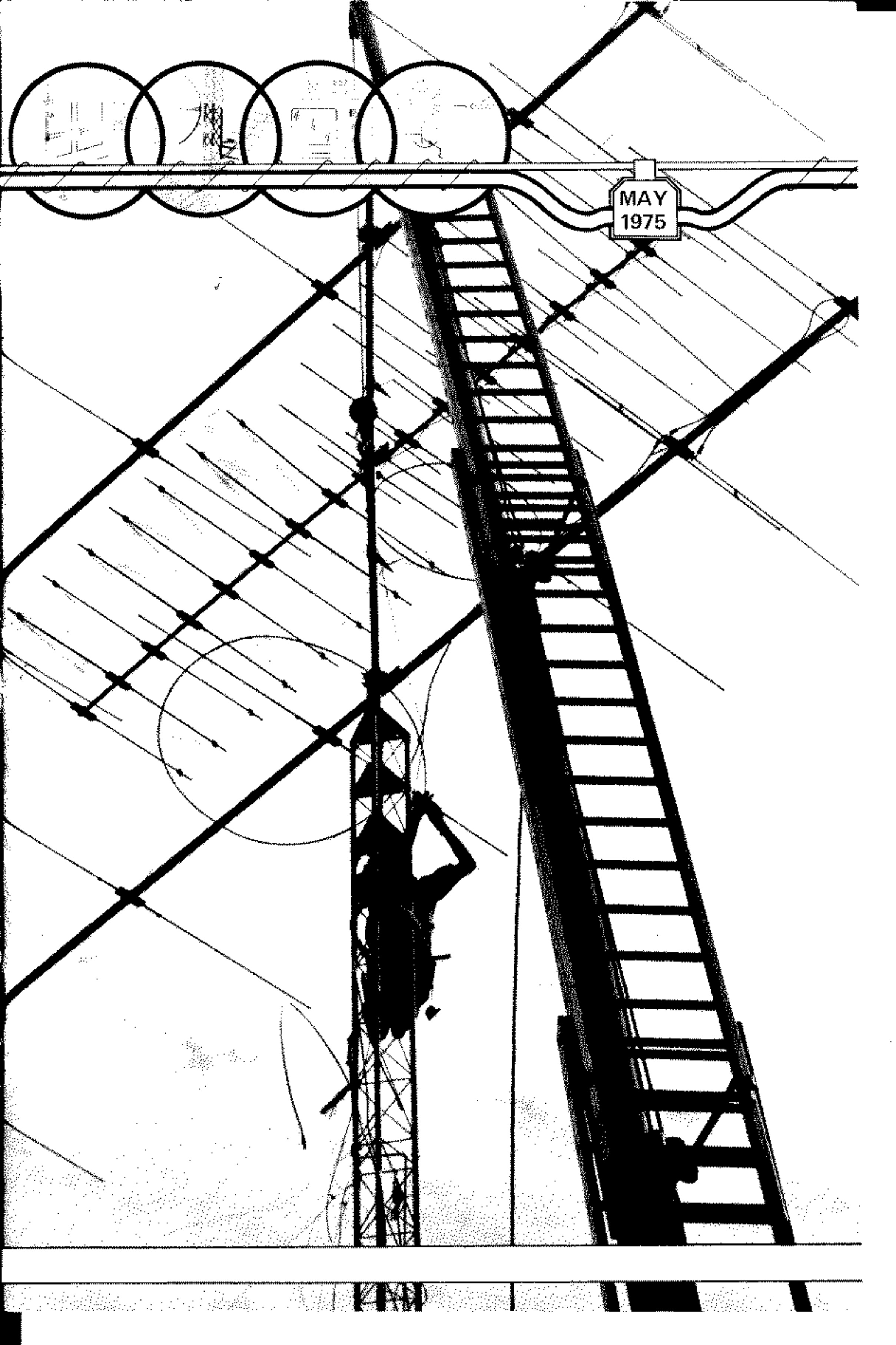
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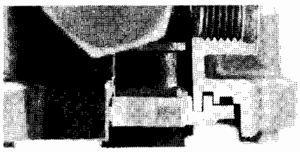

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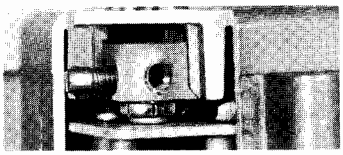

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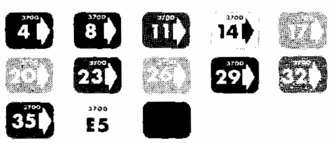

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Magnavox
catv division
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STAFF

R.B. Cooper, Jr., Editor in Chief
Celeste Rule, Managing Editor
Heather Pennington, Editorial Asst.
S.K. Richey, Contributing Editor
Debbie Teel, Illustrator

OFFICES

4209 N.W. 23rd St., Suite 106
Oklahoma City, Ok. 73107
Telephone (405) 947-4717

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—CONTENTS—

OUR COVER

Busy-busy-busy! The snow has melted, and the ice is gone. The ravages of Old Man Winter remain. Antennas to be replaced, fittings to be re-done, downlines to be checked, and guy tensions to be measured. Antenna systems — a special two-part report that begins in June **CATJ**.

CATA -TORIAL

INCREDIBLE CREDIBILITY G.A.P.

During a recent national administration the American people were introduced to the phrase "credibility gap"; which, loosely translated, meant that the administration then in power was saying one thing but doing quite another on the issues involved.

So the political art of "Gapmanship" developed, and a whole new series of political words entered our national volcabulary. In that era it was polite to refer to the "credibility gap" when it was still impolite to **outright** accuse a man of telling a lie. A man could "politely" have a credibility gap, but he was **not** a liar. And perhaps in the strictest sense of the word, few of the "gaps" were really lies; they were simply "partial truths" displayed or relayed in such a manner as to leave the vivid imagination of the listener with an "impression" of the full story, **an impression** which was often subtly (or largely) different from the full-truth actuality.

Many years ago, before television, we used to cluster about the family radio and listen to mystery stories. Through the art of marrying written dialogue with ingenious sound effects, the listener was forced to make his own mind fill in the missing pieces of the story, creating in his mind a "picture" of the full story.

Last fall, when the full horrors of Senator McClellan's S.1361 (reintroduced as S.22 this session) became apparent, through the skillful studies of former Cable Bureau Chief Sol Schildhause and others, **any mystery** which had surrounded the "true nature of Copyright for CATV" was swept away. The reader was left with few missing pieces to fill in with his own mind. All of the arguments offered by Copyright proponents ("the Royalty Tribunal is harmless," "the fees are fixed," "what is so bad about a percent or two of your gross???", etc.) disappeared in the light of the revelations of Schildhause and others. One by one, all of the supporters posts under "we-should-pay-copyright arguments" were pulled away so that at the recent NCTA New Orleans convention "we should pay" stalwarts such as Ralph Baruch were saying, "I see no rationale for paying copyright for off-the-air receivable signals...."

On April 28th the NCTA Board held a special meeting to re-evaluate **that** trade association's copyright position. Many observers expected the NCTA Board, faced with **overwhelming evidence** that Copyright as drafted in S.22 is **deadly for the future of CATV,** to make some changes in the NCTA position. And because House Copyright hearings were scheduled to begin the end of the first week in May in Washington, it was obvious this was the **last opportunity** for NCTA to **admit** it had wrongly evaluated the overtones of S.1361 last fall.

The Pennsylvania Association, represented very ably and very skillfully by George Barco, pled that NCTA **at least** compromise to push for a bill which exempts from copyright payments those off-the-air receivable signals (i.e. so-called local signals) plus adequate signals to give every town in America **at least** three networks, one ETV, and three independent signals to cable-select. He was joined by TelePrompter and United Cable (LVO).

Faced with all of the Schildhause-generated evidence, and the pleas and urgings of the Barcos, the Greenes and Schneiders, the NCTA Board did just what they did last November: **voted to reaffirm its support** of the copyright principle for CATV.

The NCTA Board, led by Amus "Bud" Hostetter, said they were fearful for "their political life in Washington if they changed position now." Hostetter said again and again that "we (NCTA) will never be able to show our face on **the Hill** again if we change position on copyright." In a word, Hostetter and the balance of the NCTA Board feels NCTA will create a "credibility gap" with political Washington if NCTA changes sides. Hostetter was joined in this chorus by the likes of OTP's John Eger, who called a change in NCTA position "suicidal."

Thus the NCTA has maintained its "credibility with Washington politicians"; **but it has lost its credibility with an industry,** and more important, with ten million U.S. cable-connected homes. And so the NCTA copyright plank joins the only other living document of mankind to survive in a mobile world, **unchanged:** the Ten Commandments. Even our nation's constitution has undergone amendment when life styles changed, or basic untruths in the original document became apparent.

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ALTERNATE APPROACH TO LINE AMPLIFIER STANDBY POWERING

One of the continuing problems in CATV systems is the requirement that systems maintain a high degree of reliability under any and all weather conditions. Aside from direct destruction of distribution plant lines and the headend vulnerability to lightning and high wind, the commercial power system to which the CATV system goes for operating power is often the most troublesome link of all.

On a day-to-day, month-in-and-month-out basis, power outages present the system with the most perplexing problems. As systems meander over larger and larger areas, often in and out of several power districts, not to speak of power-company areas, power outages which affect one area are often not directly felt, simultaneously, in other areas. This results in vital trunk-line segments becoming de-energized for brief periods of time, even though areas ahead and behind the affected region are still powered and still capable of providing CATV service.

So overall, the *weakest link* in the reliability of any system is the commercial power source itself. It is very difficult to explain why the TV screen is filled with snow, when the unaffected regions of the CATV plant do not lose their own electrical service!

by:
James R. Palmer
President, C-COR Electronics, Inc.
60 Decibel Road
State College, Pa. 16801

It is only natural that CATV systems look for alternate powering methods, to provide a back-up electrical service for those situations where power outages are not general throughout the whole region. At this point in our industry development, the state-of-the-art approach seems to be to supply standby power through reserve power storage units located at power feed points. This generally means utilizing storage batteries.

When you utilize storage batteries, you have the following associated problems:

(1) An automatic throw-over contactor (mechanical) senses the failure of commercial AC power, disconnects that power source, and switches to the standby power source;

(2) The standby (DC) source re-arranges the DC standby power into AC through an inverter or chopper;

(3) The resulting square-wave power then approximates 60 Hertz AC and powers all amplifiers connected to that AC powering location;

(4) The standby (DC storage) power source, one or more battery devices, require periodic maintenance and checking since they suffer from limited life and high exposure to the elements and vandalism.

Why Not DC to DC?

Recognizing that power storage systems are DC storage systems and that

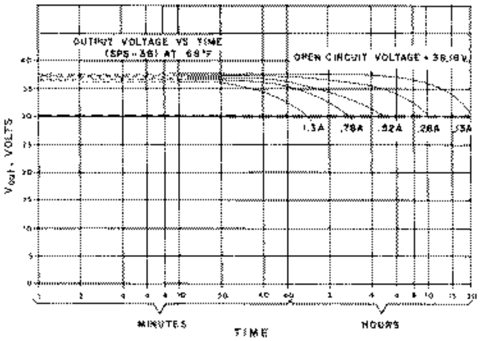


FIGURE ONE — Output voltage available from SPS-36 (36 volt) standby DC source, as a function of current loading for a 68-degree F temperature environment.

CATV amplifiers rectify the commercial AC power mains to DC before powering solid-state components (i.e. transistors, chips), the question arises "why not simply provide direct DC to DC powering for the standby mode?"

The heart of such a concept would be the types, current capacities, size, and cost of state-of-the-art DC storage cells. Space-age requirements have developed some fairly exotic batteries, one of which is a gelled electrolyte lead-acid rechargeable battery. The individual units are totally sealed, requiring no water or any other kind of periodic maintenance. Such cells offer operational safety and cost advantages without a loss in performance, and they overcome many of the inherent problems associated with wet lead-acid type cells and nickel-cadmium technologies. Another advantage of this type of sealed cell is that it may be mounted in any position; and because of its small physical size, can be mounted precisely where it is needed most: inside of the amplifier housing or in a tandem housing immediately adjacent to the amplifier requiring power standby capability.

Another advantage to this type of sealed unit is that with the lead-calcium construction the cell(s) does not have the disadvantage of high gassing during charging, or self-discharging during storage, as the lead-antimony (automotive) batteries do. Finally, the low temperature performance with the lead-calcium cells is better than the expected performance of the wet lead-acid or nickel-cadmium cells. Apparently in today's battery world, this type of battery construction is ideally suited to CATV performance requirements.

The next consideration for a DC to DC system is the obvious fact that all batteries *produce* DC power (directly) and *require* DC power for charging. Since we *begin* at DC, and *end* at DC, why do we go through the DC to AC and then AC to DC conversion processes? Each CATV (trunk, bridger) amplifier already has *its own* regulator, which can be utilized to transform (i.e. limit) the battery DC voltage to the required (regulated) B+ output, and its own AC to DC "converter" to charge the battery and keep it in a full-charge condition (i.e. float).

The final consideration is standby powering locations. Most CATV companies know (or quickly learn!) where they have difficulties with commercial power-main reliability. Certain substations and powering districts seem to carry the brunt of *irregular* operation. Most CATV systems now utilizing battery standby power do so for

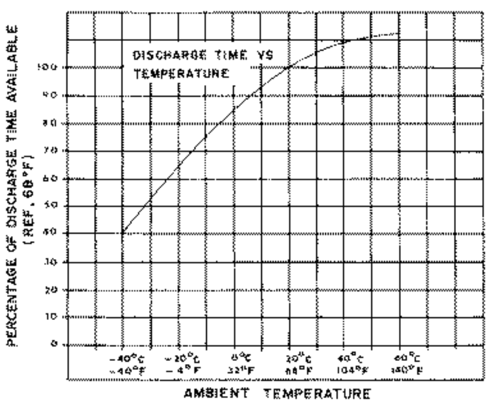
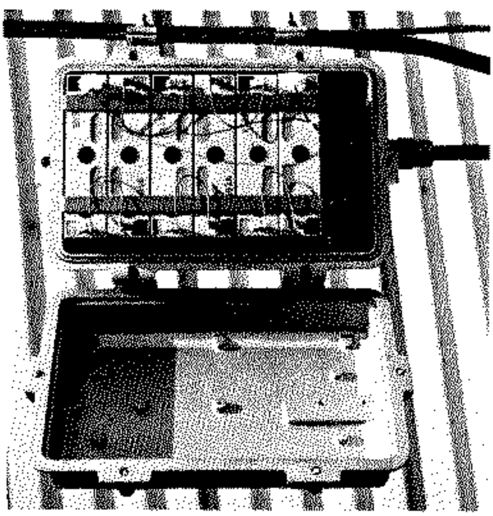


FIGURE TWO — Discharge time vs. temperature for a typical standby DC power source; an amplifier which will run two hours at 68 degrees F would operate for one hour at an ambient temperature of -20 degrees F.

only certain sections of their plants, where irregular AC power-mains service is evident. Therefore as a minimum requirement, trunk (bridger) amplifiers located in these problem areas must have standby power sources available. (In some rare circumstances, the operator might wish to standby-power *all* of his trunk and bridger plant segments.) It is usually unlikely that the operator would care to provide standby power for highly *localized* outages, such as standby-powering *individual* line extender locations. With battery (DC) standby, for direct DC to DC standby, the operator is able to design in a greater degree of localized backup to his powering requirements than with AC to DC / DC to AC conversion packages now available. The key word is flexibility, utilizing this DC to DC approach.

One more feature not to be overlooked is the difference in housing and security requirements. Large lead-antimony standby power sources not only occupy considerable pole space and require periodic maintenance, they also afford an excellent "challenge" for vandalism or outright theft



DC to DC power storage system is mounted in conventional strand-mounting housing; and powers trunk or bridger amp through short length of .412 cable.

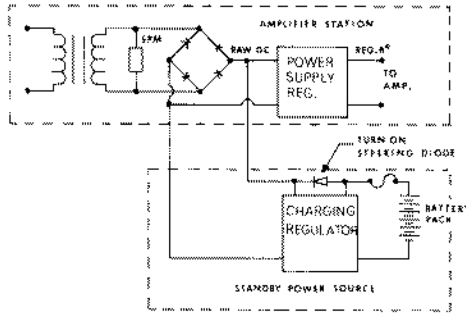


FIGURE THREE — Basic DC standby power system as integrated into an existing amplifier station location, Turn-on of the standby supply and switching back to a charge condition (i.e. with amplifier powered by normal AC mains) is instantaneous. Recharge time for a fully depleted supply is approximately eight hours.

of the expensive standby power storage units. By adopting the DC to DC approach, with the small housing (see photograph), the operator is able to strand mount the package which has the appearance of any other CATV apparatus. These special battery cells are also less likely to find a ready market for resale (if stolen) at the local service station!

