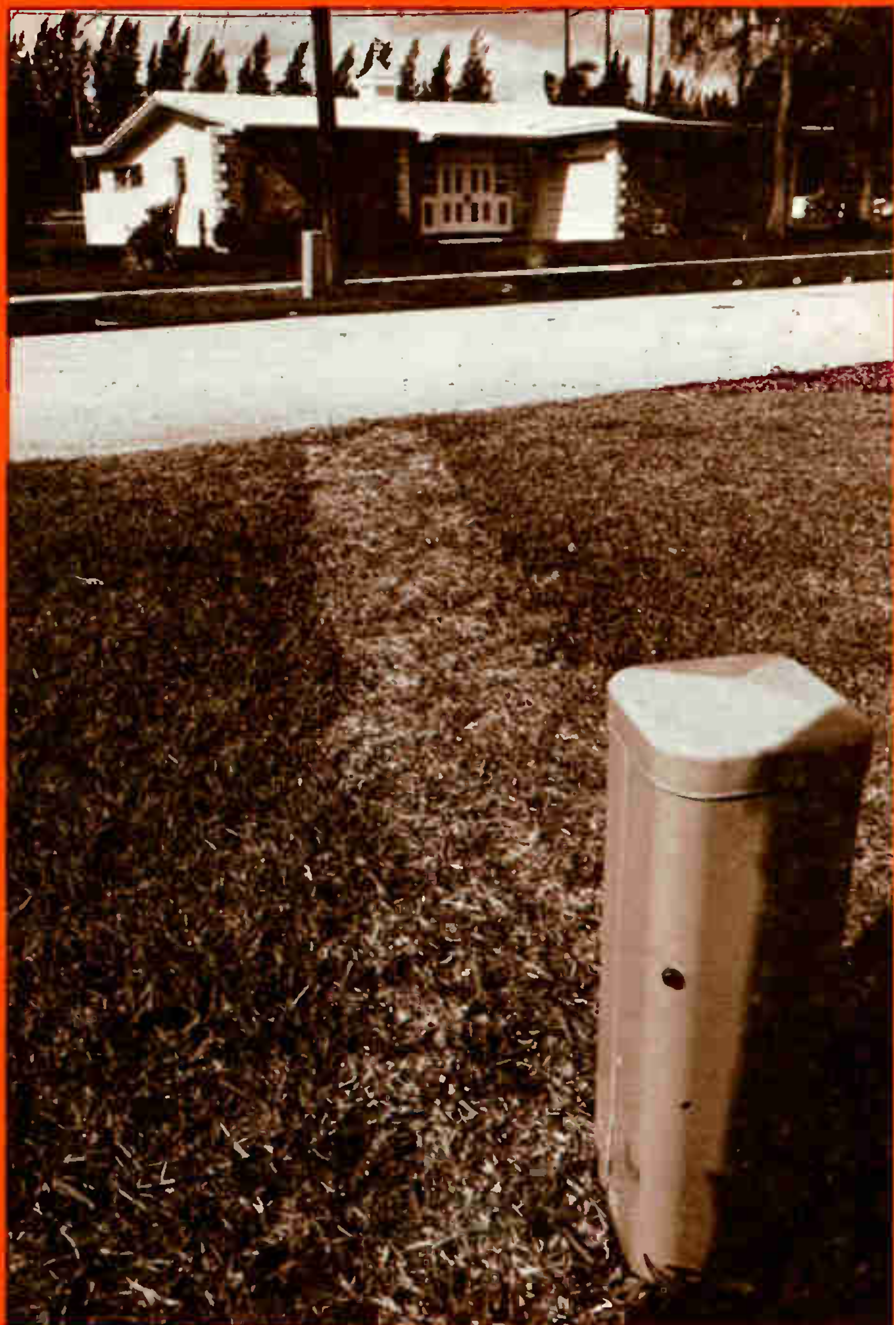
Jan./Feb. '72 vol. 8/ no. 1

CABLECASTING
Cable TV Engineering

SCTE
The official journal of the
SOCIETY OF CABLE TELEVISION ENGINEERS



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Contents

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SCTE

SOCIETY OF CABLE TELEVISION ENGINEERS

NORTH CENTRAL CHAPTER

The North Central Chapter of the SCTE has scheduled a Spring meeting for March 3 and 4 at the Cornhusker Hotel in Lincoln, Nebraska. The agenda includes seven technical sessions, led off by Herb Lubars of General Cable Corp., who will talk on Cable Specifications and Structural Return Loss. The second part of Mr. Lubars' presentation will cover the Development of Low Loss Fused-Disc Coaxial Cable.

Cost of the two-day event for members is $15; for non-members it is $20. Accommodations at the Cornhusker are $9 single room, $13 double room. For further information and reservations contact Loyal Park, 1011 Cottonwood Drive, Lincoln, Neb. 68510 (402/489-6662).

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ONTARIO CHAPTER

The Ontario Chapter of the SCTE held its first organizational meeting on February 5th at the Holiday Inn near the International Airport in Toronto. After a brief business meeting, Mr. Sruki Switzer of McClean Hunter Cable TV Ltd. gave a presentation on phase locking and other allied topics. The luncheon meeting closed at about 5 p.m. with an informal interchange of system technical problems.

For information on the next meeting of the group contact Mr. Joe Schrobback of Rogers Cable TV Ltd., 51 Beverly Hills Drive, Downsview, Ontario (249-7001).

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And the Gamut 26 has better than 100-db isolation against direct pickup and similar interferences. Plus better than 70-db input-output isolation and image rejection.

Which all means sharp, no-ghost, no-herring-bone reception on *all* VHF and 26 CATV channels—with *no* color deterioration.

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PEOPLE IN THE NEWS

JOHN T. WALSH has been appointed manger of technical operations for the engineering department of TeleVision Communications Corp. Mr. Walsh formerly a field engineer for the firm, will coordinate the engineering activities for all TVC cable TV operations. Also at TVC, WILLIAM SINKUNAS has been elected vice president and general manager of Akron Cablevision in Akron, Ohio. Mr. Sinkunas was formerly general manager of Cablevision Corp. of America, a TVC subsidiary operating in the Boston, Mass. area.

• • •

WILLIAM A. KRAUS has joined Phelps Dodge Communications Co. as Sales Engineer based in Los Angeles and responsible for the western territory. Mr. Kraus was a sales engineer for Transitron Electronic Corp., and before that, he held sales posts at Motorola Semiconductor Products Inc.

• • •

G. HAROLD WEAVER has been appointed Manager of Lake City Cablevision, Inc., a subsidiary of Cypress Communications Corp. Mr. Weaver formerly held the position of Chief Engineer at the Lake City, Florida system and replaces JUSTO CAFFI who has transferred to Cypress' Bakersfield system, Kern Cable TV. Prior to serving as Chief Engineer, Mr. Weaver was an electronic technician at TV Cable Co. in Fort Walton Beach.

• • •

JACK J. WARDELL, Advertising Manager for Superior Continental Corp., has moved up to Manager of Marketing Communications, with broader responsibilities in functional planning aspects of advertising, merchandising, promotional and informational areas. Mr. Wardell, whose communications background includes advertising agency, radio and newspaper experience, joined Superior Cable Corp. in 1961.

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EVR TELEVISION CATALOG

Listing and describing more than 600 EVR cartridge releases in an easy-to-read format, including usage clearances, prices, a complete subject and title index and a list of producers-distributors.

