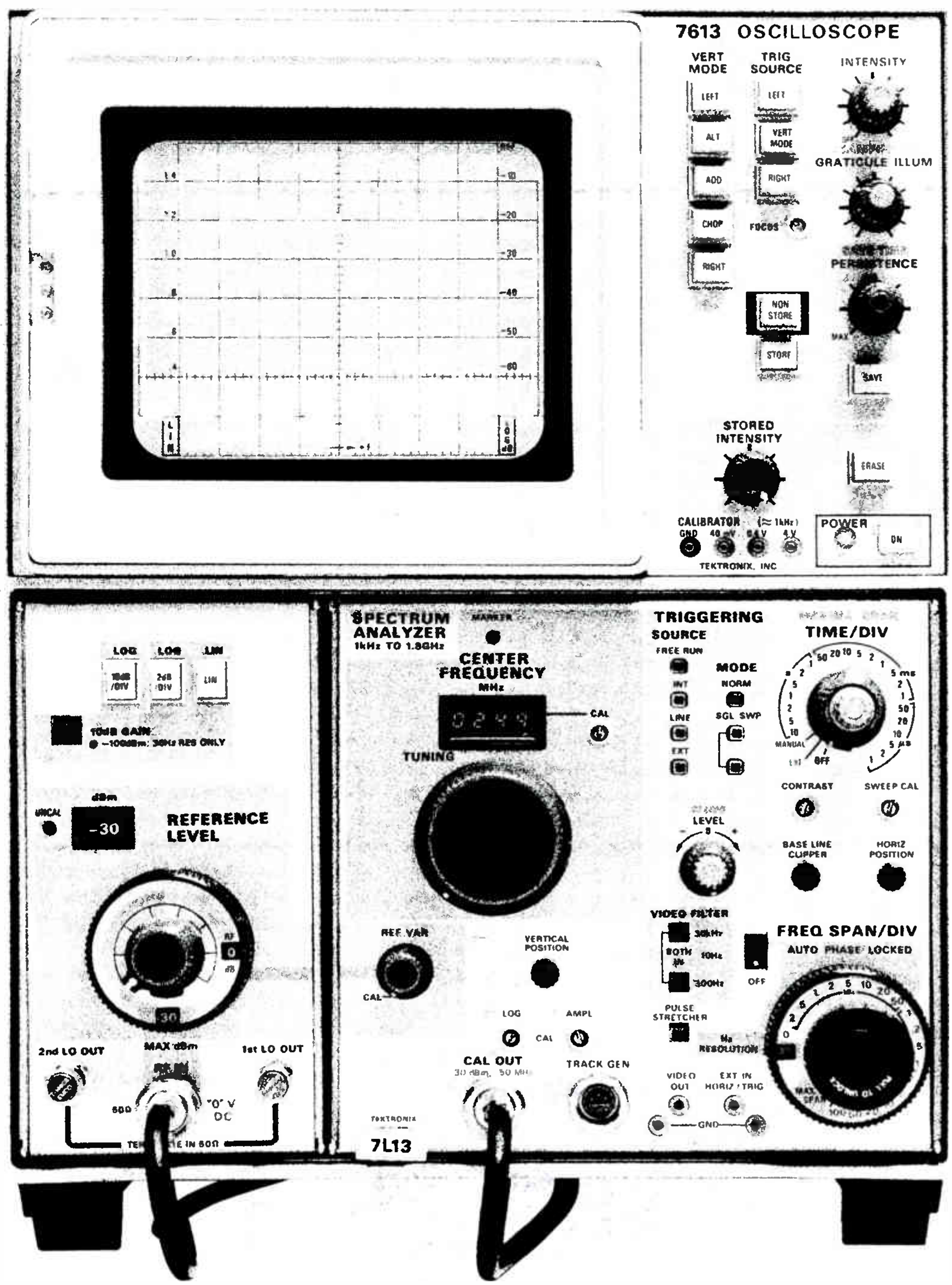
communications/engineering digest

reporting the technologies of broadband communications



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opinion/editorial

Judith Baer, Associate Publisher

There is a story elsewhere in this issue about $21 million having been spent by various federal agencies to fund studies about cable television. The story says simply, that nobody seemed to know that the other guy was doing it, and nobody knows yet for sure, what has been or is being done by 18 different federal agencies. Fascinating!

I've been roaming around the eastern countryside lately, and during some conversations with industry people, I've heard the lament that "cable television has not lived up to its promise." That got my mind working and I asked myself just what the "promise" was that this industry supposedly had made and, who in the industry had made it? Also, who was the "promise" made to? That starts the mind racing. The "promise" that was made, as far as I can remember, was that cable television could provide a varied number of services to consumers and could do so better than similar "other" communications methods. But to the life of me, I cannot remember who in the industry, (other than perhaps one past promoter who needn't be named), made such commitments.

Do you suppose that it really *wasn't* the *industry* at all making writers and study takers who made the promises?

If asked, "How's business?" — most suppliers will answer, "Great!" Even if business is not so great, that's the answer that most will give. Far be it from marketeers to let on that things are *not* rosy. Somebody else might have said that they *were* rosy and you'd look like you weren't a good salesman.

When asked how many miles of plant do you propose to build, the cable operator would give an answer that might be realistic, and then again, it might not be. "What about your thoughts on the industry's future?" Certainly you'd get a positive answer about the future, otherwise why would the guy be in it in the first place?

All this apparent enthusiasm would cause the report writer to go back to this office and develop glowing piles of paper describing this exciting new technology, one that really is not that new and up until recently, not that exciting. The reports were published and marketed through trade press and the *Wall Street Journal* and the financial community bought the reports and read them. Most of us in the industry read them and wept. We work here and we know the facts of the past. They were glorious and stunning reports about all the magic things that cable television could do, and represented, to the outside world, the industry's "promise." Some people invested, didn't get any return on their "promise" and got sour and went away. Others got truly involved and continued to work hard to get this business a "going concern" and are to be commended. Meanwhile, the report writers went on to other projects and made promises for other industries.

What we don't need are some more reports written by people outside the industry. What we need are facts, like actual miles of plant, actual number of subscribers, actual employment figures and true and firm figures that tell us where we have been and where we are, right now.

We'll never know where we're going if we can't tell where we've been. No more promises and studies, please. And by the way, the industry could have used that $21 million dollars the government spent on studies and told everybody about what we can and cannot, will and will not, be able to provide in the public interest.

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GUARANTEED SATISFACTION OR YOUR MONEY BACK

Technical News at a Glance

. . . **Receiver manufacturers have started making "engineers" of consumers with explanation of Vertical Interval Reference** *(VIR) signals in advertising. GE was first one we noticed. TV Guide carried extensive article during late August telling of receiving terminal "futuristic" home sets. Luckily, cable was mentioned in text.*

. . . **The Washington Post** *displayed its* **lack of knowledge about cablevision industry** *with, "Cable TV originates no programs but relays them to areas without television stations." Sentence appeared in Post report on progress of Copyright Bill.*

. . . *Television consultant/producer Bruce D. Stephens is scheduled to present a paper on* **Wide Screen Three Dimensional Video Projection** *at the Society of Motion Picture and Television Engineers annual technical conference to be held Friday, October 22 at the Americana Hotel in New York City. At that time, the technique will be domonstrated to those in attendance.*

. . . *Bill Bresnan, president of* **Teleprompter CATV,** *has verified that the company will install a* **long-haul run of optical cable within** *the next* **few months,** *and that the installation will be an "actual requirement, not a created need."* **Location** *of the installation has* **not** *been* **determined,** *contrary to rumors of Boca Ratan, FL, site. Hardware has not been ordered. Bresnan says company is gathering information from current "inside" experiment. This one will be on poles, subject to outside environment.*

. . . **Teleprompter** *expected to file* **application** *with FCC Common Carrier Bureau for* **4.5 meter TVRO** *in* **Kalispell, MT,** *during week of 10-18. System has est. 5,000 subs. Will* **not** *be* **redundant.** *Location is near center of footprint. Parametric amplifier will not be used according to Bresnan. If FCC does not act positively on small aperture petition on Dec. 7, Teleprompter will reevaluate situation.*

. . . **The Pole Attachment/Forfeiture Bill died** *in Congress when Speaker of the House Carl Albert made it evident that he would block the bill. The bill contained two parts; (1) setting minimum standards for pole attachment agreements and (2) fining cable systems for rule violations.*

. . . **National Association of Educational Broadcasters** *will hold its 52nd* **Annual Convention** *in Chicago, October 24-27.*

. . . *"New Ceramic Inertial Pickup for String Instruments with Mass Controlled Frequency Response Adjustments" is title of paper added to* **November 7-8 SBE program** *in Hempstead, L.I., NY, by Alan Hofer of Dyna Magnetics Devices.*

scte comments

Bob Bilodeau, President

In its history, the CATV industry has experienced several key technical developments. They include strip amplifiers (single channel), broadband lowband, and broadband all band circuitry, low loss/solid sheath cables, set-top converters, and solid state active equipment. One of the most significant is the development of broadband microwave for LDS.

Two necessary keys to unlock the major markets are Performance and Reliability. The above developments were steps in the right direction, with LDS playing not only an important role in performance and reliability, but in the ability to develop comprehensive system plans in an atmosphere of non-contiguous franchise development.

One serious disadvantage of LDS, in an otherwise democratic world, is that of technical exclusivity by the user—read licensee. Fiber optics is in the running for the next highlight in the series. It can overcome the exclusivity situation and add some unique features of its own. Such as:

1. Immunity to electromagnetic interference.
2. Independence from temperature and frequency equalization.
3. Trunk cables, the size and weight of your present drop line (to quote one supplier: "Your cable will be shipped to you UPS, instead of by tractor trailer.").
4. Reduced power requirements.
5. The ability to isolate your system from transients and sheath currents supplied by the local power utility.

Some interesting questions arise, however. One is the trade-off between bandwidth per fiber and fibers per cable. The bandwidth limitations are imposed by the active repeater devices, to the entent that they exist at all, not the fiber. It's analogous to the debate that was waged over RF capability vs. cable space diversity in the early 70's. RF repeater development prevailed, in part due to the unwieldy nature of coaxial cable bundles. Fiber bundles would not have the same impediment.

Fiber optic strand attenuation has decreased from 1000 dB/km five or six years ago to 1-2 dB/km—a dramatic improvement suggesting reasonable system design, but not without parallel repeater development!

Merely having low loss fibers is not the total solution to CATV system design, or even a point-to-point transportation system, the first likely area of development. Light repeating devices need to be at least as good as a state-of-the-art RF device.

Bandwidth or analog handling capacities of LED's or lasers poses the question of analog vs. digital transmission. While digital *transmission* on multiple fibers is technically sound, the cost of AD/DA conversions plus the per channel/per fiber conditions limit this configuration to point-to-point high priority systems.

Extracting information from a glass fiber at a multi-channel subscriber terminal and translating it to VHF format has not been demonstrated—and won't be by the next NCTA show in Chicago. However, the time frame has been shortened from that projected two years ago. This is primarily due to the Bell system activity and government interest in the subject. The projected cable market, no matter how intense, cannot support the heavy R & D required to make cost effective a new cable system technology.

The development of fiber optic transmission contains some hidden implications. Wide-spread acceptance and use by Telco may bridge the bandwidth gap that cable has maintained over twisted pair. This technological feature combined with legislation to augment it could impair cable's future plans for ancilliary services such as security, home shopping and data retrieval. We will then have to devise some other way to pick up the garbage, or put out the cat by cable.

Bob Bilodeau

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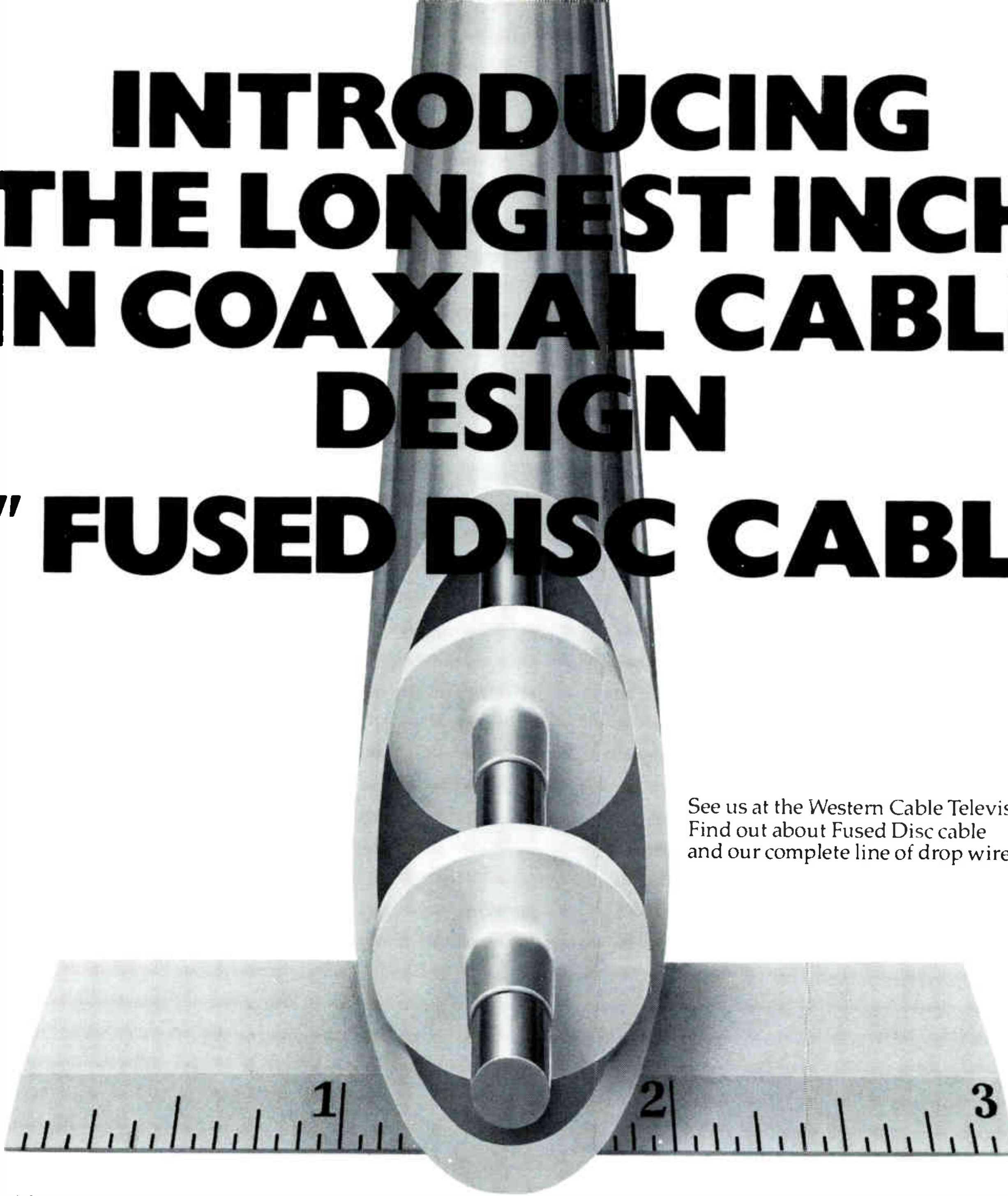

See us at the Western Cable Television Show. Find out about Fused Disc cable and our complete line of drop wires.