DC to DC Package

The lead-calcium cells mount in their own (typical) cast housing and are interconnected to the trunk or bridger amplifier through a short piece of .412 cable. The standby DC power source hangs on the strand adjacent to the amplifier station.

During normal line powering situations, the standby source receives raw DC from the normal line powered source. This creates a DC charging voltage for the standby source, which is maintained at the proper level by a charging regulator. When the commercial power fails, a steering diode immediately activates the standby source as a DC source for the trunk/bridger amplifier at that location; and the "beat goes on" with no flicker on the customer's cable television signal.

Because most power outages are of a short duration and are restored *without* any remedial action by the CATV company, it was felt that a two-hour reserve power storage capacity should be adequate for most outage situations. There is of course a tradeoff at some point where reserve capacity (i.e. size of cells) becomes so large that the housing required to hold the storage capacity exceeds the logical returns the operator could expect for the installation. After a study of most outages experienced by most systems, the "two-hour capacity" number seemed to be a fair tradeoff for most operators. It should be noted that if the power outage exceeds the two-hour standby capacity of the standby DC source, the system continues to function, although as the voltage drops, all of the expected things happen, including lower amplifier output levels and an eventual shut down of the regulator in the trunk/bridger amplifier. Full discharge of the DC standby power source will not harm it, however; the batteries chosen for the first commercial units will stand 500 complete charge/complete discharge cycles, or up to 1,000 cycles of discharge/charge if the full discharge point is not reached during each "down" cycle. Because the batteries are float-charged, normal life expectancy of a typical package should be five years or more.

What About Costs

Naturally any standby power system costs the operator *something.* There are going-in costs, maintenance costs, and replacement costs for the storage cells.

Because of the sealed nature of the cells, routine maintenance costs with the lead-calcium cells are virtually nil. And because of the strand-mounted, small-enclosure housing, replacement costs for theft or vandalism should be significantly less than with automotive-type cells.

To compute the costs of the C-COR SPS-36P with conventional standby power for a 60-mile segment of a large existing plant, the computations of Table 1 have been prepared.

TABLE ONE

(60 mile plant segment)

	Conventional	C-COR SPS-36P
Number Of Standby Units	16	79
Price Per Unit	$ 750.00	$ 139.50
Batteries (automatic per unit	150.00	00.00
Installation Cost, each	130.00	5.00
Total Going-In Costs (79 amps)	$16,480.00	$11,415.50

Thus there is a cost savings of $5,064.50 for this representative system segment, in addition to the other features already covered.

Differing Standby Voltage Requirements

Not all existing CATV plant equipment requires the same DC operating voltages. For this reason, the standby units must be available in a number of different configurations. For example, a 36-volt *positive* standby supply is required for most Scientific-Atlanta, Magnavox, Theta-Com, and Kaiser equipment. A 36-volt positive will also standby-power much of the head-end equipment commonly found in service today. A 36-volt *negative* supply is required for Jerrold Starline 20 *series* regulator units; and a 42-volt *negative* supply is required for Jerrold Starline 20 equipment with *switching mode regulation.*

This approach to standby line powering merits careful examination and study by any system operator troubled with plant power outages.

CALCULATING SYSTEM HEADEND NOISE LEVELS

System Noise

CATV system signal-to-noise ratios are determined by the composite antenna, pre-amplifier and signal processor system. The concept of excess noise over kTB, as is commonly utilized by military and deep space probe communication circuit system designers, is a concept which can be made to apply to CATV systems just as well. The beauty of such an approach to system signal-to-noise ratios is that system parameters can easily be reduced to a set of charts and graphs, which allow you, the system operator or planner, to calculate in advance closely your own signal-to-noise ratios. By using the charts and graphs presented here, you are also able to quickly determine where improvements can be made in your existing system, and to compare antenna-vs.-pre-amplifier-vs.-processor system change-outs to determine which area will produce the most effective improvement in your own channel-system signal-to-noise ratio.

Antenna Signal-to-Noise Ratio

The electro-magnetic transmission media (i.e. the atmosphere) has a *noise background* which is a function of several factors. These factors include (1) galactic noise sources (from the sun and other natural noise sources in space), (2) atmospheric (from thunderstorms and weather patterns), (3) man-made sources (see *CATJ* for May 1974, Pages 8 and 19), (4) and in dry climates (especially the Southwest) noise generated within dust storms or by the rustling of dry vegetation in the wind.

Galactic noise is at a more or less constant level, and it increases to higher levels as the frequency lowers (see Figure 1). Surface-effect noise (man-made and dry climate) levels vary with geographic areas, antenna (receiving) patterns, and elevation (above ground).

Galactic noise is specified by the function of excess noise over kTB (a scale of measurement), or that level of noise which is in excess of the noise generated by the terminal impedance of the antenna. Galactic noise comes from space, and power levels (at any given receiving site) are calculated by integrating the E and H plane antenna patterns. Increasing the antenna gains by stacking narrows the E or H (or both when quad-box stacking is followed) plane patterns; however, the reduction of plane patterns is usually balanced, as far as space galactic noise is concerned, by the increased gain of the antenna system itself. It can be

By:
Hansel B. Mead
Q-BIT Corporation
P.O. Box 2208
Melbourne, Fl. 32901

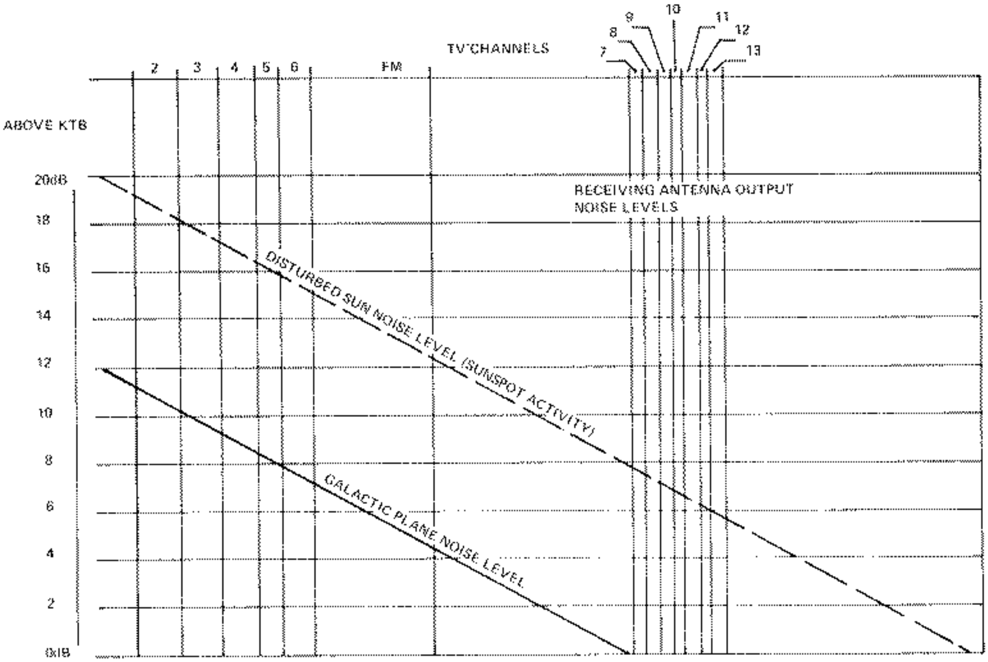


FIGURE 1

assumed that if the effective noise captured from galactic sources stays constant, with antenna stacking, but the signal level from a point-source transmitter (i.e. a terrestrial transmitter) increases, that *stacking produces an improvement* in system signal-to-noise ratios for the user.

Stacking to narrow the H plane pattern (stacking vertically, one above the other) helps lower surface-noise effects, some forms of long range co-channel, and aircraft bounce; however it does *not* help with reduction of off-path point-source transmitters (i.e. non-desired co-channel signals to the side or rear, or adjacent channel sources so located). To achieve a sharper E plane, antennas must be stacked side by side (horizontally), which effectively narrows up the frontal pattern of the composite antenna array.

In most situations, yagi-type antennas have greater forward gain than log antennas of the same boom length (gain being a function of boom length for any parasitic antenna). The main advantage to the *log antenna* is its relatively wide frequency response range (as compared to a yagi), when more than a single channel is to be received from a single antenna array. The relative merits of the front-to-back and front-to-side ratios with common logs and yagis will not be discussed here (such a discussion is planned for June and July *CATJ*), except to note that *any* antenna array which exhibits high ratios of rejection for rear of antenna or side of antenna signals will not only discriminate against man-made (i.e. co-channel, etc.) sources off of the main lobe, but will also reject galactic sources and terrestrial sources from those directions as well.

The galactic level of noise does vary from time to time. The major contributor to galactic noise here on earth is our own sun. A disturbed sun produces markedly higher galactic noise levels than a "quiet sun." Normally an active or "loud sun" coincides with the passage on the sun's surface facing earth of one or more active regions known as sunspots. These "spots" are actually violent storms raging on the surface of the sun, and the amount of energy spewed out of these "storms" is almost beyond comprehension. Fortunately very *little* of that energy reaches earth; but enough does reach us to increase the background galactic noise levels during a "sunspot storm" to increase galactic noise levels by as much as ten times in the VHF region.

The system designer has many factors to consider when designing a receiving-antenna array; the mere addressing of co-channel and man-made noise sources is really not sufficient unless your received signal level is averaging 500 microvolts or better at the antenna terminals.

Amplifier Noise

Thermal noise is generated by *any* antenna system. As a closed-loop system, with *no* galactic or man-made noise sources, the noise which is generated in a piece of 75 ohm transmission line *terminated* by a 75 ohm resistor *is measurable*. It is also something which we can calculate. For example, such thermal noise is calculated by the equation kTB:

(1) where k is Boltzmann's constant (1.38×10^{-23} J/K);
(2) where T is the absolute temperature in degrees Kelvin (K);
(3) where B is the bandwidth (Hz) of the receiving system.

In a CATV headend, our characteristic impedance is 75 ohms, and for our discussions here the *typical* bandwidth is 5,000,000 Hz, or 5.0 MHz. This calculates out to a (terminated) noise floor of —58 dbmv at room temperature (72 degrees F).

If you were to build a perfect (*none* has yet been built) amplifier, with a *0 db noise figure*, and with a voltage gain of 20 (db), driven from a 75 ohm source, you can calculate the amplifier *noise power output* as follows:

(1) —58 dbmv 'noise floor' plus 20 db gain = —38 dbmv noise power output.

Now if our amplifier has a 3 db noise figure, the calculated noise power output of the amplifier becomes:

(2) —58 dbmv 'noise floor' plus 20 db gain plus 3 db noise figure = —35 dbmv noise power output.

Taking this one step further, if your antenna system produced a signal of "X" level, and you measured an output signal level from your amplifier (i.e. after amplification) of —10 dbmv, your signal-to-noise ratio would be:

(3) Signal level after amplification of —10 dbmv minus system noise power output of —35 dbmv = +25 db signal-to-noise ratio.

As far as this system example goes, *the amplifier noise figure is excess noise above kTB*. Thus if one knows the system noise figure (SNF), the gain of the amplifier and the output signal level of the amplifier, the signal-to-noise ratio for the system can be calculated directly in db's. This is a fairly straightforward, simple exercise, for situations where there is only a single active (amplifier) stage in the line. When there are two more amplifier stages (i.e. discrete sections) in cascade, the *noise calculations* become more complicated and prone to error. The graphs presented here, to be explained shortly, will make this considerably simpler, however.

The noise figure of a device has nothing, *directly*, to do with the bandwidth of the (amplifier) device. There seems to be a misconception in the CATV industry that *only* narrow-band amplifiers can have low noise figures; and conversely, wide-band amplifiers must have high noise figures. This is *not* true with transistor devices commonly available today. Low noise figures can be obtained with both narrow- and wide-band amplifiers.

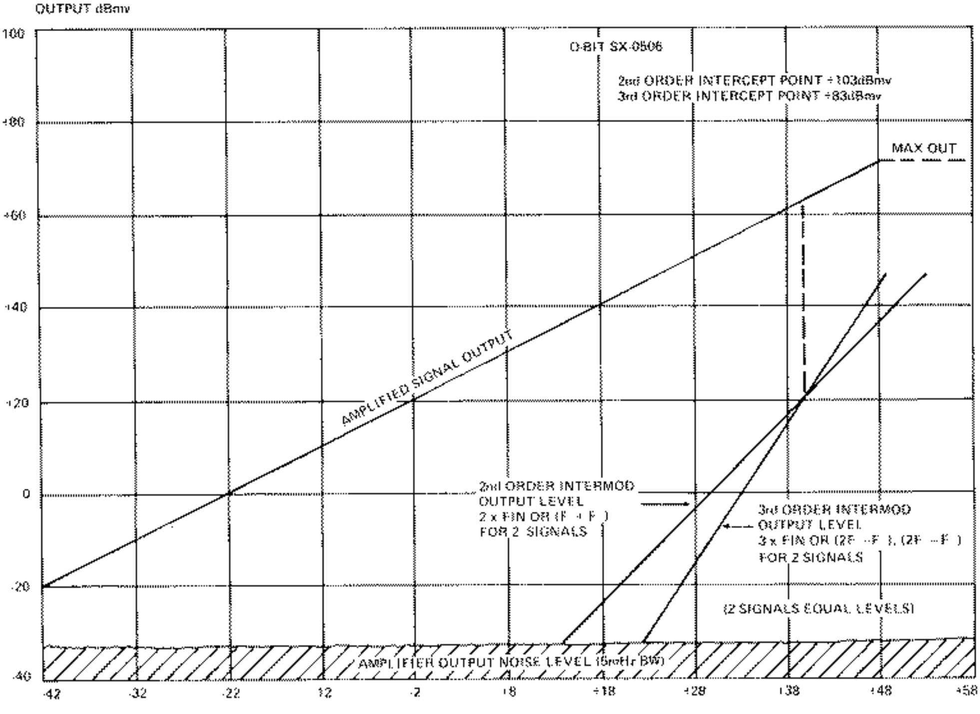


FIGURE 2

In the not-so-distant past, when vacuum tubes and early transistor devices were commonly utilized in CATV amplifiers, the individual amplifying device (tube or transistor) had to be *neutralized* to achieve low noise figures. Neutralizing is a feedback process where some small, controlled amount of the *output* signal of the amplifier device is coupled *back into the input* of the device for stabilization of the device. When you neutralize a stage, you are utilizing circuit tricks which inherently *limit the bandwidth of the stage;* and the amplifier stage becomes *optimum* for noise figure over a relatively *narrow* range of frequencies. Today's popular use of FET devices (field effect transistors) also suffer, for a different reason, from the same problem. The inherent design limitation of an FET, vis-a-vis a bi-polar family transistor, includes the limitation that an FET is a narrow-band device. It does not have a very large gain-bandwidth product (i.e. its gain is limited to a *relatively* narrow-tuned bandwidth), and consequently FET's have never made major inroads in *broadband* technology. The common FET can achieve a real noise figure of approximately 3.0 db, although some users *claim* noise figures as low as 1.5 db in special applications. One of the main advantages to FET devices is its low third-order intermodulation distortion; a function of the current which they draw (i.e. *low current* drawn results in improved third-order intercept problems).

If the designer utilizes a narrow-band amplifier (i.e. such as a FET device), the amount of external (passive) filtering required for out-of-band (i.e. non-desired channel) signals is lower. This improves the second-order beat problem.

On the other hand, if the designer utilizes a bi-polar device with inherent broadband characteristics, one amplifier (module) can be utilized for all channels, and this reduces the requirements for *spare* modules. If the system designer knows accurately the levels of in-band (i.e. desired channel) and out-of-band (i.e. non-desired channels/signals) he is going to work with, he will find in many situations that a broadband amplifier will function just as well as a narrow-band amplifier.