THE A+ SCHOOL (8 min)
About the South Salem Elementary School in Salem, VA, unusual for its circular design and added feature of fallout protection. Animation techniques explain why—how building was built. Describes slanting techniques in design and construction of buildings. (No. EVR-212)
National Audiovisual Center Sale ($23.85)
INDIVIDUAL CCTV
FLM—EVR:c
Architecture; Building Construction; Fallout

ABOUT FALLOUT (24 min)
Designed to dispell many common myths and fallacies about fallout and to present the facts as clearly as possible. The basic nature of fallout radiation, its effects on body cells, what it would do to food and water after a nuclear attack, and simple, common-sense steps to take to guard against its dangers. (No. EVR-211)
National Audiovisual Center Sale ($54.75)
INDIVIDUAL CCTV
FLM—EVR:c
Fallout; Radiation

ABOUT FLOWERS (7 min) K,P,I
A nature lesson to interest even the youngest audience, taught in a field of flowers. Two children playing in a meadow learn from an elderly neighbor how and why flowers attract bees, how fertilization occurs, how seeds are formed, how old plants die and new plants come to life. From the National Film Board of Canada. (Part of No. AB-18. For other part, see GLACIATION.)
Motorola Teleprogram Center Sale ($180.00)
INDIVIDUAL CCTV
FLM—EVR:c
Botony; Flowers

ACIDS AND BASES IN TITRATION (22 min) H, C
(also titled: VOLUMETRIC ANALYSIS: ACIDS AND BASES) Illustrates techniques the analytical chemist uses to measure precisely the quantity of a chemical species in a system. Demonstration of a procedure for standardizing a sodium hydroxide solution and for titrating an unknown acid. The data from the titration is used to calculate the equivalent weight of the unknown acid. (One of a series of 10. Listed on EVR—Film 5. See related titles under GENERAL CHEMISTRY LABORATORY FILMS.)
W.B. Saunders Company Sale ($150.00)
INDIVIDUAL CCTV
FLM—EVR:b
Associated student laboratory manual
Chemistry - Laboratory; Measurement

AFRICA (11 min)
Seldom seen animal life in natural habitats from Cape Horn to the Nile's headwaters. Exciting vignettes of animals' struggle for survival also reveal emotional, almost human, examples of caring for their young. From Pyramid Films. (Part of No. AB-15. For other part, see HOME OF THE BRAVE.)
Motorola Teleprogram Center Sale ($140.00)
INDIVIDUAL CCTV
FLM—EVR:c

AN AFRICAN COMMUNITY: THE MASAI I,J,H,A
(16 min)
The nomadic Masai of the highlands of East Africa lead lives shaped to a great degree by their environment. Grazing lands for their cattle are affected by weather and even by the health of grazing wild animals. This film illustrates the Masai's dependence on the land, their adaptation to the environment and their family and tribal interdependence, as well as the remarkable dignity of a unique people. Producers: Frank Gardonyi and Clifford Janoff. (No. EVR-1029.)
BFA Educational Media Sale ($168.00)
INDIVIDUAL CCTV
FLM—EVR:c
Study Guide
Africa; Culture—African; Geography; Peoples; Sociology

AIR: A FIRST FILM (9 min) K,P,I
Our earth is covered by an ocean of air. Although it is all around us air cannot be seen, but still it is a very important part of the world on which we live. We use air in many ways and moving air brings changes in weather to us. Without air, life on earth probably could not exist. (No. EVR-1012.)
BFA Educational Media Sale ($96.00)
INDIVIDUAL CCTV
FLM—EVR:c
Study Guide
Atmosphere; Physics; Weather

AIR FORCE NEWS REVIEW NO. 142 - AIR FORCE 20 (1917-1967) (24 min)
History of U.S. air power from its official beginning in 1907. Early days of aviation, might of airpower in WW II and Korean War, establishment of Air Force as separate service in 1947, and vital role of airpower in Vietnam. Shows increasing use of transports to airlift troops and equipment to troubled areas and food and medicine to disaster victims. Outlines U.S. progress in development of aircraft, missiles and space vehicles. (No. EVR-231)
National Audiovisual Center Sale ($54.75)
INDIVIDUAL CCTV
FLM—EVR:c
Airplanes; Missiles; Space Vehicles; US Air Force - History

THE AIR FORCE STORY - AIR WAR AGAINST JAPAN, 1944-1945 (14 min)
Highlights of the history of the U.S. Air Force, particularly the bombing of Japan, ending with the surrender of the Japanese. (One part of No. EVR-173. For other part, see THE AIR FORCE STORY - VICTORY IN EUROPE, JUNE, 1944-MAY, 1945.)
National Audiovisual Center Sale ($43.20)
INDIVIDUAL CCTV
FLM—EVR:b
US Air Force - History; World War II

THE AIR FORCE STORY - ENTERING THE ERA OF MISSILES (15 min)
Traces the beginning of modern missiles, showing "The Bug," our first guided missile, and discusses Dr. Goddard's pioneering work with liquid fuel, air-to-air missiles of WW II and development of V-1 and ... describes USAF

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editorial

Staying Up With The Field

In the last issue of CABLECASTING we presented an article on a viewer response and two-way alert system for cable television. We are presenting an article on another such system in this issue, and we plan to present technical information on such systems in forthcoming issues. We are doing this because this represents the next generation equipment for cable television systems and our technical people had better begin to understand how they work and the basic concepts underlying their design.

Admittedly, most of this equipment is now being tested only in pilot systems — there are lots of bugs to work out. There is also the need, of course, to see how the viewers react to the various formats used for getting their responses. And, the equipment is costly and system owners will need to be able to justify their installation in terms of potential revenues. This will be very difficult because small tests made in motels or hotels here or there do not really foretell the type of results that might be obtained in an entire community or small city — the conditions are different, the viewer psychology is different, the costs are different.

But the engineers who operate cable television systems can not be guided by the same criteria as that which motivates the system owner or manager. The engineer must be aware and familiar with all of the technology that effect his specialization, otherwise he severely limits the expansion capabilities of his system. Every cable television engineer should be thoroughly familiar with short-hop microwave systems, for example, so that he can take advantage of their capabilities for the expansion of his system, when conditions are right for their use. Similarly, he needs to be familiar with two-way communications systems for cable TV. To be unaware of the new technical concepts arising in our industry is to be suspicious of them, and this will severely limit the usefulness of the engineer when his system is planning for expansion.

Keeping the engineer from becoming obsolete before his time is the function of any responsible technical journal, and we hope that we fulfill our responsibility in this regard. This is also the function of any good technical society and we know, from having attended meetings of the Society of Cable Television Engineers, that the various chapters of the SCTE are fulfilling this responsibility. However, the Society needs help. More regional and state chapters need to be established so that more members can get to local technical meetings. Many of the regions covered by the existing chapters are too large for the members to get to the meetings conveniently. Any engineer, whether a member of the SCTE or not, who wants to help set up a local chapter of the Society should contact the SCTE (607 Main St., Ridgefield, Conn. 06877; 203/438-3774) for information and help to get such a chapter going.

Charles Tepfer

APPLICATION AND PARAMETERS OF MULTI CHANNEL DEVICES

By Chester J. Syp
Magnovax-Craftsman

An analysis of CATV hardware being installed in systems today brings one quickly to the realization that present technology is advancing at a very rapid pace, providing a high degree of capability, sophistication, versatility and reliability, so necessary to meet the demands of today's CATV market. One cannot deny that improvements in microwave relay systems, head-ends, low loss cable, expanded-band amplifiers and passive devices, have been coming fast and furiously.

Cable TV owners install this new, improved equipment and follow exacting installation practices in order to insure at the consumer's home, diverse, high quality signals. But here at the home, this high level of competence terminates. The very weak link in the chain is the common home TV receiver. The receiver is incongruous with today's state of the art and basic intent of cable systems to provide a wide variety of programming at high technical standards.

Appreciating the plight of the cablecaster, and realizing the speed at which this industry is moving, the Magnavox Co. has developed a cable television set or terminal unit, as it is commonly referred to. These units were initially shown at the NCTA Convention in Washington in July. At present, these terminal units are involved in shakedown testing all over the country, so that we can be sure that they will be capable of handling the wide variety of operating conditions found in today's and tomorrow's systems. Following is a brief list of the innovations you can expect to see when these terminal units are marketed this year.