We've added one inch cable to the lowest low-loss cable line. Now cable systems can reach farther than ever. In fact, up to 10% farther than any other one inch cable.

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Here are further Fused Disc advantages:

- Available in amplifier lengths—no cable to cable splicing.
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- Characteristic impedance—75± ½ ohm GUARANTEED.
- Lowest loop resistance.
- Precision formed polyethylene discs prevent conductor movement in any direction due to causes such as vibration, temperature cycling or bending for loop formation.
- Sealed compartments prevent moisture migration in the event of moisture entry due to cable damage or leakage at connector interface.

Attenuation Values—One Inch Fused Disc Cable

FREQUENCY (MHz)	ATTENUATION (dB/100 ft.) @ 68 F Nominal	Maximum
5	0.07	0.07
30	0.18	0.19
55	0.25	0.26
83	0.32	0.33
100	0.35	0.36
175	0.47	0.49
211	0.53	0.55
250	0.57	0.59
270	0.60	0.62
300	0.63	0.65

For an information package on Fused Disc cables including specifications, installation instructions, connector data and economics information, write: General Cable Corporation, Department 571-129, 500 West Putnam Ave., Greenwich, Connecticut 06830 or phone (800-323-2309).

General Cable

news

Engineering Advisory Committee Meets

The NCTA EAC held one of its frequent meetings in Chicago during mid-September. The turnout was heavy since this was the first time that the EAC had scheduled meetings of its subcommittees during the morning hours and then held its own meeting during the afternoon.

During the formal EAC meeting, topics of discussion included NCTA's comments on CATA's petition for small aperture earth stations, proposal of engineer staff oversight of funds for representation on the International Electrotechnical Commission, the Call for Papers and 1977 convention plans with regard to technical programs, signal leakage and upcoming release of NCTA standards. About 20 industry engineers serve on the EAC with subcommittee participation involving another 50 cablevision personnel.

Quello Cited by IOB

FCC Commissioner James Quello received a resolution from the Independent Operator Board of NCTA at its September meeting in Washington, D.C. Nearly thirty small market owner/operators came to the city for the one day meeting that also featured speakers on pay cable and representatives of NCTA. Quello spoke to the group for nearly two hours on topics ranging from certification to equal employment opportunity.

Quello received the resolution from the group for his support of the cable television industry and for his understanding and interest in the smaller cable systems' problems. Mac Clark of Big Timber Cable TV and member of NCTA's Board of Directors presented the resolution form the IOB at the conclusion of the meeting.

Don Andersson of Turner Communications and Bob Weisberg of Telemation Program Services spoke to the group about pay cable for small markets. Andersson said that "cooperatives on earth stations are already being talked of among small market operators in some southeast states." Andersson talked about satellites, distant signals and pay programming while Weisberg provided insight to stand-alone pay, drawing from his experiences.

Bob Schmidt, president of NCTA, and Tom Wheeler, executive vice president, addressed the group on legislative activities that were scheduled for the following week. Mel Gilbert of Snyder, Texas hosted the meeting in behalf of the IOB and Beverly Murphy, vice president of operator relations, represented NCTA and provided the logistics for the day-long programming.

GAO Reports $21 Million Spent on Cable

The major finding of a study on federal funding of cable television, prepared by the Government Accounting Office, is that at least 18 federal agencies have funded CATV development, but that none really knows what the others are doing to "advance this burgeoning new technology." In a release from the House Interstate and Foreign Commerce Committee, Subcommittee on Communications, Rep. Lionel Van Deerlin, (D—CA), said the White House-based Office of Telecommunications Policy is formally charged with coordinating telecommunications activities throughout the Executive Branch. OTP was given this responsibility by a 1970 Executive Order. The GAO report notes that an OTP circular requires agencies to notify OTP of such activities. But, said Van Deerlin, "It's clear OTP is not doing the job."

Van Deerlin, chairman of the Subcommittee, said he has no quarrel with the goals and purposes of most of the studies financed by federal loans and grants. "In general, they were designed to help cable television develop its vast potential as a purveyor of services to people in their homes, schools and places of business," he said. "My complaint is that they are carried out on a sporadic, hit-or-miss basis."

The GAO report said that 18 of the 34 agencies contacted have financed some aspect of cable development. Total outlays over the past 10 years of $21 million were traced by the GAO, mostly to finance studies ranging from electronic mail deliveries to delivery of social services. GAO said there appeared to be no guidelines for allocation of funds, nor is there coordination among the agencies in disbursing the funds.

Federal agencies granted $11.3 million and made loans of another $9.7 million to further cable television research, much of it by universities and "think-tanks." Van Deerlin said the information gap became apparent during the recent oversight hearings on federal cable regulations. He said he was also concerned by testimony about apparent policy changes by some of the agencies involved which would make cable projects and systems ineligible to receive funds. Van Deerlin said that the Subcommittee will try to find out why OTP has been "so lackadaisical" in directing the programs and coordinating policy.

Chambers To Serve As Eastern SCTE VP

Cablevision industry pioneer Ken Simons was elected to the position of Eastern Vice President of the Society of Cable Television Engineers during its recent election. Simons was elected to serve through 1978. Because of a very demanding workload and extended travel requirements, Simons feels that he cannot do justice to the position and has asked to be replaced by someone otherwise qualified.

Glenn Chambers is next in line and he has agreed to serve in this capacity. Glenn is with ATC-Fox Cities in Appleton, Wisconsin and an active supporter of the Society's goals. He was the recipient of the 1976 SCTE "Man of the Year" Award and contributor to the first issues of *C/Ed* with a series of articles on *Proof of Performance, When To Do It and How To Do It.* Chambers is extremely well qualified and eager to serve.

Simons is a recognized leader in the industry and has contributed greatly to the growth of the technology. Author of the famous "Red Handbook" during his time with Jerrold Electronics, Simons has established many industry standards. SCTE President Robert Bilodeau stated that "the Society is fortunate to have two such dedicated and talented people within its membership and both willing to take part in SCTE affairs." Simons will remain a member of the Editorial Advisory Board of *C/ED* and provide support of a local nature to the Society.□

wrap up

James Herman, formerly with Jerrold Electronics, relocates to Phoenix, AZ, and joines ***Motorola*** effective Nov. 1. Jim will stay active in SCTE and IEEE while with Motorola. The ***FCC*** will probably act on CATA's petition for ***small aperture earth stations*** by the end of 1976. ***Scientific-Atlanta*** will display a ***5 meter dish*** at the Western Cable Television Convention, Dec. 1-3 in Anaheim, CA. Plans are afoot for other small dishes at the show. ***Exhibit*** area is a ***sellout.*** Technical programs are planned.

SCTE meetings include ***NYSCC/Upstate NY*** meeting with 101 at ***Oswego*** on Sept. 21. ***Western PA*** held meeting Oct. 23 in Bedford, PA, with topic of ***Antennas.*** Next ***PA*** and ***Mid-Atlantic Appalachia*** chapter meetings are ***November 24*** and ***December 22. Hardware Update*** is subject of first, ***CATV Testing Techniques*** subject of second. October 23 was date of ***Central New York*** SCTE meeting. October 13 hosted group at ***General Cable*** in Union, NJ, for ***Central Atlantic*** chapter. October 2 was meeting in ***Southern California*** with FCC Field Office inspector and truck.

Bob Toner, ***Toner Cable Equipment,*** will ***move*** to larger quarters during ***December. Danny E. Cornett*** is Acct. Rep, Cable Communications products for ***Scientific-Atlanta,*** responsible for CATV and earth terminal products in southeast. ***Eagle Comtronics*** moves from Manlius, NY, to ***Phoenix, NY,*** consolidating sales, engineering and production offices. ***Magnavox CATV*** begins turnkey construction in ***New Haven, CT,*** first in the city, for ***Systems TV, Inc.*** System will be 300 miles when completed.

Ken Hancock, director of engineering for Canadian Cable TV Association, represented North America in recent Brussels meeting of ***International Electrotechnical Commission.*** NCTA ***Associates*** Committee requested and ***received budget of $10,000*** to underwrite future U.S. representation at such meetings. The fund will be ***coordinated*** through ***D. Ports, NCTA VP of Engineering.***

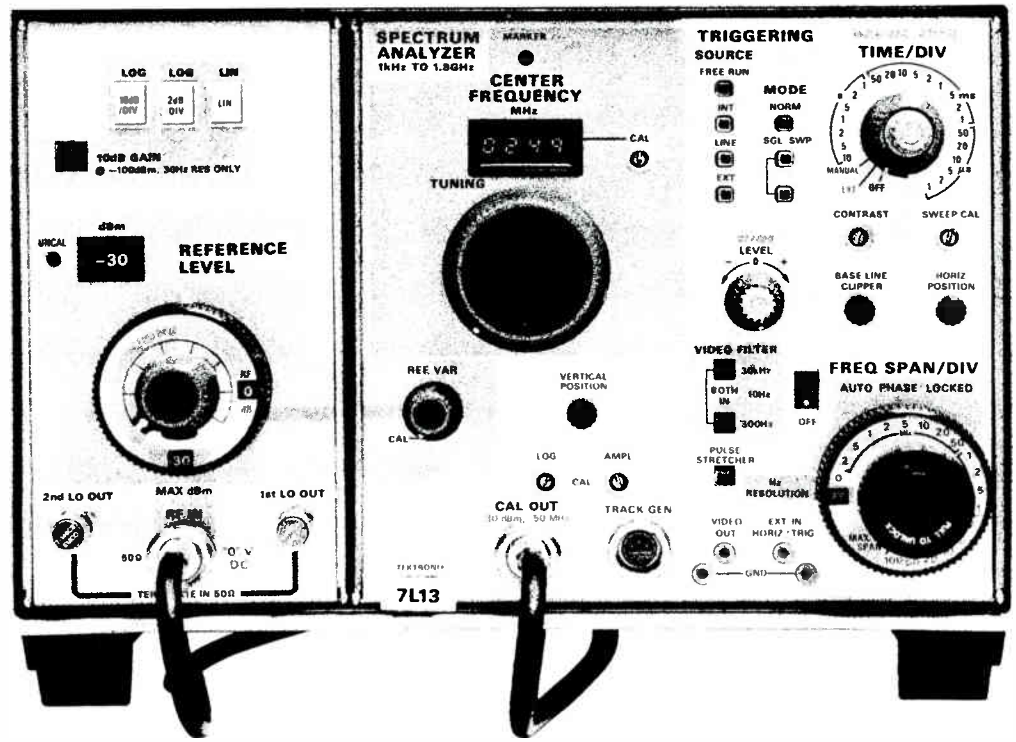
Jack Forde, formerly with Jerrold, joined ***C-COR Electronics*** as director of sales and marketing. ***Joe Romasco,*** ex-Jerrold, joined ***Theta-Com*** Division of ***Texscan*** in Phoenix, AZ. ***D. Crist*** stays with ***Theta-Com*** in ***marketing*** capacity.

The ***Japanese*** are entering ***optical cable*** with an extensive program interactive ***CATV network*** in Tokyo. Lengthy article appears in October ***Communications News*** on ***Rediffusion's*** Hastings, England, ***Installation.***

MDS begins New England service with ***HBO*** extending program service to ***Boston, Worcester, Springfield, MA,*** and ***Providence, RI.***

Belden Corp. estimated 3rd quarter sales at approximately $47.2 million, matching ***record*** level of second quarter and 22 percent ahead of 1975 period. ***Warner Communications'*** profits continue to ***rise.*** AEL changes name from straight American Electronic Laboratories, Inc. to ***AEL Industries,*** with CATV operations continuing under the ***Ultracom*** subsidiary.

Jerrold will hold ***news*** conference at ***WCTC*** meeting in Dec. with explanation of in-plant restructuring and plans for future. JEC will be out in full force with multiple booths at the meeting. FCC Commissioner ***Robert E. Lee*** will deliver the ***keynote*** address at 3rd Annual ***SBE*** meeting ***Nov. 7 and 8*** in Hempstead, LI, NY.



