on investment and corporate reputation in the community. Giving new thought to the training of the customer service function will improve both areas immensely and help preserve the industry that employs us all. ■

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Reader Service Number 23

WAVETEK®

Measuring stereo performance

Pilot injection level, stereo separation and S/N ratio are some of the things to consider.

TV stereo is not as forgiving as monaural sound. Many cable system operators ask what needs to be done when upgrading to stereo. In addition to the operational equipment required, it becomes very important to do periodic measurements of key stereo parameters, and to monitor the modulation levels of the audio programs.

Providing quality sound over cable has become an important issue. According to one cable engineer, "We do have major competition from satellite dishes, movie rentals and off-the-air programming." In very competitive markets where these alternatives are readily available, subscribers sooner or later get the opportunity to compare, and many cable systems are falling short on the quality of the on-channel audio they are offering.

Many system operators and engineers are discovering that providing high quality stereo sound on-channel can reduce pay churn and even attract new subscribers. One system operator, in evaluating the impact of stereo, said, "We have simulcasted on FM for years, and still do. It doesn't look good when a pay channel subscriber gets better stereo sound over FM than on the channel he is paying for."

So what do you measure to make sure you are providing good stereo? There are many measurements which can be made, and this article will discuss several: pilot injection level, stereo separation, signal-to-noise ratio and frequency response. Some of these measurements have similar setup procedures and can be made concurrently to speed up the testing process: for example, separation and signal-to-noise measurements are often made together.

Making daily or weekly checks of these measurement parameters will ensure a generally good quality of stereo transmission. Periodic proofs-of-performance or other rigorous test programs will quantify as well as qualify your audio integrity.

Modulation level

Quite often, measurements require the setting or checking of modulation levels. An FM system works by having its frequency shift in proportion to the input audio level. The amount which the frequency deviates from its center frequency is called the deviation or modulation level (deviation if presented in kHz, modulation level if represented as a percent of maximum deviation). Most modulation monitors come calibrated so that the 100 percent modulation level equals the maximum deviation for a given subchannel.

Table 1 shows the subchannels which combine to form the BTSC composite signal. The center frequency for each subchannel is a multiple of the pilot frequency (f_H = 15.734 kHz). Also shown is the maximum deviation for each of the subchannels. This is referred to as the 100 percent modulation level for that channel. A deviation level other than maximum is expressed as a proportional percentage. For example, a 5.5 kHz deviation for the pilot corresponds to a modulation level of 110 percent.

TABLE 1

Subchannel	Center frequency (f_H = 15.734 kHz)	Max deviation (= 100% mod level)
Main (L+R)	Baseband	±25 kHz
Pilot	f_H	± 5 kHz
Stereo (L−R)	2 f_H	±50 kHz
SAP	5 f_H	±15 kHz
Pro	6.5 f_H	± 3 kHz

Two test modes are available for working with TV stereo: the equivalent-test mode which bypasses dbx® noise reduction circuitry, and the BTSC-test mode which utilizes dbx circuits. Tests to verify stereo performance are easier to make in the equivalent-test mode, because it is a linear mode and doesn't have to fight the dbx circuitry. The BTSC-test mode is equally important, because it is the real implementation of the stereo transmission.

For a quick system check, most of the tests described below are typically performed in the equivalent-test mode (dbx off), and with the audio signal pre-emphasized (pre-emphasis is a noise reduction technique). This will enable you to make a quick daily check of your stereo, and will indicate if a major problem has been introduced. A full proof-of-performance is typically done in both the equivalent and BTSC test modes. This gives you a quick check to make sure no major problems are present, and the detailed performance of your real stereo performance.

Pilot injection level

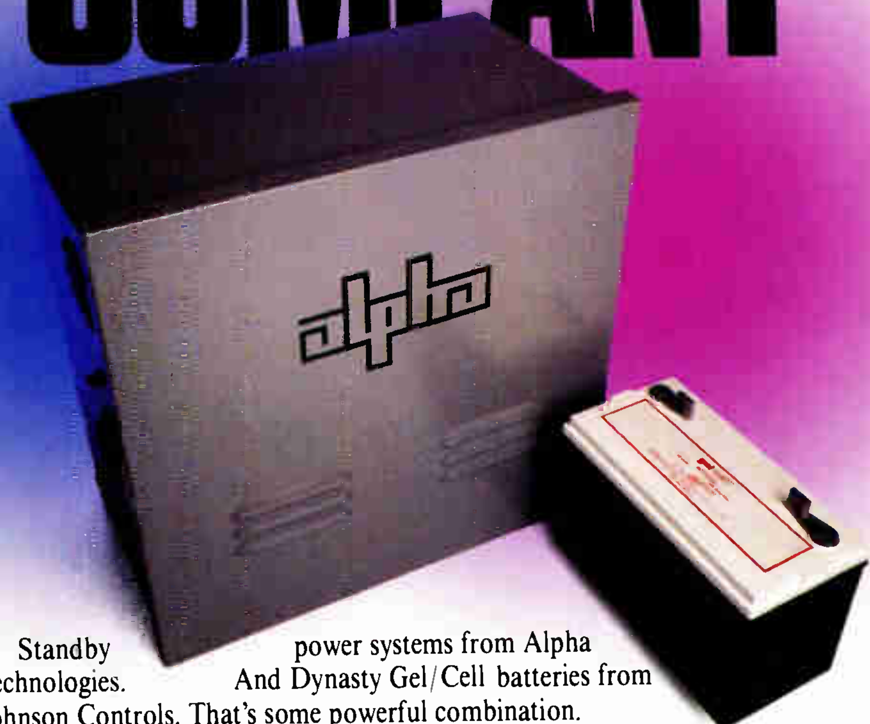
Pilot injection level is the modulation level of the stereo pilot signal. The pilot is used to regenerate the stereo subchannel (L − R), to switch the television set into stereo mode and to illuminate the stereo light on the receiver. Checking the pilot injection level tells you that the pilot is there, that it's at the right level, and that it is not interfered with by other channels.

The pilot signal has a deviation of 5 kHz centered at 15.734 kHz. To measure this, a 15.734 kHz pilot frequency bandpass filter is used to separate the pilot from the other modulating signals. You should be aware that the transmitted signal's pilot carrier can be contaminated and interfered with by video sync components. The source of interference can often be determined by turning the visual carrier on and off.

Looking at the pilot signal on a modulation monitor, you should see 5 kHz deviation represented as 100 percent modulation. If the modulation level is too low, the pilot detector in the receiver may not be activated, or worse may flash the stereo light on and off erratically. If the pilot is not steady

By Eric B. Lane, TFT Inc.

POWERFULL COMPANY



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Reader Service Number 24

Experiments show that the human ear typically can't distinguish stereophonic sound when separation drops below 18 dB.

(fluctuates), there is probably either interference from another channel, lack of a video sync on which to lock or a gated suppressed-sync scrambler.

Stereo separation

Stereo separation is the degree to which signals in one subchannel (say, the left) are not present in the opposite subchannel (right) and visa-versa.

If channel separation isn't maintained, all your efforts to produce stereo are lost. Poor separation means little or no distinction between left and right channel audio.

Experiments show that the human ear typically can't distinguish stereophonic sound when separation drops below 18 dB. If this is the minimum presentable separation to the user at the TV set, better separation must be achieved at each preceding point in the system.

The BTSC specification recommends the transmission system meet or exceed 40 dB separation when measured in the equivalent-test mode (dbx off, pre-emphasis on). For major proofs, an additional set of measurements should be made in the BTSC-test mode (dbx in).

Minimum stereo separation with dbx is shown below (10 percent modulation level, pre-emphasis on):

- Smoothly increasing separation below 100 Hz, from 26 dB to 30 dB.
- 30 dB separation from 100 Hz to 8 kHz.
- Smoothly decreasing separation from 8 kHz to 14 kHz of 30 dB to 20 dB.

The separation measurement is made under test conditions, not normal programming. It is made by first applying a sine wave signal to the left channel and grounding the input to the right channel. After adjusting the aural carrier deviation on the left channel with a modulation monitor, the level of the right channel is measured (in dB).

Most audio analyzers have the ability of setting a zero reference level to compare one signal with another, and saving the trouble of calculating the difference between levels.

The separation measurement is made at several audio frequencies. It must also be performed in the reverse fashion: grounding the left and injecting the signal in the right channel.

FIGURE 1

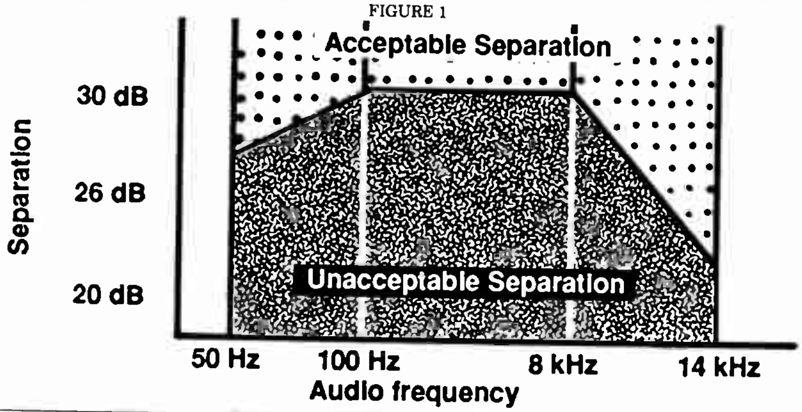


TABLE 2

Measurement	Channel	Test Freq (Hz)
Channel Separation	Left into Right	50, 100, 400, 1k 5k, 10k, 14k (sine waves)

1. Apply a 50 Hz test tone to the left channel input of the BTSC encoder.
2. Ground the input to the right channel.
3. Adjust the aural carrier deviation to 100% on the left channel with a modulation monitor.
4. Measure the output level of the left channel, and set this as the zero reference.
5. Measure the output level of the right channel. The ratio between the two (difference between the dB levels) is the measure of channel separation.
6. Repeat the test at the other test frequencies.
7. Repeat the tests for right into left channel.

Noise

Signal-to-noise ratio (SNR) is the ratio between the desired signal (for example, program audio) and the level of the noise floor. Noise has to be looked at on each signal subchannel: main, stereo, pilot, etc. Noise may be caused by a transmission system, thermal noise, video signal interference or noise energy amplified by the dbx system.

SNR is measured by determining the output level of a predetermined signal, and then removing the signal and measuring the output with only noise on it. Quick noise measurements are typically made with the dbx system off. For major proofs, both equivalent and BTSC test modes are used. Noise measurements are made under test conditions, not during normal programming.

Frequency response is the measure of signal strength and phase over a range of frequencies. In an audio signal, if the highs are lost, the sound loses its detail and gets muddy; if the lows are lost, the sound becomes tinny.

In a modulated signal, high frequency problems may show up as a deterioration of the stereo (L – R) subchannel. This appears as a significant loss in stereo separation.

When measuring the composite baseband frequency respose, in order to achieve acceptable stereo separation (40 dB or better) it is required that the amplitude response not vary by more than ± 1.0 dB, and that the phase response should not vary by more than ± 3.0 degrees over the band of frequencies from 50 Hz to 47 kHz. Such tight

Frequency response measurements are made under test conditions, not during normal programming.

tolerances of amplitude and phase are difficult to measure. An alternative method is to measure stereo separation directly. If separation is acceptable, there is probably not a frequency response problem.

Frequency response measurements are made under test conditions, not during normal programming. Frequencies over the required band are injected into the stereo encoder and measured at various points in the system. The modulation level is held constant as the input to the generator is varied, and the measurements at the test points are recorded.

Many other measurements are needed to fully verify the operation of a BTSC stereo system. The ones presented here are the most basic and the most useful.

Stereo needs to be looked at from a system perspective. Strong attention to the system (daily checks) is mandatory. To produce the desired results and remain competitive, it is imperative that the individual components of the system be of the best quality.

Because of the many variables from system-to-system, experience must accompany any instructions on testing your system. This experience can be gained only by doing it. ■

TABLE 3

Measurement	Channel	Test frequency
Signal-to-noise ratio	Main channel	400 Hz

1. Apply the 400 Hz test tone to the input of the stereo encoder.
2. Set the modulation level of the main channel to 100%.
3. Measure the output level of the main channel, and set this as the zero reference.
4. Remove the test tone from the encoder input.
5. Measure the output level of the channel without the test tone. This is the SNR for the main channel.
6. Repeat the SNR measurement process for other channels, such as the stereo and pilot channels, as needed.

Application of analog fiber optic systems...

...as broadband local area network extenders.

Modern fiber optic transmission systems employ one of two alternative transmission techniques. The most common technique for telephone trunking applications is digital. Alternatively, the common technique for many other types of information, including multiple video channel transmission, is analog. LAN technology is confusing to many. A common misconception is that in order to trasmit data, a digital system is required. Yet virtually all LAN transmission techniques are analog, including broadband local area networks (B-LAN). Popular B-LAN manufacturers include Sytek, Ungermann Bass, Allen Bradley, Applitek and Chipcom, for example.