- The terminal is cable or off-air compatible, having a coaxial cable from the "F" connector at the back of the set to the tuner.
- Input to the unit is 75 ohms unbalanced for direct connection to a drop cable without an external impedance matching transformer.
- The "front end" is varactor tuned, offering a choice of 31 cable channels, 2 thru 13, plus midband and superband, or all 12 VHF and 70 UHF off-air channels. The TV-101 received its model number from the sum of 31 V's and 70 U's. The use of varactors, eliminating the need for RF switching, is a major advance. Field-effect transistors permit operation of the terminal from a wide range of input levels with freedom from intermodulation and cross modulation products, a most common problem with conventional receivers.
- Double shielding of the tuner from interferring signals was found to be a definite must.
- Changes in standard IF strip design to trap out adjacent channel video and audio signals is a major change of such importance that it alone would justify the new set.
- Shielding of other key circuits, such as AGC, is provided in order that stray off-the-air pickup is not transferred to the first detector.
- It was found that utility lines act as antennas for low frequency pickup; therefore, power supply decoupling has been incorporated.
- Bipolar and field effect transistors are used in the low level stages where low noise figures and low dissipation are desired.

In addition to these specific changes for cable television, evolutionary TV set improvements have also been included. These include:

- Simplicity of tuning, convenience of operation and channel identification.
- Quick on-off picture and sound is available.
- Transformer developed supply voltages provide isolation from AC mains and shock hazards.

- Regulation of low voltage facilitates constant picture size, better covergence and stable operation.
- The high voltage supply has no X - radiation sources since conventional shunt regulator and regulator tubes are eliminated.

The Dilemma Now

Many years will be required for the present vintage of TV sets to exhaust themselves; probably 8 to 10 before total phase-out is realized. In the meantime, planners of new systems or rebuilds must ask themselves, "how should I build my system?" In the light of proposed rulings, major changes may be required even before the system is completed. Here are some of the factors a builder must contend with:

1. First and foremost is channel capacity. It appears numbers in the low to mid twenties are most often mentioned.
2. Should local stations be carried on their originating channels? The safest answer is yes.
3. A factor heretofore not considered is: Will my system accept the forthcoming cable terminal units without major changes or expenses?

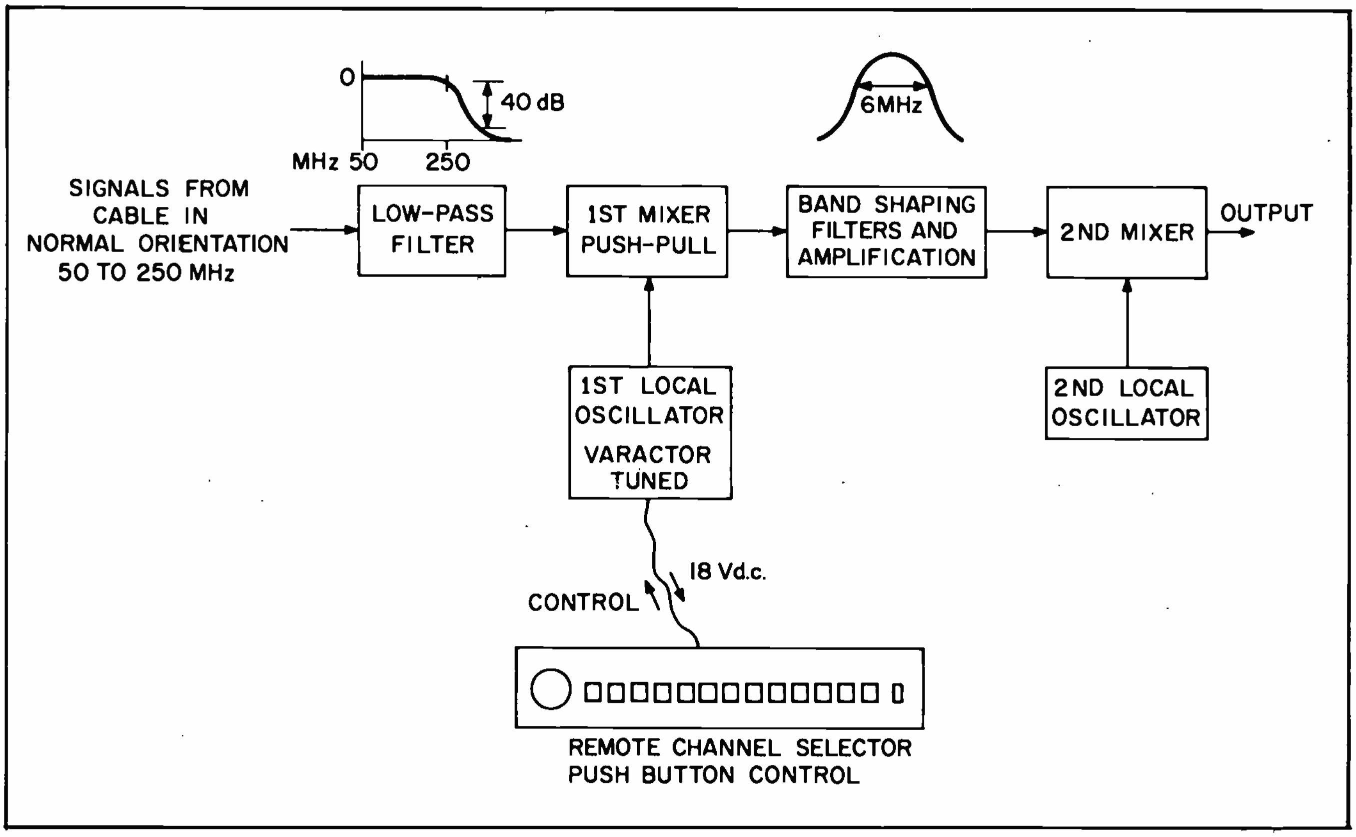
Of course, there are other factors involved, but let us consider the construction alternatives available. First, one can use a dual cable system with a switch at the back of the TV set. To overcome off-air pickup one may tie the transformer directly to the tuner, although that is not always foolproof. Pickup can be realized through the tuner, AGC circuits, power supply or other sensitive circuits. The economics of this procedure is high because of the difficulty in reaching tuners of today's portable sets. The probability of being involved in set failures not related to the cable system is also high. Warranty and underwriters complications, plus damage to sets during installation or disconnects are constant threats. One could convert local channels and provide around 18 signals but then we would deviate from our original guidelines for channel capacity and local signals on channel.

In addition, when upstream communication is activated, many areas may have low frequency interference in the sub-low 5 to 40 MHz area. This interference is picked up by the set and fed back into the cable system. Special precautions will have to be taken to eliminate this type of interference.

The Converter Approach

As an alternative to dual cable, one may take the converter approach. The first grouping of converters is the block type, which can be midband or superband. A combination of these converters could provide sufficient channel capacity, although local TV channels would be required to be carried on some other channels. An even more important characteristic of block converters is that they have only one mixer circuit in order to keep the cost of the unit down. A mixer inverts the signal being fed to it. Considering a 6 MHz television signal after mixing, the video is where the audio was and the audio is where the video was. Therefore, a second mixer is required to restore the signal to its original format in order for

Figure 1

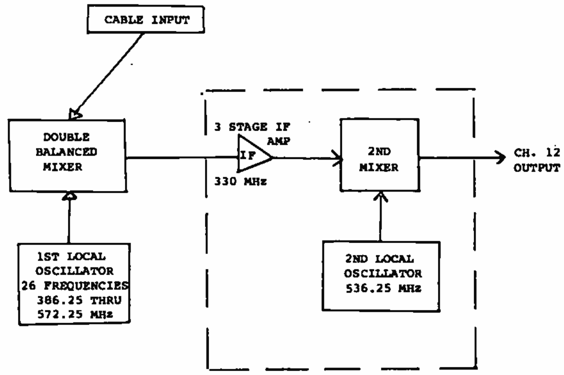


it to be used by a television set. Since the block converter has only one mixer and since two are required, the first is located at the head end. This is where the cost saving is realized, since block converters utilize the first mixing function at the head end; therefore, each converter in the home has only one mixer circuit. But this demands that the signals sent down the cable are inverted or non standard. The point of concern is that the forthcoming terminal sets will not be able to utilize this type of signal as it appears at the cable drop since its tuner will operate as conventional TV sets do. So a block converter will still be required at the home even if the cable set were installed. However this is contrary to the intent of eliminating any converter by the cable terminal set and returning the home receiver back to the TV service technician, where it rightfully belongs.