Another consideration which must be included for the system designer planning an ultimate sensitivity receiving system is intermod. As Figure 2 shows, the performance of any (pre) amplifier will be degraded when the *input* voltage level of the signal(s) *times* the voltage gain of the amplifier *equals* an output sum voltage greater than the amplifying device is capable of producing without distortion. When there are two (or more) *potent* signals through the amplifying device, and the amplifier is driven *beyond* its sum-voltage output capability, beats occur between the carriers and their products. A broadband amplifier *is more susceptible* to this problem, simply because it has gain bandwidth product over a wider frequency spectrum and is "open" to signals over a broader frequency range than say a narrow-band amplifier device. In the narrow-band case the second-order intermod is *not*

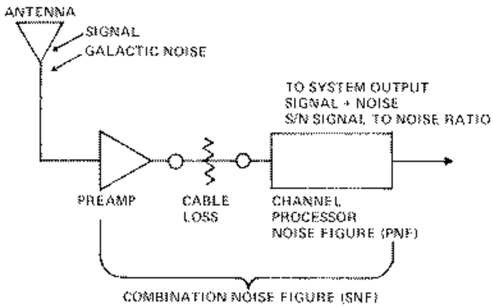


FIGURE 3

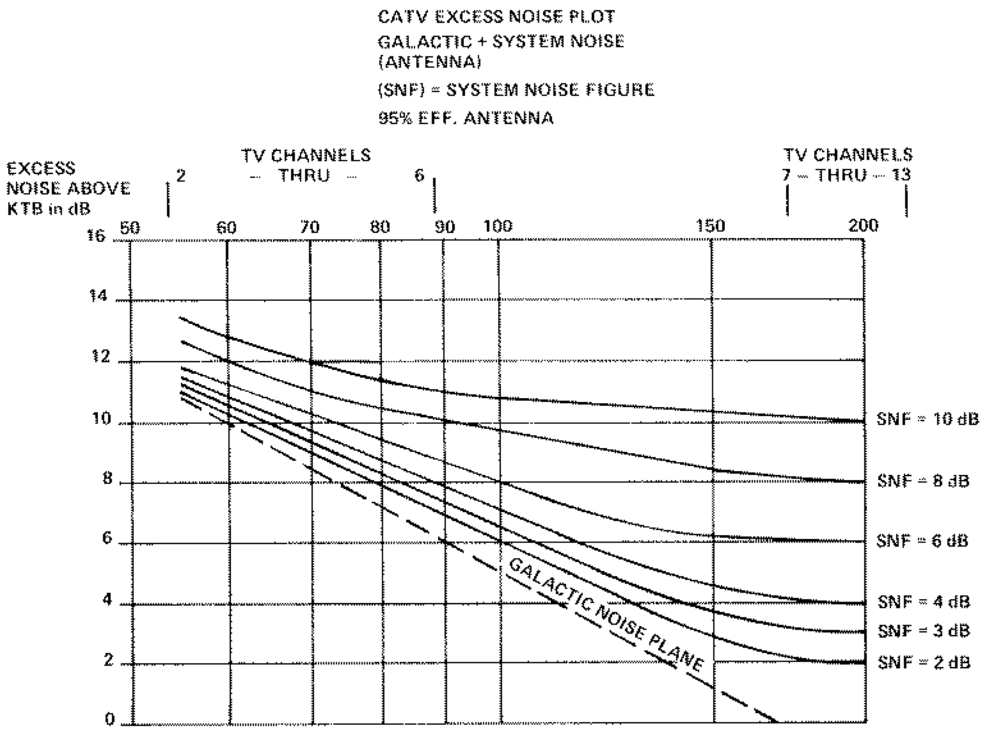


FIGURE 4

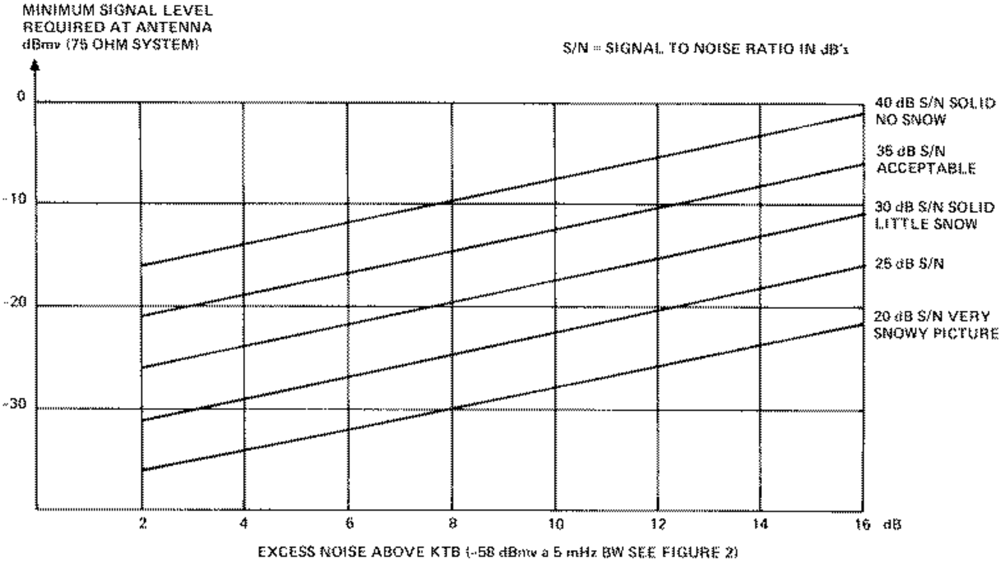


FIGURE 5

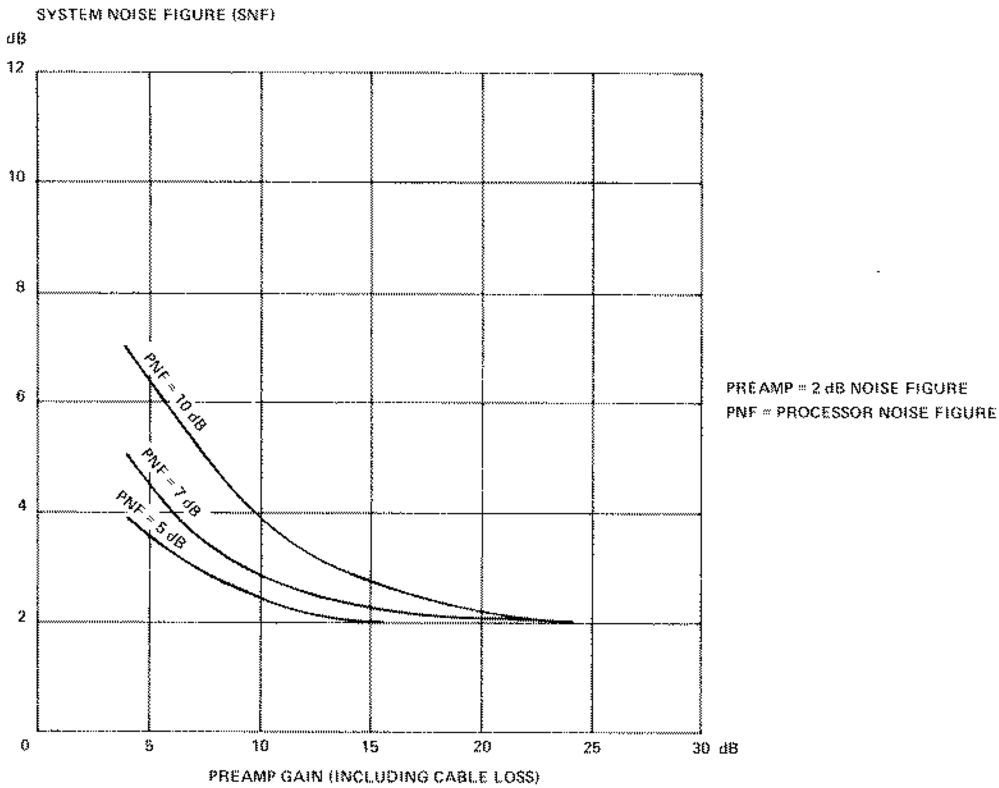


FIGURE 6

present and the third order would usually be caused by the *same channel* video and sound *beating together* (or the desired channel plus strong immediate adjacent channel carriers that are too close to the desired channel carriers to be filtered out effectively).

In any system employing a pre-amplifier, this device *sets or establishes the noise figure* for the *whole* system. If there is no pre-amp on a certain channel, the system noise figure (SNF) is the down cable *loss* (from antenna to processor input) *plus* the processor noise figure.

Use of Graphs

The graphs and charts presented are as follows:

(1) Figure 1 displays excess noise from a receiving antenna due to galactic and disturbed-sun noise;

(2) Figure 2 shows intermod products as a result of input levels vs. pre-amp gain, for the Q-BIT SX-0506 pre-amplifier;

(3) Figure 3 depicts the summing of noise sources for determination of the System Noise Figure (SNF);

(4) Figure 4 shows the net effect of the noise of the system (SNF) added to the received antenna noise. This results in an excess noise of kTB for the complete system (per channel, up to headend *input* to trunk);

(5) Figure 5 relates excess noise to signal-to-noise ratio, and corresponding input levels (from antenna) to achieve the ratios;

(6) Figures 6, 7 and 8 are plots of the combined (summed) pre-amplifier/processor packages *as a function of pre-amp gain.* These graphs are used to determine the System Noise Figure (SNF) *before* the antenna is connected.

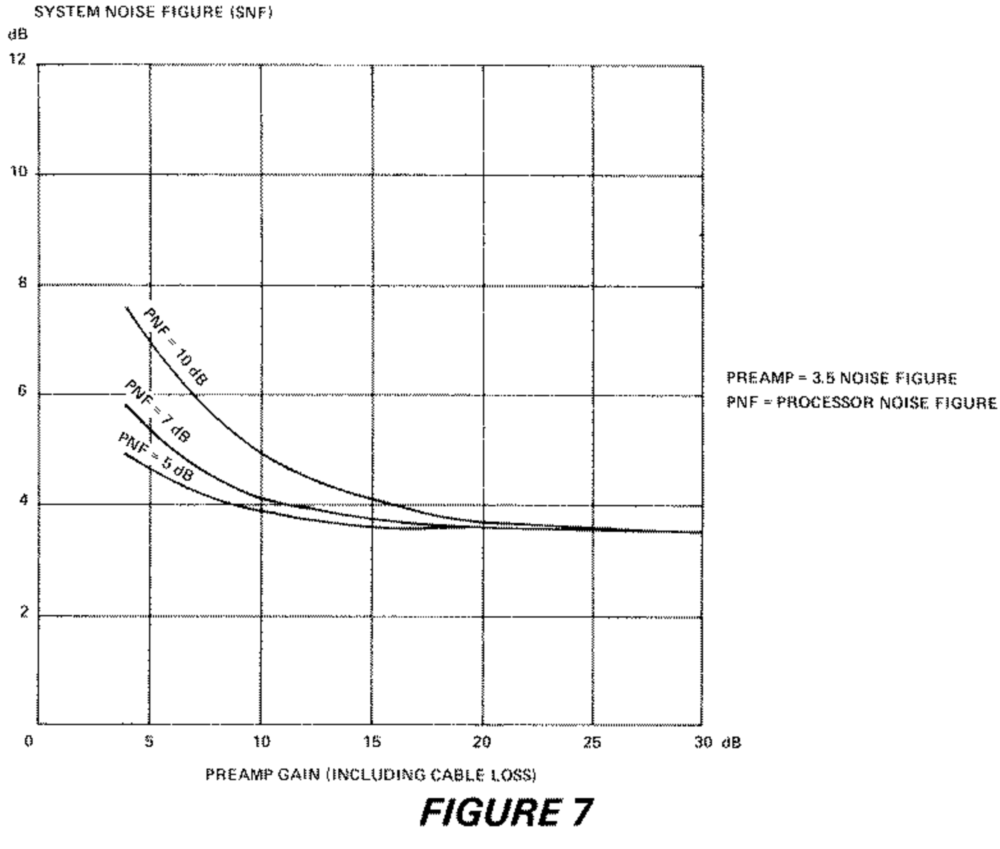


FIGURE 7

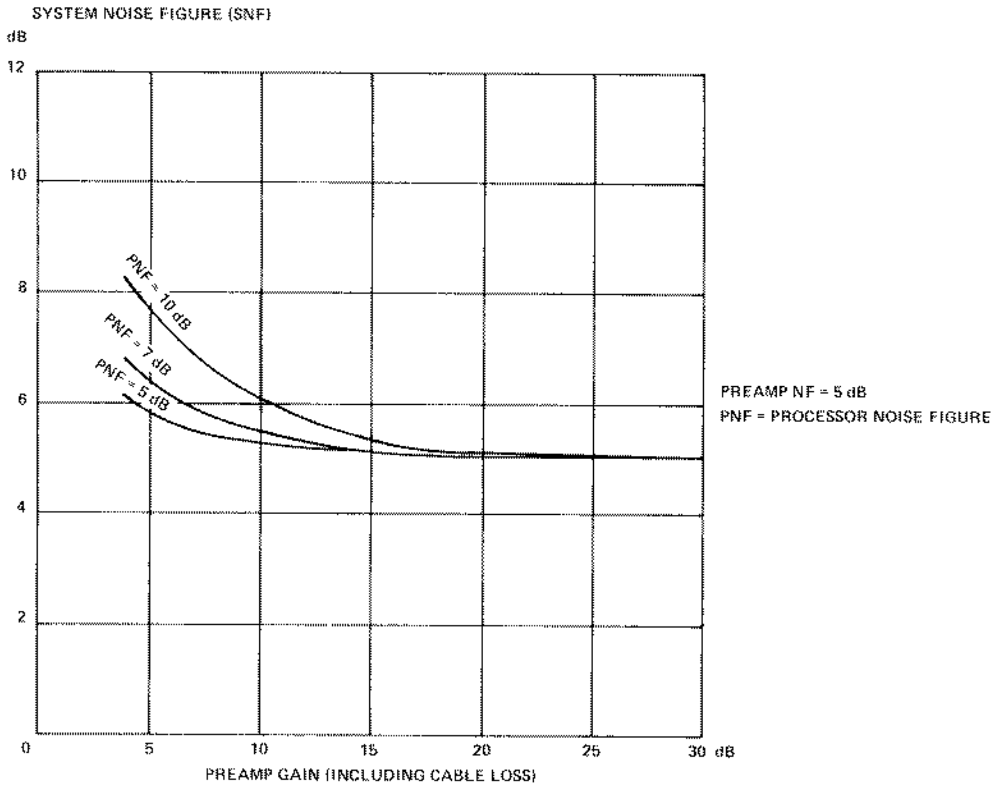


FIGURE 8

Note that not much improvement is realized *after* the pre-amp gain exceeds 20 db.

For practice, assume a 2 db pre-amp noise figure (see Figure 6) and a 7 db processor noise figure (PNF), and assuming 25 db net gain (from pre-amplifier) we can see that the System Noise Figure (SNF) is 2 db and that the *contribution of the processor* to the SNF *is negligible*.

Now refer to Figure 4 and TV channel 6. The predicted *excess noise* is around 7.5 db with an SNF of 2.0 db. Now refer to Figure 5; if you require a 35 db signal-to-noise ratio, it becomes clear that a signal level of —15 dbmv or higher is required. If your system cannot produce a —15 dbmv signal level to the pre-amplifier, there is a degradation of signal-to-noise ratio. Or, you could increase antenna gain to bring the required input signal level up to —15 dbmv.

Disagreement

If the measured results do *not* agree with the galactic noise background levels given here, there could be one of two answers: either the noise sources present from man-made or other sources are unusually *high* (if noise seems to increase or change with changes in local weather—such as during or after a local rain shower—you can suspect this), or there may be disturbed-sun conditions at the time of measurement.

BASICS OF CATV CHART RECORDING

The Case For Permanent Records

Many aspects of our industry can settle for instant diagnosis and recording. Others require long-term diagnosis and some recording of data for analysis. The field strength meter/signal level meter device records data in *real time* only; that is, the meter on the instrument tells you the level of the r.f. signal voltage present...*at that instant.*

To *record* data displayed by an SLM/FSM, the operator must be in constant attendance and must be capable (and willing) to record by hand all of the displayed readings. This is often not practical when readings must be made over several hours (days, or weeks).

The need for relatively inexpensive, trouble-free recording apparatus in the CATV industry is considerable. Strangely enough, there has never been equipment designed for this application, and very few of the existing manufacturers of display recording equipment are apparently even remotely aware of the needs of our industry.

CATJ is certain that many systems employ some type of paper-record recording systems on a regular basis; and it is our hope that by jumping into this problem area with both feet, we can pry some of these techniques loose from their creators, to share with *CATJ* readers. If, on the other hand, very few people are doing much with permanent recording systems, perhaps the series of articles we plan on the subject will stir up sufficient interest to gain the attention of one or more manufacturers of this type of equipment.

Where Needed

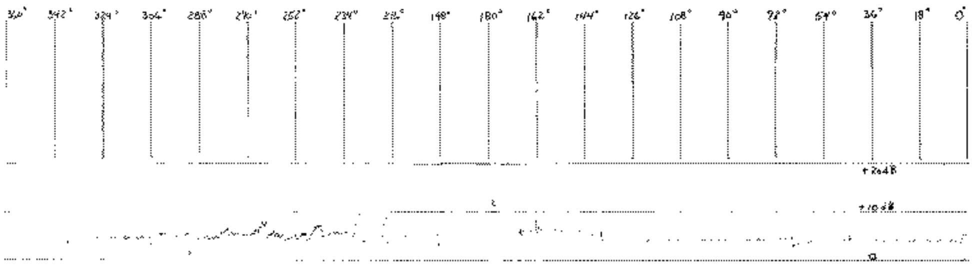
To properly plan *any* CATV system, the system designer needs accurate maximum/minimum data. For example:

(1) What is the maximum signal level from channel "X" which the system can expect?