B-LAN applications

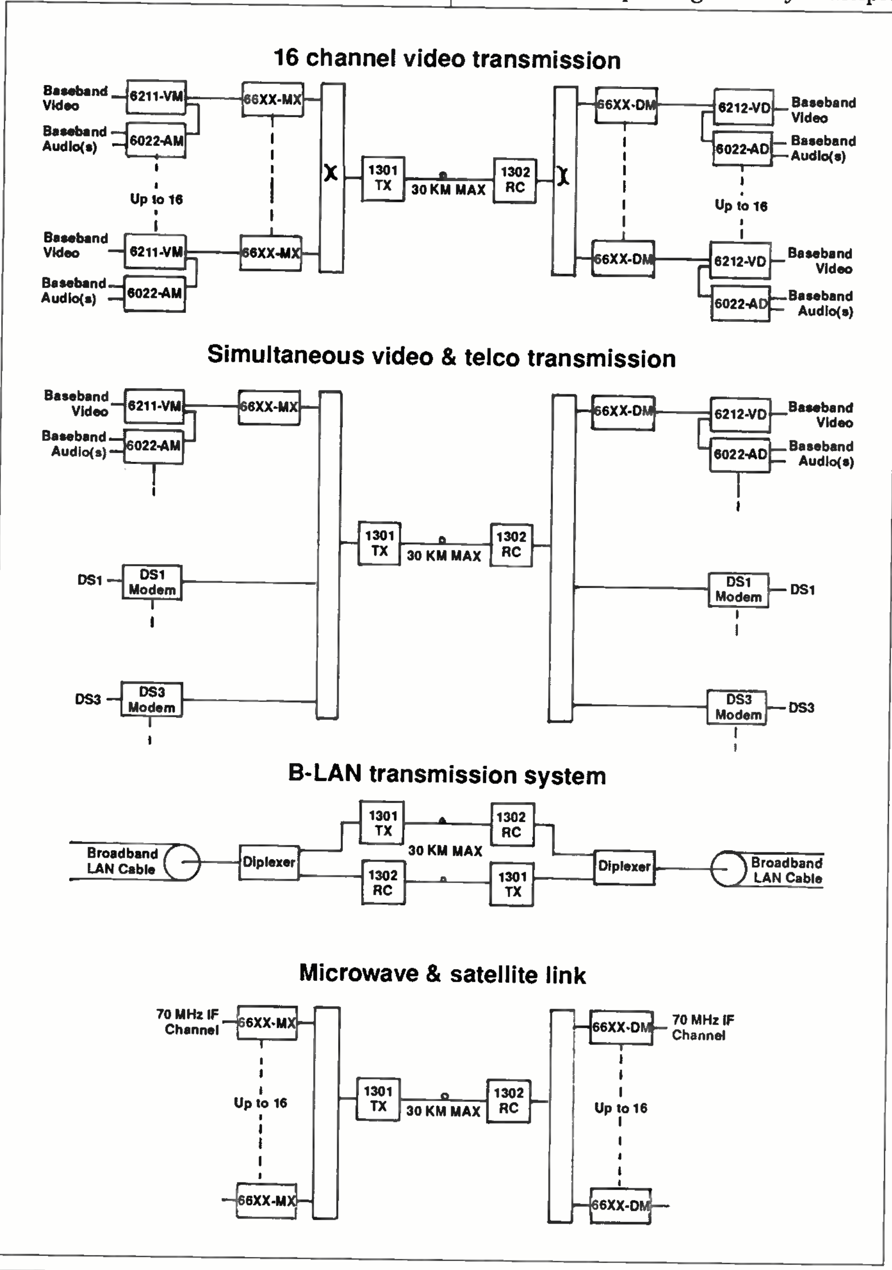
In many cases it is desired to establish a long distance B-LAN link between two buildings or campuses in order to unify the systems into a single network or to exchange data. In most cases, the use of standard coaxial cable and the required amplifiers to create the link are not practical. This is due to distance limitations and/or maintenance concerns associated with the outside amplifiers along the run, which may be many miles in length.

Many times the alternative examined is a digital fiber optic link of the telco transmission type. In digital fiber trunking systems, information is carried in one of two standard digital trunking formats: a DS1 rate (1.544 Mb/sec.) or DS3 rate (44.785 Mb/sec.). Importantly, a single B-LAN may have several independent data carriers simultaneously transmitting at the same time on one cable. Each data carrier is a separate analog FM based signal occupying a portion of the cable's total frequency spectrum. In order to transmit this information on a digital fiber optic trunking link, each one of these numerous data carriers must be converted individually to the telephone digital trunking format, and then digitally multiplexed together.

At the other end of the fiber link, the DS formatted information must again be converted back from this digital trunking format into the individual FM data carriers desired for transmission on the B-LAN. The cost of this dual conversion equipment is so expensive as to make links with more than one or two carriers economically prohibitive. In many cases this has resulted in the erroneous conclusion by corporations that a fiber optic interconnect is not financially feasible.

However, analog fiber optic transmission systems are ideal as B-LAN extenders, both from an economic and technical standpoint. Analog fiber optic systems utilize FM/FDM transmission techniques to transport multiple forms of information simultaneously. Similarly, broadband coax cable based B-LANs are analog by nature and use the technique of frequency division multiplexing to carry multiple

By John Holobinko,
American Lightwave Systems



The simplest fiber optic B-LAN extender example is a dual cable system.

data streams simultaneously on the individual FM based data carriers.

Since analog fiber optic systems use the same transmission techniques as B-LANs, transmission of numerous data carriers can be accomplished inexpensively without requiring any costly data conversion equipment. Therefore, analog-based fiber optic trunking systems offer an ideal "gateway" for transporting LAN channels over long distances without repeaters. For example, on one fiber an American Lightwave Systems 1300 nm laser-based single mode fiber trunking system can be used to transport up to 100 or more LAN data channels, or as many as 16 DS3 channels for a total data capacity of 715.76 Mbits/sec., or a simultaneous mix of video and FDM data channels of multiple types. A variety of FDM data carriers, six DS1/T1 channels (1.544 Mb/sec. per channel), or one DS3 channel takes the approximate optical energy as an equivalent video channel for applications requiring concurrent data, video and voice information.

Transmission via fiber optics

In contrast to coaxial cable, multichannel B-LAN fiber optic transmission is usually most effective utilizing one fiber for each transmission direction. To transmit the information on a broadband LAN in both directions simultaneously requires the use of two fibers: one to carry downstream data (and video) carriers, the other to carry upstream or "return" carriers.

B-LANs are of three general types: dual cable systems where a full cable is reserved for each direction; and sub-split and mid-split systems, where channels travel in both directions over the coax simultaneously. The simplest fiber optic B-LAN extender example is a dual cable system. The fiber optic B-LAN extender is a two-fiber link consisting of a fiber optic transmitter and receiver at one end, two fibers, and at the other end another fiber optic receiver and transmitter. Therefore, each end of the coaxial LAN systems to be joined has both a fiber optic transmitter and receiver.

Since fiber optic systems utilize FDM transmission techniques, the fiber optic transmitter looks like a broadband "gateway" to the coax LAN. The output of each coaxial cable is fed directly into the fiber optic transmitter, with the only possible extra piece of equipment required being an inexpensive signal amplifier in some cases to insure proper input signal levels. The transmitter converts the entire frequency spectrum into a single light signal. After traveling through the fiber, the light signal is received at the remote site, converted back into the

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The primary difference between fiber optic B-LAN extender applications is information carrying capacity and fiber type required.

original FM/FDM signals by the fiber optic receiver, and connected to the B-LAN coax cable for transmission throughout the remote site.

Installation of the fiber link for mid-split or sub-split systems also is straightforward. Inexpensive diplex RF filters are the only additional components required. The diplex filter is used to split the signals from the coax cable in the opposite direction of the desired transmission direction. Therefore, the diplexer will connect to the fiber optic transmitter and to the incoming signals from the fiber optic receiver. The desired one-way channels are sent through the fiber to their destination, where they are reinserted on to the local B-LAN at this point of origin as before. Therefore, one of the fiber links will transmit all the forward path signals, and the other fiber will transmit all the reverse path signals. The link will require two transmitters, two receivers and two fibers, identically to the two-cable example.

B-LAN application differences

The primary difference between fiber optic B-LAN extender applications is information carrying capacity and fiber type required. This will determine the type or model of fiber optic transmitters and receivers chosen for the specific application requirements.

Choosing the right technology

Selecting the proper fiber optic transmitters and receivers is determined by the following factors:

1. The maximum number of data plus video (if any) carriers anticipated in the particular direction of transmission;
2. The type of fiber selected (or already installed), which will be used to carry the signals in each direction.

Note the condition (1) above differentiates between each direction on the cable. For example, running a sub-split cable results in a return spectrum of only 4- to 6-MHz channels. Using a 600 MHz transmitter in the return path may be elegant, but not the most cost effective solution since a four-channel transmitter will be sufficient to handle the entire reverse spectrum. In other cases, 600 MHz will be absolutely necessary.

The maximum capacity of any fiber optic transmission system is optically power limited by the fiber optic transmitter chosen. Simplistically, the maximum data channels a specific analog fiber optic transmitter can transmit is proportional to the number of video channels that it can carry. As illustrated in Table 1, the ALS transmitters with the largest capacity are clearly the FT-1301-TX and FT-1501-TX, which use a laser in combination with single mode fiber.

Ideally, the best solution is simply to choose laser based single mode equipment plus associated receivers and specify single mode fiber for the link. However, if fiber is already in place, it may

DS1 modems can replace a video channel with seven DS1 channels in the same bandwidth and proper BER.

be multimode of either 840 nm or 1300 nm transmission windows. Then, the optimum fit becomes the transmitter which will best handle the data requirements within the confines of the fiber type already in place.

Rules of thumb

A good rule of thumb is that a 6.0 MHz data channel (4.2 MHz plus guard band) on a coaxial B-LAN corresponds to a single video channel on the fiber system in terms of required optical power from the transmitter. Therefore, if the fiber optic transmitter's optical power will allow it to carry four video channels maximum, it can carry approximately the equivalent number of data channels that would fit into 24 MHz of bandwidth if the data channels were packed end to end. For example, DS1 modems (1.544 Mb/sec.) available from many manufacturers can replace a video channel with seven DS1 channels in the same bandwidth and proper BER. Therefore, approximately 28 DS1s would be supportable with the transmitter cited in this example.

TABLE 1

Typical analog fiber transmitters

Transmitter model	Source type	Maximum bandwidth	Fiber type required	Equivalent video channel capacity
FT-1501-TX	Laser	600 MHz	1550 nm single mode	16
FT-1301-TX	Laser	600 MHz	1300 nm single mode	16
FT-1301-TX-11	Laser	600 MHz	1300 nm multimode	6
FT-1300-TX	LED	100 MHz	1300 nm multimode	2
FT-8301-TX	Laser	300 MHz	840 nm multimode	5
FT-8100-TX	LED	100 MHz	840 nm multimode	2

Let's say that there are two 6-MHz data channels on a sub-split system going in each direction. Further, 840 nm multimode fiber has been installed previously, and we are required to use this existing fiber to avoid the cost and time of a new fiber installation. From the table, we need an FT-8301-TX for the forward path since we require frequencies above 100 MHz and the fiber is 840 nm. If we are cost conscious, we can manage with a FT-8100-TX for the reverse path, since 100 MHz and two channels are both within our requirements.

If the existing 840 nm fiber were not a restriction and the customer desired additional reserve capacity for future growth, we would specify the FT-1301-

The number of channels that can be transmitted through the fiber optic system depends on their individual bandwidth requirements.

TX and 1300 nm single mode fiber for the application in order to provide the greatest possible reserve capacity for future growth.

Calculating capacity

In many systems, a number of data carriers are present within a 6 MHz channel. Alternatively, a data channel can also occupy more than 6 MHz of cable bandwidth. A number of 128 Kb channels, each requiring 200 kHz, can fit into a single 6 MHz slot. Conversely, an Ethernet channel usually requires more than 6 MHz. For example, a 10 Mbit/sec. broadband Ethernet channel is usually 12 MHz wide. The fiber optic system provides a broadband "gateway." There are no fixed, immovable channel boundaries. As stated previously, the capacity of the fiber optic system is dependent on both the type and the number of channels transmitted. The number of channels that can be transmitted through the fiber optic system depends on their individual bandwidth requirements, and the minimum power required to receive a relatively error free signal (usually BER is about 10^{-9}). This level can be expressed in terms of a ratio called carrier-to-noise (CNR). Different data modulators have differing minimum CNR requirements. In order to receive data with acceptable error rates, the CNR of a data carrier must be above a minimum level, usually between 26 dB and 30 dB.

To compute the number of data channels that will fit in a single video channel, the following formula can be used:

$$N = \left[\frac{B_1\, CNR_1\, 0.67}{B_2\, CNR_2} \right]$$

where B_1 is 6 MHz, the bandwidth of a video channel; CNR_1 is $10^{3.5}$ (35 dB) for the video channel for single mode systems; and $10^{3.0}$ for multi-mode systems. B_2 is the bandwidth of the FDM data carrier channel; and CNR_2 is the required CNR for the specified bit error rate of the data carrier channel.

To determine the total capacity of the fiber optic link, the number N computed above is multiplied times the number of video channels from Table 1 for the specific transmitter model chosen. This example is valid whether the data channels are greater or less than 6 MHz in required bandwidth.

Computing link data capacity

The performance of an analog broadband lightwave transport link is characterized in terms of channel capacity, the number of data and/or video channels that can be transmitted, and the link budget and the length of the repeaterless span that can be achieved.

Continued on page 50

Broadband LAN market growing

As a percentage of total LAN market yearly sales, the material value of broadband LAN hardware and software—excluding the value of pre-sale, installation and post-sale services—will range from a low of 28 percent to a high of 32 percent between the years of 1988 and 1992, says Arthur D. Little.

The dollar value of these yearly broadband LAN sales (again reflecting hardware and software only) will run from $116 million in 1988 to $546 million by 1992, analyst Markin Pyykkonen reported at FOC/LAN 87, a trade show for the fiber optics and LAN industries held in October 1987.

Arthur D. Little also expects healthy growth in the industry applications most likely to require broadband technology: intra-facility backbones; campus backbones; and high speed specialized networks, Pyykkonen reported.

> From 1988 to 1992, broadband LANs will account for 28 to 32 percent of total LAN hardware/software annual sales, Arthur D. Little says.

Intra-facility backbone networks will represent 20 percent of total LAN market hardware/software shipments, or $156 million, in 1988. By 1992 those figures should grow to $393 million and 23 percent of total LAN market hardware/software shipments, the analyst said.

Campus backbones should represent $156 million—20 percent—of total LAN market hardware/software shipments in 1988. By 1992 those figures should read $386 million—23 percent—of total LAN market shipments.

High speed specialized networks should be $77 million (11 percent) of the market in 1988 and grow to $221 million (13 percent) by 1992, Pyykkonen said.