Instrumentation is a whole field in itself. Beside an understanding of CATV, the system engineer is often required to make decisions about how to test a new amplifier, or even what new test equipment to buy. Unfortunately, if your only source of information is the salesman selling the instrument, you might get slightly biased answers to your questions. Rather than let anyone have this advantage, we asked all the major suppliers of Spectrum Analyzers and Tracking Generators to contribute in this one special issue. I think you will find the result very pleasing.

This is our annual test equipment issue, and we are featuring, almost exclusively, the Spectrum Analyzer. This instrument is no longer a stranger to the cable operator. We no longer differentiate between owning one or not owning one, instead we compare quality and performance. Depending upon what needs testing, analyzers can perform simple tasks like level measuring (the Texscan VSM-1 for instance) or provide the most power possible (the Tektronix 7L13). Most operators want a compromise (in price, of course) and settle for middle performance.

This issue covers: how to choose an analyzer, how to speak the language and how to use tracking generators. Also included are a buyers guide/comparison chart and, finally, a special article by John Huff on how to make some very special measurements with your analyzer. We hope that when that time comes for you to make the decision on what is needed in an analyzer, this issue helps.

Clifford B. Schrock, Editor

Instrumentation and Spectrum Analysis

The Tracking Generator In CATV Measurements

The CATV industry is being faced daily with more demanding test and measurement requirements. Yesterday's sweep generators with ±1 dB flatness, and with spurious responses 20 dB down were totally inadequate. Today, sweepers are ±.15 dB flat and have spurious responses 40 dB down. The sweep generator and crystal detectors have long been the measurement mainstay for frequency response measurements. The requirements for more and more dynamic range in sweep measurements has promoted the development fo the next generation test instrument, the tracking sweep-spectrum analyzer. To appreciate the differences, let's review the familiar.

Older Techniques

Most sweep generators will provide a signal output near +60 dBmV (.5V). Most diode detectors are sensitivity limited to about ±10dBmV (3.2mV), and the range from +20 dBmV (10mV) to +10 dBmV is apt to be extremely doubtful and inaccurate. This characteristic is a function of diode construction parameters.

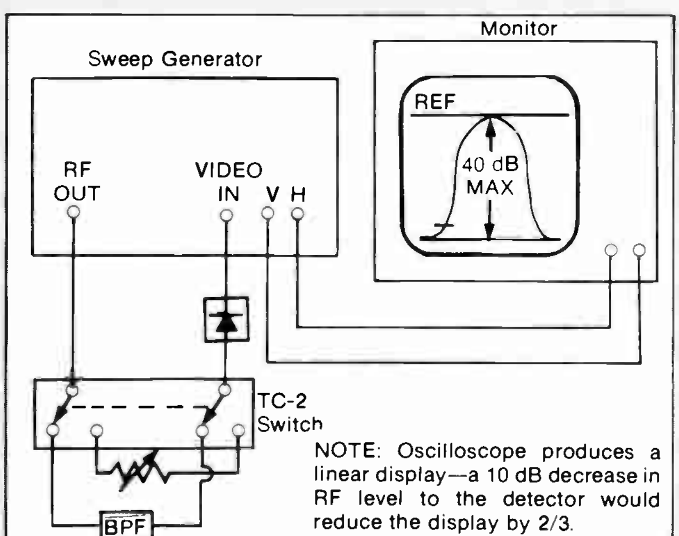


Figure 1

Fig 1—Conventional Sweep Setup

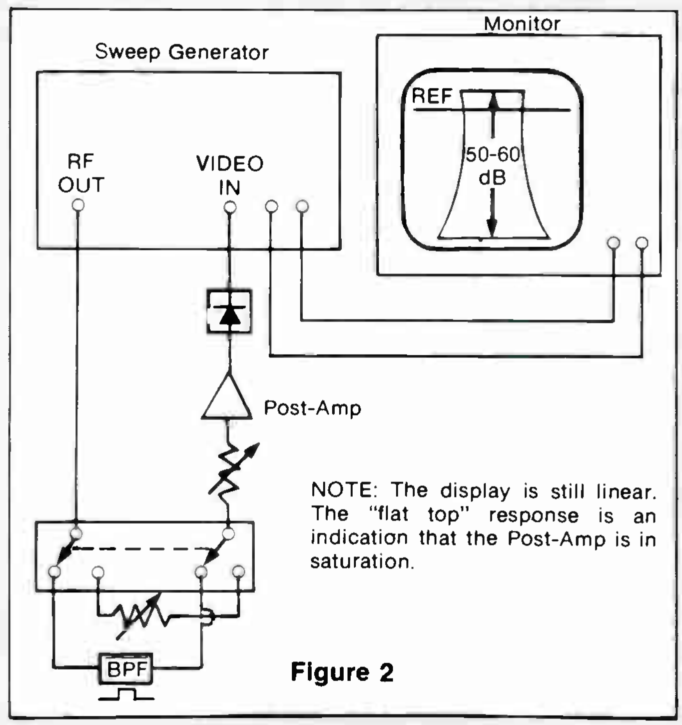


Figure 2

Fig 2—Use of a Post-amp to Increase Dynamic Range

The cable television industry utilizes the point contact diode almost exclusively, due to its frequency range, flatness and simplicity of operation. (Shottky and back diodes require bias current setups.)

Point contact diodes typically have sensitivities of about +15 dBmV, and this factor alone limits the effective dynamic range to 45 dB [+60 dBmV sweep output - (+15 dBmV detector sensitivity)] = 45 dB dynamic range. If the device under test has any insertion loss, (filters, traps, passives), or there is any padding required in the test setup, dynamic range is further restricted by the loss or attenuation values. It would appear that more dynamic range could be achieved by greater input voltage, but an increase in voltage of 6 dB (+66 dBmV=2V) would place the operator near the reverse breakdown voltage of his detector. Point contact diodes will self destruct in the vicinity of 3V input, so high voltage is not only expensive, but operates the detector near the edge of disaster.

The dynamic range of the diode detector may be extended, when sweeping loss devices, by means of a post amplifier. By driving the detector to its extremes, a dynamic range of about 55

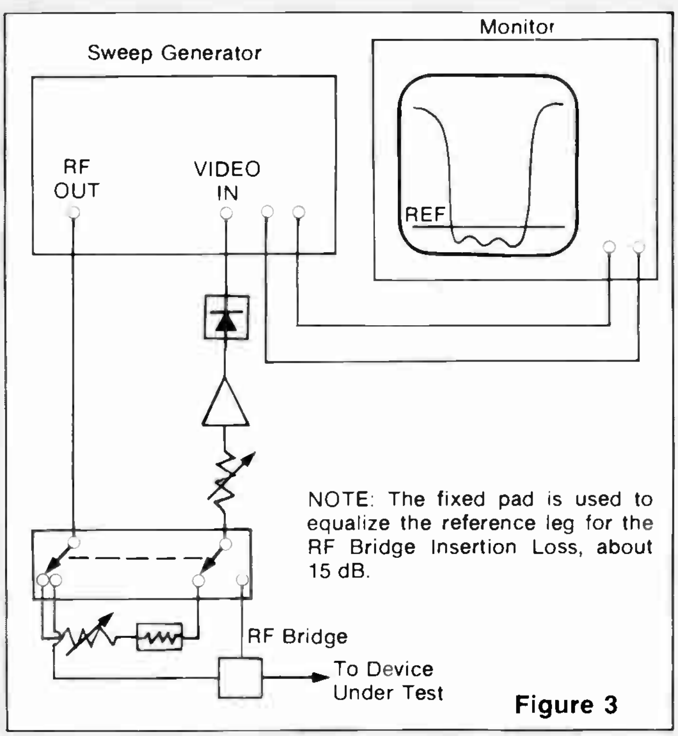


Fig 3—RF Bridge with Conventional Sweeper

dB may be achieved. (See Figure 2.) The amplifier must be carefully selected to have adequate parameters, such as 60 dB dynamic range, 30 dB+gain, low noise figure, and a 3 volt output capability without overload or distortion.

A similar setup for wide range return loss is depicted in Figure 3. Due to losses of about 6 dB in the DC type return loss bridge, the net return loss measurement can be no greater than 40 dB.

Since DC reflection bridges typically balance no more accurately than 40-45 dB, the maximum *practical* measurement limit is about 35-37 dB. To exceed these limitations, it is necessary to utilize the RF reflector bridge with a post amplifier to extend the measurement range to 50-52 dB. These bridges balance to 60 dB or better. For those of us who learned the terms VSWR as opposed to return loss, a short conversion chart is included.

Return Loss dB	VSWR	Return Loss dB	VSWR
1	17.4:1	18	1.29:1
3	5.85:1	19	1.25:1
6	3.00:1	20	1.22:1
10	1.92:1	25	1.12:1
11	1.78:1	30	1.06:1
12	1.67:1	35	1.036:1
13	1.58:1	40	1.02:1
14	1.50:1	45	1.011:1
15	1.43:1	50	1.006:1
16	1.38:1	55	1.0038:1
17	1.33:1	60	1.0020:1

Figure 4

Fig 4—Chart to convert VSWR to Return Loss

Another technique for the expansion of dynamic range is the use of a signal source and a sensitive detector such as a field strength meter or spectrum analyzer.

Those techniques depicted in Figures 5 & 6 will provide, respectively, a point to point method, or, in the case of Figure 5, a swept response. This approach will expand the useful dynamic range to the vicinity of 60-70 dB.

In the case of the signal generator field strength meter, it is necessary to first determine the frequency points to be measured and the frequency span between points. Some method of frequency identification must be utilized for accurate measurement. If the dial accuracy of the meter or signal generator is not sufficient, an external frequency counter will be

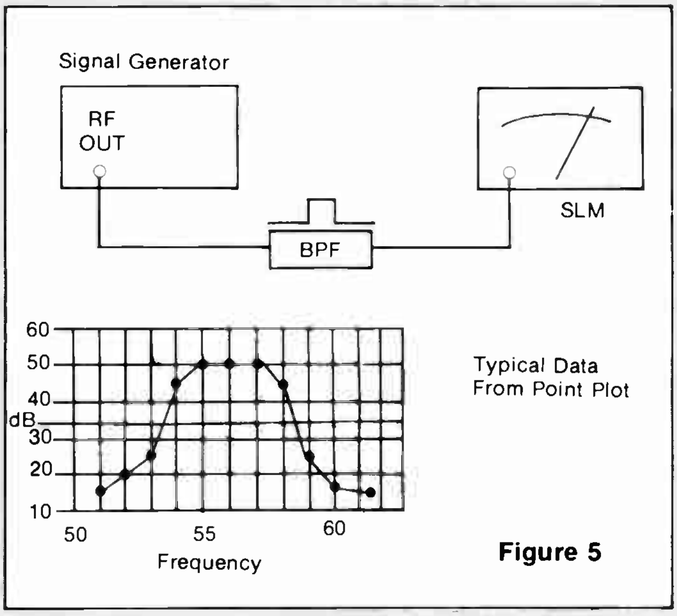


Fig 5—Point Plot of Response

required. The predetermined frequency points are set up on both instruments and level data recorded. It is then necessary to plot the data points on a graph to derive a visual presentation. This technique can be subject to several errors. For instance, RF signal radiation from the source and into the receiver, bypassing the device under test, can limit the dynamic range measurement range to about 60-70 dB. The net accuracy which may be expected is the sum of the receiver accuracy plus the accuracy to which the output level of the signal generator may be set. This method is obviously a laborious and time consuming one.

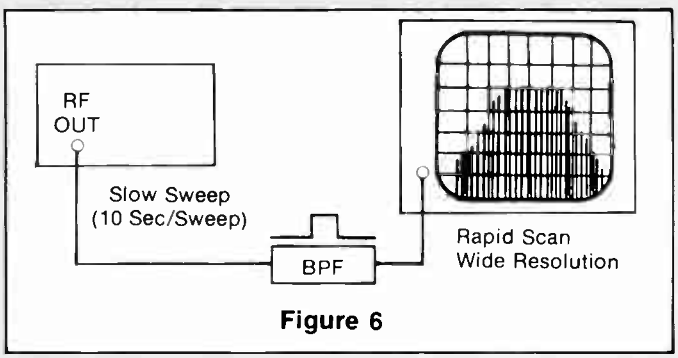


Fig 6—Spectrum Analyzer Response Display

The setup in Fig. 6, utilizing a sweep generator and swept receiver (spectrum analyzer) will produce results similar to the discrete frequency method above. This method has the advantage of speed but also may be inaccurate in relation to frequency. The generator should be adjusted to sweep very slowly (about 10 seconds per active sweep). The spectrum analyzer rate should be set to about 20-30 times the rate of the sweep generator. Adjust the instruments so as to display the desired response on screen. Fig. 6 depicts a band pass filter response using this method. Assume the following:

1. Spectrum analyzer adjusted for 3 MHz/div dispersion; widest possible resolution; scan rate 0.3 seconds per scan.

2. Sweep generator adjusted to 30 MHz sweep width at the same center frequency as the spectrum analyzer. As the swept RF generator moves across the filter response, the spectrum analyzer will display one "blip" each time it scans. Since the analyzer rate is 30 times the sweep generator rate, 30 separate spikes will appear which represent the filter response curve.