(2) What is the minimum signal level from channel "X" which the system can expect?

Or, what are the maximum co-channel levels the system can expect (or is experiencing) from channel "Y"? Often a system engineered from afar (i.e. an MSO system maintained locally but *hard-engineered* from a distant point) suffers from a lack of precise data. The local (resident) tech reports, "We had bad co-channel the other night on channel 11." The hard-engineer type wants to know (and needs to know) (1) co-channel from which direction (i.e. station), (2) over how long a period of time, (3) at what level.

Or take the case of a wayward section of plant, where customers inter-



PERMANENT LOCAL NOISE SOURCE RECORD — By attaching your rotating search antenna to your SLM, and recording the SLM detected level on a low band channel (such as channel 2), while the TV station is not broadcasting, you can rotate the antenna with rotor 360 degrees and record the level and direction of noise sources at your head end. This channel 2 chart, prepared in the wee small hours of the morning, shows there was ambient noise of approximately 5 db (over no-antenna connected SLM noise) with various headings, rising at several distinct antenna-headings to as much as 13 db over the SLM noise figure. By making records annually, and comparing results, you can quickly locate new noise sources that pop up as time goes on.

mittently report weak signals, or cross mod, or whatever else equipment failure can dream up. Again, (1) when did it happen, (2) what levels were involved, (3) what areas were affected?

In virtually any situation where you have a need to know maximums and minimums, you can send a man out to take up residence in the trouble area, or atop the hill at the head end, and wait for the trouble to reoccur. This is both expensive and a serious waste of valuable manpower. If the trouble is truly intermittent or dependent upon varying (off-air affecting) weather conditions, the man may have a *very long wait* before he reports back with sufficient data to allow hard-engineering to make a determination of the trouble source.

In the case of head-end designs, we *seldom* (and let's be frank about it) design the head end *properly from the start*, when we are dealing with signals beyond their grade B contours (and the job we do within the grade B contours is not always that great!). Once you have been bitten a time or two with an *under-engineered* system, your tendency (if *you* are the hard-engineering responsible agent) is to *over-engineer* the next system to save yourself the embarrassment of being caught with your antenna level down when a weather front moves through. Even if you are dead certain your calculations are correct, you are *tempted* to double the size of the antenna array (i.e. from two bays to four bays) "just to be sure." When we are dealing with $500 per bay arrays, doubling from two to four bays is a $1,000 safety factor that might not be justified at all, except in the pocket of the antenna salesman!

In short, a recording system for data which allows the system engineering personnel to accurately analyze hours, days, or weeks of signal levels and other associated information should be a prime concern of every system operator. Even the smallest of systems (and perhaps they *more than others* with more available personnel) should consider the advantages of being able to set up an SLM/FSM with a data recorder at the head end, and walking away to come back a day or two later to analyze what really happens to the signal in question over period of time.

But It Costs Money!

The recording of data naturally costs a few bucks. But it probably costs *much less* than you suspect, and certainly for the rudimentary recording of off-the-air signal levels, when utilized with your existing SLM/FSM, it need *not* be an expensive investment. Like any other investment, it needs to be weighed against the benefits. If a $250 recording apparatus saves you $2,000 in antenna investment, because you have accurate off-the-air signal level data to plan with, then it is a good investment. If it makes you spend $2,000 more for antennas than your paper calculations prepared in advance indicated, it is *still* a good investment because you have begun with the proper (and documented) information to plan the system-receiving antennas. And that quickly translates into *more* subscribers in a hurry, which means *improved* cash flow.

Because no one has designed a paper-impression recording system *for the unique requirements of CATV,* any machinery which we look at will have to be either adapted to CATV uses, or accepted as is with whatever limitations the natural form of the machine includes. Our preliminary investigation of recording equipment and techniques will center here on (for the most part) accepting existing non-CATV equipment as is, with suitable explanations as to how you can work around the limitations where they exist. Future segments of this series will delve into modifications of existing equipment for more-extensive recording applications.

What Is Available

Paper-record recordings are hardly new to electronics; dozens of different recording machines have been available for decades. Most work on the principle that an input voltage (or current developed across a load impedance by a varying voltage) is translated into calibrated paper records through the use of a servo device that moves a marking device (i.e. pen) back and forth on a paper chart (or strip). The paper chart or strip is driven by a motor which has fixed or variable speeds, calibrated, so the operator is able to pre-set the recording medium (paper chart or strip) for a known amount of *advance per hour.* The forward advancement of the paper chart or strip is a function of time, and with suitable markings for time, the operator of the machine knows at a glance that a certain event or series of events, as recorded on the paper record, took place at a certain time.

The control voltage (or current) emanates in the signal *monitoring* device, in our case the SLM/FSM. It is fed to the recording apparatus through a connecting cable, where it provides "drive" to a servo mechanism. When the control voltage is high, the servo records in one area of the paper or strip; when it is low, the opposite end of the chart or strip gets the recording.

Impressions on the paper record or strip are commonly made by ink pens (mostly special nylon tipped felt-type marking pens these days), or by physical impressions (inkless) on a pre-carbonized paper/strip. Impressions made by a pen are continuous, and as the chart drive (paper/strip) motor advances the chart paper/strip ahead, the path of the pen is traced on the paper/strip. Impressions made by physical contact between the servo-driven recording indicator and the carbonized paper are usually not continuous; a "hammer mechanism" lifts and strikes the carbonized paper repeatedly, with the result being a series of "mice tracks" across the paper/strip where the hammer has repeatedly fallen while the chart drive motor advanced the paper/strip.

There are many "brand names" in recording devices, a few of which are Esterline-Angus (pen type), Heath or Heath/Schlumberger (also pen type), Rustrack (primarily inkless recording systems), and Simpson (also primarily inkless recording systems).

The basic recording machine consists of:

(1) A basic meter-type movement (i.e. such as 0-1 volt dc, or 0-1mA), which replaces the usual meter-movement scale (i.e. panel display) with a servo-driven arm that moves left/right (or up/down) as a function of input voltage (current);

(2) A chart drive motor, which advances the recording medium (paper or strip chart) at some precise (calibrated) speed;

(3) A case and set of on/off and (hopefully) calibrate controls.

Beyond the basic instrument, which may be AC operated and/or DC (battery) operated, the buyer is selecting add-ons or choosing between things like paper/strip physical width, multiplex opertion (i.e. offering the capability of recording *two or more events simultaneously* on the same paper/strip), and so on.

Recall in our series on SLM/FSM devices in CATJ (1) we investigated things like meter-scale definition (i.e. how easy it was to read *small changes* in indicated levels), and the 20 (or 30) db meter scale width for most instruments available on the CATV market. Both are important to our present discussion.

Strip/Paper Width

The *width* of the paper (i.e. the left-to-right paper expanse available for impressions) is important because it affects *recording definition.* Just as you have more trouble spotting interference on a five-inch Sony than you do on a 21-inch receiver, if your recording area for a paper/strip is limited to two inches, and you are compressing 20 db of range into that two-inch paper width, the "definition of the recording" may prove to be a problem in critical analysis.

Of course smaller machines are more portable and less expensive (many of the single voltage/current scale units available are not much over $100). But like any other tradeoff, you do lose something in the transition to small size.

One of the areas of recording where high definition may *not* be a problem is the single-event recording, such as noting precisely when a station comes on or goes off (or any other signal or voltage measurable function). If the variation in level is not great, the lower-definition machines (and less expensive machines) are well worth looking into (these are primarily Simpson and Rustrak units).

On the opposite end of the scale, where high definition is desirable, units such as those offered by Esterline-Angus or Heath (Heath/Schlumberger) have standard chart widths of 10 inches (about equivalent of going from a 5" TV screen to a 25" screen when compared to a 2" wide chart/strip). For this you pay a few more dollars, but in the process you (honestly) get a whole lot more machine. Naturally, each has its place, and perhaps you will find a place for both before we are done with this series!

Meter Scale Width

The common CATV meter has a 20 db (or 30 db in the case of Sadelco) display scale meter. Because CATV voltage levels (r.f.) are a log function, we end up with a voltage range in a typical SLM/FSM instrument of something like 10 to 1 for any given meter-scale range (32 to 1 in the case of Sadelco). Keep in mind that the SLM/FSM display circuitry (i.e. the electronics which drives the meter element) is *always* operating in the *same* range (i.e. the same 10-1 or 32-1

(1) See CATJ for October, November, December 1974, January 1975.

range); the actual range you read is varied by adding or subtracting external (i.e. external to the amplifier-electronics in the meter drive circuit) attenuators. This means the basic electronics is a 10-1 or 32-1 voltage range circuit. The voltage/current developed for the meter-scale reading is bottomed out (i.e. let's call it zero here) when the particular scale reading you have going is at a minimum, and it is topped out (let's call it maximum here) when the meter indicator is "pegged." In between zero and maximum we have a drive voltage/current which causes the SLM/FSM meter indicator to read out signal levels to us.

The voltage/current range of the recording machine enters into the scenario when you have a known output drive voltage/current range available from the SLM/FSM. For example, if you own a Blonder-Tongue FSM-2, you chart recorder drive voltage, available at the MODulation output jack on the front panel, is approximately 0.25 volts (DC) when the SLM/FSM signal level pegs the meter in the maximum range-level portion of the meter (SLM/FSM) scale. A recorder which has a lowest input range of 0-1 volt DC would probably not give you a full chart/strip display in the 0-0.25 volt range when connected to an FSM-2 meter. So it is important to know (1) the output voltage range available from your SLM/FSM for chart recording purposes, and, (2) the recording range of the instrument you are considering, before buying. In short, when selecting a recorder, give some basic thought to the range you select if you select a recorder with only one fixed range. It may be lower than your maximum full-scale SLM/FSM chart recorder drive voltage (you can build up a resistance bridge to drop it down into your range), but it should not be higher than the maximum (full-scale) voltage available from the SLM/FSM if you want to use the full paper-width definition of the recorder.

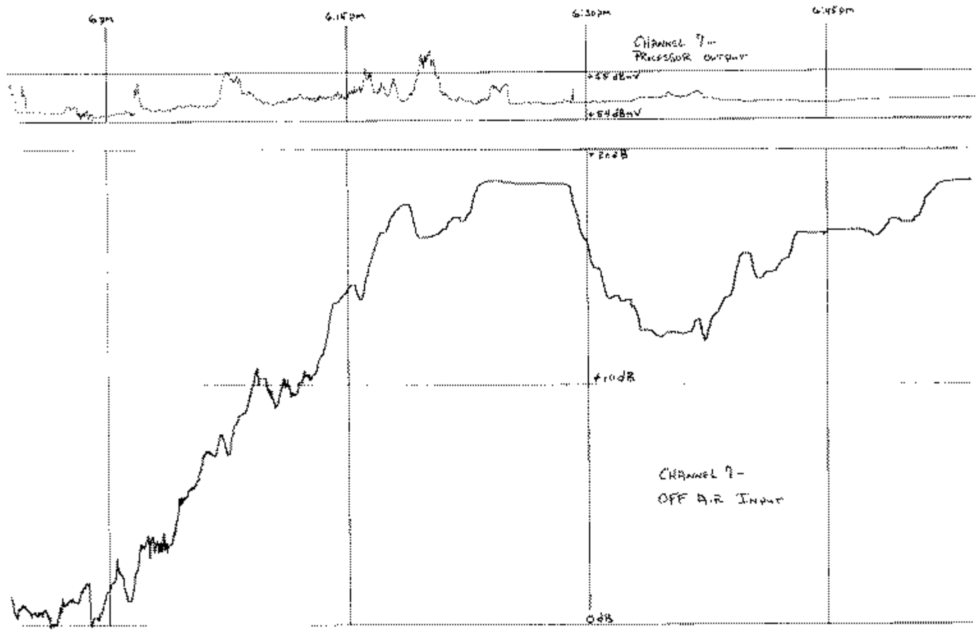
Drive Voltages Available

Because the CATV industry has never given more than passing interest to permanent recording apparatus for signals and the like, there is nothing like a uniform approach to providing a chart recorder drive voltage output on SLM/FSM meters. Only Blonder-Tongue (FSM-2) and Jerrold (727, etc.) even mention SLM/FSM applications of chart recording devices in their manuals. Blonder-Tongue says (regarding the level available at the MODulation OUTput jack), "A minimum of 50 microamps is available at full-scale deflection...(sufficient) current to drive a recorder or external meter...." Jerrold, of their 727, says "...the current through M1 (meter display) is made available at jack J1 for operation of a recording device...." And that is about all of the guidance either gives.

Most chart recorders have relatively high input impedances (500K to infinite, depending upon the input voltage range and servo balance). This is an on-purpose design to keep circuit loading at a minimum when recordings are being made of delicate circuits. This means that essentially the voltage appearing at your SLM/FSM chart recorder jack is going to be the voltage which the chart recorder actually sees.

The B-T FSM-2 and the Jerrold (727) provide operational jacks for this purpose. As noted, the B-T unit provides aproximately 50 microamps (roughly 0.25 volts DC) at their MODulation OUTput jack on the front panel. The 727 provides approximately four times as much output voltage at their recorder jack as the FSM-2.

There are two schools of thought regarding *how to go into meters* that do not provide specific chart recorder drive voltages for the operator. One suggests that you utilize the video output jack (level) since they typically provide from 0.5 to 1.0 volt peak to



DEFECTIVE PROCESSOR OUTPUT LEVEL CONTROL — This chart, made of a channel 7 off-air signal (bottom) and the channel 7 processor output (top) with two separate chart recorders shows output level varying beyond unit-spec range, but **not** as a function of input level change. Problem was traced to a defective diode in pin-level-control circuit.

peak output. The principal problem with this approach is response time of the SLM/FSM detector and the response time of the recorder. In effect, at the video output jack you have greater voltages present when the station is full white transmitting (the rough equivalent of 80% video modulation at the transmitter); and your chart recorder response, if sufficiently fast, will record not only varying signal levels (interpreted as varying amounts of video modulation) but *also varying modulation levels*. In addition to this, some SLM/FSM's produce very little *video-out* (voltage) at relatively *low* SLM levels (i.e. below mid-scale on the display) which means that when a recorded signal fades, you may lose video output from the SLM/FSM much *faster* than the r.f. signal level.

The other school of thought suggests that while recording the video-out level is a quick, simple and not very complicated approach, it would be better for the user of a Sadelco, Benco, Mid-States, etc. (which do not have recorder output jacks) to go into the instrument and install a simple phone-type jack (or F fitting) which goes in series with the existing meter element in the SLM/FSM. Diagram 1 indicates how Jerrold does this with the 727; the same approach with other meters would work just as well.

Recording Speeds

The speed at which the chart drive motor advances the recording paper or strip is an important consideration because like the physical width of the chart, it affects the definition of the recording. The faster the chart paper moves through the machine, the more definition you have. At one inch per minute you pile up 60 inches of paper per hour, a considerably higher grade of "definition" than at one inch per hour!

Machines available offer fixed *or* selectable chart (advance) speeds. Typically, in the lower-cost inkless machines, you have fixed (or switch selec-

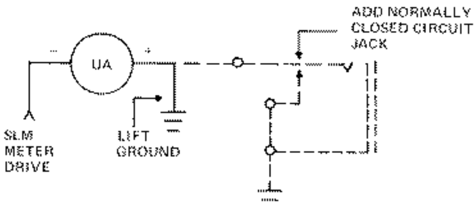


DIAGRAM 1

table) speeds in the 1-12 inches per hour *range*. And in the ink-impression machines, you have wider ranges from as low as 0.2 inches per hour to as high as 30 inches per minute. Chart paper naturally costs money, and if you intend to use your recorder frequently, it should be a consideration. Inkless machines usually have rolls averaging 50 feet in length, which at one inch per hour develops 600 hours (25 days) of continuous (non-stop) recording space. Table 1 here indicates what you can expect with various chart speeds vs. chart paper roll lengths. The Heath machine, to be discussed shortly, has 120-foot rolls (of 10-inch-wide paper), which at 30 inches per minute nets you 48 minutes of recording time. The same roll running at 0.2 inches per hour in the same Heath machine will require only 4.8 inches per day, and will last 300 days in non-stop use.

The recording speeds (i.e. chart advance speeds) you require will depend to a large extent on the *variety* of uses *you* envision. Very fast speeds (i.e. 30 inches per minute) are probably of *little* use to the average CATV field personnel, but anyone interested in plotting the AGC response time of a processor or the fade-modulation rate on beyond-the-horizon signals would find it useful. Accordingly, very slow speeds (i.e. 0.2 inches per hour) probably are useful only for recording on-and-off events (i.e. channel off, channel on). At very slow speeds the recorder simply compresses time into such a *narrow display width* that individual (or even short-term cum) variations cannot be "read" from the chart.

Recording roll paper varies in price with the type machine, paper source and quantity purchased at one time. Typical prices for 50-foot rolls of the inkless-variety machines average $2.50/$3.00 each, while the 120-foot rolls for the Heath family of recorders run $4.00/$5.00 each.