The analysis suggests that Ethernet will continue to hold its ground and twisted pair networks will grow. Fiber optic networks will grow dramatically,

U.S. LAN market forecast

Medium	Topology	Access	1988	1989	1990	1991	1992
1. Baseband coax	Bus	CSMA/CD	39%	33%	28%	24%	21%
2. Broadband coax	Bus	CSMA/CD	20%	19%	17%	16%	15%
3. Broadband coax	Bus	Token passing	8%	11%	14%	16%	17%
4. Twisted pair	Bus	CSMA/CD	4%	4%	3%	3%	3%
5. Twisted pair	Ring	Token passing	16%	17%	17%	17%	18%
6. Twisted pair	Star	TDMA	4%	3%	3%	3%	2%
7. Fiber optics	Bus	CSMA/CD	4%	5%	6%	6%	6%
8. Fiber optics	Ring	Token passing	5%	8%	10%	12%	15%
	Other		0	0	2%	3%	3%
Total Market Size:	($M)		$769	$954	$1,193	$1,444	$1,704

Annual LAN market hardware/software sales by medium, topology, access method.

U.S. LAN market by product class ($M)

Medium	Topology	Access	1988	1989	1990	1991	1992
1. Baseband coax	Bus	CSMA/CD	$300	$315	$334	$347	$358
2. Broadband coax	Bus	CSMA/CD	154	181	203	231	256
3. Broadband coax	Bus	Token passing	62	105	167	231	290
4. Twisted pair	Bus	CSMA/CD	31	38	36	43	51
5. Twisted pair	Ring	Token passing	122	162	203	245	307
6. Twisted pair	Star	TDMA	31	29	36	43	33
7. Fiber optics	Bus	CSMA/CD	31	48	72	88	102
8. Fiber optics	Ring	Token passing	38	76	119	173	256
	Other		0	0	23	43	51
Total Market Size:	($M)		$769	$954	$1,193	$1,444	$1,704

Annual LAN market hardware/software sales by dollar volume.

Office applications for fiber optics will be driven by the need for backbone networks or repeater segments.

1988 U.S. LAN market forecast ($M)

Application Segment	PC Clusters	General Office Automation	Intra-Facility Backbone	Campus Backbone	High Speed Specialized	Total
Office	$ 78	$169	$ 56	38	$ 36	$377 (49%)
Factory	6	13	22	20	7	$ 68 (9%)
Office/Factory	5	44	25	20	5	$ 99 (13%)
Government	15	13	19	31	13	$ 91 (12%)
Education	16	8	12	31	11	$ 78 (10%)
Medical	4	9	22	16	5	$ 56 (7%)
Total	$124 (16%)	$256 (33%)	$156 (20%)	$156 (20%)	$ 77 (11%)	$769 (100%)

Broadband technology is best suited to backbone and high-speed applications.

as will networks based on the Manufacturing Automation Protocol (MAP).

From the broadband community's viewpoint, the important aspects of the study are:

- Broadband's projected growth over the five-year period. Fiber optics grows, but doesn't replace broadband.
- The growth of intra-facility backbone, campus backbone and high-speed specialized networks. These are the areas where broadband's high bandwidth and long-distance capabilities are crucial.
- Office applications for fiber optics will be driven by the need for backbone networks or repeater segments: all areas where broadband is a functional substitute.
- As network devices achieve higher processor speeds there will be a demand for higher bandwidth networks. This is the arena where fiber and broadband are the best media. ■

1989 U.S. LAN market forecast ($M)

Application Segment	PC Clusters	General Office Automation	Intra-Facility Backbone	Campus Backbone	High Speed Specialized	Total
Office	$ 93	$189	$ 65	$ 47	$ 39	$433 (45%)
Factory	8	19	37	32	9	$105 (11%)
Office/Factory	7	50	40	32	7	$136 (14%)
Government	18	15	26	34	17	$110 (12%)
Education	17	9	15	34	12	$ 87 (9%)
Medical	7	12	28	25	11	$ 83 (9%)
Total	$150 (16%)	$294 (31%)	$211 (22%)	$204 (21%)	$ 95 (10%)	$954 (100%)

Office, factory, and office/factory LANs will grow most between 1988 and 1989.

1990 U.S. LAN market forecast ($M)

Application Segment	PC Clusters	General Office Automation	Intra-Facility Backbone	Campus Backbone	High Speed Specialized	Total
Office	$107	$208	$ 74	$ 56	$ 48	$493 (41%)
Factory	14	25	57	43	14	$153 (13%)
Office/Factory	14	57	60	52	13	$196 (16%)
Government	22	19	34	38	21	$134 (11%)
Education	19	11	17	38	14	$ 99 (8%)
Medical	10	15	35	36	22	$118 (11%)
Total	$186 (16%)	$335 (28%)	$277 (23%)	$263 (22%)	$132 (11%)	$1,193 (100%)

Backbone and high-speed LANs are 56 percent of the market in 1990.

As network devices achieve higher processor speeds there will be a demand for higher bandwidth networks.

1991 U.S. LAN market forecast ($M)

Application Segment	PC Clusters	General Office Automation	Intra-Facility Backbone	Campus Backbone	High Speed Specialized	Total
Office	$122	$223	$ 89	$ 71	$ 63	$568 (39%)
Factory	25	36	72	58	25	$216 (15%)
Office/Factory	22	65	74	66	19	$246 (17%)
Government	27	24	40	44	24	$159 (11%)
Education	20	12	21	43	16	$112 (8%)
Medical	12	21	42	43	25	$143 (10%)
Total	$228 (16%)	$381 (26%)	$338 (23%)	$325 (23%)	$172 (12%)	$1,444 (100%)

Backbone and high-speed LANs are 58 percent of the market in 1991.

1992 U.S. LAN market forecast ($M)

Application Segment	PC Clusters	General Office Automation	Intra-Facility Backbone	Campus Backbone	High Speed Specialized	Total
Office	$138	$239	$104	$ 86	$ 79	$646 (38%)
Factory	34	52	86	72	37	$281 (16%)
Office/Factory	32	76	87	79	24	$298 (17%)
Government	31	28	46	50	30	$185 (11%)
Education	21	14	24	48	18	$125 (7%)
Medical	15	24	46	51	33	$169 (11%)
Total	$271 (16%)	$433 (25%)	$393 (23%)	$386 (23%)	$221 (13%)	$1,704 (100%)

Backbone and high-speed LANs are 59 percent of the market in 1992.

Continued from page 47

The following formula can be used:

$$C/N > CNR_{max} - 15 \log k - 10 \log(b_n)$$

where CNR_{max} is the maximum CNR achievable in fiber link measured in 1 MHz bandwidth; k equals the number of data channels; and b_n is the noise bandwidth of the data demodulator (broadband modem) in MHz.

For example, the CNR_{max} performance of the FT-1301-TX based (single mode, 1300 nm) transmission link is 60 dB. Assume that the broadband modem is for transmission at the DS1 (1.544 Mb/sec) rate and uses QPSK modulation. To guarantee a BER (bit error rate) of 10^{-10}, the transmission link must guarantee a CNR > 30 dB in a noise bandwidth of 1 MHz. Substituting these numbers in the above inequality provides an estimate for the number of DS1 carriers that can be transmitted:

$$CNR > 60 - 15 \log k - 10 \log(1.54)$$

$$15 \log k > 30$$

$$k > 100.$$

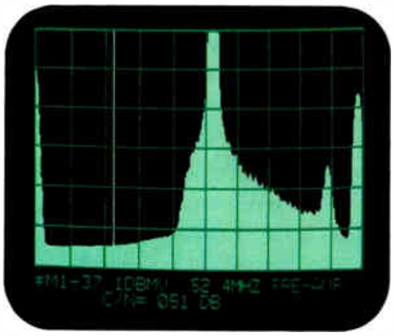
Transmitting video channels

In CATV transmission systems, video channels are typically sent across the cable in VSB-AM format. Amplitude modulation provides the advantage of being very frequency efficient, and therefore requires extremely linear components. (However, AM is quite noise sensitive, which is why it is not used for data carriers.) Since fiber optic systems offer much longer distance capabilities at the expense of linearity, they cannot transmit video in AM format.

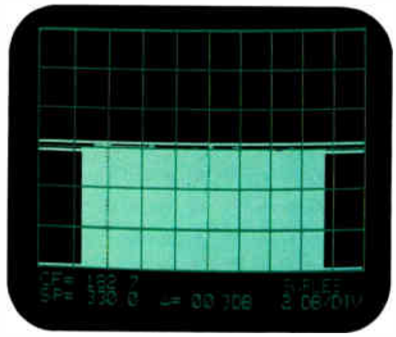
Transmission of video requires that the channel be converted to an FM format. For baseband signals, this means that an FM modulator is required. For VSB-AM signals, they must be first demodulated to baseband, then remodulated to FM. For satellite based signals which also use FM modulation, no modification may be required. It is important to note that TV sets require VSB-AM format, or baseband video if TV monitors are used. Placement of TVs and program origination locations will determine where modulation and demodulation of signals will be most efficient.

Conclusion

Analog fiber optic trunking systems are ideal as technical and economic solutions for B-LAN extender applications. Since they use FDM transmission techniques, analog fiber systems require no data conversion equipment. A wide variety of equipment is available for systems requiring 840 nm, 1300 nm, single mode and multimode technology. Analog fiber systems are ideal for use as feeds or extenders to interconnect B-LAN systems. ■



Improve picture quality.



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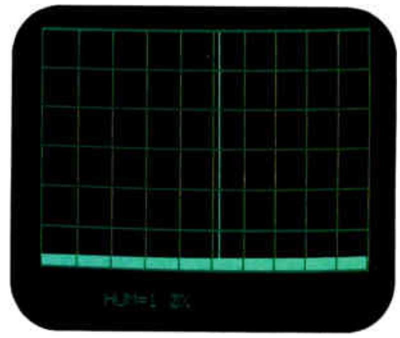
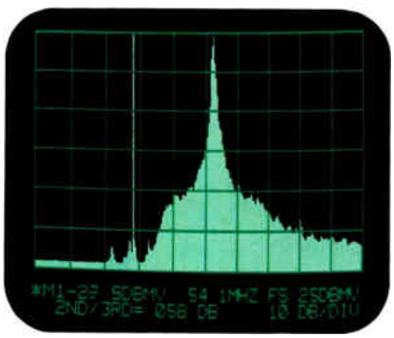
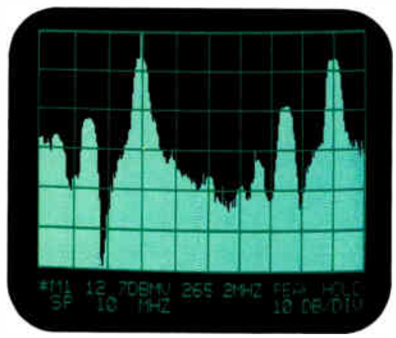


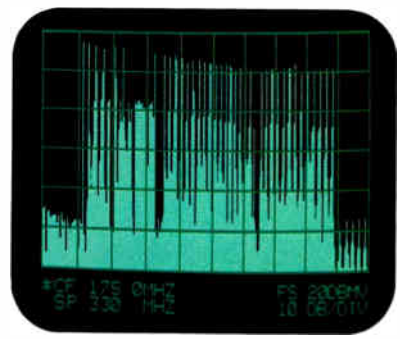
Minimize hum.



Pinpoint distortion problems.



Peak RMS of suppressed sync.



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Reader Service Number 34

WAVETEK®

Ancot, BT&D and others debut new LAN products

ANCOT Corp., formerly D-Designs Inc., has announced the availability of the model DSC-202 SCSI bus analyzer/emulator. The DSC-202, a standalone instrument, was designed for use as a non-intrusive SCSI bus tracer or as a SCSI device emulator. It is programmable as an initiator, or as a target controlled from an external terminal, or an IBM PC-type host computer.

The DSC-202 can be used for software development and troubleshooting, performance testing or control testing of SCSI devices, controllers and adaptors.

The analyzer/emulator was initially designed as a laboratory instrument for use by engineers developing SCSI-bus based products and integrating such products into systems.

Several test routines can be stored in its 1K bytes of EEPROM or downloaded from the host to the 30K bytes SRAM. The unit is priced from $5,650 to $8,950 when fully configured. Deliveries are 30 to 60 days ARO. Volume discounts are available.

Raven Electronics Corp. has added an RS-232 interface to its 422 Series polling alarm and control system. It provides accurate status monitoring and control of remote facilities in a digital or analog transmission network. With the new interface all functions of the 422 series system can be controlled by a PC-type computer.

A 422 Series master station can accommodate up to 64 remote stations for a total of 4,096 alarm points, which are programmable in a 16-point alarm group, for a system total of 2,016 control points.

When the maximum number of remote stations is used, each station is limited to 64 alarm points. When there are less than the maximum number of remotes, each station may have a greater than 64 alarm point capacity.

The system can be used as a standalone or with the Raven 416 Series order wire system. Remote station cards plug into the order wire chassis for space efficiency and economy when order wire and alarm systems are combined.

Master and remote units are housed in standard 19- and 23-inch rackmountable equipment shelves. In addition to remote computer-based operation, an operator's panel at the master station provides audible alarm and displays all alarm data via LED annunciators. All control functions can be initiated from the master station by front panel control switches.

Write Raven Electronics Corp., 400 Wolverine Way, Sparks, NV 89431, for more information.

A fiber optic coupler for single-mode system applications is now available from **BT&D Technologies**. The company's fiber optic coupler line includes tree and branch couplers, star couplers, wideband couplers and wavelength division multiplexers. All products are available in ruggedized versions to provide added strength and protection for operation in demanding telecommunications and military applications.

BT&D's couplers are produced using a computer controlled manufacturing process; several automated production steps ensure coupler performance, accurate control of power splitting ratios and superior excess loss ratios for very low insertion loss specifications. All couplers feature polarization stability and operate over a wide range of temperatures (-55 degrees C to +125 degrees C).