The Tracking Generator

The fastest, most accurate measurement of large dynamic range is the tracking sweep-spectrum analyzer. "Tracking" is a

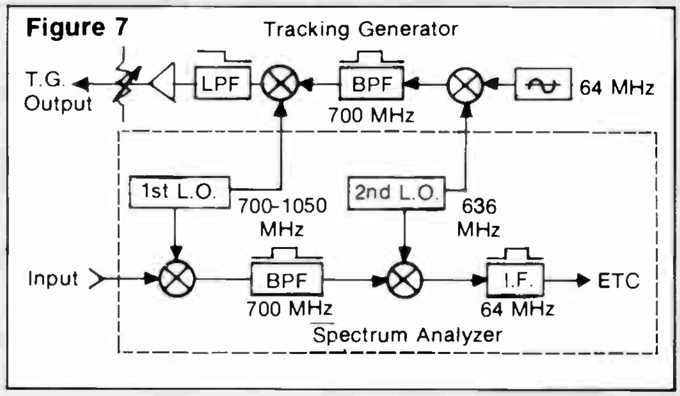


Fig 7—Simplified Block Diagram of Texscan 9600 Spectrum Analyzer/Tracking Generator

method whereby the RF generator and the spectrum analyzer are tuned to the same frequency at every instant of time. Tracking is accomplished by utilizing the same swept oscillator for both the RF sweep generator and the spectrum analyzer. See Fig 7 for a partial block diagram.

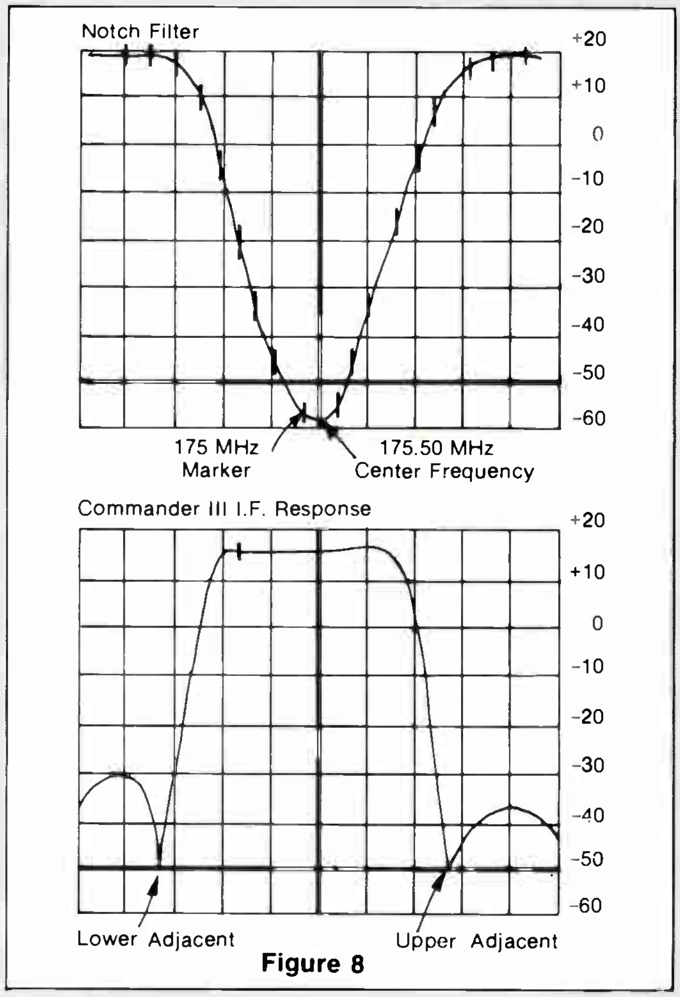


Fig 8—Examples of Response Curves on Tracking Generator

With the tracking sweep, the following measurements are easily made:

1) Deep notch filters (traps)
2) Adjacent channel traps in processors
3) Filter bandpass measurements
4) Extended range return loss
5) Precise frequency vs response curves

The RF output of the sweep portion of the tracking generator is adjustable, with a maximum output of about +50 dBmV. Since the sensitivity of the spectrum analyzer is -60 dBmV or better, this combination will produce dynamic range measurements in excess of 110 dB.

Combining the tracking generator with a frequency counter can provide the most accurate frequency response curves available today. Since the swept display accurately represents the frequency response of the device under test, it is necessary only to connect the RF output sample to the counter input, adjust the swept trace to any portion of the response curve and read the response on screen and read frequency from the counter. With this method, high frequency accuracy and amplitude accuracies in the area of 0.5 dB are easily obtainable. See Fig 9.

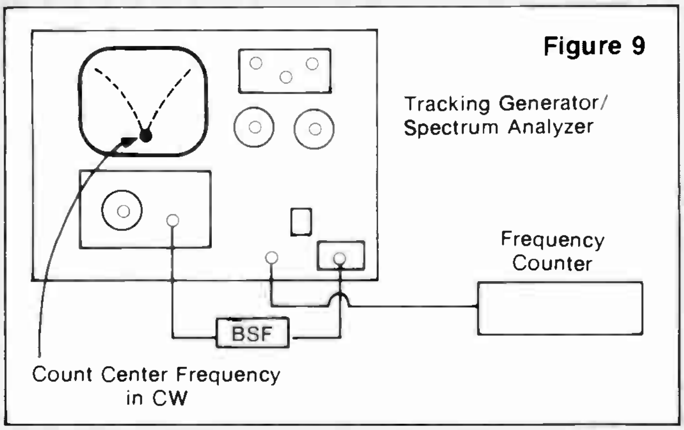


Fig 9—Accurate Frequency Identification Using an External Counter

Examples of Special Uses

Traps and filters may often exhibit responses at frequencies other than the primary. These responses are of two varieties, resonances and leakages. For instance, a cavity type filter or helical resonator will exhibit a response at approximately three times the design frequency. This phenomena may cause the filter to pass undesired signals. See Fig 10.

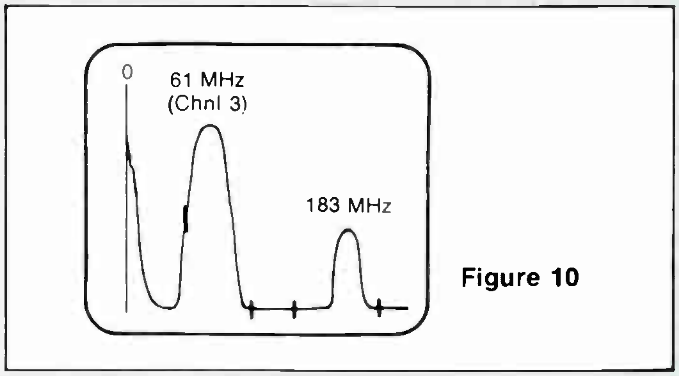


Fig 10—Re-entry Mode on a Filter

The leakage response is more general and may be even more troublesome. See Fig 11.

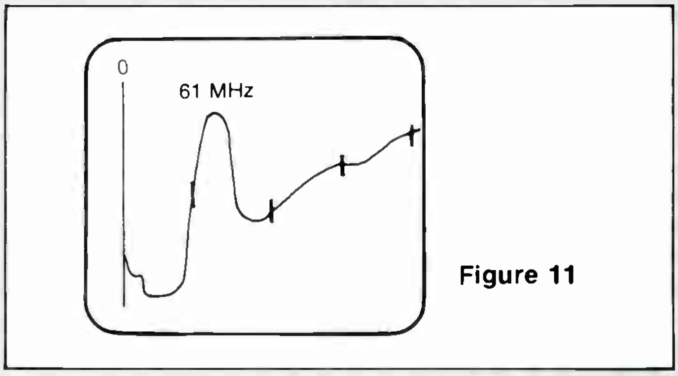


Fig 11—Leakage thru a Filter

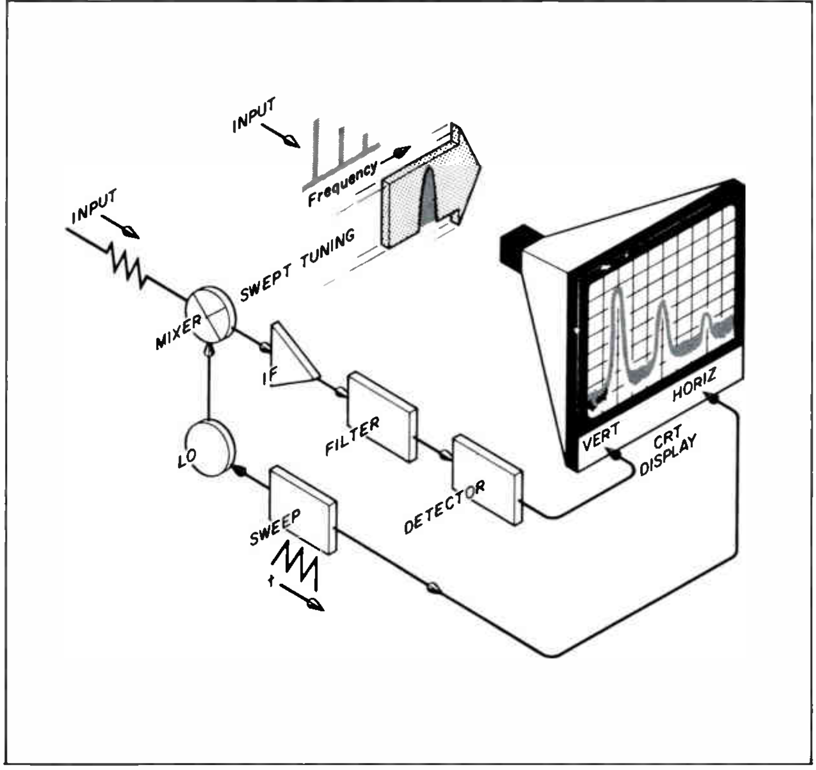
Utilization of the analyzer sensitivity and an RF type reflection bridge can provide return loss measurements to 50 dB.

RF bridges characteristically exhibit rather high insertion loss, which would require post amplification if used with a crystal detector. The tracking generator greatly simplifies this measurement.

Summary:

As the state of the art in CATV grows, it is necessary for measurement techniques to remain apace. The tracking generator as a combination instrument utilizing sweep and spectrum analysis techniques is becoming more and more a required test instrument for the up-to-date system operator. □

What You Need To Know Before



The spectrum analyzer is a swept-tuned receiver. The input is mixed with a swept local oscillator, the resultant amplified through an IF strip, and displayed as the vertical deflection on a cathode ray tube. The horizontal deflection of the CRT is proportional to the frequency of the swept LO. For further information see HP Application Note 150.

Today's spectrum analyzers offer a great variety of features and levels of performance. These questions and answers will help you best match you application with the various features and specifications available.

What Frequency Range Is Adequate?

Of course you will want to cover the fundamental frequencies of your direct application, but don't forget harmonics on the high side, baseband and IF on the lower end of the spectrum.

How Accurately Can a Spectrum Analyzer Measure Frequency?

Typical frequency accuracies are:

For Frequency Measured	Accuracy Is
50 kHz	±100 Hz
300 kHz	±3 kHz
11 MHz	±200 kHz
350 MHz	±1 MHz
1500 MHz	±5 MHz
6 GHz	±15 MHz
14 GHz	±45 MHz
18 GHz	±60 MHz

And this accuracy holds even down to low signal levels, voltages far below frequency counter trigger thresholds.

Companion instruments such as the tracking generator/counter can greatly improve frequency accuracy. For example ±10 kHz accuracy to over 1 GHz is readily achievable.

What Is Absolute Amplitude Calibration?

Simply, it means that each horizontal line on the CRT display represents a specific power or voltage level. And as front-panel adjustments are made, such as increasing the input attenuation to allow for a stronger input signal, the display is re-calibrated to match. Even with major tuning frequency changes the display grid lines represent a specific number of volts, dBm or dBmV.

How Is Amplitude Measurement Range Specified?

To get the most from a spectrum analyzer, it must be able to read from very weak signal levels to very strong ones with no ambiquity. At the low signal levels, spectrum analyzer performance is measured as *sensitivity*, the dBm level (measured on the screen) of internally generated noise. Below this noise an input signal cannot be detected. Generally, sensitivity is on the order of -90 dBm to -150 dBm (or 0.13 mV to 7 nV into 50Ω).

The high power end of the rage is limited only by how much built-in attenuation the analyzer has to protect its sensitive input circuitry.

The difference between this maximum power and the analyzer's sensitivity is *not* the best measure of an analyzer's amplitude range because, for certain conditions, any swept-tuned analyzer will generate spurious signals internally that will confuse the CRT display. *Dynamic range* is a good measure of performance. Dynamic range, measured in dB, tells you how much of the CRT range will be free from unwanted signals when your input signal is at the top of the screen. A typical dynamic range of 70 dB is wide enough to allow the display of AM sidebands for 0.06% modulation.

Selecting a Spectrum Analyzer

How Do You Measure Two Signals That Are Very Close Together In Frequency?

Hum sidebands and intermodulation products are two cases where you need to be able to distinguish between signals very close together. *Resolution bandwidth* is the spectrum analyzer spec that is important here. After you decide what minimum spacing you will require, select an analyzer with a resolution bandwidth of at least equal to that frequency differential. For example, for a 1000 Hz signal separation, the resolution bandwidth must be 1000 Hz or lower.

Can a Spectrum Analyzer With a Specified Resolution Bandwidth Measure All Signals Spaced That Bandwidth Frequency Apart?

Only if the two signals are within 3 dB amplitude of each other. Because of the IF response, the greater the amplitude difference the more the lower signal gets buried in the skirt of its neighbor's response. (See figure.) This is important because most close-in signals you deal with are distortion or modulation products and by nature are quite different in amplitude from their parent signal.

In the analyzer, as in any receiver, high selectivity means rejection of weak adjacent signals. Since a spectrum analyzer is simply a swept tuned receiver, high rejection is a desirable attribute. Selectivity in a spectrum analyzer is specified by the term filter *shape factor,* a ratio that measures essentially the sharpness of response of the anlyzer passband. The lower the shape factor, the sharper the filter response and the better the frequency resolution, especially between signals of different amplitudes.

What Else Limits Resolution?

Two other spectrum analyzer specs can limit the resolving power of two unequal signals, short-term frequency stability (residual FM) and noise sidebands.