Virtually all paper rolls have grid markings, in both the vertical and horizontal directions. Paper markings tend to be linear markings (for example the Heath has 100 marks or grid lines in the vertical direction—up and down for the recorded voltage—in 0.1 inch increments, and 5 grid marks per horizontal inch—along the direction of paper flow—at 0.2 inch markings). These grid markings provide convenient methods of calibrating the recording for time (using the 0.2-inch markings per inch) or signal level (using the 0.1-inch markings per inch).

An example of how this calibrates is as follows:

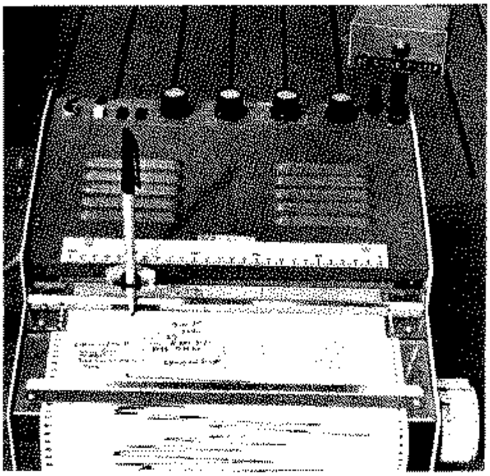
(1) *At one inch per minute*—each horizontal marking grid equals 12 seconds
(2) *At one inch per hour*—each horizontal marking equals 12 minutes

The vertical markings (of signal level) work out to fractions of a db per mark for the typical 20-db-wide recording span. With 100 marks or grids on the scale and 20 db of record width, you have 2 db per inch or 0.2 db per grid mark.

TABLE ONE

Chart Speeds vs. Run Times

Speed	50' Roll	120' Roll
.2 IPH	125 days	300 days
.5 IPH	50 days	120 days
1 IPH	25 days	60 days
2 IPH	12.5 days	30 days
4 IPH	6.25 days	15 days
8 IPH	3.12 days	7.5 days
16 IPH	1.06 days	3.25 days
32 IPH	0.53 days	1.12 days
64 IPH	0.26 days	0.56 days



HEATH EU-20B RECORDER - tube-type (no longer in production) recorder with 60 cycle filter described in text

Practical Recording

More than six years ago, a Heath EU-20B recorder with the *then* available EU-20-26 multi-speed chart drive was acquired and put to work in CATV applications. *Both units* have subsequently been replaced *by Heath* by more-modern (i.e. solid state) instruments. What follows is more of a six-year report on cumulative experiences than a product report for an instrument no longer commercially available new (2).

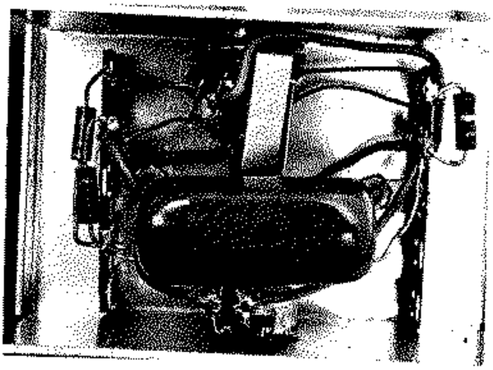
The EU-20B was intended *primarily* for laboratory applications, and with the EU-20-26 multi-speed chart drive, it cost approximately $350 new (in 1969). It offered 21 chart drive speeds which resulted in paper speeds of from five seconds per inch (12 inches per minute) to 0.5 inches per hour. The input voltage ranges (for full-scale recording deflection) are 10, 25, 50, 100 and 250 millivolts. *Other* ranges of input voltages are accommodated with fixed resistor pads, and the instrument has a vernier adjustment that allows the user to adjust for full-scale deflection (i.e. maximum level recording) down as low as 3.3 mV in the 10 mV scale (for example).

This particular EU-20-B with multi-speed drive has seen hundreds (perhaps thousands) of hours of use in CATV applications. In one three-week span it ran almost continuously, sorting out data for three projected CATV head-end sites in Texas, for example. Because the unit was produced *prior* to the solid-state re-design at Heath of their recorders, *it is* a tube-type unit. Yet in six years of heavy use it has required only one tube change-out, and very minor maintenance. This is mentioned *primarily* because when we purchased the unit, initially we had some misgivings about taking a lab-application recorder *out into dusty fields* or hauling it to the top of inaccessible mountaintop peaks (it once travelled to such a site on a mule's back for several hours). Seemingly, if the user shows *modest* concern for his investment, *most* chart recorder instruments should reward you with many years of faithful service.

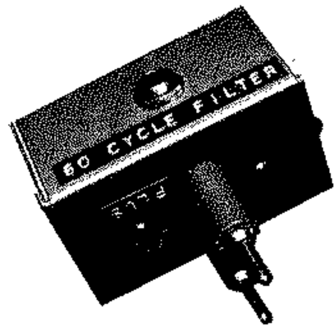
The biggest single *limitation* with most recorders is the 20 db (or 17-20 db) span-width which a stock recorder will record when connected to a stock SLM/FSM. There are some tricks you can play to *expand* the range to more than 20 db, but they will not be covered here in this *initial* look at recording devices.

The primary thing to remember about *any* chart recording device is that *you calibrate the chart as you set up the recording session.* This is done by adjusting *the SLM* so that you have exactly a full-scale reading (i.e. if the SLM is on —10 to +10 dbmv range, you would indicate +10 dbmv on a test signal) on the SLM/FSM; then by *adjusting the input range* (with vernier if

(2) *Although the chart recorder discussed here is no longer available from Heath, several newer solid state versions are available. These units will be discussed in future issues of CATJ as this series continues.*



60 CYCLE FILTER - see text

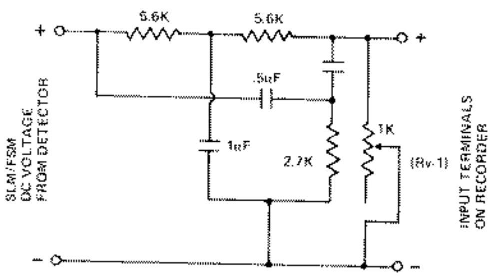


AC FILTER CONTAINER — see text

available) *on the chart recorder* so that at full scale on the SLM corresponds to full scale (maximum level being recorded) on the chart recorder. If you start out this way, the window or range of the chart recorder will be approximately 20 db wide, and you can then proceed to initially *calibrate your chart or strip* at the start point *with the actual level being received.* Because the chart is scaled (i.e. has graduated markings), you can then mark at the start point on the recording paper *what the actual level is* at full scale, and proceed to count down in one db steps *for the corresponding marks* on the raw chart paper.

Most chart recorders have quite accurate chart-drive motors, especially in the slower ranges of 12 inches per hour down to fractions of an inch per hour. Therefore if you start off by marking the chart at (say) 6 PM on the horizontal grid, you can easily calibrate the *completed* chart for time at a later point *after* the recording is completed, provided you know *how many inches the chart drive advanced the chart* per hour.

Some of the newer chart recorders have built-in 60 Hz line filters. Any servo-operated chart recorder has a *potential* problem with *false responses* to 60 Hz fields in the area, and some have a "60 Hz null" control to phase the 60 Hz out of the tracking mechanism drive. Many years ago we built a small 60 Hz filter for this purpose, as shown in Diagram 2. This is built into a small minibox, outfitted with a standard two-prong banana plug jack so that it fits *directly* into the input line on our EU-20-B. The use of the external 60 Hz filter improves the 60 Hz null control response *on the EU-20-B;* and later versions of this recorder from Heath have such a filter built in. Some years after purchasing the unit we were faced with making some recordings using a meter *other than* the B-T FSM-2 for a signal source. The FSM-2 has a 20 db (approximately) *variable i.f. attenuator* control, which means that you can take *any* signal and using the variable i.f. attenuator bring the reading up to full scale (see preceding data)so as to allow *full-scale alignment* of the servo on the recorder. This is a very handy feature which the FSM-2 has, but



60Hz T-NOTCH FILTER WITH OUTPUT "MATCH" POT

DIAGRAM 2

which other SLM/FSM devices do not have. Left with only the 10 and 20 db step attenuators on the second meter we were forced to use for recording, we found that the vernier adjustment on the range scale of the EU-20-B was *not quite adequate* to allow us to make full scale on the EU-20-B correspond to full scale on the SLM. So potentiometer Rv-1 (see Diagram 2) was hastily added to the 60 Hz filter box. This 1K pot across the input to the EU-20-B gave us the *added flexibility* we needed to "pad" the SLM output level so that we could *net the two devices together* for *full scale* equals *full scale*. As they say, necessity is the mother of invention!

Longtime readers of *CATJ* will recall our features appearing in the October issue (*92 Miles of Terrain*, Page 7) and January issue (*Signal Propagation*, Page 7). The charts appearing in those reports were prepared on the Heath EU-20-B.

Any Reasonable Voltage

Virtually any reasonable voltage (or current) can be permanently recorded with most of the relatively inexpensive chart recorders. For example, any of the \$100-\$150 inkless (impression) units can handle monitoring of plant AC amplifier powering voltages. You would be surprised how often you can trace intermittent cases of amplifier crud to faulting AC power supplies, or unexpected AC supply drops *below the regulator-requirement* for voltage at the far end of a distribution line.

Co-channel can be monitored by running the output of a good-quality SLM/FSM through a simple 10 or 20 kHz filter so that *only the beat signal* (voltage) produced by the two beating TV carriers gets through to the recorder.

Proof of performance tests would be decidedly simpler if you left an unattended chart recorder and SLM/FSM at a test monitoring point. Since we are only concerned in these FCC mandated tests with *variations* of 12 db or less, even the inexpensive inkless recorders should suffice. And by attaching the *actual recording strip* to the test results for the year, and filing all of it away, you greatly simplify the potential question of test validity.

In Future Reports

In future reports we will take a look at some of the present-day instruments available, and look into the many unusual (i.e. useful) ways you can use such an instrument in your system.

CATJ ONE YEAR OLD

My how time flies when you're having fun! More than 624 pages ago, **CATJ** entered the CATV world with the May 1974 issue. It featured a report on off-the-air noise sources, RFI (radiation from transmitter sources), a do-it-yourself marker/signal generator, a short course on single-ended line extenders and a maintenance piece on tube-type strip amplifiers.

A few more than 1,000 early **CATJ** subscribers have recently been sent subscription renewal notices; and as each month rolls on, later subscribers to **CATJ** will also be receiving their renewal notices. We ask that when you renew that if your name or address is incorrect on the renewal form, that you correct it for us. The same computer memory which prepared your renewal notice label also prepares your monthly magazine address label.

It has been an eventful year, and for that we thank every reader/supporter. In the coming year there will be new (additional) wall charts, and special manuals for tests and measurements. We like having you as a reader and we look forward to your continued support!

WAVETEK 1050 SWEEP MACHINE

A Re-Birth?

Many (many!) years ago *Jerrold* brought out the first sweep-signal generator intended for CATV. It was outfitted in a box very similar (if not identical) to the box which would later house the 704 FSM device, and it had two large knobs on the front to control sweep width and sweep-center frequency. Today if you can find one of these antiques, it will set you back around $15. Early users remember that the unit covered 140 MHz sweep width, "wide open," which meant that you could not *quite* cover the span from channel 2 (55 MHz) to channel 13 (215 MHz) in one whack.

Later *Jerrold* brought out the now-famous 601 CATV sweep machine. The 601 extended the range so you *could* look over the channel 2-13 spectrum in one whack, but like its predecessor, it was (*also*) a 50 ohm version. If our memory serves us correctly, the 601 *never* was anything but a 50 ohm machine, and *Jerrold* provided the CATV user with a 50/75 ohm loss/match pad. When the 601 came from the factory, it had BNC fittings on it. Chances are if you have one floating around your system backshop gathering dust, someone has taken the time to *convert* the BNC fittings to CATV "F" series fittings; but chances are also good that the machine, even with an "F" series fitting on it, is *still* a 50 ohm machine.

The beauty of the 601 was its price: around $500. The 601 used a sweeping method dependent upon a saturated reactance scheme. Some of the other VHF sweepers of that era, such as the *Telonic* units, had a motor-driven sweeper (i.e. mechanical). *Telonic* must have had a great deal of sales success with the motor-driven sweeper, because there are many people in CATV who believe *all* early sweepers were mechanical sweeps.

Later still, *Jerrold* came out with a "fancy machine" that obtained its sweep from an acoustical system that moved a capacitive vane in and out of a speaker cone. Apparently there were many techniques available for creating a "swept signal" in those earlier days. But the first real stir towards modern sweep equipment was, if our memory is correct, the product of *Kay* when they devised the first varicap (solid-state) sweep product.

Now this is not meant to be a history of, or thesis about, sweep machines. At some future date CATJ will investigate the fundamentals of sweep-test equipment. However, the sweep which we depend upon, and take pretty much for granted in CATV today, is really not all that recent an event.

Most current approaches to CATV sweep equipment are tagged in the $1,000/$2,000 pricing range. When you add markers (most sweeps make mark-

1050 SPECS

Freq Range	1-400 MHz
Modes	Sweep and CW
Freq Dial—	
Calibration	50 MHz intervals
Accuracy	5% full scale
Sweep Width	200 kHz to 400 MHz
Display Linearity	2%
Spurious Signals—	
Harmonic	30 db below output
Non-harmonic	30 db below output
Residual FM	less than 15 kHz
Drift—(30 min warm-up)	100 kHz, 5 mins; 2 MHz, 8 hours
Blanking—	Retrace blanking of RF output for sweep operation; removed for CW
RF Output	+10 dbm (+64.5 dBmV)
RF Output Impedance	75 (or 50) ohms
RF Output Flatness	+/— 0.25 db
Attenuation—	
Vernier	0-20 db
Step	0-50 db, 10 db steps
Sweep Rate	AC line freq, 50/60 Hz
Scope Horizontal—	18 volt p-t-p triangular
RF Markers	Birdy bypass, provision for six markers (see text)
Marker Size—	Adjustable 4mV to 4 volts
Marker Width—	Adjustable 100 kHz to 400 kHz
Programming	Remote programming plug on rear apron for center freq, sweep width, 0-20 db vernier control
Power Requirements—	115 VAC at 50/60 Hz, 15 watts or 230 VAC 50/60 Hz
Dimensions	4.125"h x 9"w x 9.5"d
Weight	7 lbs
Price	$495.00
Manufacturer—	Wavetek, Inc., P.O. Box 190, Beech Grove, IN. 46107

ers optional), detector, and some attenuators, you usually have a pretty fair amount of cash tied up in a piece of test equipment which is *mandatory* only for FCC tests, although it is highly desirable for routine daily work as well.

The 601 from Jerrold brought sweep-test equipment down to the price range which most (if not virtually all) CATV systems could afford. But it was *at the end* of the non-solid-state era. When solid state hit, the prices jumped *back up* again. The subject for this review, the Wavetek 1050 solid-state sweep, threatens to bring the price tag *back down* to a point where once again every system should be able to afford at least one 1050.

1050 Specs

The 1050 sweep/signal generator is, as the manual states, *a general-purpose broadband instrument covering the range 1 to 400 MHz.* The abbreviated operating specs are shown separately here in box form.

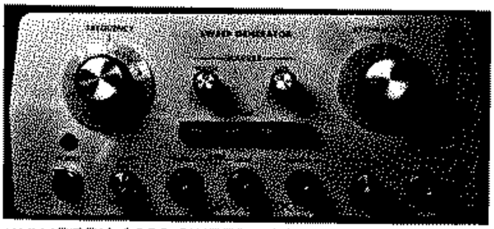
Basically, a sweep generator is a standard *reference* source. It is intended to provide a signal of *known level* over a wide or narrow band of frequencies; and to do it with such precision that when you run this test-signal source into and through an amplifier (filter, etc.), the detected signal, when displayed on a scope, can be relied on to truly represent the gain-and-tilt characteristics of the amplifier (filter, etc.) under test.

Because you rely on the sweep generator as a reference source, one of the primary concerns any user should have is the "RF output flatness" of the sweep generator. Most sweep generators spec RF flatness (i.e. the amount of variation over the sweep display width in the measured/displayed output) as a function of sweep width. Generally, with most instruments, the wider the display range the greater the deviation above and below the supposed output level. And most sweep machines, the 1050 included, have rated (or spec-denoted) maximum output levels (+10 dBm in the case of the 1050 — *that is not +10 dBmV*). By cranking in attenuation on the machine, the operator is able to *reduce* the sweep level (by a known and calibrated amount) to an appropriate *input* level for say a line extender which may be under test.