BT&D will also produce products with custom wavelength, splitting ratios and packaging based upon specific customer requirements. Samples are available upon request. Other products include laser transmitters (sources), receivers (photodetectors) and switches. For additional information contact: BT&D Technologies, Delaware Corporate Center II, Suite 200, 2 Righer Parkway, Wilmington, DE 19803.

A 265-page report entitled *The U.S. Market for Intelligent Communications Processors* was recently released by **Frost and Sullivan** of New York.

Products in the report include front end processors, one of the earliest applications of computers to the problems of T-1 multiplexers, PBX systems (voice, data and voice/data) and digital central office switches. These products, according to the report, constitute an estimated 1987 market of $13.5 billion.

Among the individual product segments, the report estimates digital central office switches to have the largest 1987 dollar sales: $5.6 billion. Predicted growth is to $6.3 billion by 1992.

The report also looks at the effect on future markets for ICPs of regulatory factors, from deregulation of packet switching to the use of rights-of-way in the interstate highway system for optical cable installation. Major vendors of ICPs are profiled and the effects of technological developments are analyzed, notably the more powerful micro processors, which allow vendors to develop a new tier of markets for ICPs among companies who could not previously afford this kind of communications environment. The price of the report is $1,950.

DSC Nestar Systems Inc. made available the industry's highest data throughput Ethernet card for users of Novell Advanced Netware 2.0a.

In an extensive series of network benchmark tests conducted by the LanQuest Group—designed to exercise and accurately measure file servers, operating systems and interface cards—DSC's Turbo Ethernet Card enhanced Novell end-user productivity potential and performed up to 81 percent faster than competing products.

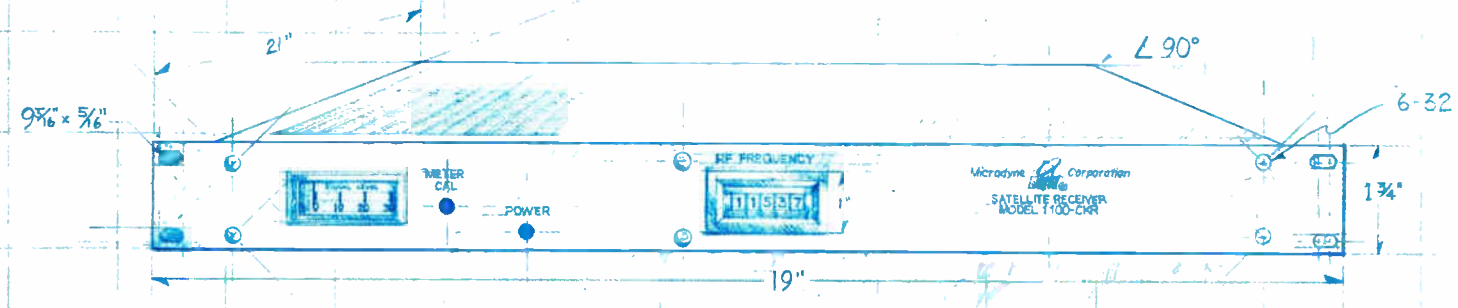
The Turbo Ethernet Card running Novell Advanced Netware 2.0a is available in both 8 and 16 bit versions. It can be installed in any IBM PC/XT/AT or compatible and is available for IBM's Personal System/2 Models 25 and 30.

Keith Amundsen was chosen as chairman of the IEEE 802.3 Fiber Optic Star Study Group. The newly formed group will study various star topology fiber optic proposals that offer compatibility with IEEE 802.3 network nodes, with the intent of standardization.

Amundsen is the director of interconnect development with **Chipcom Corp.** He also spent nine years at DEC where he was the chief architect of DEC's ThinWire Ethernet. He has been a member of ACM, Sigma XI, ANSI X3T9 and ISO SCI3.

—*Greg Packer*

Inch For Inch



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Reader Service Number 35

When is a drop-in upgrade possible?

Where it is possible, an upgrade using drop-in electronics saves money over a rebuild approach to increasing channel capacity. A rebuild requiring new actives, passives, power supplies, cable, connectors, associated hardware, construction costs and permits might run $18,000 per mile. If feasible, the same upgrade using a drop-in electronics approach would require new actives, possibly new passives, new connectors, splicing costs and possibly no new permits for a cost of about $4,000 per mile. But how do you know it's feasible?

Scientific-Atlanta Applications Engineering Supervisor Bob Loveless and Times Fiber Vice President Sales Rex Porter offer a few guidelines.

In general, the upgrade is feasible if it "doesn't affect the picture quality the subscriber currently has and causes no noise or distortion performance degradation," Loveless says. The system has to be in good physical condition, be delivering a good quality picture already and have satisfactory current tap output levels. The reason? The existing cable and amplifier stations will continue to be used. That means cable, for example, has to be structurally sound and capable of flat frequency response across the entire new passband of interest. And there's really no way to be sure except to do an SRL test.

When noise performance, cable SRL and tap output levels already are good.

Older-generation cables manufactured in 1972 might be flat to 300 MHz, but almost certainly will not be predictably flat to 450 MHz, Porter says. So an SRL test of the actual cables is mandatory before an upgrade can be considered. Attenuation properties of the older cables also can be a problem. Earlier generations of coaxial cable did not have the moisture blocking and absorbing properties of newer low-loss dielectrics. And after hanging on poles long enough, such older cable might have unacceptably high attenuation. And since an upgrade requires both higher levels at the tap and the carriage of higher frequencies, the attenuation characteristics are critical. It might be more economical to replace older cable with newer and more stable cable.

Moisture in an older cable also will cause impedance changes that produce echoes or ghosting. Also, with time, the

Upgrade requirements
Distortion

Maintaining the same amplifier output levels:

Channel Loading Degradation (dB)

Existing system (Freq)	(Ch)	Upgrading to: 260 (30)	300 (36)	330 (40)	400 (54)	450 (62)	550 (78)
220	(21)	3	5	7	11	14	19
260	(30)		2	4	8	11	16
300	(36)			2	6	9	14
330	(40)				4	7	12
400	(54)					3	8
450	(62)						5

Upgrade requirements
Trunk Gains

Trunk gain required utilizing P-1 type cable:

Existing system	260	300	330	400	450	550
22 dB at 216	24	26.5	28.3	31.6		
260		24.3	26.0	29.0	31.0	
300			23.5	26.2	28.1	32.4
330				24.6	26.3	30.5
400					23.6	27.3
450						25.5

An upgraded system will be running higher frequencies with higher losses so higher gain amplifiers are needed.

outer conductors become brittle because of cyclic stress—repeated bending of the cable during connectorization and equipment replacement. The more times it has been bent, the greater the chance of a fracture, Porter says. And look at the expansion loops. If they are less than 5 inches deep they probably aren't good enough to withstand the normal cable expansion and contraction with temperature changes. The problem is the differing thermal flexure properties of steel strand and the cable itself. The differential causes cracked sheaths.

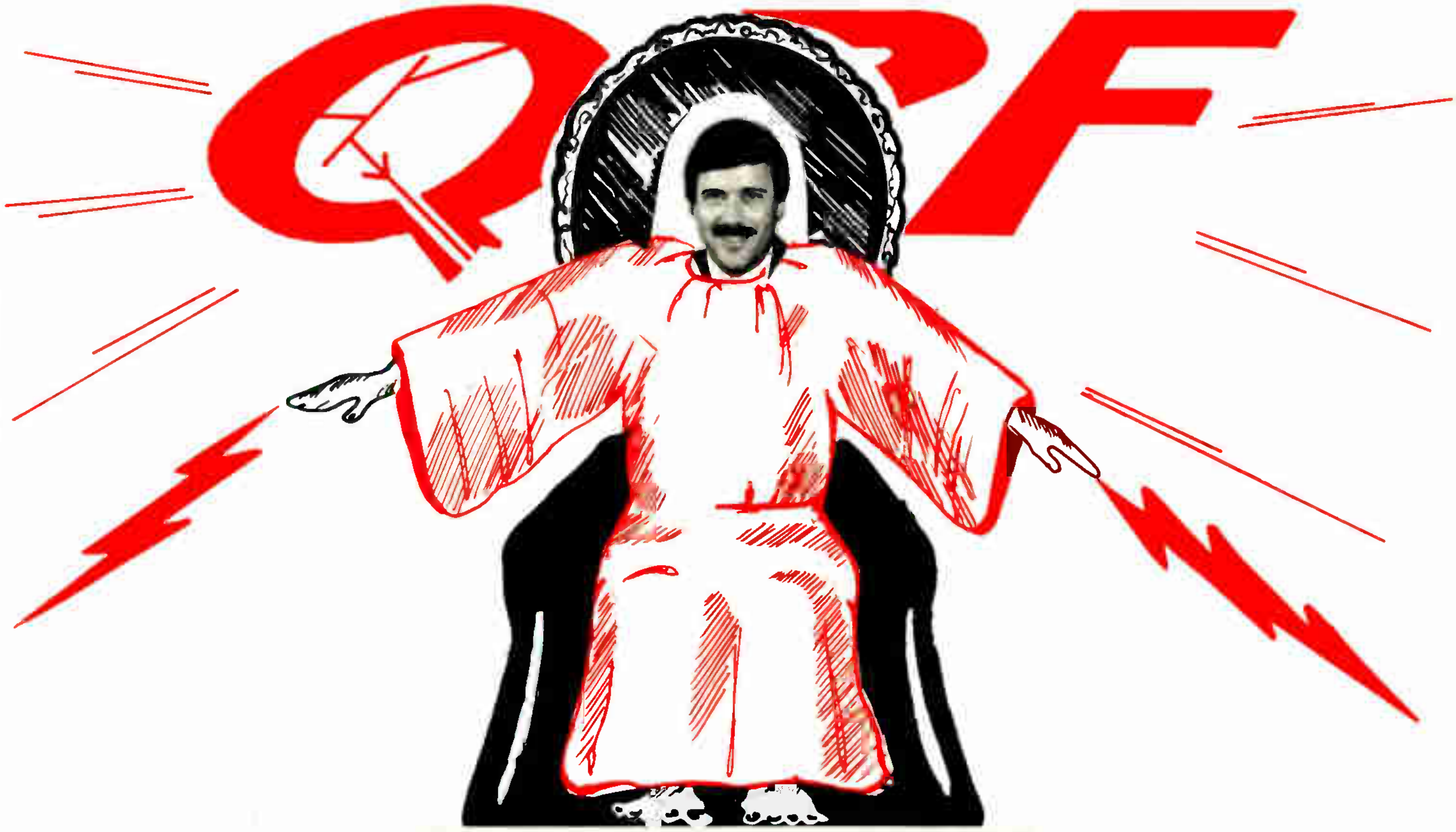
Other possible problems with older cable are pin holes in the sheath caused by corrosion or loose gaskets on amp housings that have allowed moisture ingress. Feed-through connectors can be a problem. "Use sealed pin-type connectors to amps, not feed-through," Porter says. The problem: Amps are sealed so pressure builds inside them during the summer. Suppose the amp is serviced during the summer. That puts moist air into the chamber. After resealing, the pressure builds again. "The moisture wants to get out and unless sealed connectors are used, it will go out the cable."

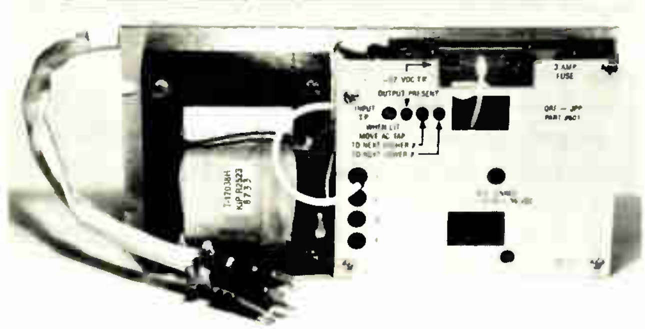
Several types of upgrades

Several types of upgrade are possible. A drop-in involves replacement of actives and passives at their current locations. An electronic drop-in might require replacement of amplifier modules but leaves the passives in place. A narrow upgrade is a frequency expansion from one range to the next: 220 to 270 MHz; 270 to 300 MHz; 300 to 330 MHz; 330 to 400 MHz; or 400 to 450 MHz. A broad upgrade means jumping up in frequency two or more steps: 220 MHz to 300 MHz or 300 MHz to 450 MHz, for example. A trunk upgrade uses a drop-in approach for mainstations but requires replacement or reworking of the feeder system.

An upgraded system will be running higher frequencies and encountering higher losses so amplifiers with higher gains are needed. And while newer hybrids offer improved distortion performance, they provide no improvement in noise performance. So systems that are candidates for drop-in upgrades already should be delivering adequate signal levels to drops. The reason: the converters need to see equivalent input levels to maintain the existing noise performance. As a rule of thumb, assume that new amplifiers will produce the same amount of noise as existing amps if the same input levels are maintained.

About half the total distribution system noise is contributed by the trunk amplifiers. Here are some of the parameters. Typical system C/N is about 45 dB and trunk amps probably represent about 99 percent of total system noise. Trunk amps will put out





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DMV

A Super-VHS VCR, for example, has to see at least 45 dBmV to record video delivered over a cable system.

Upgrade requirements
Trunk Gains

Trunk gain required utilizing P-3 type cable:

Existing system	260	300	330	400	450	550
22 dB at 216	24.3	26.3	27.8	30.6	———	———
260	———	23.8	25.1	27.8	29.3	———
300	———	———	23.2	25.6	27.0	30.0
330	———	———	———	24.3	25.7	28.4
400	———	———	———	———	23.3	25.7
450	———	———	———	———	———	24.4

Upgrade requirements
Trunk improvement

The distortion improvement required when: Inputs equivalent as existing
Outputs higher to accommodate higher gains
Increased channel loading

TRUNK
Distortion Improvements Required
Upgrading to:

Existing system (Freq)	(Ch)	260 (30)	300 (36)	330 (40)	400 (54)	450 (62)	550 (78)
		Frequency (channel loading)					
220	(21)	8	14	19	28*	———	———
260	(30)	———	6	10	19	26*	———
300	(36)	———	———	5	13	19	30*
330	(40)	———	———	———	9	14	25*
400	(54)	———	———	———	———	6	15
450	(62)	———	———	———	———	———	10

*Beyond any individual amplifier technology.

about 45.7 dB C/N; bridgers about 60.7 dB C/N; and line extenders about 54.2 dB C/N, S-A's Loveless estimates. Noise figures for push-pull and parallel-hybrid amps are about 9 dB. Feedforward amps come in around 10 dB. That affects end-of-line performance in important ways. A Super-VHS VCR, for example, has to see at least 45 dBmV to record video delivered over a cable system. If the S-VHS VCR doesn't see 45 dBmV it will show the noise.