A second group of converters is the double mixer type, having both mixers in the unit located in the home. They offer 26 channels, and local channels can be kept on channel since the output of the converter is selected to be different than local stations so that off-air interference will not be encountered. This type of converter does not "customize" a system and thereby permits a gradual substitution of cable television sets for converters. There is no spectrum pollution or custom frequency orientation to contend with.

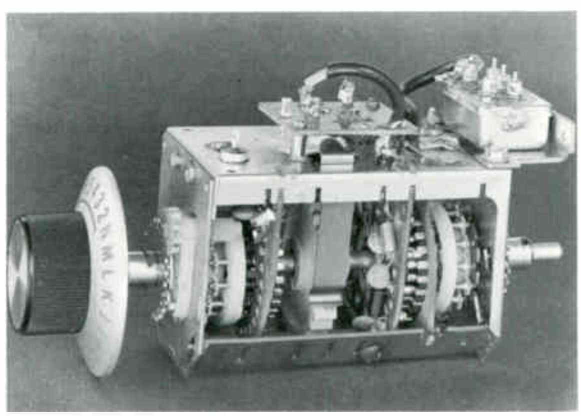
An example of a double mixer converter, the Craftsman Model FV-25, is shown in Figure 1. A low pass filter feeds a push-pull mixer stage which combines the varactor tuned local oscillator signal and the cable signal to produce a constant frequency IF signal. This signal travels through a 6 MHz band shaping filter and amplification stage into the 2nd mixer. This 2nd mixer combines the band-shaped thru signal and a constant 2nd local oscillator signal to produce the output signal, usually on channel 12. This particular scheme had many field trials before it was brought to market. Some of the reasons for this design format include:

1. The low pass filter has 4 adjustable poles which offer negligible attenuation to the 50 to 250 MHz channels but then falls off rapidly beyond the high end, providing a minimum of 40 dB rejection to the by products of the 1st mixer stage. Earlier converters not having this type of filter permitted signals to leak out the front end resulting in beating with other converters. One can now operate converters side-by-side and get no interacting beats since the isolation between converter mixers is at least 80 dB.
2. The first mixer was selected to be a balanced push-pull, keeping 2nd order beats to a minimum. The center output frequency of this mixer is a constant 400 MHz.
3. A varactor is a DC voltage sensitive capacitor in the tank circuit of the first oscillator. When this impressed DC voltage is changed it varies the capacitance of the varactor and hence the frequency of the oscillator. Use of this varactor in place of



Another double-mixer type converter is shown here. In this unit, two oscillators mounted back-to-back on a shaft drive a double-balanced mixer which, in turn, converts the television signal to a 300 MHz IF. This technique gives an image rejection of 70 dB minimum, with an input/output isolation greater than 70 dB and eliminates image frequency interference. The unit has a single knob detent channel selector which handles up to 26 channels. The output is fed on channel 12 or 13.

The heart of this converter, the Oak "Gamut 26", is the tuner. At the left is oscillator A and associated switch section. In the center is the detent mechanism. To the right of this is the pass/stop filter and then oscillator B and associated switch section. Mounted atop the chassis on the center is the double balanced mixer. In the sealed can at the right is a low-pass filter.



conventional RF tuner switching vastly improves the life and maintenance of the switch since it transfers a maximum of only 18 volts DC. Cleaning of contacts every few years can be eliminated. The varactor utilizes, pushbutton channel selection. Pushbuttons on the remote unit are aesthetically very appealing, simple to operate and represents present day convenience. The pushbuttons are rated at 100,000 operations each. The standard remote control unit has 25 feet of shielded cable but can be extended to 100 feet without retuning, should the layout of the viewing area demand it. The case is made of high impact plastic capable of withstanding severe shocks and contains no active components to damage because of rough handling. All active components are located in the metal encased electronics portion, which can be mounted near the set or at a great distance from it. In fact, the gain of the converter is 9 dB, permitting mounting of the electronics box in closets, corners or many other non-traffic areas. Taking the electronics out of the hands of the consumer, can only add to its life and reliability. A 2 MHz pot serves as the fine tuning control by being a fine frequency control of the first oscillator. It was electrically located here so as not to get involved in distortions of bandpass, should the first oscillator not always be exactly on frequency. Using this technique, video and audio carriers are kept on their proper location of the band pass response. If the television set has AFC it will, of course, override the fine tuning control.

4. The band shaping filter is 4 pole and symetrically shapes a 6 MHz bandpass. Ten dB of amplification is added at this point providing the overall gain of 9 for the converter.
5. The second mixer combines the 400 MHz band shaping signal and the one from the second local oscillator to produce a standard channel 12 output. There is no need to have this second mixer push-pull since it is being fed by the narrow band 6 MHz signal and hence, second order products will not occur. The second oscillator has sufficient range so that practically any high band output can be supplied.
6. All voltages to active components and the remote control unit are double regulated to keep drift to a minimum.
7. The unit draws 40 mA at 115 volts, which is less than 5 watts, therefore, if desired, it can be on continuously.
8. Most circuitry is double shielded to keep it free of interference even in extremely high RF ambient areas. FCC radiation requirements are met with plenty to spare.

In closing, I would like to urge television set manufacturers to hurry and provide the cable TV set; cable operators have enough other problems to contend with. In the meantime, the system operator should think to the future by keeping his signal orientation clean and "uncustomized" by using double-mixer converters. They have come a long way and will be with us for some time to come.

AML Microwave in Local Distribution Service

By Robert W. Behringer
Theta — Com

This paper was presented at a meeting of the Central Atlantic Regional chapter of the Society of Cable Television Engineers.

The AML system is capable of transmitting as many as 38 television channels in the Community Antenna Relay Service (CARS) Band. Each receiver will put these channels onto the cable at the same frequencies they occupied at the transmitter site. Modulators or demodulators are not required. If desired, the AML System may send the entire FM broadcast band on one transmitter channel. Digital data can also be transmitted.

AML has effective application in both urban and suburban systems.

In urban-metropolitan systems, dry trunking through the streets of an industrial or commercial area may be prohibitively expensive — even for distances of a few miles. AML can serve the various residential neighborhoods from receivers located in these areas. Local origination programming can be tailored to the characteristics of each locality.

In less densely populated areas, AML can eliminate long cascades, dry trunking, or multiple headends through the use of several receivers located in the local centers of population.

Another important use of AML is to cross natural barriers such as ravines, rivers, lakes or swamps. Man-made barriers such as superhighways or canals can be crossed faster and less expensively with AML than with trunk cable. While the transmission ranges may be relatively short, the ability to easily bypass such barriers with AML can be very attractive economically.

AM Vs. FM

AML stands for Amplitude Modulated Link. In choosing amplitude modulation instead of FM three design objectives were considered most important: the capacity to carry a large number of television channels; the ability to furnish clear, distortion-free pictures to the cable subscribers; and high reliability and easy maintenance through equipment simplicity.

The first consideration is the bandwidth available in the CARS Band. The FCC has allocated 250 MHz for Local Distribution Service. Frequency modulation systems require an RF bandwidth at least twice as large as the input bandwidth. Thus the theoretical maximum number of 6 MHz TV Channels that can be transmitted in the CARS Band is 20. This number is further reduced if the modulation index on the FM carrier is greater than approximately 1, because higher order sidebands occur and require an even larger RF bandwidth. FM is most effective when the modulation index is significantly greater than 1. Many high quality FM transmitters use a modulation index of 5.

On the other hand, AM systems using single sideband suppressed carrier transmission require an RF bandwidth equal to the input base bandwidth. 41 separate 6 MHz channels can thus theoretically be transmitted in the CARS band using amplitude modulation.