Wavetek rates the 1050 flatness as +/— 0.25 db over the spectrum 1-400 MHz. Using an external detector (Wavetek D171), we compared the output linearity of the 1050 against a more expensive sweep generator, and found the 1050 well within the +/— 0.25 db spec. For narrower sweep rates, such as 50-100 MHz, the variation we measured with the 1050 supplied to us by Wavetek was in the +/— 0.15 (or better) region.

The 1050 provides either a swept output (over any width from 200 kHz to 400 MHz) or a CW (single-carrier) output. The single-carrier output is useful, in case you have not utilized a sweep previously, for the same functions you might use an RF signal generator for. In the CW (output) mode, the stability of the carrier is about 100 kHz for five minutes of operating time, *according to Wavetek*. Again, we found the stability considerably *better* than this with a counter (frequency) connected to the output; approximately 10 kHz for five minutes operating time at 50 MHz where we ran our check.

Built into the 1050 are two output attenuator controls. One has six positions and is in 10 db steps (0 db to 50 db of attenuation). The other is a 0-20 db vernier control (see photo of front panel). The 0-20 db vernier control reminds us of the i.f. gain control on the front panel of the Blonder-Tongue FSM-2 meter, because it has no panel markings behind or around the control. There is a small dot on the knob, apparently to tell you where the knob is on an unmarked panel behind. *Our first preference*, for this vernier control, would be a front *panel marked scale* calibrated from 0-20 db. If Wavetek finds that the calibration between



WAVETEK 1050 SWEEP with 1, 10, and 50 MHz markers

units varies substantially, and they feel *uncomfortable* marking this vernier control from 0-20 db, then at least a series of panel markings with reference numbers would be useful; the operator of the 1050 could calibrate his own vernier dial.

It would be good at this point to re-emphasize the price of the 1050: $495, less your choice of optional markers. The price needs to be re-emphasized because (1) it is *lower* than anything else available on the CATV market today, (2) we, like you, run the risk of trying to compare the unit *across the board* with other sweepers costing two or three times the $495 price tag.

Wavetek has put the 1050 together utilizing some pretty clever solid-state technology and by utilizing many basic building blocks which they happen to have around the factory, building blocks which show up in identical or similar form in other Wavetek sweep machines.

Because Wavetek has a pretty extensive line of solid-state sweep equipment, and because anyone who builds more than one version of anything today had better double up on parts and module usage wherever possible, the 1050 is really as clever a *packaging job* as much as anything else. By borrowing modules from other sweeps, Wavetek has been able to pass the savings along to you, the user, and to break through the CATV sweep price barrier at the same time. In the end, the CATV industry benefits because the price tag puts the sweep into the marketplace at a level where people who need sweeps but who feel they could

1050 Manual A Winner

Often when a new piece of equipment is introduced, in the rush to get to the marketplace, the manufacturer hurries the unit into shipment without a **complete** manual enclosed.

This is **not** the case with the 1050, which has a **very** comprehensive manual. The manual not only adequately covers theory of operation, setup and operation, but it also provides a wealth of practical trouble-shooting data. Because **CATJ** has found so many other units lacking in the manual department, we were especially pleased to see such a fine effort from Wavetek for the 1050.

not afford one until now will upgrade to sweep technology for system maintenance.

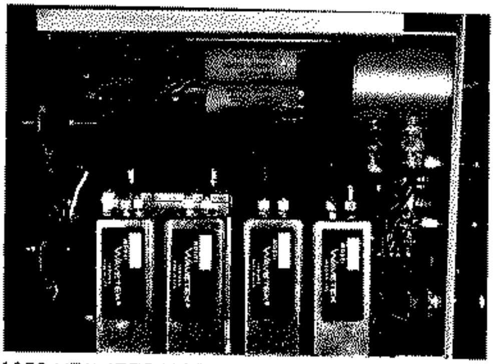
That much said, let's move on with what the 1050 does, and how we are tempted to backseat re-engineer the box with plenty of free advice for the folks at Wavetek. One of the first things you notice is that the 1050 draws all of 15 watts on 115 VAC (the unit will operate from 115 or 230 VAC at the throw of a switch). Now 15 watts is not very much power. Next if you check the manual you find that the power supply puts out 30 volts *DC* and is regulated down to an operating voltage maximum of 18 volts DC. This brings up the interesting *possibility* of line powering the 1050 from virtually any place in town off of your CATV trunk or feeder lines.

To accomplish this handily, the CATV system would locate a convenient source of *30 volts DC* in a line amplifier, and through an external power insert jack *not presently located* on the 1050 (i.e. it would have to be *added*), be able to power a 1050 at will from *any* spot in town. To make this change at the factory, Wavetek needs a jack and diode. To make this change at the CATV plant, the system would have to open up an amplifier case and alligator clip into the amplifier supply. Or *a progressive amplifier manufacturer* might add this external powering capability to their amplifiers. We bring this up at this point because it appears that *more and more highly IC/solid-state test equipment is coming on the market.* Being tied to sometimes-not-so-handy 110 VAC outlets *is hardly necessary* when we have 30 or 60 VAC available *all over town* in our own systems; and the ability to plug in could be accomplished so easily.

The basic $495 priced package is complete. Markers are optional, and they are available (at approximately $60 each) in ones, 10's and 50's, plus whatever else you can dream up. There are provisions for six plug-in marker modules. The front panel switches (push in/out) select the markers you desire for the display you are working with. Markers are developed using the birdy bypass technique, and there is a plug-in provision for an external variable marker (such as from a signal generator) as well. Marker size and marker width are adjustable with front panel controls; size from 4 mV to 4 volts and width from 100 to 400 kHz. If you intend to utilize an external signal generator for a marker, it must have .1 volt (RF) level at 50 ohms to produce a marker on the display. If you select the 1, 10 and 50 MHz markers (total of three), which is pretty standard, you have approximately $675 total tied up.

Basically Modular

As the electronics world becomes more and more IC-ized, *the block diagram* for any piece of equipment begins to look more and more like *the real unit.* In other words, as IC's take over the complex world of dozens or hundreds of discrete parts, you will eventually end up with a piece of PC board with etched inter-stage connec-



1050 UTILIZES MODULAR APPROACH for most of basic functions

tions (i.e. hard wiring replacements), interconnecting the IC devices. As the interior photo of the 1050 shows, this unit is well on its way to that eventual day. See also Diagram 1.

The swept RF output of the 1050 originates in the M9U sweep oscillator. The ramp voltage required to drive the sweep oscillator comes from the sweep drive circuit. The (AC) line-locked triangle drive circuit for the scope horizontal and for the sweep-drive circuit comes from the sweep-rate circuit.

The power transformer has two secondary windings to provide AC power to the two full wave rectifiers which supply about 30 volts DC to the 18 volt DC regulators.

The sweep-rate circuit generates a line-rate triangle wave and a synchronized square wave. The sweep-drive circuit converts the sweep width and frequency programs into the appropriate signal for driving the sweep oscillator module.

An oscillator leveler circuit contains an "error amplifier" for the sweep oscillator which monitors and maintains the RF (output) amplitude constant over the frequency range of the sweep. The 0-20 db vernier control is located in this circuit.

The sweep (output) signal for the 1050 is generated by heterodyning the output of the UHF (internally generated) sweep oscillator against the out-

Do's and Don'ts

There are a few tricks in using sweep systems which old-timers do as second nature but that newcomers to sweep techniques may not know about.

(1) **RF OUTPUT CABLES**—Keep output cables from the sweep (source) to the test unit as short as possible, under three feet;

(2) **CONNECTORS**—the 1050 has BNC fittings; it is **far** better to go to the trouble of making up BNC-59 patch cords than to try to use BNC/F transition fittings (which are usually a **sorry** lot, especially for shield/ground connections);

(3) **DETECTOR**—Virtually anyone can throw together a detector to demodulate the sweep signal. Steve Richey tells you how in a companion piece here this month. But throw-together detectors have a strange habit of being nonflat. Check your homebrew detector on several units (i.e. wideband amplifiers) which you **know** to be flat to be **sure** your detector is flat. A detector with poor high-band (for example) response will cause you to misadjust every wideband amplifier you look at, unless caught and corrected.

(4) **INPUT LEVELS**—At nearly +65 dBmV, the output of a 1050 will clearly drive a 25 db gain-line amplifier into convulsions. Always **match** the input level of the amplifier under test, with the sweep output level, to insure that you do not overdrive (i.e. into distortion) the unit you are testing.

(5) **LOW LEVELS**—The opposite of too-high levels is (too) low (sweep) levels. At very low levels, where required, it is best to use double shielded cables and common grounding between the sweep, scope, amplifier, detector. Ground loops at low levels cause hum pickup, which distorts displays. It may be necessary, if the scope is grounded at the vertical input, to **raise** the horizontal input ground terminal above ground.

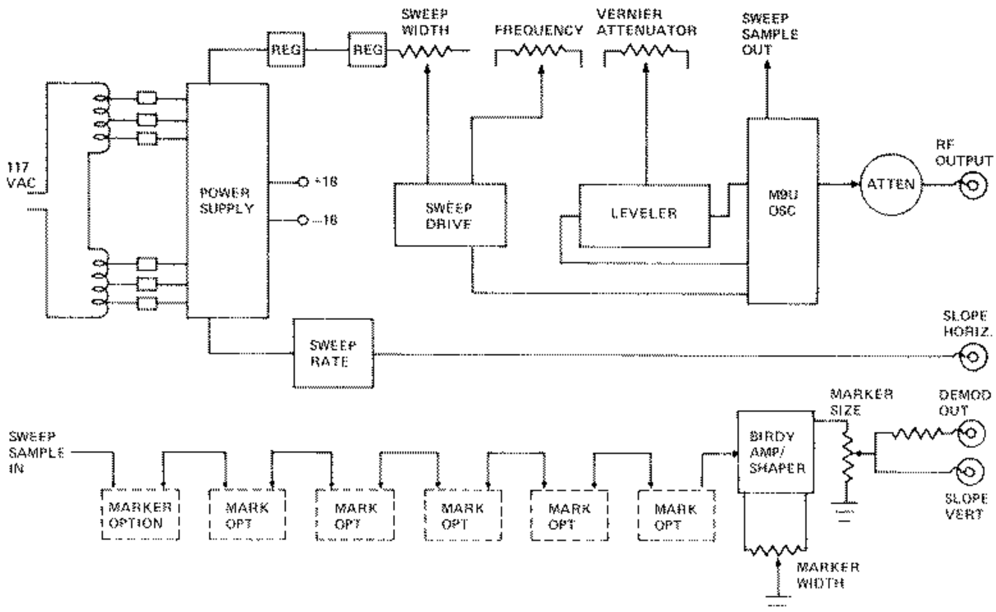


DIAGRAM 1

put of a 1 GHz fixed-frequency carrier. The output of the "mixer" (where the 1 GHz fixed oscillator runs into and mixes with the UHF sweeping oscillator) is the *difference* frequency of the mix, and it is amplified by three wideband (1-400 MHz) amplifier stages. Vernier RF level adjustment is provided by a pin diode attenuator, controlled by the oscillator leveler (which is regulated by a voltage from the output [RF] monitor diode). It all sounds very exotic if you are still in the 601 sweep era, but then electronics has changed a great deal in 10-12 years! Even the familiar "power-on" pilot lamp is missing from the 1050, replaced by its newer low-current replacement, the LED (*pilot lamps*, you see, draw up to 15 watts *each*!).

General Operating Impressions

The 1050 offers something for virtually every system operation. For the small system (and here we mean the system with 250 subscribers or less), the 1050 offers you the opportunity to move into the signal/sweep era with a minimal outlay. If you have a DC coupled scope, a detector (see companion article) and virtually any type of external RF signal generator (for a variable marker), you have the makings of 1975 state-of-the-art. If your system already has a bench full of sweeps, the 1050 with a companion low-cost DC coupled scope (such as the Telequipment [Tektronix] D66) or a battery operated scope will put you into the sweeping business with your field-service trucks.

The 1050 weighs virtually nothing (seven lbs), and while this may be an advantage (for comparison, a 727 weighs 15 pounds), the 1050 may create some inventory-control problems. In addition to being lightweight, their 4" x 9" x 9.5" profile is easy to overlook. We lost it twice just taking it home, under an issue of *CATJ* on the front seat with us!

BUILD YOUR OWN SCOPE DISPLAY DETECTOR

$6.00 In Parts

The detector in a sweep set-up can cost you from $25 to $150, if you go into the marketplace. However, for about six dollars in parts and an hour of your own time, you can build your own and perhaps add a few wrinkles found in only the more expensive versions (if at all), thereby expanding the usefulness of your scope/sweep system.

Detectors come in two basic versions: the feed-through detector (Diagram 2) and the terminated detector (Diagram 1). Both have special features, as we shall see. The basic difference between the two is that on the terminated model there is only one input (terminated at the input with 75 ohms to ground), while on the feed-through version the termination is *removable* for device-application in numerous additional testing applications.

The basic terminated version is shown in Diagram 1. It consists of a terminating resistor, a diode and filter capacitor, and a resistor. The slightly more complicated voltage doubler approach (twin diodes) with an external (removable) terminator, *the so-called feed-through approach*, is shown in Diagram 2.

by:
Steve Richey
Richey Development Company
Oklahoma City, Oklahoma

In the feed-through version, the RF input is bridged through the termination *externally*. With the addition of the input .001 capacitor and a second diode, the unit becomes a voltage doubler, which means that you end up with approximately 3 db increased DC output level. This is handy for driving scopes where you always seem to be on the bottom *border line* of having adequate vertical sensitivity with the scope.

Note in the photo of the feed-through version that all leads internal to the detector are kept as short as practical. This is the *only* warning; otherwise, follow your common sense and good construction practices. The parts required probably are lying around your own junk box. The 1N82 (or 1N82A) diodes are the common UHF tuner-type diodes found in abundance at most TV service shops (and in UHF to VHF converters, such as the Blonder Tongue UX-3). For ease of installation, repeatable performance, and proven RF detection ability, the 1N82 family of diodes is recommended; i.e. do *not* substitute unless you *know* the substitution is guaranteed to be better for this application.

Both detectors, as shown in schematic form, provide a positive output voltage. If you need a negative output voltage, for some reason, simply reverse the polarity of the diodes.

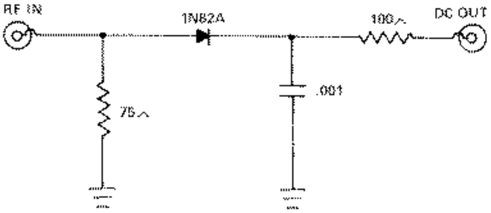


DIAGRAM 1

Detector Uses

Other than the most common use for a detector, which is as a demodulating device in a sweep set-up, many other everyday uses for the detector are possible.

For example:

(1) *Observing Video Wave Form*—Changing the .001 output (at DC) capacitor from a .001 to a 10 pF capacitor, and eliminate the 100 ohm resistor (see Diagram 3). With this simple change, the video output of a signal processor, modulator, etc. can be sampled for signs of sync clipping, modulation percentage, and other maladies;

(2) *Measuring Return Loss*—The feed-through detector can be used to measure return loss, as shown in Diagram 4. To make this measurement, insert attenuation into the variable pad box *equal to ½ of the amount of return loss you wish to verify* (i.e. if you believe the return loss to be 16 db, or that is the spec which you are going to verify, insert/switch in ½ of that value, or 8 db, of pad/loss

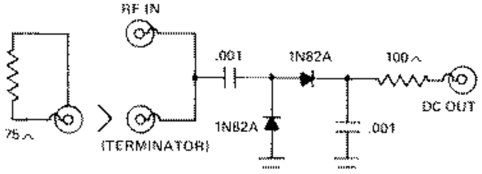
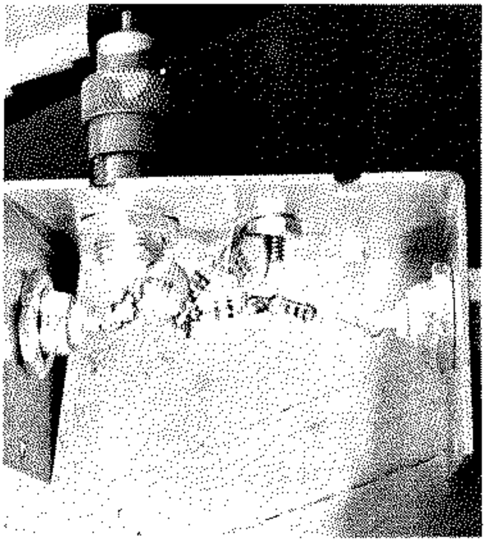


DIAGRAM 2



KEEP LEADS SHORT, especially on RF-IN end of of detector

into the pad box). Note the peak-to-valley response of the display, as a function of amplitude, on the scope display screen (i.e. make note of the upper and lower limits on the scope screen of the sine wave display).

Now take *all* of the attenuation (8 db in our example) out of the pad box *and connect the device under test* to the end of the 2 db of cable line. If the second scope display *is equal to or less* amplitude than your initial display with the pad box attenuation switched in, the return loss is 16 db (or better).