The minimum parameters that must be met therefore are set by the amplifier and converter input levels. Amplifier output levels and distortion performance are the critical variables since distortion products will increase as a function both of additional channel loading and higher output levels.

Approximate "knee" of compression

MHz:	550	450	400
Push-Pull	+48	+50	+52
Parallel Hybrid	+51	+53	+55
Quad Power	+54	+56	+58
Feedforward	+47	+49	+51

To get the distortion performance required, it will almost certainly be necessary to move to quad power or feedforward hybrids, Loveless says. A typical -53 dB CTB standard will be met on a typical 20-amplifier cascade if trunk, bridger and line extender stations are each one-third of total stations and if each type of amp maintains CTB performance of -63 dB, producing a combined system CTB of -53 dB. Visibility of the artifacts occurs at about -48 dB. To maintain CTB performance after the upgrade while keeping amplifier output levels the

Continued on page 82

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Reader Service Number 39

What to look for in a fiber optic connector

A fiber optic connector is not a trivial thing. On casual inspection, it may be viewed as a simple means of getting a signal into and out of electronics or as a convenient way of re-arranging a system. However, fiber optic systems, by virtue of their large bandwidth, usually carry large amounts of information and are usually carrying that information at all hours. A connector that fails or performs poorly could cause the loss of that information, which could be worth millions of dollars and incur the ire of thousands of paying customers.

Copper or coaxial connectors' principal operating function is contact—electrical contact. Provided there is secure electrical contact, a copper or coaxial connector will have essentially zero loss and will otherwise perform adequately in the system.

A fiber optic connector's principal operating function is alignment—alignment of very small fibers. Alignment is a function of materials, mechanics and tolerances. Just a small misalignment of a fiber can cause unacceptable loss, which can limit the size of a system, how many users it has and its flexibility of use.

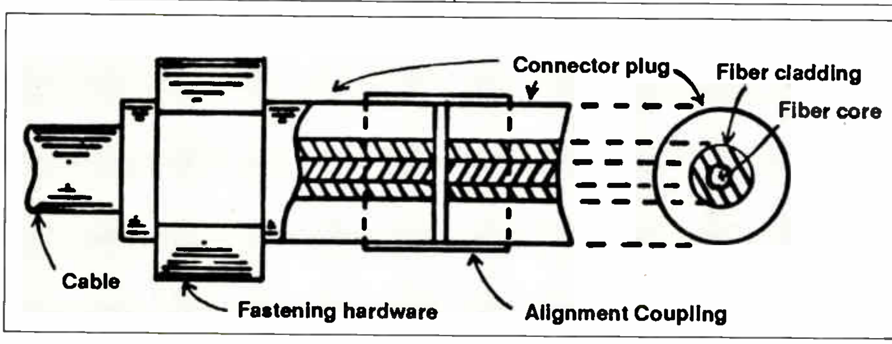
However, there are many fiber optic connectors available today that can easily and consistently achieve and maintain good optical alignment, at low cost. One needs only to be careful when selecting an optical connector. In most respects, optical connectors can be handled in the same way as connectors used with metallic media (e.g., coax). Optical connectors must, however, be kept clean.

By J. E. Denny,
AT&T Technologies Inc.

The decision on which connector to use goes deeper than at first glance.

Connection loss

Loss is probably the dominant factor to consider when choosing a fiber optic connector. In premises distribution and LANs, many connectors are used over a short distance to permit flexibility in arrangement and rearrangement of the system users. For cost considerations, such systems usually use LED transmitters and PIN diode receivers, which yield relatively low power budgets. These opposing constraints of tight power budgets and the need for flexibility dictate the use of low loss connectors. Just a few tenths of a dB reduction in connector loss can increase a system's service area by several hundred meters and/or permit the addition of several more users. Even in laser powered, long distance systems, using better connectors can add kilometers between repeaters.



A fiber optic connection usually comprises three parts: two plugs and an alignment sleeve (or coupling). The plugs are permanently attached to the ends of cable, and the alignment sleeve holds and aligns the tips of the two plugs. See Figure 1.

The principal factors affecting proper alignment and, therefore, loss are:
- dimensions and tolerances of the fiber
- mechanics of the connector design
- materials of the connector
- tolerances of the connector manufacture.

It is the core of the fiber that carries the light; therefore, the core must be properly aligned to achieve low loss. However, it is the fiber cladding (the outside layer of the fiber) that is held by the connector plugs. Therefore, to get low loss, both the fiber and the connector need to be of high quality. Even if the connector is perfect, if the fiber is not round (low ovality) and/or the core is not concentric to the cladding, the connection could still have unacceptably high loss. The mechanics of the design, the materials and the design tolerances all interact to determine the loss associated with a particular connector design. The quality of manufacture will also affect the loss seen among connectors of the same design, but from different vendors.

The loss of a fiber optic connection is usually expressed as a mean (average) loss, u, and a standard deviation (variation) of that loss, o. These statistics are used in the system loss model. For most systems, one usually wants both values to be small, consistent with cost constraints. Smaller values of u and o generally mean a better connector and a correspondingly higher price. Most systems are designed for a 98 percent confidence level, meaning that maximum connector loss is assumed to be u + 2o. In today's systems, an average loss of 0.5 dB and a maximum loss of 1.0 dB are considered acceptable, although there are many connectors that do better.

Connector loss is quoted for a complete connection: two plugs and a coupling. It is meaningless to specify loss for a single connector.

When comparing connector loss values, one should be careful that the loss is quoted at the same fiber size and tolerances. Losses quoted for larger core fibers are usually better than for those quoted for smaller core fibers, and can, consequently, hide poor design and sloppy manufacture.

Also, one should be aware that the loss test method can affect the stated or measured loss. The method in general use today is a concatenation method, wherein many jumpers are randomly connected in series to derive the statistical values of what one can expect such jumpers to yield in system use.

A fiber optic connector will be exposed to a range of temperatures. It may be used indoors and out. A poorly

A consideration related to temperature stability but of secondary importance is the effect of humidity.

designed and manufactured connector will exhibit wide fluctuations of its mean loss with changes in temperature. These changes are caused by thermally induced expansion and contraction of the parts. Proper choice of materials and design can minimize these fluctuations.

Temperature induced loss variations can cause temporary disruption of the system. In extreme cases, the connector plugs will back away from each other (called jacking), introducing a permanently increased loss, until someone is able to find that connection and remake it. Connectors that do not adequately secure the fiber in the connector plug (e.g., do not use adhesives) can allow the fiber to move within the plug as the temperature changes, inducing loss variations. This fiber movement is call "pistoning."

One should typically look for a temperature stability specification of 0.3 dB change over -20 C to +60 C. Such performance will usually assure reliable performance and will not adversely limit system size or flexibility.

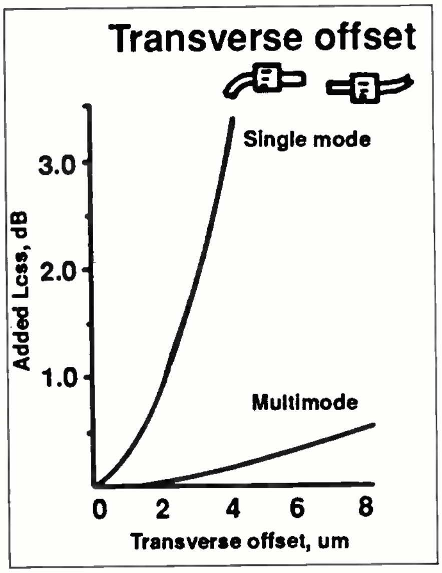
A consideration related to temperature stability but of secondary importance is the effect of humidity. The materials used in some low cost fiber optic connectors can degrade significantly when under mechanical load (e.g., threaded in too tightly), during or after being exposed to high humidity and temperature.

Connectors, by definition, are repeatedly plugged and unplugged. A poor connector can, therefore, over time in use, degrade in loss to the point where the system fails. Even if poor loss repeatability is accounted for in the system design, that poor repeatability can limit the size and/or flexibility of the system. The repeatability is primarily controlled by the mechanics of the design, materials and the cleanliness of the connection.

Ruggedness is a measure of how well a connector can withstand "normal" handling (and normal handling may well include abuse). Ruggedness is a function of mechanics and materials. The tests of ruggedness usually include vibration, drop, crush and flexure tests. The details of these tests are too extensive to cover here. However, one should look for hard materials, low mass and a robust design (a connector with a long tip is more apt to be damaged from a drop than is one with a short tip).

Pull-out strength is a measure of how hard one can pull axially on the cable terminated with a connector before something breaks (fiber, cable or connector). This is an important consideration because fiber is often exposed to tugs and pulls. If a connector cannot hold its cable when tugged, it is not a practical connector.

A minimum pull-out strength of 35 lbs. is recommended, with an average of about 50 lbs. One should be careful to select per the minimum because it is possible to find connectors with a 50 lb. average and only a 10 lb. minimum.



Mounting ease and reliability

The introduction of fiber optics to premises environments dictates the mounting of connectors in the field. It is impractical to accurately measure, have made in a timely fashion, and install cables with connectors already mounted, in all cases. Instead, cable is placed from a reel, cut to length and terminated. The connector mounted in the field must mount easily, quickly and reliably and should yield the same performance as any connector used when the system was engineered.

Installation crews are generally familiar with the termination of coax and copper connectors; therefore, the fiber optic connector termination tools and procedures should be similar. The tools should be simple and robust, not requiring trick alignment, maintenance or testing. Precision tools, such as cleaving or precision alignment tools, usually do not hold up in field use.

Installation time should be short, less than 10 minutes per connector. One should bear in mind that mounting procedures that do not include high quality adhesives (e.g., epoxy) or polishing generally sacrifice performance, usually loss and pull-out strength. Most field mounting kits in use today include curing ovens (thermal or UV) to speed the set-up of adhesives, and a one- or two-step dry polishing procedure to simplify and speed polishing.

The tools and procedures should yield a high percentage (90+ percent) of usable connectors. It does little good to mount a connector quickly if only half are acceptable or they fail after the installation crew is gone.

With the introduction of single mode systems as the preferred medium for long distance, high speed (high bandwidth) and video communications, all of the connector considerations already covered become even more critical. The fiber cores in single mode systems are from 1/5 to 1/10 the size of those in multimode systems—less than a 10 um core diameter. In comparison, an ordinary sheet of paper is 100 um thick.

Achieving and maintaining acceptable alignment of single mode fibers in connectors is a feat. Even a casual look at the chart in Figure 2 shows that very small misalignment can cause very high loss. Just a few microns off, and the system could fail. An average bacterium is only a few microns in size.

However, there are connectors available which can achieve and maintain excellent single mode quality performance at reasonable cost, due to advances in design and manufacturing techniques. Many single mode connectors available today achieve better than 0.5 dB average loss. Examples of such connectors are the AT&T Biconic Connector and the AT&T ST® Lightguide Cable Connector.

Reflections

There is an additional consideration in single mode systems that usually is less important in multimode systems—

Single mode systems require low reflections from connectors.

reflections. Reflections are the small amounts of light that get reflected back to the transmitter when the light encounters a discontinuity in refractive indices. Such discontinuties usually occur at fiber-to-air interfaces, which usually occur at connectors.

Most multimode connections have an air gap between the connector plug tips. This air gap is permitted since such gaps do not have an adverse effect on system performance. Having such a gap reduces the chances that the connector tips could touch and grind against each other, causing damage and higher loss. Such gaps also reduce the need to maintain exceptionally tight tolerances during the manufacturing process, thereby reducing costs.

However, since single mode systems usually operate with high powered laser transmitters and at high data rates, reflections that get back to the transmitter can cause instability in the transmitter. Therefore, single mode systems require low reflections from connectors.

Reflections can be reduced either by eliminating the air gap or by putting a special finish on the ends of the tips such that the reflected light is reflected at an angle that does not couple back down the core of the fiber.* The first method runs the risk of end-face damage of the fiber; the second increases forward loss.

The way to reduce the risk of end-face damage for contacting tips is to improve manufacturing tolerances such that the tips may never grind against each other (as opposed to just touching) and/or keying the connector body such that the tips cannot rotate relative to each other.

Connector systems that rely on special finishes require that the user be familiar with, buy, stock and know when to use at least two variations of a connector—one for low loss and one for low relections.

The measure of reflections is return loss. In general, one should look for connectors that have a single mode return loss of -28 to 32 dB or better.

Again, because of the small dimensions one deals with in single mode, the slight variations one can tolerate in multimode could cause problems in single mode. If one is not careful in his connector selection, he could find that just the day-to-day plugging and unplugging of his patch panel causes unacceptable variations in system loss. Therefore, one should be careful to select a connector that gives acceptable repeatability in single mode use. ■

** It is possible to reduce reflections by using index matching fluids. However, such fluids can be messy and are easily contaminated when used with connectors.*

'Integration' is byword for PPV hardware vendors

Because 1987 was the year pay-per-view gained respect as a genuine revenue generator, a dramatic increase of PPV system rollouts will occur in 1988, according to the manufacturers of hardware that orders and delivers the service.

PPV has become big business. As an Oak Communications' ad states, even systems that use telephone ordering systems have generated revenue of $1 million a month. Consequently, manufacturers like Oak, Jerrold and Scientific-Atlanta have integrated store-and-forward hardware directly into their addressable converters.