Another consideration is providing clear distortion-free pictures to the subscriber. Both frequency and amplitude modulation systems are susceptible to distortions due to nonlinearities in the transmitters and receivers. In the case of amplitude modulation, the system is susceptible to amplitude distortion. Such distortion causes crossmodulation and intermodulation products. In a very similar way a frequency modulation system is susceptible to nonlinear phase distortions across the transmitter and receiver pass bands, modulation and demodulation nonlinearities, AM to FM conversion processes, multipath FM distortion especially in congested urban areas, etc.

One method of eliminating some of this distortion is channelization. For AM this is both an effective and economical solution and it is employed by AML. In the case of FM, frequency channelization is not economical for a multiband multi-receiver system. Even if it were economical, the number of channels available decreases with channelization. Significant crossmodulation and intermodulation may be introduced in a frequency division multiplexed transmitter not using channelization.

The output signal-to-noise ratio for either AM or FM systems is directly proportional to the input signal. That is, if the input signal varies for either an AM or for an FM receiver, the output signal-to-noise ratio will vary directly with the input signal variation. However, because of the serious intermodulation present in FM multiplex systems and the limited bandwidth allotted by the FCC, the modulation index for a FM multiplex system must be kept very low. This provides a significantly lower signal-to-noise ratio than for an AM system having similar power capabilities.

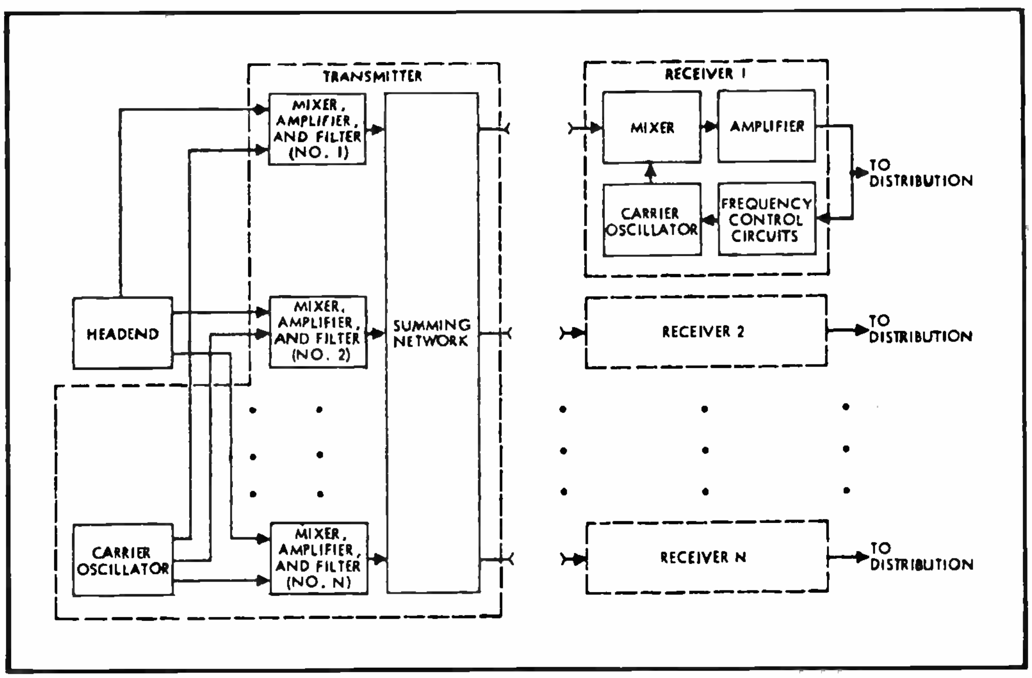
Finally, the two modulation methods must be compared on the basis of implementation simplicity. In an FM system the input spectrum must be arranged carefully to avoid excessive RF bandwidth. If, for example, Channel 2 were modulated directly onto an RF carrier using Frequency Modulation, the corresponding RF bandwidth would be at least 2 times the sum of 54 and 6 MHz or 120 MHz. To avoid this problem, and to reduce crossmodulation and intermodulation, conventional FM systems use several carriers spaced at 25 MHz intervals in the CARS Band, one channel per transmitter

Frequency Division Multiplex systems which are not channelized must shift all inputs into the range between 0 and 125 MHz in order to fit their full 20 channels into the 250 MHz CARS Band. At each receiver, TV channels must be returned to their proper frequency slot for transmission on the cable system. Furthermore, in systems which do not use adjacent channels, each channel must be heterodyned separately to adjacent frequency locations. Block conversion is not always possible.

Single-sideband amplitude modulation avoids the complications and distortions arising from these up and down conversions. The AML uses one common 25 watt klystron at 12,646.5 MHz for FCC Group C per 8 channel or one rack transmitter. Each TV channel after it has been processed at the headend is fed, as shown in Fig. 1., to the AML's VHF driver/amplifier at + 39 dBmv with the audio 17 dB below the video. The amplified VHF signal is then heterodyned with the klystron output in an upconverter using a varactor diode. The carrier is suppressed and the lower sideband eliminated with appropriate filtering. The resulting microwave signals are then combined through circulators in groups of 4, as shown in Fig. 2. The groups of 4 are combined in magic tees and fed to the antennas. In addition to the television signals the AML uses a pilot tone at 73,956 MHz for FCC Group C to phase lock the receiver to the transmitter, as well as to operate the automatic gain control in the various receivers.

At the receiver, the incoming signals are mixed with a signal from a local oscillator at 12,646.5 MHz which is phase locked to the transmitter through the pilot tone. This beats the microwave down to VHF at the same frequencies as the input to the transmitter — all without the use of modulators or demodulators. The VHF spectrum is then on the cable at + 17 dBmv and is ready to go through the conventional distribution system. The receiver itself is internally temperature controlled to extend the life of the electronics, and is cable powered. Of course, it can be

Figure 1



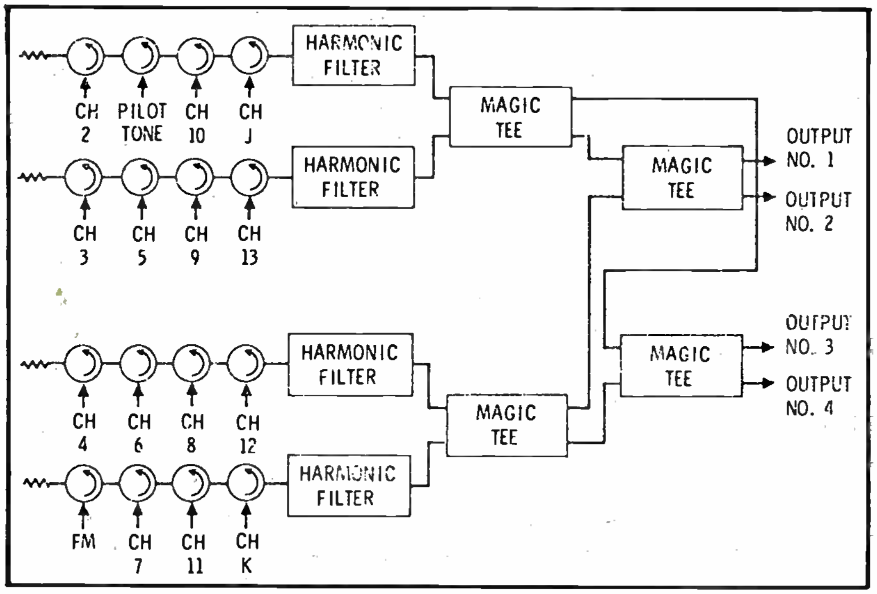


Figure 2

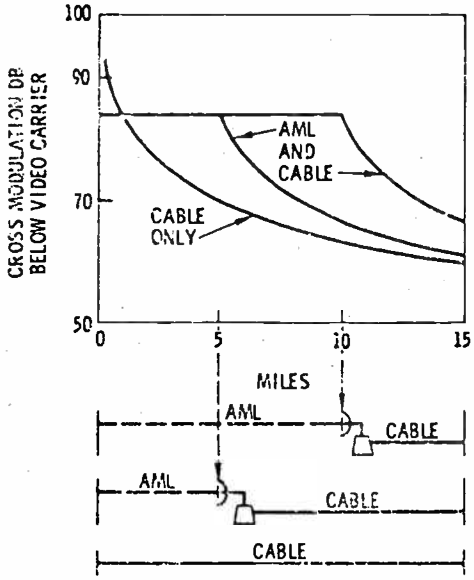


Figure 3

placed in an outdoor environment and may be pole mounted near the antenna.