Instability can produce a wider-than-specified IF response on the CRT which can mask close-in signals that would otherwise be resolved. Noise sidebands on the CRT signal response can also cover close-in signals at low levels. In selecting a spectrum analyzer for high resolution, check both of these specifications carefully.

What Are Some Spectrum Analyzer Features That Will Make It Even More Effective?

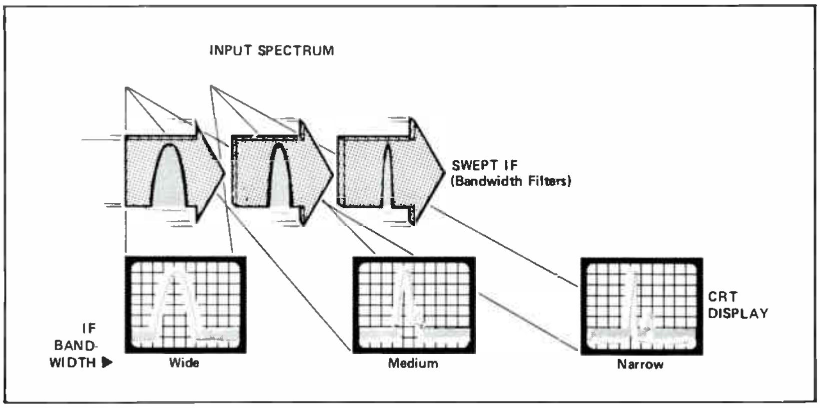
Display Storage enables you to retain any spectrum picture for photography or data analysis and to record the slow sweeps required for very narrow resolution sweeps.

Internal Calibrator provides a front-panel signal for analyzer calibration in frequency and voltage.

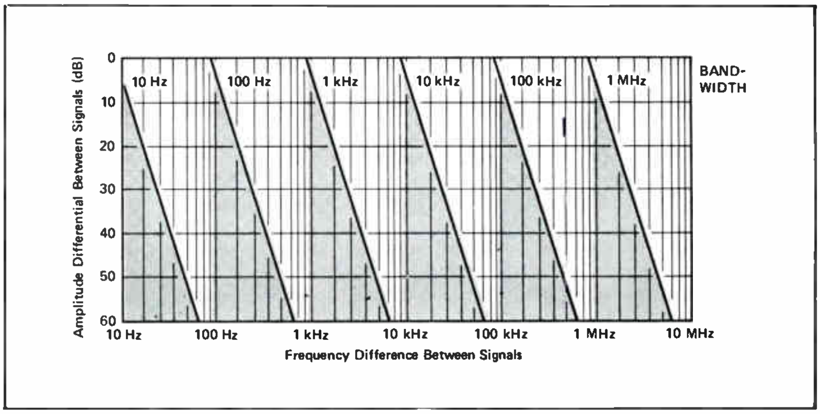
Zero-Frequency Span allows you to view the modulation envelope of an RF signal with both horizontal and vertical scales calibrated as an oscilloscope.

Video Filter averages the noise response of the analyzer output for easier noise-level measurements. ☐

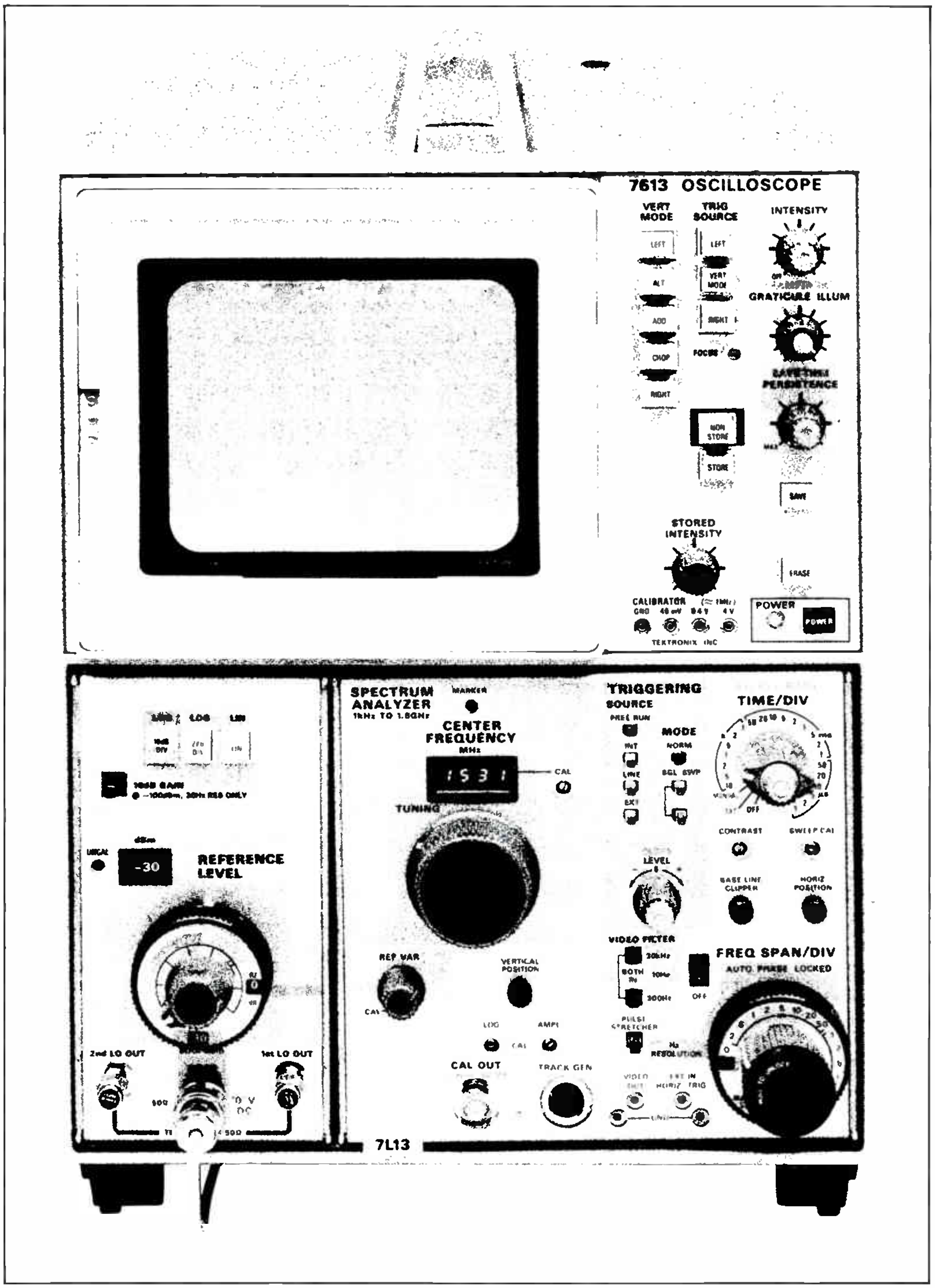
By Jeffrey Thomas
Reprinted courtesy of Hewlett Packard



As the IF "window" is essentially swept across the input, the CRT display will show only as much detail as the IF allows. By narrowing the IF bandwidth (increasing its filter Q) more and more detail information about the input spectrum gets transferred to the CRT.



You can see from the typical graph above, the relationship between amplitude differential and minimum frequency resolving power for an analyzer with a typical shape factor of 15:1. The signals falling in the shaded areas cannot be resolved for the bandwidths shown.



System Performance Using Time and Frequency

Editors Note:

Sometimes you can be so busy off solving the problems of measurements, independently of the rest of the world, that you pass up everyone else. This is John Huff's story. Back in 1970, John devised a way to measure system parameters quite ahead of its time. He devised and perfected the use of spectrum analysis, keyed to present only the portion of a signal as desired. He uses a number of unique combinations of equipment such as a plotter for all measurement presentations and special headend insertion techniques. While performing the actual system tests, he records all the data on audio cassettes and constructs the graphs later using the audio tones on the tape. John's new techniques *make use of both time and frequency displays obtained on the spectrum analyzer.*

John works for Tele-Vue Systems and has been trying to get a major equipment manufacturer to commit to building the equipment in a more convenient form for CATV. As is the case with most good ideas, no manufacturer has taken an interest, so we in CATV are faced with doing something that we all do well . . . improvising. John has given C/Ed permission to reprint the bulk of the information on his testing techniques. In this issue, we are going to whet your appetites with John's own story of how he developed his test system and give you an idea of the measurements possible. In a later issue, we will cover, in detail, how the equipment and special black boxes are arranged and samples of the actual plots.

And just to fill you in, John is off testing all the Tele-Vue Systems yearly, and full of new ideas. When he has a chance, you might even hear him buzzing overhead in a J-3 Cub. This is the first plane I've seen with a field strength meter instead of an altimeter and a yagi antenna sticking out of the rudder. Yep, he's off trying to perfect a good way to do antenna surveys.
The Editor

The Development of My Philosophy on Spectrum Analysis Techniques

Having been around for some time and curious by nature, it is not surprising that when television came into being I immediately got my fingers into it. I already had some experience in some areas of radio communications, and some knowledge in the use of electronic equipment and test gear. Even then, the objective was to attempt to make the picture and sound as good as possible by experimenting with the tuning and other normal functions of the television set.

Not much time had passed before it became obvious that standard communication test equipment was not enough to keep track of all that takes place in a television set. Probably, the first step taken along these lines was in the use of a swept radio frequency generator and a scope to display relative responses of a tuned circuit to a changing radio frequency source. Shortly thereafter, the scope was used to display some version of the demodulated television carrier in a time domain presentation. My ability to interpret what I saw on a television set, a waveform monitor, or RF presentation, improved with the passage of time. When I started using spectrum analyzer techniques, many theories learned in school started to fall into their respective places relative to what happens to modulated radio frequency carriers. No longer did I have to depend on faith, theories and accepted facts of knowledge acquired in school. Doors to many mysteries were opened, however, quite often only to find another door, still unopened, challenging my ability to understand. The industry was not going to stand still waiting for me to catch up, many more closed doors had to be opened, considerable more progress was still to be made in the field. Thanks to American commercialism, new ideas are visible when new products are sold. Some test equipment manufacturers tried to stay in an easier smaller field, so time domain vs. spectrum domain divided thinking into easier mechanical, but still confusing electronic test systems. Packaging of *time domain* test and *frequency domain* equipment are different departments still competing within the same company.

Finally, I arrived at a point when I was using both techniques, but still separately. Needless to say, waiting for a manufacturer to open the next door for me developed frustrations and anxieties. I could not sit around waiting so I went through side doors and peeked in at the side shows. At last I came to a keyhole in a door that had not been used before, not in this field at least.

By taking the two different techniques, time and frequency, harnessing them together and removing time domain vs. frequency domain perspective, a new team with considerably more power came out of the combination. I learned a lesson a long time ago behind a team of horses on a cultivator, that they know more collectively of how they like to work. My frustrations, anger and cussing wiped out many sprouting stalks of corn before I learned to sit there and just help them turn at the end of the field. Unharnessing, watering, giving them grain and doing other menial tasks were all that was required of me to insure that they performed their task. My job was made easy because someone else had done a good job of training some very adaptable animals.

So, I didn't re-invent the wheel by using time and frequency together! However, I think I did see something that a lot of people overlooked. The keyhole was there a long time before me and there have been many keyhole peekers before me. Guess I stood around that particular keyhole long enough and something happened.

In 1970 I wrote my first bit about "Whatever Turns You On." It didn't make the bestseller's list, however, it did get read by some people that saw some of the same things that I did. Since no one was around to tell me it wouldn't work, I experimented with enough different things until I found a combination that started to work for me. Using audio amplifier techniques and knowledge gained long ago through electronically deleting commercials from a musical program and making volume expanders, the first working simultaneous performance of time and frequency gave their all and was recorded on graph paper of selected test signals transmitted by a television station, then presented on a spectrum analyzer display of radio frequency energy distribution.

I had to go back and look into some other attractive keyholes before I got real lucky and used some digital techniques. Lo and behold, using clocking information transmitted by the television station and time selective test equipment geared to the station's clock pulses, a spectrum analyzer presented these very short events and happenings in a plotted form now at real time, which is usually seen only as a graphic presentation of a mathematical formula of a complex voltage waveform.

To proceed further now will not be necessary as all else presented here was the outcome and extension of my philosphy.

Time and Frequency

The CATV business is to provide a communications medium whereby television signals can be transmitted from one point to another with the least amount of distortion or degradation. The primary endeavor of CATV is to communicate television signals that will arrive at the television set in such condition as to still be usable and saleable. In order to perform this task satisfactorily, the communications medium must be as transparent to the television signal as possible. The portion of the communication medium over which we as CATV operators have a degree of control occurs after the television signal has left the transmitting antenna. We can control passage of the signal through the airways onto the receiving antennas, through headend processors, through microwave or coaxial transportation and distribution systems to termination at the terminals of the television set.

Sub-standard picture quality; whether as a result of noise, ghosting, power, or other interferences causing distortion to picture or sound, is usually the result of the manner in which the television signal is handled. The degree of control exercised in communicating television signals determines the quality of the picture seen by the television viewer.

With all test equipment, the main and practically only things that can be accomplished are monitoring, measuring and assuring the quality and condition of the transportation system and intermediate processing. However, we have very little or no control over the original source of the video signal. Thus, we can only accept responsibility for that area over which we have control as CATV operators. This is done by observing those parameters that we can control and having considerable ability in interpretation of the samples and test signals.

The most commonly used piece of test equipment is a good quality television receiver. This valuable tool is used for determining picture quality; however, if the quality is poor enough to be seen on a picture monitor, the degradation of the signal has, in most cases, proceeded too far. The second most often used piece of test equipment is the video waveform monitor, which has the capability of determining various amounts and forms of picture distortion. A visual graph presentation on an oscilloscope is used best in the analysis of test signals being transmitted by most modern television stations. These test signals are transmitted with video picture information during the vertical interval at the proper place, and when there is sufficient time in respect to pictures that will not be seen by the general TV viewer.