The most bullish hardware vendor is, not surprisingly, also a programmer. The Jerrold Division of General Instrument recently integrated its store-and-forward sidecar units into its brand new Starcom 7000 converter, which was introduced last December at the Western Cable Show in Anaheim. Integrating the impulse buying capability directly into its converter shows that the box's utility has become most important, according to Hal Krisbergh, vice president and general manager of Jerrold's subscriber systems division.

"Our industry has been too caught up in simply getting the box smaller and smaller," he said. "That's got to be done, but if that's all you're doing, you're not going to go anywhere. The focus isn't so much to get off the TV, but to predominate on the TV—not so much in space, but in utilization. We're focused on making that box do more and more things."

1988 looks bullish for pay-per-view.

Some of those other "things" Krisbergh mentions include providing CD-quality audio over cable, home shopping via impulse, advanced definition television and information provision (like stock quotes, etc.).

Buoyed by the success of its buy rates for Cable Video Store, Jerrold most recently completed a test where cable subscribers could order a regional pay sports channel via impulse. The results showed that nine times as many customers subscribed to the service by using the impulse technology than when it was offered by traditional phone-in subscriptions, according to Jerrold.

Krisbergh is so enamored of the potential that impulse holds that he predicts within 12 to 18 months, virtually all new product orders will have the capability built-in. "In 1988, the industry must begin to expand its perception of itself," said Krisbergh. "Impulse is happening—the question is, 'what do we do with it?' "

The other vendors, to varying degrees, share Krisbergh's enthusiasm.

Hal Krisbergh

Pioneer Communications will most likely introduce a new converter with integrated impulse capability.

COMPANY	CONTACT	PHONE NO.	PRODUCT	PPV APPLICATION
Business Systems Inc.	Jack Sunderman	(800) 424-0101	Telephone Entry System	Audio Response Unit
CableData	Nancy Frank	(916) 636-5800	Phone Entry Processor	Audio Response Unit
AM Cable	Tom Saldi	(215) 536-1354	Tier Guard	Store-and-forward
Interface Technology	Dave Young	(314) 426-6880	TOES 350	Audio Response Unit
Jerrold	Hal Krisbergh	(800) 523-6628	Impulse 7000	Store-and-forward converter
Kanematsu-Gosho	Neil DeCostanza	(201) 271-7544	Sprucer converter	Real-time
Melita Electronics		(404) 457-3700	4000 DVD	Audio Response Unit
Oak Communications	Carl Brown	(619) 451-1500	Sigma ASAP	Store-and-forward converter
Pioneer Communications	Mike Hayashi	(800) 421-6450	Pulse	Store-and-forward sidecar

Continued on page 67

Oak Communications debuted its Sigma ASAP converter recently. It features impulse store-and-forward capability that allows advance ordering of events and instant purchasing from home shopping or pay-TV channels.

Scientific-Atlanta, which engineered its "Masterworks" converters to accept an impulse chip but held off delivering the chip until the past month, also expects the impulse universe to grow. In fact, S-A will make the chip available in its RF boxes beginning in the late fall of 1988, said Andy Meyer, market specialist.

"We're very bullish about pay-per-view," said Meyer. But clearly, S-A isn't as optimistic as Krisbergh. Meyer said he expects the impulse world to grow, but doesn't expect it to be a majority of the universe for another two or three years. "It's an evolutionary step; people have to get involved in pay-per-view first, then go into impulse pay-per-view," said Meyer.

Pioneer Communications will most likely introduce a new converter with integrated impulse capability in time for this year's National Cable Show in May, said Mike Hayashi, marketing manager. The new impulse-capable converter will replace the Pulse, an add-on sidecar unit that has been sold

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Reader Service Number 44

Look for a new offering from Panasonic at either the National Show or the Western Show.

Continued from page 65

COMPANY	CONTACT	PHONE NO.	PRODUCT	PPV APPLICATION
Scientific-Atlanta	Steve Necessary	(404) 441-4000	Model 8580	Store-and-forward converter
Tocom	Richard Brown	(214) 438-7691	ITM-100	Dialer attachment
Telstar			Zapper	Automatic dialer
TV Answer Inc.	Steve Symonds	(703) 356-7800	TV Answer System	Over-air broadcast
Zenith	Vito Brugliera	(312) 391-8181	Z-View	Real-time
			Phonevision	ANI
			PM Pulse	Store-and-forward

to only three or four systems, yet still be the same size as the present converter, Hayashi said. The decision to take on the added expense of integrating the technology within the converter shows that vendors are convinced of IPPV's viability, Hayashi added.

Although he preferred not to commit to any definite new product rollout, Jim Slade of Panasonic Industrial Co., which only recently entered the converter marketplace, acknowledged that the company is "absolutely" looking at offering a store-and-forward converter sometime in 1988. Having an impulse-capable box is "an important area" for Panasonic, said Slade. Unless something unforeseen happens, look for a new offering from Panasonic at either the National Show or the Western Show.

A totally new form of IPPV delivery remains in the testing mode, but look for something to happen soon. TV Answer has petitioned the FCC to allocate one-half of a megahertz somewhere between 216 and 222 MHz to use for offering viewer response service. The FCC has responded with a notice requesting statements from interested parties. The statements were due Jan. 27.

TV Answer uses standard broadcast, cable or microwave signals to deliver "questions" to viewers, who respond by pressing a button on a remote control unit. The responses are returned via a microburst of radio frequency from a transmitter located in the home. More than a million responses per minute can be accommodated, according to Steven Symonds, executive vice president and CEO of TV Answer.

Testing of the system is taking place in and around the Washington, D.C. area, Symonds said. Product roll out will ultimately depend on what action the FCC takes and the results of the test.

So, it seems the operative word for 1988 will be integration as vendors roll out new products that can do more things and operators begin to count IPPV revenues as genuine portions of their revenue streams.

—Roger Brown

FM fiber optic systems

On the technical side of the cable industry, two exciting things are occurring at the same time. You can't go to a cable show or talk to industry leaders without the subject of high definition television and/or fiber optics coming up somewhere in conversation.

In many ways, the two developments are interrelated. Both focus on delivering a better picture to the viewer. HDTV takes up a lot of bandwidth; fiber provides more bandwidth. But mostly, there seems to be a lot of confusion, claims and counterclaims surrounding both technologies.

When it comes to fiber optics, many of the arguments center around modulation schemes: should a fiber system be FM or AM? FM systems are proven technology and have been installed in a number of CATV systems as supertrunks—getting the signals from one headend or hub to another without repeaters (amplification). But the application has never gone farther than that because at some point the signal must be converted to AM to accommodate all the AM converters and television sets in subscribers' homes.

Conversely, AM fiber systems are much more susceptible to noise and non-linearities of the lasers, which has so far kept AM systems on the drawing boards and out of the field. Although there are improvements being made almost daily by manufacturers of AM equipment, this profile will be limited to true working systems available today for CATV use. Therefore, the reader should be aware that each system discussed here—from Synchronous Communications, American Lightwave Systems, Catel Telecommunications and Pirelli Communication Systems—is an analog FM system.

"FM is the only means of transmission which has been field-proven to provide reliable, high quality transmission of multiple video channels over a single fiber," says John Holobinko, vice president of marketing and sales at ALS. Holobinko says his company continues to work on making a viable AM system, but it remains elusive. "We don't believe we have an AM system that is bullet-proof," he says.

Dr. James Hood, president of Catel, agrees, but holds hope for the future. AM is "improving rapidly," he says. "What I've seen in terms of better (signal-to-noise) numbers over the last six months says to me that AM is definitely something to look at. Fiber to the home, however, would have to be based on both (AM and FM) techniques."

The improved picture quality gained from an FM scheme is the whole crux of the matter, says Vince Borelli, president and CEO of Synchronous. With the new Super-VHS cassette recorders able to deliver 440 lines of resolution with a signal-to-noise ratio of 45 dB, VCRs are now able to deliver better pictures than most cable systems (which typically deliver between 240 and 330 lines of resolution at 38 to 42 dB S/N). Therefore, "we need some kind of a hybrid (AM and FM) system" to deliver a quality signal to the home, says Borelli.

The other issue related to installing fiber systems is cost. Because hardware costs are high, most of the research and development efforts going on today center around multiplexing a higher number of channels on a single transmitter laser. For a while, the best anyone could do was put 16 channels over one single mode fiber. Now, however, it's a different story.

American Lightwave says it will deliver 16 or 18 channels over a single fiber, guaranteeing a S/N ratio of 60 dB, says Holobinko. However, he also says 32 or 40 channels could be delivered with specifications meeting RS-250B medium-haul quality. "We could conceivably deliver 32 or 40 channels over a single fiber. But if you're looking at delivering HDTV in the future or linking a number of systems together, 60 dB is really a good minimum requirement. We will deliver 16 or 18 channels per fiber with that figure guaranteed," Holobinko says. He added that the "leap-frogging" claims of more channel capacity by all the companies will probably always exist, but people should be more concerned with the signal quality because that is rapidly becoming the issue of most importance.

Borelli says 20 channels is probably the maximum for long distance delivery for wide-band FM signals. At Catel, 16 channels is what the brand new system for Cleveland will deliver, but the company's just-announced Trans-Hub product, which converts FM signals to AM, boasts 40 channels, says Hood. And Pirelli says it can deliver 24 channels over a single fiber.

Regardless of their ultimate capacities, all the system manufacturers recommend loading no more than 10 to 15 channels per fiber and using a four-, six- or eight-fiber cable bundle. This way, if a problem should occur, only a portion of the channel lineup is affected, not the entire system. And leaving some room during construction will allow operators to add future channels without changing out the cable.

"We recommend that people build for 20 channels per fiber, but put 16 on," said Borelli.

All of these systems operate at or around an optical wavelength of 1300 nm. At that number, single mode fiber optic cable has lower attenuation than at most other frequencies. Because of that fact, most of the lasers built today are made to operate at that frequency. The other operating "window" is at 1550 nanometers, where the cable attenuation is about half of what it is at 1300 nm. But dispersion is greater and today, less hardware is built for use at this frequency, so the product that is available is more expensive.

Pirelli uses both frequencies to simultaneously deliver 12 channels of video over a fiber, giving the user a total of 24 channels. Each group of channels is wavelength division multiplexed at the different frequencies over a single mode fiber and then received, demultiplexed and distributed. Because most installed single mode fiber was designed to operate at 1300 nm (which precluded the use of 1550 nm signals because of high dispersion losses) a distributed feedback laser must be used. The DFB laser operates over standard non-dispersion shifted fiber, acting as if the fiber is also optimized for 1550 nm—without affecting the

Low noise amplification is provided by a GaAs FET transimpedence amplifier stage, followed by a chain of RF gain stages.

1300 nm performance.

Although these manufacturers may also produce LED-based systems or systems designed for use in multi-mode fiber environments, following are brief descriptions of single mode products, designed to operate at 1300 nm, offered by each manufacturer:

ALS's fully loaded mainframe.

American Lightwave Systems

The FT-1301-TX is a 600 MHz lightwave transmitter designed as a plug-in module for ALS's 1300MF mainframe, which provides the power supply and status monitoring connections. The laser driver portion of the transmitter board contains the broadband RF signal conditioning and pilot carrier multiplexing circuitry in addition to the InGaAs laser diode module. The index-guided injection laser diode is enclosed in a 14-pin hermetic dual-in line package with monitoring photodiode, thermistor and thermoelectric cooler. Average output power is 0 dBm or -3 dBm.

The FT-1302-RC and FT-1302-PRC are linear, wideband lightwave receivers which convert an intensity modulated optical input to an electrical signal. The FT-1302-RC receiver uses a Germanium APD (avalanche photodiode) for increased sensitivity for longer links. The FT-1302-PRC receiver's InGaAs PIN diode provides enough sensitivity for shorter fiber spans.

Low noise amplification is provided by a GaAs FET transimpedence amplifier stage, followed by a chain of RF gain stages. AGC is applied to provide constant output. The Ft-1302-RC receiver contains additional circuitry to provide temperature-compensated operating bias, which provides optimum avalanche detection gain.

The FM6600 series of frequency division multiplexing products is designed to allow transmission of up to 16 wideband signals over a single fiber. Each module accepts a 70 MHz IF carrier from an FM-2200-VM series modulator and frequency translates it to a spectrum slot. Each module is cabled to an eight-way power combiner with an additional two-way required for more than eight channels. The combined output can then be used as a drive signal for a lightwave transmitter. At the far end, the output from the receiver is distributed to the companion demultiplexing modules where each channel is converted back to the original 70 MHz IF frequency for processing by the FM demodulators.

Catel Telecommunications

In a typical application, four Series 3000 modules are required for each input or output channel. Therefore, a single 3000 chassis supports two input channels, two output channels or one modem.

The OT-1010 optical transmitter's long wavelength laser module incorporates the laser chip, back facet photodetector, thermoelectric cooler, temperature sensor and fiber pigtail in a hermetically sealed package. The combined FM signals modulate the laser, which is biased. An opto-electronic feedback loop at the rear mirror facet of the laser controls the magnitude of the optical signal. The output signal from the front mirror closely tracks that of the rear mirror. The light signal is coupled from the front mirror to a fiber pigtail and launched to the outside plant fiber via an optical connector. Finally, an alarm monitor circuit activates alarm indicators in the event of failure of any part of the control circuitry.

The OR-1010 receiver converts the optical signal to an electrical signal

The R1301 receiver board employs a PIN photodiode, RF AGC and alarm circuitry.

with a Ge APD. The signal is initially amplified by a low noise pre-amp and is further amplified and then controlled with an AGC stage.

The wideband 3000 FM modulator is phaselocked on 70 MHz to insure precise channel centering. Test points are provided for incoming processed video and an AFC alarm and LED deviation indicator are provided. The demodulator provides adjacent channel selectivity through phase corrected IF filters. AGC is provided and front panel diagnostics include a low input level indicator.