Power Output

Having selected amplitude modulation as the method of modulation, the power output was the next decision point. Using the klystron as a pump, clear distortion-free signals are available from the upconverters at 100 mw per channel. The power per channel for 1 or 14 channels is the same — 100 mw per channel.

One point which has come up relatively frequently is the comparison of AML's stated power of 100 mw and a Frequency Division Multiplexed system which is specified at 10 watts. This 10 watt power is not directly comparable to 100 mw per channel for two reasons. First because it is the total amount of power in all the channels. By this measure, a 24 channel AML system would have 2.4 watts of power. But second and more important the 10 watts is not entirely useful — most of the power remains in the unmodulated carrier which transmits no information because the system uses narrow deviation FM with a relatively low modulation index.

The result of this has been calculated theoretically, and confirmed by actual measurement of the output spectrum of an operating 12 channel Frequency Division Multiplex system. AML has an average of 4½ dB signal-to-noise advantage over the FM system even though the latter is specified at a higher total power output.

Another aspect of power output is the tradeoff between the reliability of the equipment itself, cost, and the reliability of propagation through the atmosphere. The fade margins available from the AML, about 30 — 35 dB, are adequate for reliable performance in most climatic situations. An option available to us was the use of 1 output traveling wave tube per channel. Even if 10 dB more margin resulted, the overall reliability of the system would suffer. This is due to the fact that the outages due to rainfall would only be reduced by 25%. But the use of 1 output TWT per channel would greatly increase the maintenance expense for tube replacement, and the overall reliability of the system due to tube failures might be significantly degraded.

Crossmodulation Performance

Turning to the other important measure of performance — synchronous crossmodulation, the AML, according to published specification sheets, delivers

OUTPUT SIGNAL QUALITY: (16 Channels)	SYNCHRONOUS CROSS-MODULATION PER NCTA TEST SPECIFICATIONS	SIGNAL-TO-NOISE RATIO
	-82 dB	45 dB
	-77 dB	48 dB
	-71 dB	51 dB
CASCADABILITY:	25 Trunkline Amplifiers can be fed	

a signal at the end of the transmitter/receiver system with crossmodulation products 82 dB below the modulation peak. The comparable link using the Frequency Division Multiplexed approach, according to their published specification sheet will give — 74 dB crossmodulation products for the entire system including transmitter and receiver. And this cross-modulation figure is quoted at 6 dB under their nominal input.

The AML receiver, similar to trunk amplifiers can be adjusted to optimize the trade-off between signal-to-noise ratio and distortion products for the individual system. The nominal operating level of the receiver produces an output with a signal-to-noise ratio of 45 dB and crossmodulation 82 dB down. But if a very long cascade is required behind the AML receiver, the output can be at 51 dB signal-to-noise and crossmod 71 dB down. 25 trunk amplifiers can then be cascaded from each receiver in the system and still maintain a signal-to-noise ratio of 45 dB and crossmodulation 57 dB down at the end of the trunk run.

The cross modulation distortion introduced by AML will now be compared with that of high quality trunk amplifiers. In Fig. 3, three configurations are considered which span 15 miles. In the first configuration, the AML spans 5 miles with the remainder being cable. In the second configuration, the AML spans 10 miles with the remainder being cable. The third configuration uses a cable system for the entire 15 miles. It is apparent that by using the AML, a much lower crossmodulation output is available. From this point, the cross modulation deterioration is due to the line amplifiers. It is therefore possible to bypass long sections of trunk by using the AML and to provide higher quality signals at the point where the signals are used than would be possible by using only a trunk system. Better cross modulation distortion is available than with cable for AML microwave links greater than 1 or 2 miles.

Fading

There is another aspect of performance which relates to propagation or atmospheric phenomena. These atmospheric conditions actually consist of two broad categories: multipathing and rainfall.

Fading from multipathing effects is caused by such phenomena as inversion layers, non-stable ground reflections, and sub-or super-normal refraction.

Estimates of fading durations due to multipathing are derived from an equation by Bell Labs modified by the Theta-Com Applications Engineering Staff. This equation relates the transmitted frequency (in this case CARS 12.70 — 12.95 GHz), the fade margin available on the path, and the path distance, to the fraction of the year the received signal will be less than a specified value. In addition to the three variables mentioned above, the equation takes two more into account: quantification of the roughness of the terrain along the path and a variable describing the climatic conditions (principally humidity). Multipath phenomena are more likely to occur when the path is over very smooth terrain or over water. Hot humid areas like the Gulf Coast are also more likely to experience anomalous propagation. Conversely, an excellent place to put microwave and find a very small amount of multipath would be over very rough terrain (mountains), in a dry area, over a short distance.

An example will help clarify this. Let us take a 10 mile path in Washington, D.C. The terrain is average (not very smooth or rough), climate (taken on a year round basis) is average. Using 6' antennas, on one of 4 output ports from the AML, a margin of 22 dB over 35 dB S/N is available and the expected multipath outage would average less than 1 hour per year. In Mobile, Alabama (smooth terrain; hot) on a 10 mile path the outage would average 4 hours per year.

For most applications, rainfall is the major cause of fading at CARS Band. Unlike conventional television broadcasts (VHF), the signal from microwave transmitters may be absorbed and refracted by heavy rain.

To determine the effect of rainfall on microwave propagation for a given area, one must know the statistical distribution of rainfall throughout the year. For it is not the total amount of rain, but the amount of time it exceeds certain rates that is most important. A given area could have 100" per year spread evenly over 1000 hours at 0.1" per hour with almost negligible effect on microwave. Another area could have a total accumulation of 20" spread over 10 hours at 2.0" per hour, and be much worse for microwave than the first example.

Theta-Com applications engineers can determine the distribution of annual rainfall using methods which thay have developed. Their method involves the use of a relationship between attenuation at CARS Band and rainfall in inches per hour. The expected fading durations due to rainfall can then be estimated for each proposed path, based on the path length and fade margin.

Cost Comparison

Fig. 4 compares conventional trunk cable and AML links. The horizontal line is the estimated cost of a typical 12-channel AML installed on a turnkey basis with four receivers, including estimated maintenance over a 10-year life. The cost of trunk cable is graphed against average distance of each of the four receiver sites for typical turnkey cable costs of $3,500 — $4,000 — $6,000 — and $10,000 per mile, plus $3,400 per mile total 10-year maintenance, pole rearrangement, tree trimming, and pole fee costs. The breakeven is an average distance of 5 miles per hop for turnkey cable which costs $4,000 per mile. But the signal at the end of the microwave links will have less distortion than an equal distance of cable.

When compared to the cost of conventional single-channel CARS Band FM, as shown in Fig. 5, AML is

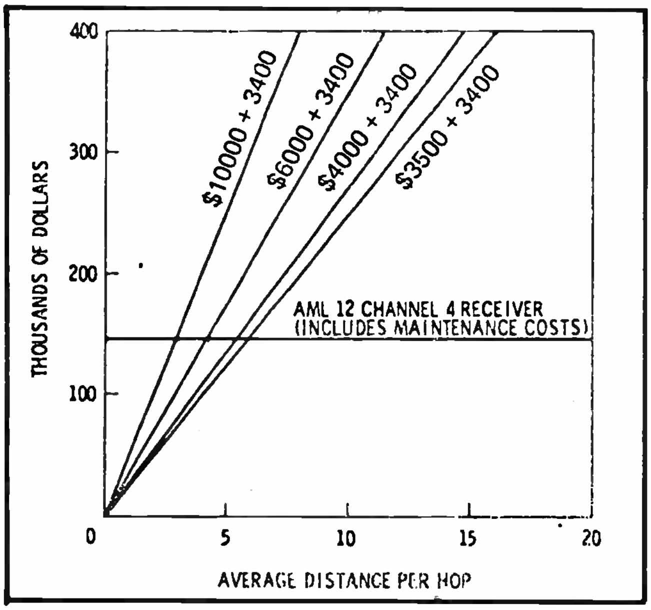


Figure 4

more economical for systems requiring more than 2 channels with 4 receive sites.