However, if the second display has a *greater* (scope screen display) amplitude than the reference display, use the variable attenuator to *switch in pad* (1 db at a time) until you *return* the display to the *original* reference level. The amount which you have to switch into the variable pad box to bring the display *back* to the *original* reference is *subtracted* from your original goal (16 db), and that is the return-loss match of the device. For example, having to switch in 2 db of pad to bring the second display to the original reference display results in 16 minus 2 db, or a 14 db return-loss match.

(3) *Checking Antennas*—By substituting your downline from the antenna (can*not* be performed on antennas *with* pre-amps) for the 2 db of cable shown in Diagram 4, the termination and basic frequency response of an antenna at the end of a downline can be checked. The procedure is *exactly* the same as with measuring return loss (number three), just given.

(4) *Cable Length To Shorts/Opens*—The length of (trunk, distribution) cable to a short or open can be calculated with a fair degree of accuracy with the *same basic set-up* outlined for measuring return loss. By connecting the (unknown) length of cable *in place of* the 2 db of cable (delay line) shown in Diagram 4, the spacing (in frequency) between successive dips on the display is a measurement of standing waves (i.e. indicating an open or shorted condition). Into your set-up *insert a variable marker* or signal generator (RCA WR99A, Mid State MC-50, Measurements 950, DBC FST-4, etc.) to indicate the exact frequency of each "dip" (see Diagram 5). If you determine that from "dip to dip" is (for example) 1.5 MHz, *the length of cable* from the point where you are plugged in, *to the short or open* can be computed as follows:

$$\text{Distance} = \frac{984 \times (\text{velocity of cable prop})}{2\ (\text{frequency})}$$

If we assume a cable velocity of propagation of 0.82 and we have 1.5 MHz between successive "dips," the equation works out:

$$D = \frac{984 \times .82}{2\,(1.5)} \quad \text{or} \quad \frac{806.88}{3} \quad \text{or} \quad 268.96 \text{ feet}$$

This can be a very handy tool; I have personally used it to locate a broken center conductor while installing new cable.

Good luck—*and may all of your detectors be flat ones!*

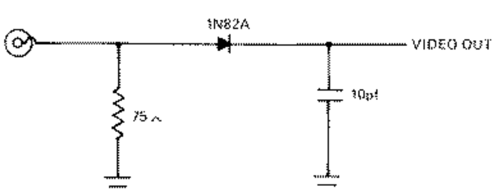


DIAGRAM 3

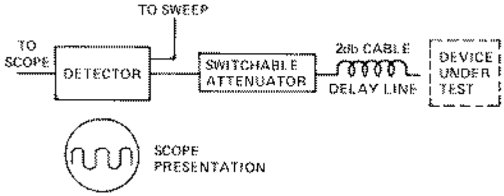


DIAGRAM 4

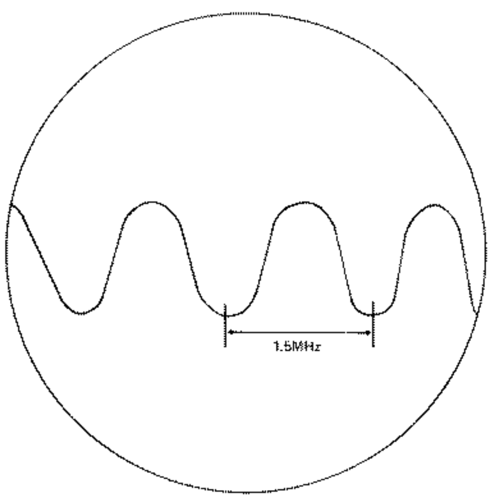


DIAGRAM 5

TECHNICAL TOPICS

ARVIN REPLIES

"The February CATJ included an evaluation of the Arvin 500B Signal Level Meter. While we at Arvin feel that **CATJ** did an excellent job explaining our new meter, there are a few points which we would like to clarify for the industry.

First, the report stated, 'If you operated the unit while it was plugged in and charging, you would be drawing out 120 mA per hour and replacing only 100 mA per hour, thereby losing 20 mA of charge for each hour operating.' This is not the case, since the charger circuit provides power to the unit as well as the battery. The battery charging is **independent** of the operation of the meter (on 110 VAC).

In the previous four issues of CATJ, several meters were evaluated. **CATJ** found it necessary to draw the reader's attention to meter linearity and detector efficiency (errors) a total of 27 times. Since the Arvin 500B does not have any meter linearity error or detector efficiency error, we think **CATJ** should have emphasized this feature that is not provided by any other meter manufacturer.

The report also suggests that our 355 MHz diplex filter must be quite flat from 355 to 359 MHz to preserve accuracy between video and audio carriers. The actual response of this filter is flat 350 MHz to 365 MHz; therefore there is no problem and the accuracy between audio and video is unaffected. **CATJ** expresses concern in that the aural carrier would be filter sloped down or perhaps peaked upward out of proportion to its associated video carrier. This would be true if the 355 MHz filter were only 4-5 MHz wide, but since the 355 MHz filter is 15 MHz wide, this is not a problem at all.

In a paragraph near the end of the report **CATJ** says, 'The argument Arvin makes for absolute accuracy is an interesting one. Meter inaccuracies are primarily due to detector efficiency changes, meter-element non-linearities, and meter DC amplifier non-linearities and temperature environment, they theorize.' Again, I would like to note that **CATJ** found it necessary to discuss the first three problems 27 times in previous articles, noting these potential errors cause major concern or problems in existing meters on the market today. Apparently **CATJ** thinks this argument is more than just interesting!

While **CATJ** says the circuit is very straightforward and that anyone who has an electronics parts house in a city of 50,000 or more could probably duplicate the meter on its own, **CATJ** failed to mention that Arvin has been granted six basic electrical patents on the meter and is currently negotiating for five more. A copy of the Arvin patent and a letter from the U.S. Patent Office was shown to **CATJ.**

Since **CATJ** ran a linearity test on all other meters from +10 dbmv to —10 dbmv, Arvin would like to see the same chart published on our meter. Accordingly, we have **on our own** run these tests and here are the results:

ARVIN-RUN 500B SCALE ACCURACY TESTS

Input Level True	CW Carrier Reading	Modulated Carrier Reading
+10	10 +/— .1	10 +/— .1
9	9 +/— .1	9 +/— .1
8	8 +/— .1	8 +/— .1
7	7 +/— .1	7 +/— .1
6	6 +/— .1	6 +/— .1
5	5 +/— .1	5 +/— .1
4	4 +/— .1	4 +/— .1
3	3 +/— .1	3 +/— .1
2	2 +/— .1	2 +/— .1
1	1 +/— .1	1 +/— .1
0	0 +/— .1	0 +/— .1
—1	—1 +/— .1	—1 +/— .1
—2	—2 +/— .1	—2 +/— .1
—3	—3 +/— .1	—3 +/— .1
—4	—4 +/— .1	—4 +/— .1
—5	—5 +/— .1	—5 +/— .1
—6	—6 +/— .1	—6 +/— .1
—7	—7 +/— .1	—7 +/— .1
—8	—8 +/— .1	—8 +/— .1
—9	—9 +/— .1	—9 +/— .1
—10	—10 +/— .1	—10 +/— .1

Because the 500B has no meter linearity error, detector efficiency error or DC amplifier error, all readings on the meter are within + /— 0.1 db of the original calibration of the meter. The use of high-quality rotary attenuators preserves the accuracy of the meter at all levels. This is the reason the Arvin Signal Level Meter is a high-accuracy instrument that can be trusted to + /— 0.1 db from calibration at any point from —30 to +60 dbmv.

Again, we would like to congratulate **CATJ** on an excellent coverage of our meter. Since **CATJ** elected not to let the manufacturers review the articles before publication, it is necessary for Arvin or any other manufacturer to write a response to these articles. We feel that had Arvin been given the chance to review the article before publication, these points could have all been straightened out, and there would be no differences when the first article was published.

Finally, I have elected not to say anything about modulation error at this time. I would like to analyze this before making a statement."

Jack Cauldwell
Dir. Cable Operations
Arvin Systems, Inc.
Dayton, Ohio 45403

Jack:

Healthy differences of opinion keep the world turning around in an interesting direction. Our policy is, as you stated, to prepare an honest user-oriented review of products tested, and, as you have suggested, to make space available for reply responses from the manufacturers in our Technical Topics column. By submitting prepared reviews in advance to manufacturers, we feel we

would be compromising our responsibility (self-assumed, we admit) **to our industry. We also noted early in the four** (plus) **part on SLM/FSM devices that** "nobody has yet produced a perfect anything: and that includes equipment reviews." **CATV as an industry has suffered for years by not having an open forum for conscientious discussions of equipment design merits; CATJ is attempting to fill that void when the opportunity offers itself, in conjunction with a more detailed discussion of some particular theme. We will, for example, begin an extensive series on antenna designs in June, and we will be reviewing a few antennas in the process.**

Jerrold Replies

Your series of articles in **CATJ** on field strength meters was excellent. In particular, the review of the 727 FSM was good, which limits our comments to a few.

First, we would like to cite an additional capability of the 727 which was not mentioned. The plug-in module Model SB 727 extends the frequency range of the 727 to include super-band frequencies (216-300 MHz).

A second comment addresses the absolute level and accuracy tests. We believe that these tests were not representative of what we normally get. We will check the unit out for these specifications when returned. In the meantime, to reassure ourselves of this statement, we checked four stock units and found them to all be within the absolute specifications. These same four units were also found to be within the scale accuracy specs from +10 to —5 db on the scale. Below this, where the scale graduations are 5 db apart, the units we checked were 0.5 db out of spec, which we are looking into.

The third comment relates to reading and interpreting the scale to the left side or below "0." This is only required when signals are below —30 dBmV. It then requires a little more eyeballing to read within specs. To overcome this measurement range potential problem, with signals lower than —30 dBmV, down to as low as —60 dBmV, we recommend our low-noise preamplifier, Model VSX-92S, be used ahead of the 727. It should be noted that the accuracy will start to drop off at lower signal levels (—40 dBmV with the VSX-92S) **unless** the calibration curve supplied is used to provide calibration.

Wm. H. Lambert, V.P.
Division Manager, CATV
Jerrold Electronics Corp.
Horsham, PA.

McGRAW-EDISON 950 CALIBRATOR

"We are pleased to comment with regard to your field strength meter article in the January CATJ. Congratulations on an article that describes the Measurements Model 950 Calibrator in easy-to-understand language. Our only correction is the address of our company, as follows:

McGraw-Edison Company
Edison Electronics Division
Grenier Field Municipal Airport
Manchester, N.H. 03103

Your article raises the question as to our 950 calibration accuracy, inasmuch as the operating manual specs the unit accuracy at only 100,000 microvolts (+40 dbmv) output. Our attenuator design is based upon the generally accepted premise that the voltage in a piston attenuator is mathematically proportional to the distance between the generating coil and the pick-up loop inside of the tube. In turn, the output dial, which drives the attenuator, slides along the tube through a gear mechanism and is calibrated in microvolts and the dbmv scale. The mechanical drive mechanism and the dial calibration markings were calculated and calibrated during the initial design stages. In production, all attenuator mechanical parts are held to tolerances of well within +/— 1%, and they contribute relatively little error to the overall r.f. output accuracy. The output level of each instrument is set at 100,000 microvolts within an accuracy that is in reality much better than the published +/—0.75 db. We do this with a periodically checked sensitive r.f. millivolt meter with accurate digital readout.

Outputs of various 950's at levels other than 100,000 microvolts and at various frequencies are often checked during proof-of-performance tests, and we find that instruments in normal operating conditions are well within our accuracy specs even after long periods of continual use."

Kent Threlfall
McGraw-Edison Company

PICOWATTS REVISITED

"With respect to the alleged plot to do away with the dBmV scale in CATV (see December CATJ, Page 6), I think there is a need for a better understanding on your part as to what has really happened (or not happened) so far.

Panel 1 of C-TAC has simply come in with a recommendation that since CATV levels, primarily in the head end, are much lower than 1 mV, that a new level of power be utilized as the basis for measurements and specifications. This unit is called the dBc, and it would be comparable to the dBmV, except that a dBc is one microvolt into 75 ohms, or 1/75 picowatt.

One dBc is simply 60 db down from a dBmV. Or, one dBmV is 1/75 microwatt; one dBc is 1/75 picowatt.

A dBmV is not 1.333 picowatts (as CATJ suggested); it is actually 1/75 times 0.000001 watts, or 0.01333 microwatts, or 13,333 picowatts.

In the unlikely event that the dBc is adopted by the CATV industry, it will not be necessary to recalibrate and rescale instruments in present use. The relationship is a simple 60 db down from dBmV."

O.D. Page, P.E.
Bethesda, Md.

Your explanation of dBc and its place in the CATV world is quite plausible. However, our concern was not with dBc vs. dBmV; rather it was with the flat statement made to CATJ by a couple of FCC (Cable Bureau) personnel that in the currently underway re-write of Part 76.605 (technical specifications for systems) that the new specifications would be referenced only in picowatts (not dBmV or dBc). The explanation for this, from the Commission, was that everyone they regulate has power measurements (i.e. watts); and that CATV should also (in fractions of a watt

delivered as power, not as voltage as we now do it). C-TAC Panel 1 may have meant well with the dBc suggestion, but someplace between your suggestion and the re-write of 76.605 now underway, the action of Panel 1 is being referenced by the FCC as their reason for the change. CATJ suspects that if the new Part 76.605 comes out requiring that all systems deliver "not less than 13,333 picowatts across 75 ohms" that your Panel 1 people will be just as irate as the rest of the industry!

Editor

DON'T TRUST ME...

"In your excellent report on lightning protection in the February CATJ, you note that the SPM is a 'trust me I am working' kind of device and that 'unless they fail shorted, you have a difficult time checking them when they are in the air.' Actually, **the SPM fails,** if it fails, **open,** not closed. Thus as you say 'checking while in the air is difficult,' but for just the opposite reason you give! Our experience with the SPM is that they do **not** fail; or at least we have **yet** to find one that failed, after several years of operation."

Jim Palmer, President
C-COR Electronics, Inc.
State College, Pa.

CURSED 3 DB

"Reference December CATJ, and the diagram for permissible signal level variations (76.605 [a] [5]) appearing on Page 20. The text states (correctly), 'The visual signal level on each (Class 1) channel shall not vary more than 12 decibels within any 24-hour period and shall be maintained within (i) three decibels of the visual signal level of any visual carrier within 6 MHz nominal frequency separation, and, (ii) 12 decibels of the visual signal level on any other channel.'

Then you note, 'See Diagram 1 here. This diagram (Page 20, December) shows one of the worst case (but passable) number sets which you can measure, and pass.'

Unfortunately, the diagram shows a 15-db (not 12 db) variation between channels 3 and 5, and between 7 and 12. So you are 3 db out of spec!"

Edgar Geiman, Manager
Coldwater Cablevision
Coldwater, Mi.

Egads! Curse those decibels! Let's see, how many picowatts would that be?

ONE MORE VSM-1 USE

"Reference your articles on calibration instruments and on the VSM-1 in the January CATJ; we here at EMCO CATV have found still another use for the VSM-1 and the Delta FSM-C. We use them together with a Heath SM110A frequency counter to measure frequencies of carriers on the system.

We split the FSM-C output to the (1) counter, and, (2) one input of a second mixer. The second input of the second mixing device is driven by the signal we wish to measure. The combined signals of the FSM-C and the to-be-measured carrier are fed to the VSM-1.

The FSM-C is frequency tuned so that both the FSM-C A0 marker carrier and the TV (or other) carrier are superimposed (i.e. on same, zero-beat, frequency) as displayed by the VSM-1. The dispersion of the VSM-1 is narrowed while keeping the two signals zero-beat with one another. After spreading out the display (i.e. adjusting the dispersion for maximum display width for the two zero-beat carriers) the FSM-C is fine-tuned for maximum display between phase nodes (i.e. exact zero-beat is obtained with the FSM-C dead on top of the frequency of the carrier to be measured, as shown by the zero beat condition displayed on the VSM-1); and the frequency of the FSM-C is read out by the Heath SM110A counter. Measurements of carriers with known (stable) frequencies have led us to the conclusion that accurate frequency measurements to +/— 1kHz are possible using this technique. As you noted in your article, we found the FSM-C voltage control could be used advantageously for fine frequency adjustment for exact zero-beating of the two carriers."