System specifications are as follows: differential gain, ‹0.4 dB; differential phase, ‹2 degrees; signal-to-noise (CCIR weighted, 13 to 16 channels per fiber), ›56 dB.

Pirelli Communication Systems

The Pirelli 1300 nm system offers 580 MHz of bandwidth capacity. The T1301 transmitter board contains a 1300 nm optical source, automatic laser current circuitry to stabilize output and compensate for laser aging and temperature control circuitry. A pilot tone of 10.7 MHz for AGC and alarm purposes is also generated.

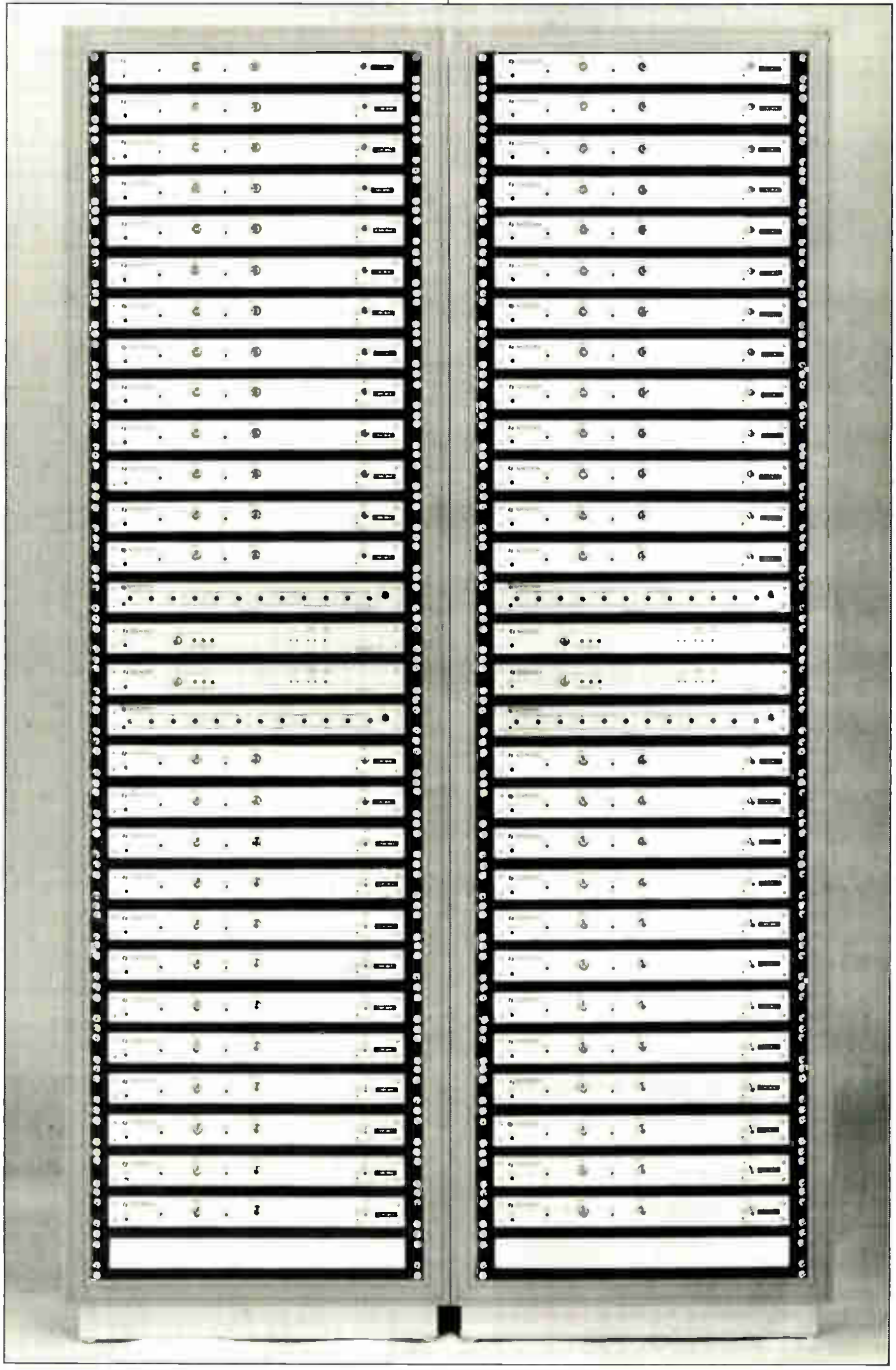
The light source is an injection-type semiconductor. An active temperature stabilization circuit with thermoelectric cooling element maintains a constant laser temperature. Premature laser failure caused by power supply transients or control circuit failure is prevented by special circuitry.

The R1301 receiver board employs a PIN photodiode, RF AGC and alarm circuitry. The PIN photodiode employs reverse bias to provide wider bandwidth due to lower diode junction capacitance, less noise due to reduced random recombination of electron-hole pairs, and greater linearity due to operation in a region where transfer characteristics are best.

The capacity of an existing fiber network can be doubled by overlaying the Pirelli 1501 system on a standard 1300 nm system. The T1501 transmitter employs a DFB laser to solve dispersion problems and is used with the R1501 receiver.

Transceivers (repeaters) are available for both wavelengths also. The RP1301 and RP1501 receives optical signals, converts them to an electrical form, amplifies them and retransmits in an optical form. While in an electrical form, signals can be dropped for local use and additional signals inserted for transmission.

The 800 series modulators are used to convert baseband input signals to an FM output signal. The units are frequency agile from 40 MHz to 540 MHz in 1 MHz steps. Four carrier



Synchronous' 1300 nm system.

The SMOR-1300 receiver uses a Ge APD to convert light energy back to RF carriers.

deviations are available.

System specs are quoted as follows: differential gain, 5 percent; differential phase, 1.3 degrees; and S/N (weighted 10 kHz to 5 MHz), ‹60 dB.

Synchronous Communications

The SMLT-1300 optical transmitter's hermetically sealed laser diode module is comprised of the laser chip, photodetector for power monitoring, thermal electric Peltier cooler, thermistor for temperature monitoring and single mode fiber pigtail. After receiving the RF carriers the diode generates an intensity modulated 1300 nm lightwave which is then coupled through a high return loss connector to the outside plant. Front panel test points allow measurement of necessary laser parameters via digital voltmeter. Modulation bandwidth is 5 MHz to 700 MHz.

The SMOR-1300 receiver uses a Ge APD to convert light energy back to RF carriers. The carriers are then amplified through a transimpedence amp and low noise monolithic RF amps for combining to the wideband FM demods. Front panel diagnostics include APD bias and optical input power. LEDs indicate proper optical input and presence of RF carriers.

(Note: both of the above products will also operate at the 1550 nm wavelength.)

The FMVT-4001-40 modulator and FMVR-4001-40 demod are used to space channels every 40 MHz, ensuring that all second order products fall between the carriers. The frequency of the modulated carrier is 820 MHz, allowing a single down conversion to the required RF channel.

System specs include: differential gain, 2 percent; differential phase, 1 degree; and S/N (10 kHz to 5 MHz), greater than or equal to 60 dB.

—Roger Brown

For more information on the companies mentioned in the story, contact the following companies:

American Lightwave Systems: John Holobinko, vice president of marketing and sales, 358 Hall Avenue, P.O. Box 1549. Wallingford, Conn. 06492-1149 (203) 265-8880.

Catel Telecommunications: Dr. James Hood, president, 4050 Technology Place, Fremont, Calif. 94537-5122 (800) 225-4046.

Pirelli Communication Systems: David Friel, marketing services manager, 2 Tower Drive, P.O. Box 5031, Wallingford, Conn. 06492 (203) 284-1680.

Synchronous Communications: Vince Borelli, president, 1885 Lundy Ave., Suite 102, San Jose, Calif. 95131 (408) 943-0222.

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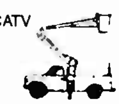

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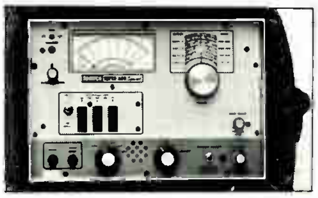

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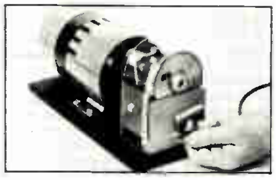
Sadelco Signal Level meters have features that dollar-for-dollar surpass other brands. The Super 600 has ±0.5 dB accuracy. AM hum modulation, voltage and other measurements are standard. Audio output, X-Y recorder jacks, NiCad batteries, video output jacks, and readouts in dB millivolt or dB microvolt are also standard.

Sadelco **Circle 261**



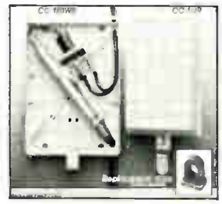
Coaxial Cable Stripper

Fast consistent cable preparation is easy with the CX-8 Motorized Coaxial Cable Stripper. Prepares a 3-level strip in a single action for any connector configuration. Strips cables from .400 to .430" diameter. Twenty years proven use by leading networks and independent stations. Call us for complete descriptive literature.

WESTERN ELECTRONIC PRODUCTS CO.

Circle 262

CC-1 Subscriber Terminal Entry Enclosures



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- Dress Up Your Drops
- Improve the Perceptual Value of Your Service
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Multilink **Circle 263**

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Super-NTSC system announced; ABC making plans to go stereo

With all the attention the various forms of high definition, enhanced definition and advanced definition television are getting, it's also significant to note that intense efforts are underway to improve the standard NTSC signal.

Yves Faroudja, founder of **Faroudja Laboratories** of Sunnyvale, Calif., and owner of a slew of patents (JVC incorporated some of his ideas in its Super VHS machine), has developed and encoder/decoder package, dubbed Super NTSC, that generates NTSC signals free of cross-color and cross-luminance components by utilizing sophisticated comb filtering techniques. In fact, Faroudja says if the signal generated by the encoder is also passed through a companion decoder, the resulting image is virtually indistinguishable from RGB.

Electronic Designers SR-101 receiver

Faroudja wowed members of the NCTA Engineering Committee during a demonstration of his equipment during a meeting in Denver last December.

Faroudja's Vertical and Horizontal Detail Processor is an internal circuit that improves the visibility of small details, whether they are present in the horizontal or vertical direction, without enhancing the large outlines, said Faroudja. This approach makes the picture more natural, gives it the look of film and doesn't show the "cartoon" effect typical enhancers do, he said.

The encoder, designed to be placed in a headend (for cable applications) is single-ended, meaning it will provide benefits to all viewers regardless of the equipment they have in their homes. The decoder provides even better pictures and could be reduced to a simple IC costing less than $2 which could be built into TVs or baseband set-top converters.

Perhaps the most significant concept here is that the system provides near-HDTV results but in a form that is completely compatible with today's technology. Watch for the system to get a lot more attention in the future.

This type of technology may be used to launch Super Cable programming, said Paul Perez of Recoton, chairman of the Super Cable subcommittee (formed under the NCTA Engineering Committee). Super Cable would offer nearly 500 lines of resolution while eliminating ghosts, adjacent channel interference and video noise, Perez said. Six-and 12-MHz systems are under consideration. Perez expects a concrete product soon. "This committee is geared toward implementation, not hours of tests and meetings," he said. "If this doesn't work, then by God, there is a flat earth," he added.

In other tidbits, **ABC** is saying it plans to deliver better pictures and sound to the consumer. The network already utilizes a Faroudja encoder on its cameras and generators. In addition, a spokesman noted the network was scheduled to begin broadcasting in stereo on Jan. 15.

Electronic Designers Inc. has introduced the Model SR-101 multichannel FM receiver for use with coaxial cable networks. The unit provides up to 60 channels of audio monitoring per 6 MHz of bandwidth when used with an FM headend system. It features pushbutton channel selection with LED display, dual conversion off the 88 to 450 MHz range, RF carrier and audio visual monitoring and two-watt audio output. Call (516) 242-6400 for information.

In a private presentation ceremony, Tony Cox, chairman and CEO of Showtime/The Movie Channel, and Andrew Setos, senior vice president engineering and operations, Viacom Networks Group, present an Appreciation Award to J.H. Levergood, president and COO of Scientific-Atlanta Inc. and Vincent Godleski, Satcom Division of S-A. Pictured from left to right are: Cox, Setos, Levergood and Godleski. The award was developed in special recognition to S-A for successfully manufacturing the antennas for the Galaxy III antenna program. The award is an authentic replica of the S-A antenna and the Galaxy III satellite.

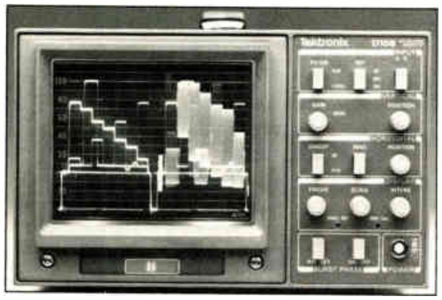
Alphasoft, a new remote status monitoring software package, has been announced by Alpha Technologies.

During the Western Cable Show in December, **Alpha Technologies** held a contest to name two of its new products. The names "Amp Clamp" and "Amp Eater" were chosen. Ticket holders with numbers 318118 and 318173 should contact Carla Denney, Alpha Technologies, 3767 Alpha Way, Bellingham, Wash. 98225, (206) 647-2360 to claim their prizes.

Cable TV Supply Co., through its Startron Systems division, unveiled its SPS series standalone power supply. Six-, 12- and 15-amp capacities are available with 30 and/or 60 VAC outputs. Standard features include volt/amp meters and time delay circuitry available in rack mount, aerial and pedestal cabinets. Call (800) 241-2332 for information.

Sola, a unit of General Signal, is now offering its SPS/R, a new standby power source featuring a one-millisecond transfer time. Models are available in 500 1,000 or 1,500 VA outputs with 60 Hz units rated for input/output of 120 volts AC. Front panel indicator lights show various operating and fault conditions. For information, call (312) 439-2800.