This method works well enough to show various degrees of degradation to the television signal and provides methods of measurement to put a value on the quality of the television signal in all the required areas. There are, however, shortcomings with the use of a video waveform monitor. *It hampers the ability to correct deficiencies.* The major problem is that the television signal must first be removed from the radio frequency carrier. This function (demodulation) presents the problem of how well the removal of the signals from the carrier is performed. There is usually degradation just in the performance of this function, and there are several built-in changes that must take place precisely as required. The demodulation also removes or reduces certain side bands of the broadcast signal that prevent one from determining the cause of certain picture degradation.

Since most of degradation are difficult to interpret or identify, another method is used to assist in determining and correcting problems causing degradation to picture quality while the television signal is still on the radio frequency carrier. This relative newcomer is the use of an analyzer.

A spectrum analyzer has the ability to measure the voltage of radio frequency carriers, and display the energy level of selected bands of radio frequency energy over a wide spectrum.

Example: 100 kHz resolution bandwidth in a spectrum band of 6 kHz (a single RF carrier)
The 100 kHz is the selected bandwidth measured at any one instant.
The 6 MHz is the spectrum scanned over a period of time.

We can control other things suring spectrum analysis.

1. The bandwidth across which we would like to measure RF energy level.
2. The RF frequency from which we start to scan.
3. How much RF spectrum we would like to scan.
4. How fast we would like to scan.
5. How often we would like to scan.
6. What vertical scale we would like to display the energy.
   a. Linear/the scale goes one voltage unit by one division vertically.
   b. Log^{10}/each vertical division has an increase in energy of 10 dB.
   c. Log^{2}/each vertical division increase in steps of 2 dB.
7. How we display information from a cathode ray tube.
   a. Repeated quickly to appear to the eye as one single display.
   b. Stored information in one scan for delayed viewing.
   c. Plotted on paper as equivalent information for recording and indepth analysis.

The method of time domain analysis is a well developed art and a very useful tool in the total television industry. Spectrum analysis is a much newer tool to CATV . . .

New techniques presented herein allow the spectrum analyzer information to be controlled so that a single, short time duration in video signal can be spectorally analyzed in a variety of bandwidths of resolution, and over a broadband of frequency dispersion, giving a true tool to allow the frequency domain to be presented in the same small detail previously possible only in time domain.

The spectrum domain takes its place in the wide radio frequency spectrum, allowing television carriers to be analyzed in detail at RF, with the same accuracy as signals are measured in the time domain.

The spectrum analyzer reduces the need to demodulate a radio frequency video carrier to baseband with the usual demodulator, eliminating the strict operating characteristics that determine quality of the video signal.

In addition to the new presentation technique, more information and resolution is required than is normally obtained on a CRT display. Therefore, the use of a plotter is recommended. Mathematical analysis of complex waveforms requires considerable mathematical understanding as well as an understanding of the principles of electronics. (The prerequisites for understanding a plot is less if there is faith in the method of the plot.)

A time domain graph of a video signal is a presentation of voltages across a 75 ohm resistor of DC value of that signal for a series of points during a selected short period of time.

A spectrum domain graph presentation of the same video signal is a presentation of the distribution in frequency bands of electrical energy dissipated in a 75 ohm resistor during the same selected short period of time.

Note: We will cover the detailed measurement techniques in a future issue.

What Is a CATV System Signal Audit?

A CATV system signal audit is the measuring and recording of RF signals on a cable television system to determine the degree of the television, and other RF signals to the standards outlined by Tele-Vue Engineering recommendations or FCC regulatory requirements. The record is in a plot form that can be used for determining many operational characteristics of the CATV systems.

Information provided:

I. Levels of all carriers.
   A. Carriers of audio FM signals, TV audio and FM broadcast.
   B. Carrier ratio of visual and aural carrier.
   C. Pilot carriers.
   D. Spurious signal carriers.

II. Characteristic of the television composite signal sideband energy distribution.
   A. In-channel video frequency response of vertical interval test signals multiburst.
   B. Picture quality by spectrum analysis of a single equalizing pulse and its energy frequency distribution.
   C. In-channel spurious response.
   D. Carrier to noise levels.
   E. Frequency of television visual and aural carrier as they appear on a CATV system.

Why Do an Audit At This Time?

To provide a point from which future progress can be determined.
To make use of special equipment and a technique that can perform a reasonable audit.
To record many CATV system parameters for later study.
To start a permanent record of audit.
To have records that can be easily copied (xeroxed).
To record frequencies of TV channel carriers for the FCC.
To provide an educational tool for operational personnel. □

To provide a record of television station performance and propagation effect to different systems.
To provide some measure of performance of antenna and processors.
To provide a new and hopefully better method for recording system performance for the FCC.
To provide a new and better method for recording system performance and signal quality for system operations.
To provide experience with a new technique so that a procedure can be developed for future use.
To locate shortcomings in technique and provide information for improvement or development of other techniques.
To provide experience in applying both time and frequency domain techniques together.

For Measurements in the Field Sample of Check List Used

Date Start ______________ Date Completed ______________

CHNL DOM	Plot Domain	S Spectrum	T Time	Plot # DOM
X	Horizontal Calibration	1″ = MHz	1H = 63.6 sec. Scale per 1″	X
y	Vertical Calibration	1″ = dB, Unity 1:1	IRE Units Volts per 1″	y
s	Scan Rate	Seconds per 1″	Samples per sec.	s
h	I.F. Bandwidth, resolution	100-300 kHz	Slow, Fast - Slow, Fast	h
t	Start Scan	MHz 0-1500, TV CH #'s	CH #	t
p	Frame Position	Line #/Field #	Line #/Field #	p
g	Max. Input Level	(DBM)	Volts	g
b	Gain Setting	Gain - Pad (in dB's)	#15 - .05V #2 5V - 0.5V	b
i	Tracking Generator	Pad (dB) or Modulation kHz		i
a	Preamplifier Gain	Keyed K Tracking Gen. Kl	Clamp used	a
v	V.I.T.S. (MB) Multiburst (LTB) Linear, 2T, 12, 5T, Bar (N) Noise (FF) Flat Field (W) Windows			v
r	Video Response (F) Flat (I) IEEE (C) CCIR (L) Low Pass (H) High Pass (P) Preamplifier 6 dB			r
d	Detector	(R) RMS (P) Peak Memory	(C) Conrac (S) Sony (T) 147	d
m	Magnetic Recording	Tape Reel # and Address #	Tape Reel # and Address #	m
c	Functional Diagrams	Circuit #	Circuit #	c
n	Cross Reference Data	Plot # of T	Plot # of S	n
z	Time and Distance Conversion			z

System ______________ Model # ______________ Serial # ______________

Mfr. ______________ Location ______________

Sample of check list used for measurements in the field.

Spectrum Analy

By Morris Engelson
Tektronix, Inc.

The spectrum analyzer has become an increasingly important tool for CATV measurements. Measurement technique and interpretation of results is discussed in application notes available from several companies[1]. Nevertheless, some people find it difficult to interpret what the spectrum analyzer shows. Usually, it is just a matter of understanding the specialized nomenclature used. This article addresses the problem by providing illustrated definitions of some of the more important spectrum analyzer parameters. Read on and you, too, will be able to say "spectrum analysis spoken here."

Basic Parameters

A modern spectrum analyzer has many specified parameters. This includes such characteristics as: frequency range, frequency span, resolution bandwidth and shape factor, incidental FM, video filter bandwidth, display flatness, reference level, vertical display law, sensitivity, input impedance. The meaning of some of these, such as input impedance is obvious. Other characteristics, such as video filter, are more obscure but also less important. Let us consider some of the more important yet confusing characteristics.

A good place to start is the CRT readout which is standard on most Tektronix instruments. Figure 1 shows a spectral display taken on a Tektronix 7L13 Spectrum Analyzer. The CRT readout shows the characteristics of six instrument parameters. Going from left to right across the top we have: A reference level of -30 dBm, a center frequency of 300 MHz, and the resolution bandwidth is set at 3 MHz. The bottom row of CRT readout shows that the vertical display is set for 10 dB/div, 30 kHz of video filter has been actuated to smooth the noise on the baseline, and the frequency span is set at 50 MHz/div. The signal is a 50 MHz comb showing a response at every graticule line. This is in agreement with a frequency span of 50 MHz/div. With the center of the screen representing 300 MHz, the display goes from 50 MHz to 550 MHz. Let us now consider some of the more difficult to understand characteristics.

Vertical Characteristics

Figure 2 is a multi exposure photo illustrating the meaning of reference level and vertical display law. The reference level is +10 dBm as indicated by the CRT readout. This means that a signal display at the top graticule line is +10 dBm. This is the largest signal level that can be displayed on screen. The signal display was generated by starting with a +10 dBm signal and reducing the level in 10 dB steps. With the vertical display at 10 dB/div, as shown in the lower left hand corner, each 10 dB of signal reduction is equivalent to one graticule division. The smallest signal level displayed is seven divisions below reference level or +10 -70 = -60 dBm.

Another important vertical function is instrument sensitivity. This is specified in two different ways. Measurement results will differ by about 6 dB depending on which definition is used. Users should, therefore, be careful to use the appropriate technique when checking an instrument against a specification or when comparing different instruments. One specification method is "signal plus noise equals twice noise." This is illustrated in Figure 3. Here the vertical display is linear with voltage as shown by CRT readout. The gain is increased to display a reasonable level of instrument noise. It is helpful to insert video filtering to smooth the noise fluctuations for ease of measurement. Video filter bandwidth in Figure 3 is 10 Hz. Input signal level is now adjusted so that the signal plus noise display level is equal to twice the noise display level alone. In Figure 3, these are 3 divisions and 1.5 divisions respectively. Instrument sensitivity is equal to input signal level as determined by signal generator setting, power meter and attenuator settings, or other means of establishing the input signal level.

The input signal level cannot be measured directly on the spectrum analyzer since the instrument shows signal plus noise rather than just the signal level alone. The effect due to presence of noise can, however, be computed. Thus, the S + N level is 2N or 6 dB above the noise alone. Theoretically, for RMS addition the signal level is about 1.2 dB below the combined display signal plus noise. Actually the error is smaller because the spectrum

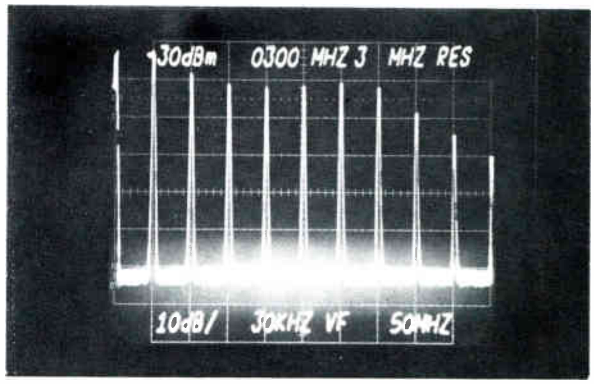


Figure 1—Spectrum analyzer display including CRT readout of specified parameters.

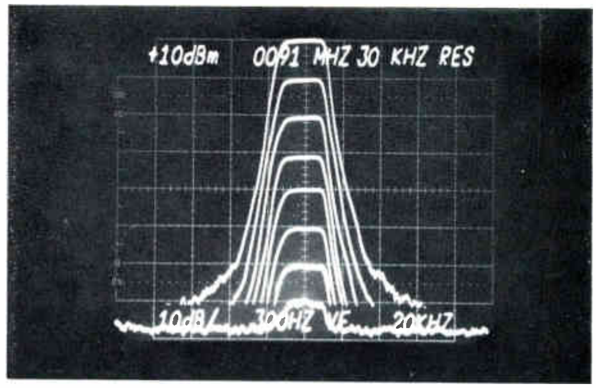


Figure 3—Measuring sensitivity by signal plus noise equals twice noise method.

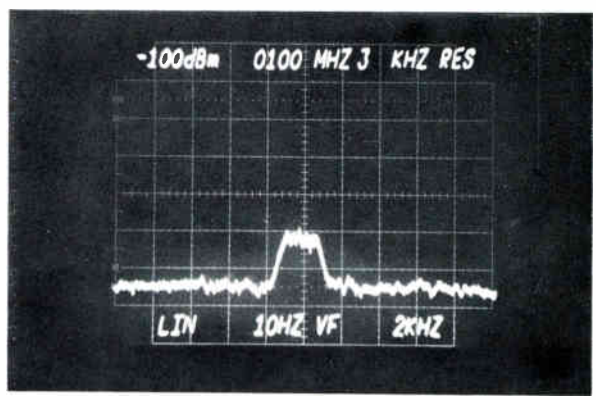


Figure 5—Illustration of shape factor.

analyzer envelope detector is not a true RMS type. For Figure 3, the signal generator shows a signal level of -110 dBm. The S + N level is 3 divisions where 8 divisions is -100 dBm or 20 log 8/3 = 8.5 dB below full screen. Adding a one dB approximate correction factor, we have -100 - 8.5 - 1.0 = 109.5 dBm, in excellent agreement with the signal generator reading of -110 dBm.

The second way of specifying instrument sensitivity is to state the equivalent input noise level. This would show a number about 5 dB less than the signal method when the noise level is checked in the linear vertical mode. Another 1.45 dB error will show up when checking the noise in a logarithmic vertical mode[2]. Thus, the total difference between the two techniques is about 6 dB.