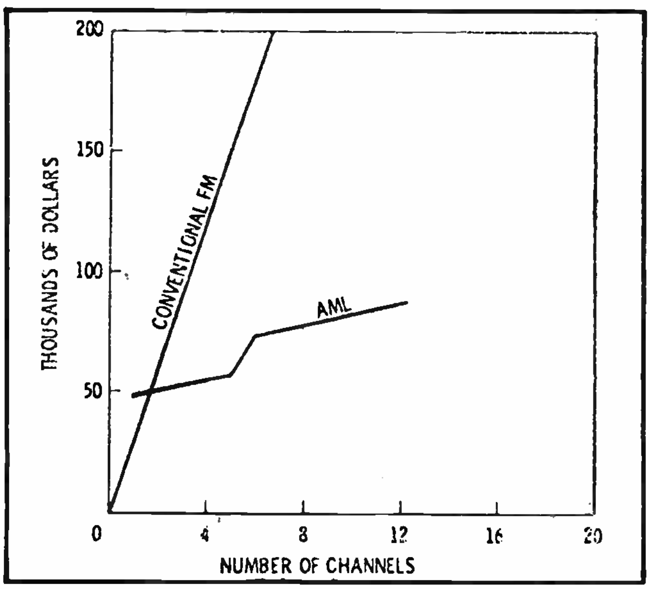


Figure 5

CATV Modulators

The relationships between the transmission characteristics of demodulation/remodulation or modulator/TV set link.

By Robert Hamell
Senior Design Engineer, EIE

The CATV modulator is a vital component in the cable system, being used for local origination and in demodulation/remodulation of off-air signals. Requirements for local origination assure the increased usage of modulators in cable systems. Therefore, familiarity with the characteristics and performance requirements of modulators can aid in the delivery and maintenance of a high quality signal.

This paper explores the relationships between the transmission characteristics of demodulation/remodulation, or modulator/TV set link as applied to a cable system. In particular, the amplitude and group or envelope delay requirements for the modulator vestigial sideband filter and the demodulator bandpass filter are examined. Methods for measuring these important parameters within the vestigial sideband transmission system are discussed.

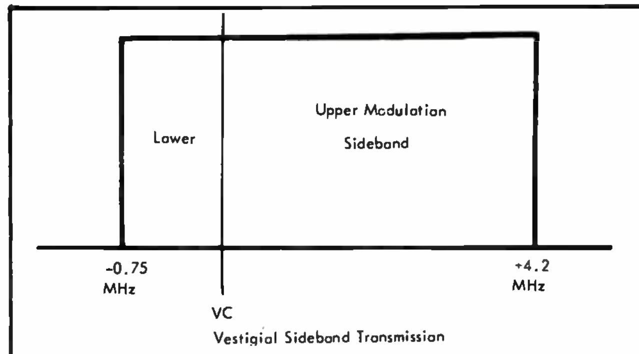
Mod and Demod Amplitude Response

Low Frequency Response. The basic vestigial sideband transmission characteristic for television broadcasting is shown in Figure 1. Video modulation frequencies up to 0.75 MHz are transmitted double sideband, then above a transition region are single sideband. The idealized transition in shown in Figure 2, along with an overlay of the ideal demodulation response curve.

The exact shape of the transition is not important in the case shown since the demodulator response is zero at all frequencies less than 0.5 MHz above the channel edge. In practice the demodulation characteristic in this area will not be the idealized shape shown, but will have a more gradual slope with rounded corners, the so-called "Nyquist slope", Figure 3. This more gradual slope is used in the interests of economy allowing the use of a simpler receiver filter design, and also to reduce group delay errors around the video carrier. Thus in practice, the cutoff rate of the modulator will influence the recovered video to some degree since the demodulator response is finite in this area.

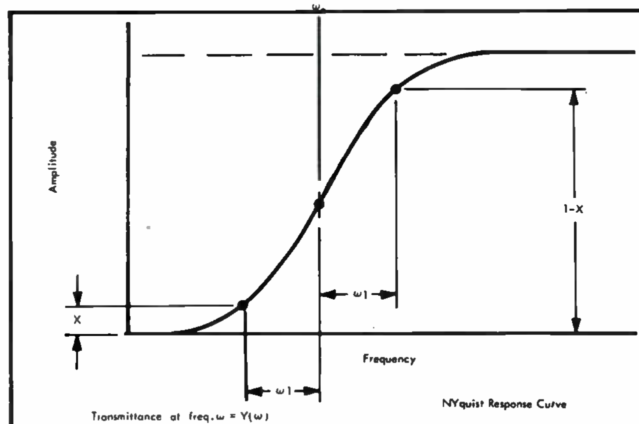
To control this variability in recovered video through a mod-demod link, the transmission characteristic of the transmitter is required to develop a signal which when demodulated by a broadband detector will provide a standardized response conforming to the limits of Figure 4. In turn, the receiver manufacturer working to this known transmission characteristic produces a receiver performing to satisfactory limits though the video carrier may not be located at the 0.5 amplitude point of the Nyquist slope, and a slope differing from that of Figure 3 may be used. Figure 5 shows the response of a production modulator vestigial filter measured at the output of a diode detector.

High Frequency Response. No particular problems exist in meeting the necessary high frequency bandwidth response within the modulator, but obtaining a flat passband up to 4.18 MHz is difficult in a demodulator or receiver due to the sound trapping required at a 4.5 MHz above the video carrier.