Raymond N. Bostock
Chief Technician
EMCO CATV, Inc.
Manchester, Vermont

MORE SLM CALIBRATION

"Your January issue carried an excellent piece on calibration of FSM/SLM devices, although I believe that you skirted around the problem of establishing a reference carrier level for modulated vs. CW carrier reference signal sources. Here is how we handle the problem. Using a spectrum analyzer set for 300 kHz dispersion, we carefully establish the peak sync tip level of a TV signal from a modulator. Then we bring our Measurements 950 CW source level up to that same spectrum analyzer display level. This becomes the reference level for the FSM/SLM calibration. Typically, we find that on the 727 meter, it may be as much as 1/2 db low (i.e. modulated level vs. CW level) at full scale, and as much as 1.5 db low at half (0 on the scale) scale. We have approximately 60 FSM/SLM devices, and they traditionally read lower (by 0 to 1.5 db lower).

Jerry Laufer
Engineering Manager
Gill Cable, Inc.
San Jose, Ca.

The "G-Line" Community TV System

By ROBERT B. GARY

Fig. 1. TV reception by "radiation." One subscriber merely placed his yagi near the "G-Line" and picks up good signals.

The use of a novel transmission line has cut the cost of system installation and maintenance at Helena, Montana.

THE economies of most community TV installations dictate that the operator bring the TV signal from the antenna to the community before he can start collecting his installation fees. This means that the initial investment involves the cost of erecting the antenna and installing the transmission line and its associated amplifiers.

Maintenance of the system is largely confined to the servicing of the amplifiers and this item is, therefore, a direct function of the distance between the antenna and the community. This article will describe a new method of bringing the signal to the community, a method which is far more efficient and economical than the conventional cable systems.

Coaxial cable has an attenuation on the order of 20 db per 1000 feet on the lower TV channels. This means that for sound design at least two amplifiers are required per mile. In addition to the initial cost of the amplifiers and their maintenance, in many instances a special power cable must be strung to these amplifier sites. In some localities, therefore, consideration was given to a microwave relay to bring the TV signal from the mountain to the town. FCC regulations permit public utilities, like *A. T. & T.*, to lease their microwave facilities to community TV systems but forbid the community operator installing his own microwave link. As a result, many community TV installations remain paper projects.

Television reception is not possible in Helena, Montana, but only 15 miles away is McDonald Pass and the Continental Divide, and channel 13 can be picked up there from Missoula. By conventional coaxial cable methods the 15-mile haul would cost $40,000 to $50,000 just for the initial installation.

Helena was fortunate in having Bruce Hamilton, an alert engineer, in charge of its community TV project. He had read about the "G-Line" and realized that this technique might solve Helena's transmission problem. After some study and investigation, Mr. Hamilton started on the project of installing the first "G-Line" in a community TV system.

The "G-Line" is named after its inventor, Dr. George Goubau, who developed this single-wire line for the U.S. Signal Corps. (Details on this line were given in Leonard Lieberman's article, "The G-Line Antenna Lead-In," in the April 1955 issue of this magazine). Fundamentally, the characteristics of this line are those of a coaxial cable of fixed dielectric except that the outer conductor is placed at infinity. By choosing the proper relationship between the inner conductor and the surrounding dielectric diameter, the mode of wave propagation is largely axial. It is only necessary that the single-wire line be fed from a coaxial system by means of a carefully designed "launcher." This is, effectively, a cone with the center conductor at its apex and the outer conductor making the transition from the coaxial cable to the infinite spacing.

Fig. 3 shows a typical "launcher" as used in the Helena installation. The "G-Line" has some remarkable properties. Its losses at the lower TV channels are on the order of 10 to 20 db per mile depending on the particular installation. The installation of the single-wire line is slightly tricky. When the line is about a half wavelength from the pole or other object, the loss at that point will be .05 db. Losses due to bends in the line become appreciable as the corner is made sharper. Theoretically, the db losses vary with the square of the bending angle and whenever bends are required they must be as gradual as possible. Another important characteristic of "G-Line" is that, theoretically, there is very little radiation. In actual practice Mr. Hamilton found that the radiation from the single-wire line was a maximum of 1.5 microvolts-per-meter at a distance of ten feet and this was at a point of greatest signal energy level. This factor is confirmed by the photograph of Fig. 1, which shows a rather unique method of tapping off a TV line. A home owner along the route of the "G-Line" simply placed his yagi antenna close to the wire and got good TV reception. This method has the operator's sanction since the regular rental fee is paid by this "radiation subscriber."

The channel 13 signal from Missoula is received by a conventional antenna array and amplified before it is converted down to channel 4. This conversion was suggested by the poor performance of the channel 13 strip amplifiers which were tried first. The "G-Line" itself is more efficient at the higher frequencies but the amplifier considerations outweighed this feature. For channel 4 transmission, the maximum diameter of the "launcher" is 58 inches with a taper angle of 45 degrees. The inner conductor of the "G-Line" is #8 Copperweld and the dielectric is brown pigmented polyethylene with an outer diameter of .253 inch.

Although the theoretical distance from foreign bodies should be on the order of half a wavelength, for practical reasons the wire was suspended about 15 inches below the lowest crossarm of the telephone poles belonging to the Mountain States Telephone trunk line. In most straight sections the line is suspended by ¼-inch nylon rope as shown in Fig. 2. At some bends 15-inch polystyrene rods are used to brace the line horizontally. The telephone poles from McDonald Pass (altitude 6000 feet) to Helena (3000 feet) predate the road and therefore run along the road at only a few points. Distances between poles vary and the line crosses the new U.S. Highway 10 several times. Because power is not readily available at all points along the line, the line amplifiers are located at unequal intervals and the longest stretch of "G-line" is about 2.5 miles between amplifiers. On that stretch the total losses over 2.5 miles are only 53 db.

A total of nine line amplifiers is required to cover the 15-mile stretch. Mr. Hamilton found it necessary to space the receiving and transmitting launchers about 120-feet apart at the amplifier stations in order to avoid ghosts caused by feedback. Recent Signal Corps tests seem to indicate that "launchers" can be placed back-to-back without appreciable separation and it may well be that some mismatch exists in the Helena system which causes this feedback problem. A typical horn and associated amplifier are shown in Fig. 4, and it is clearly apparent that the output of the "launcher" apex goes through the RG-11/U to the conventional line amplifier.

In Helena, the signal is distributed to over 500 homes by means of RG-11/U, double-shielded coaxial cable and conventional distribution amplifiers. A total of 70 miles of RG-11/U has been used to date in Helena just to hook up subscribers to the distribution amplifiers. The installation fee is $125.00 with a monthly tariff of $3.75. The major initial investment, as in all community TV projects, was the cost of bringing the signal down from McDonald Pass. While conventional coaxial cable and amplifiers would have cost at least $40,000, the actual cost of installing the 15 miles of "G-Line," including the price of the wire itself, the amplifiers, antennas, power connections, etc., was only slightly over $12,000.

The weather conditions at the Continental Divide are probably the most severe, with regards to snow and ice, in the country. During the past winter, however, the signal was lost for only half an hour when an inch of wet snow accumulated on large portions of the line. As soon as the snow had melted or fallen off, the signal was restored. Since there is no outer conductor, the problem of moisture seeping in or condensing between the outer conductor and the dielectric does not exist. The outer polyethylene jacket has, in other applications, proven to be almost impervious to weathering for a considerable time.

Helena TV Inc., the operator of this pioneer "G-Line" community TV system, is licensed by *Surface Conduction Inc.* of 521 Fifth Avenue, New York, the company which holds all commercial rights to Dr. Goubau's patents. So successful is the Helena installation that its owners are now intent on

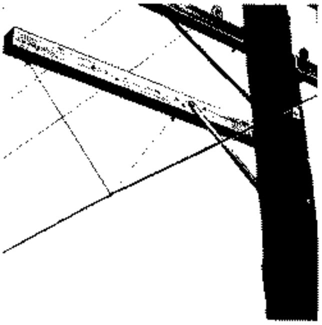


Fig. 2. The "installation" of the "G-Line" consists, for the most part, in suspending the line from the crossarm of a utility pole by a quarter-inch nylon rope.

tackling a 27-mile line in the area.

Other community TV systems which are planning to use the "G-Line" include the *Neighborhood TV Corp.* of Owen Sound, Ontario. Here the TV signal will be received at a suitable high point as close to Toronto (150 miles away) as possible and then transmitted to Owen Sound along the telegraph poles of the *Canadian Pacific Railroad.*

The most recent application of the "G-Line" to community TV was in September 1956 when an "open wire" transmission line was replaced by a single wire "G-Line" extending over 8000 feet in the Port Jervis community TV system. *Port Video Corporation*, owners of this system, found that this changeover resulted in improved performance.

This new "G-Line" installation extends (apart from poles belonging to *General Telephone* and *Rockland Light and Power*) over system-owned poles separated by 600 feet or more, thus showing the adaptability of the line to varied local conditions. —30—

Fig. 3. One of the "launchers" used in the Helena installation.

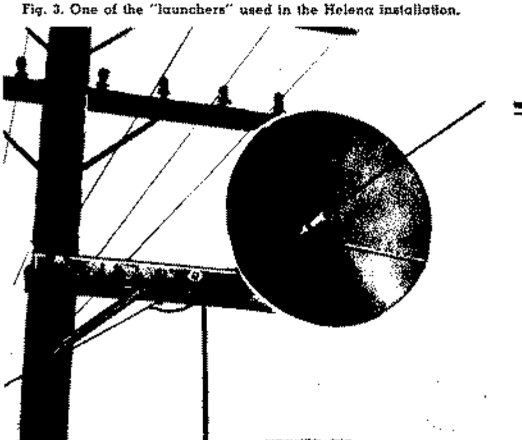


Fig. 4. Nine horns and amplifiers cover the 15-mile stretch.

cata ASSOCIATE MEMBER ROSTER

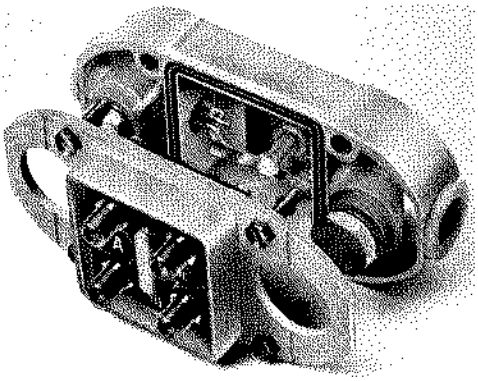
In recognition of the untiring support given to the nation's CATV operators, and their never-ending quest for advancement of the CATV art, the COMMUNITY ANTENNA TELEVISION ASSOCIATION recognizes with gratitude the efforts of the following equipment and service suppliers to the cable television industry, who have been accorded ASSOCIATE MEMBER STATUS in CATA, INC. for 1975.

Anixter-Pruzan, Inc., 1963 First Ave. S., Seattle, WA. 98134 **(D1)**
Avantek, Inc., 3175 Bowers Avenue, Santa Clara, CA. 95051 **(M8)**
Belden Corp., Electronic Division, Box 1327, Richmond, IN. 47374 **(M3)**
BROADBAND ENGINEERING, INC., 850 Old Dixie Highway, Lake Park, FL. 33403 **(D9, replacement parts)**
Burnup & Sims, Box 2431, W. Palm Beach, FL. 33401 **(S2, S7, S8)**
Cable Dynamics, Inc., 501 Forbes Blvd., So. San Francisco, CA. 94080
CABLE NEWS, 2828 N. 36th Street, Phoenix, AZ. 85008 **(S6)**
Cerro Communication Products, Halls Mill Road, Freehold, NJ. 07729 **(M3, M5, M7)**
COMM/SCOPE COMPANY, P.O. Box 2406, Hickory, NC. 28601 **(M3)**
Jerry Conn & Associates, 550 Cleveland Ave., Chambersburg, PA. 17201 **(D3, D5, D6, D7)**
C-COR ELECTRONICS, Inc., 60 Decibel Rd., State College, PA. 16801 **(M1)**
DAVCO, Inc., P.O. Box 861, Batesville, AR. 72501 **(D1, S1, S2, S8)**
DEVINES Trailers & Accessories, Grantville, PA. 17028 **(M9, cable trailers)**
ENTRON, Inc., 70-31 84th Street, Glendale, NY. 11227 **(M4, M5, D4, D5, S8)**
GAMCO INDUSTRIES, INC., 317 Cox St., Roselle, NJ. 07203 **(M5)**
JERROLD Electronics Corp., 200 Witmer Road, Horsham, PA. 19044 **(M1, M2, M4, M5, M6, M7, D3, D8, S1, S2, S3, S8)**
Kay Elemetrics Corp., 12 Maple Avenue, Pine Brook, NJ. 07058 **(M8)**
Microwave Filter Co., 6743 Kinne St., Box 103, E. Syracuse, NY. 13057 **(M5, bandpass filters)**
MID STATE Communications, Inc., P.O. Box 203, Beech Grove, IN. 46107 **(M8)**
OE Manufacturing Co., Box 227, New Berlin, PA., 17855 **(M9, tools & equipment)**
RMS CATV Division, 50 Antin Place, Bronx, NY. 10462 **(M5, M7)**
TEXSCAN Corp., 2446 N. Shadeland Ave., Indianapolis, IN. 46219 **(M8, bandpass filters)**
Theta-Com, P.O. Box 9728, Phoenix, AZ. 85068 **(M1, M4, M5, M7, M8, S1, S2, S3, S8, AML Microwave)**
Times Wire & Cable Co., 358 Hall Avenue, Wallingford, CT. 06492 **(M3)**
TONER Equipment Co., 418 Caredean Drive, Horsham, PA. 19044 **(D2, D3, D4, D5, D6, D7)**
WAVETEK Indiana, 66 N. First Ave., Beech Grove, IN. 46107 **(M8)**

NOTE: Supplier areas are keyed at the end of each listing, as follows:

Distributors:	Manufacturers:	Service Firms:
D1—Full CATV equipment line	M1—Full CATV equipment line	S1—CATV contracting
D2—CATV antennas	M2—CATV antennas	S2—CATV construction
D3—CATV cable	M3—CATV cable	S3—CATV financing
D4—CATV amplifiers	M4—CATV amplifiers	S4—CATV software
D5—CATV passives	M5—CATV passives	S5—CATV billing services
D6—CATV hardware	M6—CATV hardware	S6—CATV publishing
D7—CATV connectors	M7—CATV connectors	S7—CATV drop installation
D8—CATV test equipment	M8—CATV test equipment	S8—CATV engineering

COST-CUTTING TAP INNOVATION—Entron, Inc., 70-31 84th Street, Glendale, NY, 11227 is now offering a new type of CATV line tap which features a housing that connects to the CATV distribution cable by itself, independent of the subscriber-outlet connecting tap plate. Entron President Joseph Ross labels this new approach to subscriber line taps "the first totally new concept in multi-taps for CATV since the CATV industry began." The new product, the Entron SMT A-Line Multi-Tap, should significantly reduce the cost of installing, maintaining, and modifying CATV systems. An exclusive shorting bar between input and output (in-line) ports maintains RF and power (thru) integrity exclusive of any tap-plate being present. The shorting bar disengages automatically when the tap-plate is added and re-engages each time the plate is removed. This is a direct improvement over multi-taps which must be maintained only as compelte units, breaking RF and power integrity each time a change out or addition must be accomplished. With this approach the housing alone can be installed on new cable sections, and the tap plates added as subscriber needs demand. The housing costs approximately one-third as much as the whole tap, resulting in a considerable savings to the new system or new sections. The SMT A-Line Multi-Tap has a patented seized center conductor device, die cast aluminum housing, weatherproof test point access, universal mounting, replaceable F-connectors, and protection against cable disconnect. Full information is available from Entron.



STATE-OF-THE-ART REPAIR SERVICE—Cable Dynamics, Inc., 501 Forbes Blvd., South San Francisco, CA. 94080 (415/873-2906) announces a new professional approach to technical support for the nation's CATV systems. Incorporating the latest in test equipment technology and many years of CATV practical experience, Cable Dynamics Services head Joe E. Hale reports the new repair, maintenance, and equipment refurbishing service is ready to go to work as your "technical support team." CDI Services is headed by 13 year Jerrold veteran Glen Shafer, and they specialize in head end equipment, distribution equipment, converter updating and repair. Matv equipment and test equipment maintenance and repair (including SLM calibration).

In the photo here, a CDI Services technician is checking the output match on a converter, using an HP 8620-B sweep oscillator, a 1220A scope, and a Jerrold TC-2-7F coaxial switch. Full information is available from CDI Services.

CHANNEL-ELIMINATION FILTER—C-COR Electronics, Inc., 60 Decibel Road, State College, PA. 16801 has announced a new Channel Elimination Filter (Model CEF-*) for trunk line applications where one channel must be blocked at the boundary of one political subdivision, or where rate differences require one or more channels to be eliminated in certain cable areas.

The Channel Elimination Filter is a multiple-cavity absorption type filter with 45 db minimum attenuation of the unwanted channel and no more than 2.0 db attenuation on the adjacent channel(s). The CEF is said to be stable with temperature, so that attenuation does not change materially as ambient changes take place with the air temperature. The units are housed in cast aluminum enclosures for strand mounting with standard seized input and output ports. Full technical information is available from C-COR.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