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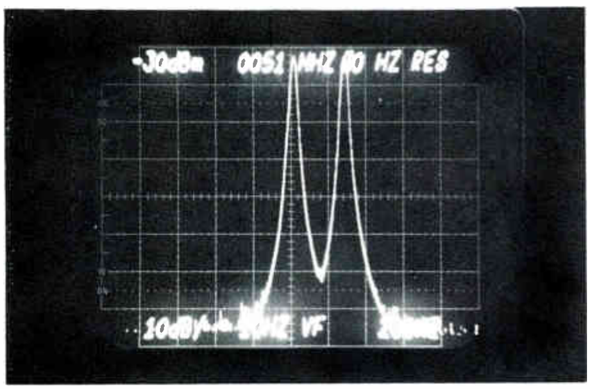


Figure 2—Illustration of 10 dB/div vertical display.

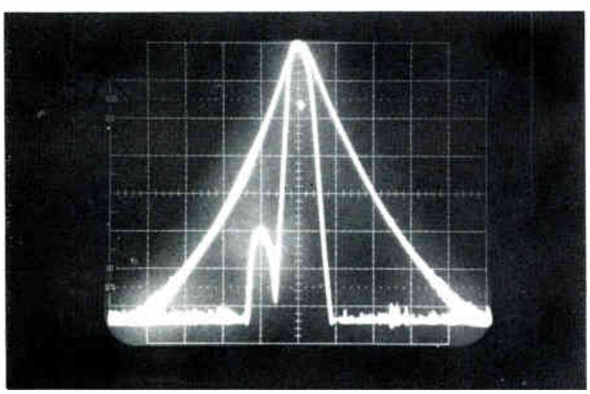


Figure 4—Illustration of resolution bandwidth.

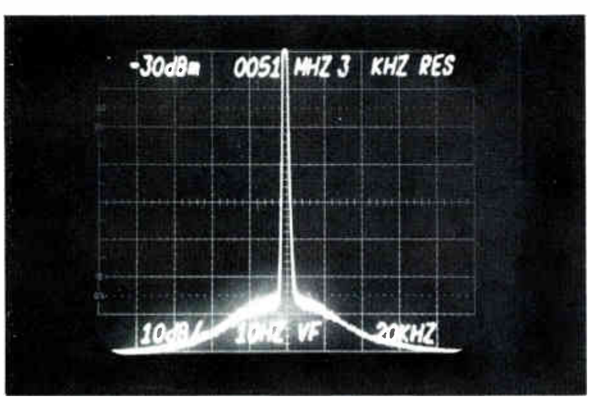


Figure 6—Illustration of noise sidebands.

It might be noted that the specified sensitivity for the 7L13 at 3 kHz resolution is -108 dBm when checked by the S + N = 2N method. The same instrument could be specified at -114 dBm sensitivity when checked by the equivalent input noise method.

Horizontal Characteristics

Frequency span and center frequency have already been discussed. Let us now consider those parameters which are related to resolution bandwidth[3].

The resolution capability of a spectrum analyzer is an indication of the frequency separation between signals that can be separated or "resolved" by the instrument. Figure 4 illustrates the resolving capability of the Tektronix 7L13. Here, we observe two signals with a frequency separation of 300 Hz. The resolution bandwidth of the instrument is set to 30 Hz as indicated in the upper righthand corner CRT readout. Two conventions on resolution bandwidth specifications are presently in use. Some manufacturers, such as Tektronix, specify the 6 dB resolution filter bandwidth. Others specify the 3 dB bandwidth. In any event, resolution bandwidth indicates how well equal amplitude signals can be separated. What about signals of unequal amplitude? Here, we have to consider the shape factor.

Shape factor is the ratio between the bandwidth at the 60 dB down points and the resolution bandwidth (either 3 dB or 6 dB down). A lower shape factor means a steeper filter slope. This has both good and bad connotations. Sharp cutoff filters require more sections and hence, cost more. Also, a low shape factor means a lower equivalent bandwidth which requires a longer measurement sweep time. Conversely, low shape factor means that one can better resolve a small signal next to a big one. This is illustrated in Figure 5, a double exposure photo showing the effect of shape factor. The 6 dB bandwidth is the same for both filters but the shape factors are 3:1 in one case and 12:1 in the other. The steep filter easily resolves the small signal 50 dB down from the adjacent response. The 12:1 shape factor hides the smaller signal completely.

Finally, let us consider the specification of noise sidebands as an illustration of the interdependence between vertical and horizontal characteristics. This is illustrated in Figure 6. The signal response is 3 kHz wide at the 6 dB down point, and less than 12 kHz wide at the 60 dB down point for a shape factor of less than 4:1. At 70 dB down, however, the response seems to be 40 kHz wide. This is a rather strange shape for a resolution filter. Actually, the filter does not make a sudden shape change 65 dB down. The broad pedestal around the bottom of the response is sideband noise, also known as phase noise. The shape and size of the pedestal is a function of spectrum analyzer oscillator cleanliness and resolution bandwidth setting. The narrower the bandwidth, the less noise is displayed. Sideband noise is characterized as an amplitude level compared to full signal amplitude when measured with a particular resolution bandwidth at a given frequency spacing from the signal response. For Figure 6, we observe that sideband noise is 70 dB down 20 kHz away in a 3 kHz bandwidth.

---

[1]See for example: The Tektronix Proof of Performance Program for CATV. Note A-2698.

[2]Noise Measurements Using the Spectrum Analyzer: Random Noise - Tektronix AX-3260.

[3]For a more detailed discussion of resolution see: Engelson, Understand Resolution For Better Spectrum Analysis - Microwave, December, 1974.□

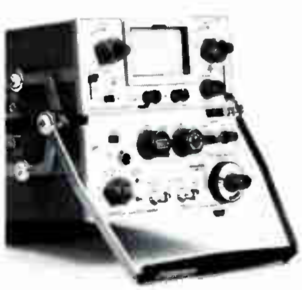
Buyers

Spectrum Analyzers

Make/Model	Frequency	Narrowest Bandwidth	Dynamic Range	Log Ranges	Calibrator
Avantek CR-2000	1-300 MHz	20 kHz	55 dB	10 dB/2 dB	30 MHz Comb
Hewlett Packard 8557A	.01-350 MHz	1 kHz	70 dB	10 dB/1 dB	250 MHz
Hewlett Packard 8554B/8552B	.1 MHz-1.25 GHz	100 Hz	65 dB	10 dB/2 dB	30 MHz Comb
Hewlett Packarc 8558	.1 MHz-1.5 GHz	1 kHz	70 dB	10 dB/1 dB	280 MHz Comb
Kay 9040	.5-300 MHz	1 kHz	72 dB	10 dB/2 dB	30 MHz Comb
Nelson Ross 4808	.01 MHz-1.8 GHz	100 Hz	70 dB	10 dB/2 dB	100 MHz Comb
Tektronix 1401-A1	1-500 MHz	10 kHz	60 dB	10 dB	50 MHz Comb
Tektronix 7L12	.1 MHz-1.8 GHz	300 Hz	70 dB	10 dB/2 dB	50 MHz Comb
Tektronix 7L13	1 kHz-1.8 GHz	30 Hz	80 dB	10 dB/2 dB	50 MHz Comb
Texscan VSM-1	4-300 MHz	150 kHz	40 dB	10 dB/5 dB	None
Texcan VSM-2	4-1000 MHz	500 Hz	60 dB	10 dB	None
Texscan VSM-5	4-350 MHz	500 Hz	70 dB	10 dB	1, 10, 50 MHz Freq. Mkr.
Texscan 9600	1-350 MHz	500 Hz	66 dB	10, 5, 2.5 dB	1, 10, 50 MHz Freq. Mkr.

Tracking Generators

Make/Model	Frequency	Output	Response
Avantek CT-2000	5-300 MHz	+18 dBmV	±1.0 dB
Hewlett Packard 8444	5-1250 MHz	0 dBm	±.5 dB
Tektronix TR-501	1-1.8 GHz	0 dBm	±2 dB
Tektronix TR-502	1 kHz-1.8 GHz	0 dBm	±2 dB[2]
Texscan 9600	1-350 MHz	+51 dBmV	±.25 dB



Textr. 1401

Texs. VSM-2

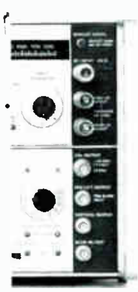
Guide

FM Stability	Phase Lock	Freq. Span	Display	Comments	Price
Not Specified	No	30 MHz/-600 kHz/ Plus Variable	Long Persistence	Complete low-level sweep system	$9800[1]
1 kHz	No	20 MHz/-5 kHz/ 12 Steps	All Available	Plug in to 180 Series mainframes	$3650
100 Hz	Yes	100 MHz/-2 kHz/ 15 Steps	All Available	Plug in to 140 Series mainframes Two units - RF & IF	$7800
1 kHz	No	100 MHz/-5 kHz/ 14 Steps	All Available	Plug in to 180 Series mainframes	$4675
Not Specified	Yes	30 MHz/-10 kHz/ 8 Steps	Bi-Stable Storage	Plug in, will fit Tektronix 5000 mainframes	$2100
150 Hz	Yes	200 MHz/-1 kHz/ 18 Steps	Var. Persistence	Plug in	$5900
20 kHz	No	50 MHz/-100 kHz/ 9 Steps	Long Persistence	Separate unit, requires oscilloscope Battery portable with scope, $4500	$3200
200 Hz	Yes	100 MHz/-500 Hz/ 17 Steps	All Available	Plug in to 7000 Series mainframes	$5200
10 Hz	Yes	100 MHz/-200 Hz/ 18 Steps	All Available	Plug in to 7000 Series mainframes	$7750
Not Specified	No	Variable 30 kHz-300 MHz	Long Persistence	Battery portable intended only for levels	$1695
500 Hz	Yes	2, 20, 200 kHz Plus Var.	Long Persistence	Battery portable	$4576
200 Hz	Yes	3, 15, 200 kHz Plus Var.	Long Persistence	Battery portable	$3950
2 kHz	Yes	1 kHz-35 MHz Variable	Long Persistence	Built in bridge and tracking generator	$6600[1]

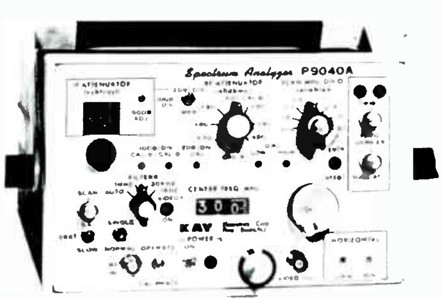
Impedance	Comments	Price
75 ohm	Part of low level sweep system	$9800[1]
50 ohm	Works with 8554 and 8558	$3500
50 ohm	11 dB attenuator, works with 7L12 and 7L13	$3650
50 ohm	Dot marker, 60 dB attenuator, works with 7L13	$4650
75 ohm	Built into analyzer	$6600[1]

[1]Total price entire system
[2]System response includes analyzer

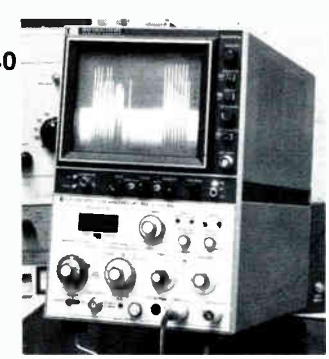
Every attempt has been made to insure the accuracy of the information presented, however, we recommend checking with the manufacturer for absolute specification and prices.



HP 8554



Kay P-9040



HP 8558

Southern Meeting Scores a Hit

Ted Turner hosted post-convention crowd at Atlanta Stadium and announced an important agreement with Jon Berentson and Tom Cousins, Omni Sports Teams.

ATLANTA, GA—The Atlanta Fairmont Hotel hosted a successful 16th Annual SCTE meeting with an attenoance of over 500. More than 70 exhibitors displayed products and services on the popular "Table Top" format.

Sunday, September 12, started the event with Tower Club meetings, SCTA board of Director meetings, a cocktail buffet and opening of the display area. Nearly half the people registered came to these opening events.

General business sessions started Monday. Technical sessions were hosted by Richard Hickman of Cox Cable. SCTE took responsibility for staging the technical programs coordinated by Judith Baer, executive director of SCTE.

Technical Sessions Well Received

Measurements, Methods and Techniques was the first topic and David Large of Avantek provided the program material. Large, and all of the other five speakers during the day and a half of programming, encouraged discussion and questions from the audience. Average attendance at each of the six tech sessions was forty people. This was the first year that SCTA had invited such programming and since it was a success, the Society of Cable Television Engineers has been invited back to do it again in 1977.

Jim Farmer, Scientific Atlanta, covered using the *Demodulator as a Tool.* Buzz Van Hecke of Andrew Corporation addressed *CATV Earth Station Technology.* Van Hecke provided a comparison of costs between small and large aperture TVRO's, determining the difference to be somewhere arond $25,000 to $40,000 depending on supporting electronics. George Bell of Microdyne talked about *Satellite Receiver Technology* and hosted a group touring terminals set outside the hotel. Andrew displayed a 4.5 meter dish and AFC hauled their conical horn antenna to the show.

Monday's luncheon featured NCTA Chairman Burt Harris as speaker, introduction of eleven new Tower Club members and presentation of the Morris Dunn Memorial Award to Otto Miller, executive secretary of the SCTA. Business sessions included a panel on pay-cable with Russell Karp, Teleprompter; John Malone, TCI; and Robert Rosecrans, UA-Columbia.

David Large, Avantek, spoke on Measurements & Methods at the first of six technical sessions.

Bill Hemminger presents the Morris Dunn Award to Otto Miller, executive secretary of the SCTA.