Alphasoft, a new remote status monitoring software package, has been announced by **Alpha Technologies**. Utilizing an IBM or compatible PC system, an operator can monitor the operational status of the cable network from headend or office locations. When alarm conditions are recognized, information is displayed on the terminal to direct service personnel to the exact nature of the problem. Call (206) 647-2360 for information.



Tektronix's S 1710B monitor

The new **Tektronix** 1710B waveform monitor include A and B inputs, filter selection, DC restoration, external reference, timing and amplitude calibration signals and vertical gain control. Its two horizontal lines and two field sweep rates offer magnification sweeps. Its burst phase capability, combined with its horizontal timing capability, allows an operator to set both horizontal and color timing of a TV system. For information, call (503) 627-7111.

ISS Engineering's GL2610XT modulator

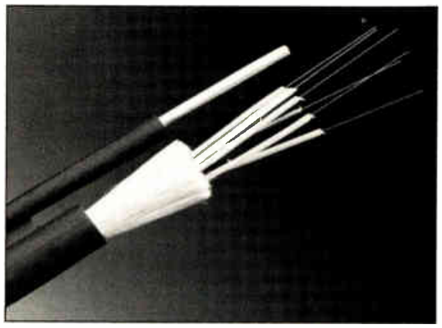
ISS Engineering has revealed an addition to its modulator line. The GL2610XT Series II offers front panel selected zero, 12.5 and 25 kHz offsets that do not change the 45.75 MHz IF frequency, allowing use with standard scramblers. Other features include phaselocked dual modulators for audio and video, an external pre-emphasis select switch, SAW filtering to insure spurious-free outputs and optional serial or parallel interface. For information, call (800) 351-4477 in the East or (800) 227-6288 in the West.

Pay TV access can be controlled with the new frequency agile audio/video modulator from **R.L. Drake**. Model VM2410 incorporates IF loop-throughs to permit operation with descrambling equipment. With the unit, users can regulate the decoding of pay channels, directing the unscrambled signal to subscription-paying customers. The modulator is a vestigal side-band unit with access to 60 channels. Price is $700 and it is available immediately. For more information, call (513) 866-2421.

For operators of MATV and SMATV systems, **Pico Macom Inc.** introduced the Geomax-10 off-air processing system that contains all of the components of a pre-racked headend in one compact case. It features a 10-channel capacity and a frequency range that spans all VHF channels. Other features include dual power supply, full AGC and aural carrier controls for all channels and modular strip amplifiers. Call (800) 421-6511 for information.

Qintar is now offering custom-designed commercial headends. A 12-channel headend with four VHF channels, four UHF channels converted to VHF and four satellite channels is priced as low as $5,500 not including satellite descramblers. Qintar also announced a new channel elimination filter. Model CEF eliminates a full 6 MHz-wide channel. Suppression is -55 dB minimum with adjacent channel loss of -4 MHz maximum. Cost is $399 for low band, $499 for mid and high band. Call (800) 252-7889 for information.

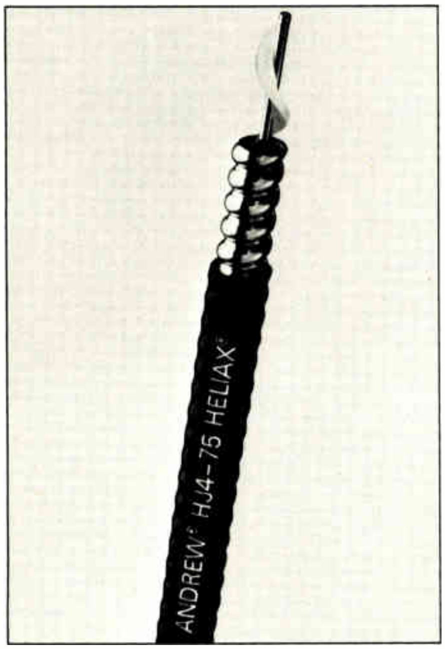
Optical Cable Corp. introduced a new "figure-8" cable for aerial applications. The new M-Series cable consists of a steel strength member attached by an extruded plastic webbing to a D-series fiber optic cable. The cables are custom made to order. For more information, call (703) 389-9900.



Optical's "figure-8" cable

A new trap, dubbed E.T. Micro Tap, was announced by **Eagle Comtronics**. Because of its small size, three traps can now fit in the space previously taken by two traps. A blocking capacitor is included to help prevent theft and single PC board offers better ground continuity and signal flow. Permanent channel identification is included. For information, call (800) 448-7474.

New filters from **Microwave Filter Co.** include the Model 6003 highpass filter that suppresses comb carriers on a CATV or other broadband system. It suppresses from 54 MHz to 450 MHz. Price is $725. Series 6008 UHF bandpass filters protect UHF translators from unwanted off-air UHF reception. Typical passband is 18 MHz centered at the customer's specified frequency. Price is $725. Model 3328B-41.25 bandpass filter eliminates spurious signal output from IF channel processors. Price is $185. Model 4616UA terrestrial interference trap is for IF frequencies between 230 and 700 MHz and is used to suppress TI at the final IF stage of TVRO receivers. Price is $427. Finally, Model 3378-12/J is for use in CATV or SMATV headends to separate the VHF super and hyperband channels from the low, mid and high band VHF channels. Price is $225. Call (800) 448-1666 for information.



Andrew's HJ4-75 coax cable

Two new cables are now available from **Andrew Corp.** The FSJ4-75A is a new half-inch diameter superflexible Heliax with low loss foam dielectric. It features a one and one-quarter inch bending radius to allow routing in tight places. Attenuation is 0.965 dB/100 feet at 100 MHz and 2.28 dB/100 feet at 500 MHz. HJ4-75 is a new half-inch diameter air dielectric Heliax coax. Bending radius is 5 inches and attenuation values are 0.759 dB/100 feet at 100 MHz and 2.57 dB/100 feet at 1,000 MHz. For information, call (800) 255-1479.

Klein Tools has appointed **Michael Klein** chairman of the board and chief executive officer; **Mathias Klein** is now executive vice president, manufacturing and **Richard Klein** is now executive vice president, engineering.

Dennis Campo has been appointed vice president of sales and marketing of Texscan MSI Corp.

J. Larry Bradner has been elected corporate vice president of **Scientific-Atlanta**. He is also president of the Broadband Communications Business Division.

Michael Watson has been named vice president of sales at **Channelmatic Inc.** He was previously West Coast regional manager for Video Systems, the former sales arm of Channelmatic.

Dennis Campo has been appointed vice president of sales and marketing of **Texscan MSI Corp.** Campo will report to David Keller, VP and general manager of Texscan MSI. He was formerly with TV Decisions. Also, **Phyllis Torres** was named in-house sales supervisor for the firm.

General Instrument's **VideoCipher Division** has named **Michael Meltzer** vice president, sales and marketing. He will report directly to J. Lawrence Dunham, general manager and executive vice president. Meltzer was most recently vice president, national sales and marketing, for the Consumer Video Products Division of Sony Corp.

Howard Weiner

Howard Weiner has joined **Panduit Corp.** as vice president, connector division. He was most recently director of engineering, commercial and industrial products, for Allied Amphenol Products.

Richard Houghton has been promoted to southwestern regional vice president for **CableAmerica Corp.** He has been with CableAmerica since 1983.

Jim McCauley has been named vice president for the Northeast Region by **Midwest CATV**. He comes to Midwest from Jerrold, where he was distribution sales manager. Also, **John Johnson** has joined **Midwest CATV** as purchasing manager. He was corporate purchasing manager at Cox Cable Communications in Atlanta.

Michael Conrad has joined **Pico Products Inc.** as sales support specialist and distributor liaison for the Standard Products Division.

Ruben Lugo has joined **RF Superior**, a division of Brad Cable Electronics, as a CAT system specialist. Lugo

Jim Chiddix has been promoted from vice president to senior vice president, engineering and technology, at ATC.

was most recently executive VP for a cable manufacturing company.

Robert Freedlund has joined **C-COR Electronics** as north central regional account executive. He comes to C-COR from General Electric, where he was regional sales manager for Comband products.

Jim Chiddix has been promoted from vice president to senior vice president, engineering and technology at **American Television and Communications**.

Dr. Emerson Pugh, research staff member at the IBM T.J. Watson Research Center, has been elected 1988 president-elect of the **Institute of Electrical and Electronics Engineers**.

The **Rocky Mountain Chapter** of the **SCTE** announced the results of the election of the board of directors for 1988. Those board members are: **Alan Babcock**, ATC; **Richard Covell**, General Instrument/Jerrold Division; **Steve Flessner**, TCI; **Eric Himes**, Magnavox CATV Systems; **Ron Hranac**, Jones Intercable; **Dave Pangrac**, ATC; and **Ron Upchurch**, United Cable of Colorado. The chapter's next meeting will be held Saturday, Feb. 27. For information, call Steve Johnson, 799-1200.

Speaking of the **SCTE**, here is a schedule of meetings for other chapters and meeting groups:

The **North Country Meeting Group** will meet Wednesday, Feb. 3 at a location yet to be determined to discuss and administer the BCT/E Category II exam on video and audio signals and systems. Contact Tony Werner, (612) 445-6151.

The **Oklahoma Meeting Group** will meet Wednesday, Feb. 10 at a location yet to be determined. Contact Herman Holland, (405) 353-2250 for information.

The **Central California Meeting Group** will gather on Thursday, Feb. 11 at the Picadilly Inn in Fresno. The topic will be the FCC and FAA. Contact Andrew Valles, (209) 453-7791 for information.

The **North Country Meeting Group** will meet for a second time to administer BCT/E exams on Wednesday, Feb. 24. Contact Tony Werner for information.

The **Greater Chicago Chapter** will meet Feb. 24 at the Embassy Suites Hotel in Schaumburg to discuss data communications. Call John Grothendick, (312) 438-4200 for information.

Corrections

In the December 1987 issue of CED, an omission occurred in the Contractor's Callbook. An entry should have been prepared for Johnson Enterprises of Jacksonville Inc., 330 South 3rd Street, Jacksonville Beach, Fla. 32250 (904) 249-1100. We regret the omission.

In the December 1987 issue of CED, CAB-LAN TEC Inc. was inadvertently left out of the profile of converter repair companies. We apologize for the mistake.

In the January 1988 issue, two paragraphs were inadvertently omitted from the Western Show wrap-up. The copy under Texscan Instruments on page 73 should have read: "Texscan Instruments rolled out a slew of new products. Among them: the TFC-600 tuned frequency counter with a 600 MHz bandwidth. Customers asked for a lighter, smaller package for the 600 MHz SP700 SLM so Texscan built the Spectrum 700A, priced at $1,495 and on special until the end of January for $1,295. It's tested to MIL-STD 810, which means it is dropped onto concrete from about chest height. Does the box still work? If so, it passes. The 700A does. The 700A also has a waterproof front case and is temperature compensated from zero to 130 degrees F.

"The new TG-1000Z tracking generator mates to the Spectre 1075 spectrum analyzer and provides a six-digit readout. It sells for $1,600. The new 1,000 MHz Spectre 1075 is a rugged, field-portable spectrum analyzer selling for $4,995. Optional batteries provide over 12 hours of intermittent operation.

"The new Spectrum II is a handheld dual-channel (high frequency/low frequency) SLM selling for $275. The Spectrum II uses channels 3 or 4 for low and 12, 13, 36, 37, 52 or 53 for the high channel. An LED display automatically displays the drop level when the Spectrum II is attached to a drop.

"The price of the Searcher leakage detection receiver also has been dropped to $255. Call (800) 345-2412 for details." We regret the omission.

—Roger Brown

Since increased output levels are required for the upgrade there is the danger of amplifiers being driven into compression.

Continued from page 58
same as they were, use the degradation factors shown in Figure 1.

Additional trunk gain also will be required to handle the higher frequencies, however. If using P-1 cable, use the guidelines in Figure 2. If using P-3 cable, use the guidelines in Figure 3.

The distortion improvement performance required is shown in Figure 4. A 300 MHz system using 22 dB gain push-pull circuits and 0.750-inch P-3 cable that is upgrading to 400 MHz, for example, requires 26 dB of gain and 13 dB better distortion performance over the existing trunk amplifiers.

Tap output

In the feeder, plant tap output is the issue. Simply, the lower the existing output, the tougher the drop-in becomes. A system designed for 10 dBmV output uses longer feeder spans than if designed for 12 or 13 dBmV. So at the higher frequencies, attenuation will change. The problem is compounded by the increasing prevalence of second and third outlets in homes. If a typical 150-foot drop supplying 1 dBmV at each outlet is assumed, RG-59 feeding two outlets at 300 MHz requires 11.2 dBmV output. At 450 MHz, that same outlet requires 12.7 dBmV. If four outlets are supported, 14.7 dBmV is needed at 300 MHz while 16.2 dBmV is needed at 450 MHz.

A 150-foot drop supplying 1 dBmV to each of two outlets needs 9.7 dBmV at 300 MHz and 11 dBmV at 450 MHz. A four-outlet drop requires 13.2 dBmV at 300 MHz and 14.4 dBmV at 450 MHz. To upgrade a system designed for low tap output there is no choice but to raise amplifier outputs to maintain the existing subscriber signal levels.

Conversely, the higher the existing feeder amplifier output, the tougher the job. Since increased output levels are required for the upgrade there is the danger of amplifiers being driven into compression, where the predictability of response is lost. The approximate "knee of compression," (See Figure 5). At this point, predictable response is lost. Saturation of response occurs 3 or 4 dB above the knee point. So upgrade feasibility in a system with high feeder levels requires enough additional headroom to avoid amp compression points. Sometimes, though, that may not be possible without simultaneously lowering tap output and restricting the increase in LE or bridger output.

An existing 300 MHz system being upgraded to 400 MHz will require trunk gain of 26 dB with 13 dB of distortion improvement (about 18 dB with a 5 dB reserve if using feedforward) and a companion increase in the feeder system of 2 dB output, 4 dB gain for the LEs and 10 dB of distortion improvement.

—Gary Kim

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