Van Deerlin Addressed Banquet

Congressman Lionel Van Deerlin, chairman of the Communications Subcommitte of the House of Representatives, spoke at the Monday banquet. Van Deerlin had arrived in Atlanta on Sunday and attended sessions throughout the following day. He mentioned that he'd like to have stayed for the conclusion of the meeting since he was enjoying himself, but that he had to return to Washington.

Tuesday Continued Busy

Tuesday opened with Jim Palmer of C-COR speaking on *Reliability and Your Pocketbook.* Bob Powers, senior engineer at the Cable Bureau of the FCC, spoke at the last technical session and was kept on his feet for more than two hours fielding questions. Jim Hobson, chief of the Cable Bureau, was the luncheon speaker. The afternoon business session centered on equal employment opportunity.

New officers of SCTA elected during the meeting are Grady Ireland of Cox Cable as president. Fred Kennedy, Jr. of CSRA Cablevision in North Augusta, SC, as vice-president and Bill Ryan, Gulf Coast TV in Naples, FL, as secretary treasurer.

John Thorne, immediate past president of SCTA, John Weeks, associate director, Otto Miller of SCTA and Judy Williams of Cox Cable are among the people who helped make this meeting a success. □

PNCCA Convention

SPOKANE, WA—The Pacific Northwest Cable Communications Association held its annual convention in Spokane, Washington, Sept. 26-29.

A number of exceptional talks were delivered on the first full day beginning with "The Courageous Angel Rides Again" delivered by Troy Bussey. Stuart Feldstein, NCTA general counsel, described the counsel's recent activities and fielded questions on poles, copyright and forfeiture.

The luncheon speaker was Commissioner Benjamin Hooks, who alternately had the audience either in stitches or goose-bumps. To set the record straight, he said that "the FCC has, in 47 instances since 1972, relaxed the rules." Hooks recounted his concerns: To allow enough latitude to permit some of what critics call "blue sky." On the subject of pay, "Cable must have sufficient products, yet protection against siphoning must be provided." Hooks ended with his personal plea for operators to recognize the minorities. He quoted the late LBJ and ended his speech with a stanza from "America the Beautiful."

Technical sessions were all held on Tuesday with Andy Vallejo, technical vice-president of PNCCA, opening the first program on *Headend and FCC Specifications.* Duane Staler, engineer with Blonder-Tongue on *Using VIT Signals* at the second session and the program concluded with a technical roundtable discussion. Panelists included Delmer Ports, engineer and vice president of NCTA; Tom Bowles, engineer with King Video; Gene Fry, engineer with Telecommunications; and Dell Heller, engineer, Viacom. Discussed were such topics as CB Interference, Power Surges, FCC Testing, CARS Microwave - Rule Changes, Preventative Maintenance and Choosing Pay Channels and Using Tapping Devices.

PNCCA elections were held and W. H. Sexton of Butte, Montana, is the Association's new president. Don Mackin, president of Idaho Cable Communications Association, will serve as management vice-president and Andy Vallejo of Tacoma, Washington, was reelected technical vice-president.

PNCCA presented the first annual Harley Steiner award to Sam Haddock, who pioneered cable television in Idaho. □

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critique/letters

Gentlemen:

On page 42 of the Fall issue of CableVision's Tech Review there is a "catv off-air interference chart," containing two errors. Your chart shows 146-148 MHz as being assigned to space communications; this segment, along with 144-146 MHz, is allocated in ITU Region 2 and Region 3 exclusively to the amateur radio service, "hams."

Your chart shows the frequencies 220-225 MHz as being assigned to "Class E Citizens Radio Service." Actually, these frequencies are assigned to government radio location on a primary basis, and to amateurs on a secondary basis. There *is* a proposal in FCC docket 19759 which would *create* a Class E Citizens Radio Service using 1 MHz within the 220-225 MHz band, but the proposal has been vigorously opposed by the governments of Canada and Mexico, by the ARRL, and by several organizations in the broadcasting industry. A report of the FCC Chief Engineer's office indicates that a great deal of interference to television could be expected if a Class E Citizens Radio Service were established on any frequencies in this region of the spectrum.

Since the correct frequency allocations are shown in part 2 of the FCC Rules, we are at a loss to understand how your chart got so far off the track with respect to these two areas.

Perry F. Williams, W1UED, Manager, Membership Services Department, The American Radio Relay League, Inc.,

Dear Perry,

I received your letter concerning errors in our off-air interference chart, and will indeed concede the two errors you cited. The 2M ham band does extend from 144 to 148 MHz and space-com moves to 150 MHz. The Citizens Class E at 220 MHz was also in error and remains HAM, 220 to 225 MHz. I used a McGraw-Hill chart (with permission) to start my chart and obviously attempted to compress or expand some areas of the spectrum to point up the interference of various services. Many cable operators have little idea what lies outside their cables. I hope the chart helped educate both the cable operators and those off-air users who received the chart.

The errors, of course, disturbed me and will be corrected, however, your comments and the tone of your letter concerning docket 19759 really disturbed *me. While I am not a CB user, I fail to see how any 1 MHz in the 220 MHz bands would interfere with TV. Hams have no problems at 220 MHz with TVI (do they)? Usage at 220 MHz is practically nil, so how would you know anyway? And since when does the ARRL crusade for the broadcasters?*

Last night I reviewed part 2, the FCC Allocations and found that below 225 MHz, CV has 250 kHz. In 1974, FCC records show 273,000 Hams, and 4,129,763 CB'ers. That's 88 Hams per 5 kHz voice channel, and 103,244 CB'ers per voice channel. And we know CB is growing like wildfire. I have used 1974 CB figures and given CB'ers the 40 channels they will have after January 1st, so my figures are even less than the real case.

Since one can only apply rules of physics, math and electronics to what will and will not interfere with a given service, I am at a loss to understand how the ARRL came to "so vigorously oppose" the Class E Citizens proposal in your 220 MHz ham band. I think what we're really seeing is the age old flap between the hams and the CB'ers.

Clifford B. Schrock, Technical Editor

classifieds

Help Wanted

TECHNICIANS

We need three techs with 2 or more years experience in CATV plant maintenance. Formal electronics training desireable. Must be able to climb. Reply to: Jackson County Cable TV, 1600 S. Noland Road, Independence, MO 64055 (816) 836-8800.

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ad index

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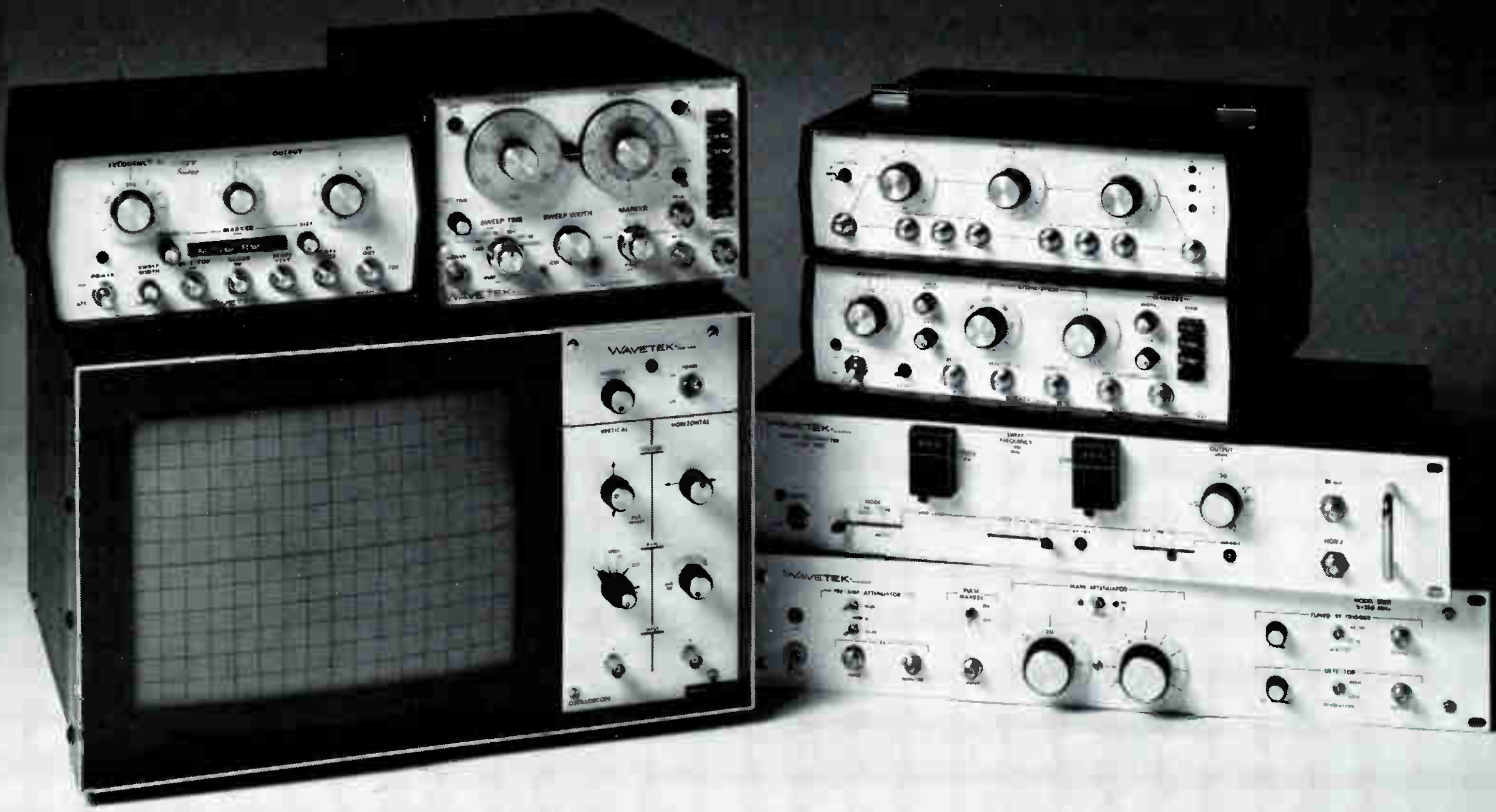

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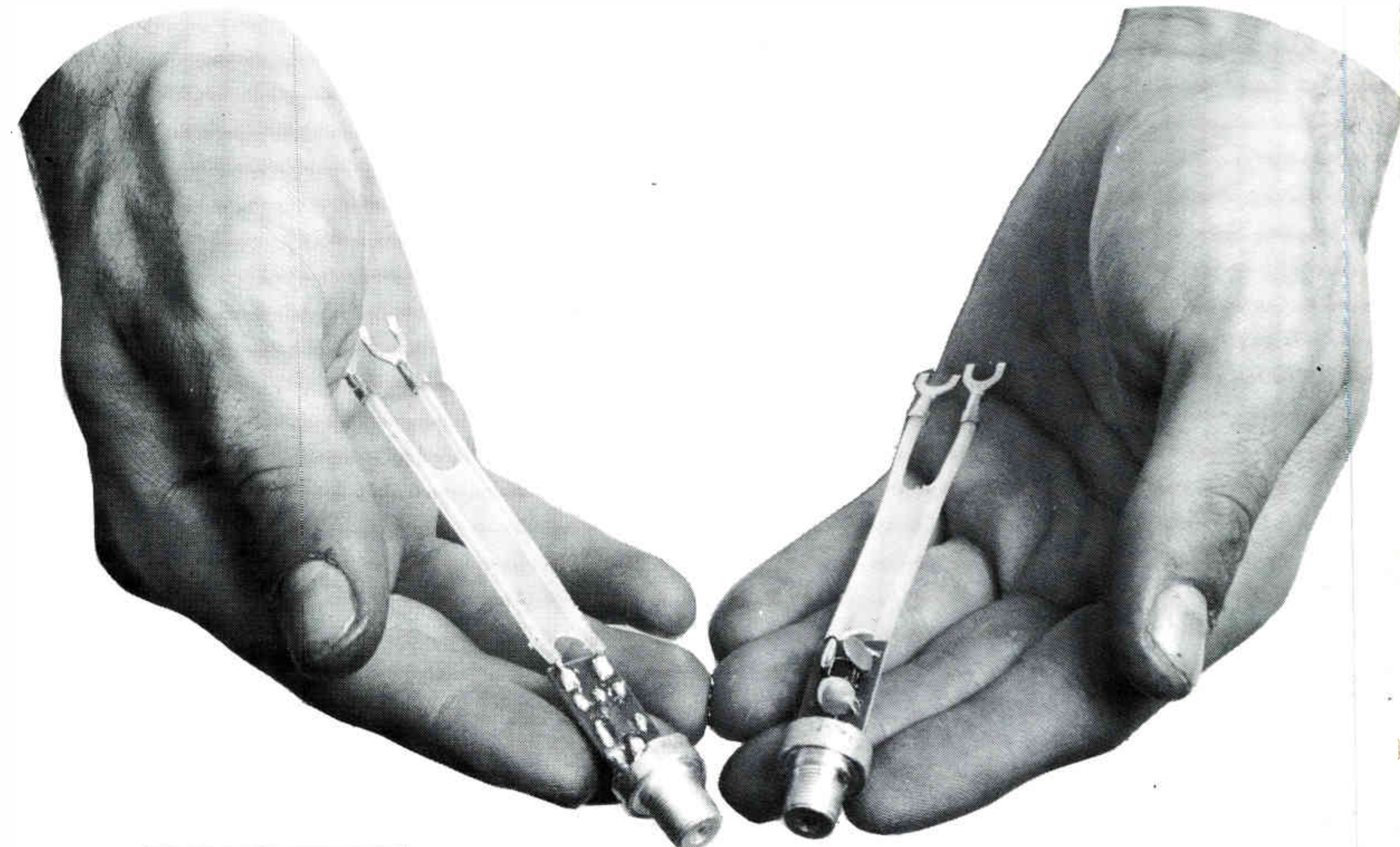

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