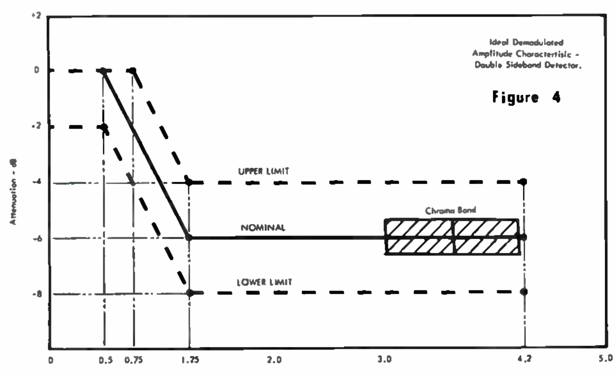
Vestigial Sideband Transmission

Figure 1



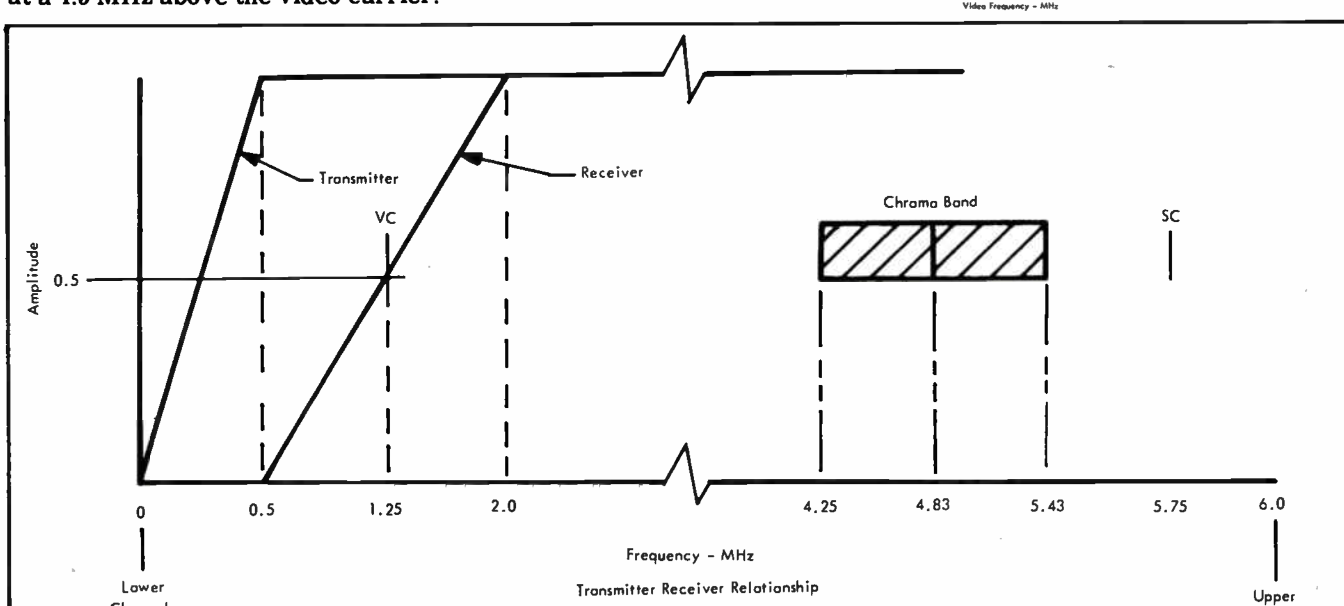
NYquist Response Curve

Figure 3



Ideal Demodulated Amplitude Characteristic - Double Sideband Detector.

Figure 4



Transmitter Receiver Relationship

Figure 2

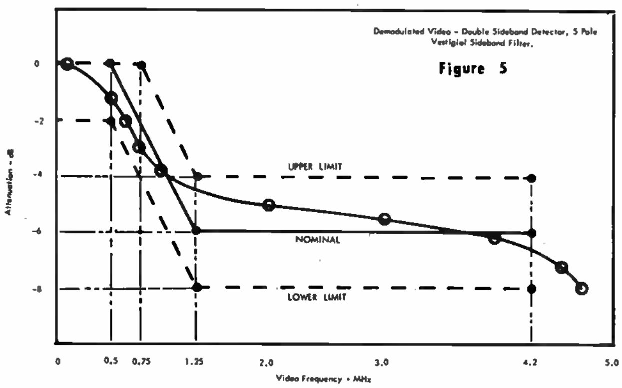


Figure 5

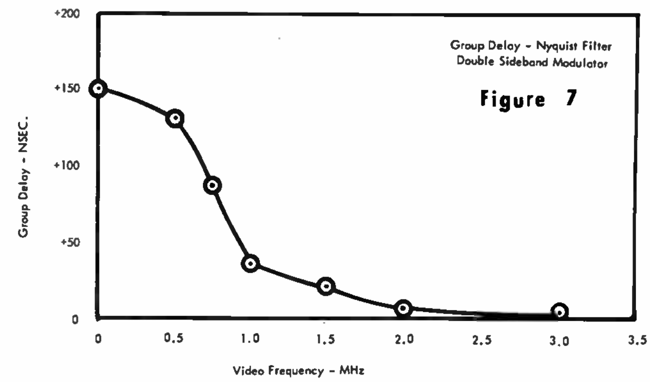


Figure 7

Since these higher video frequencies contain mostly chroma information with very little luminance, this loss of video can be made up in a TV receiver by appropriate chroma passband shaping. This is not the case for demodulators which must provide an undistorted video signal out to 4.2 MHz to a modulator or microwave link, although video peaking circuits can be used to compensate moderate video shaping caused by high frequency roll-off.

Bandstop Requirements. The transmitted spectrum of the TV signal must be controlled beyond the channel band edges to prevent adjacent channel interference. FCC requirements specify a minimum of 20 dB attentuation at band edge and beyond, a lower chroma sideband attentuation of 42 dB below video carrier level, and 60 dB minimum attentuation of all emissions greater than 3.0 MHz from band edge. These levels have been established for normal TV transmission where channel assignments are grouped by geographical location which serves to provide a guard channel or band between signals.

Limits must be established which are optimum for a cable system where full channel operation is the accepted (or expected) norm. In particular, the areas of chroma signal transmission in modulators, and responses in receivers or demods must be well controlled. For example, the interfering lower chroma

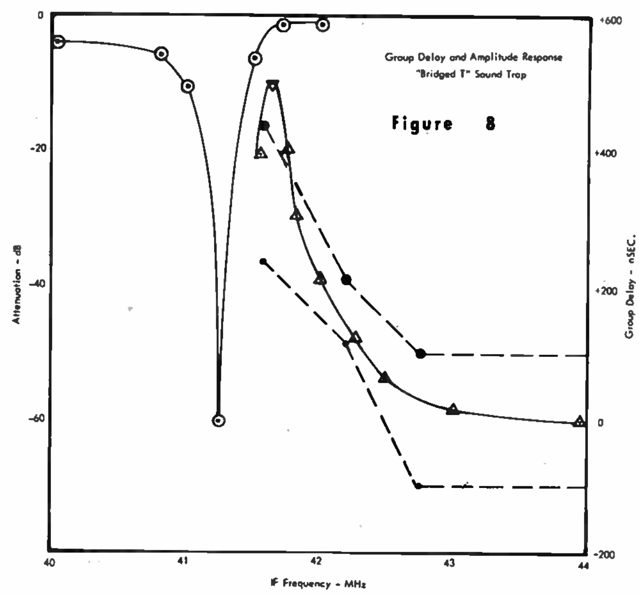
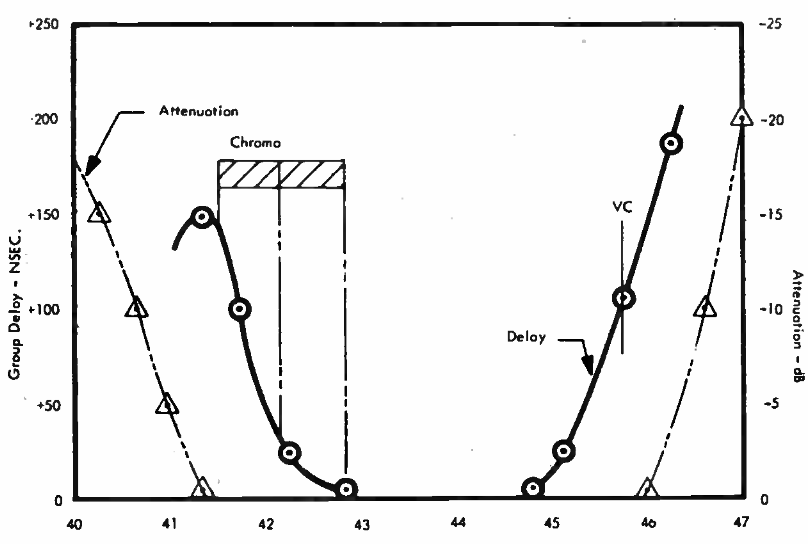


Figure 8

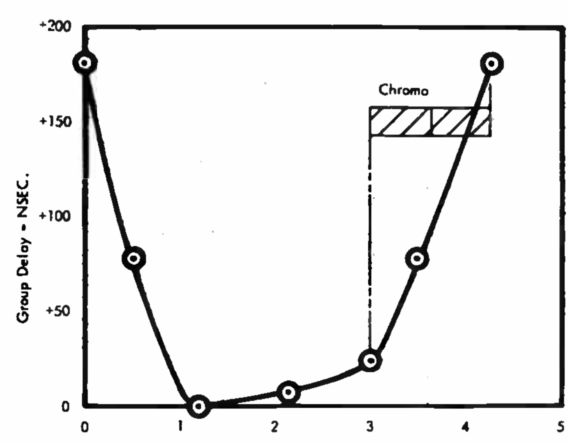
sideband falls at a point 3.65 MHz above the lower adjacent channel video carrier, and lower sideband signals generated at 2.42 MHz fall within the center of the lower adjacent channels chroma band.

Modulator traps must control energy transmitted at these frequencies to prevent lower adjacent channel interference. Upper adjacent channels are not as



Group Delay - Vestigial Filter
Measured at IF Frequency

Figure 6A



Group Delay - Vestigial Filter
Measured at Baseband Video
Nyquist Demodulator

Figure 6B

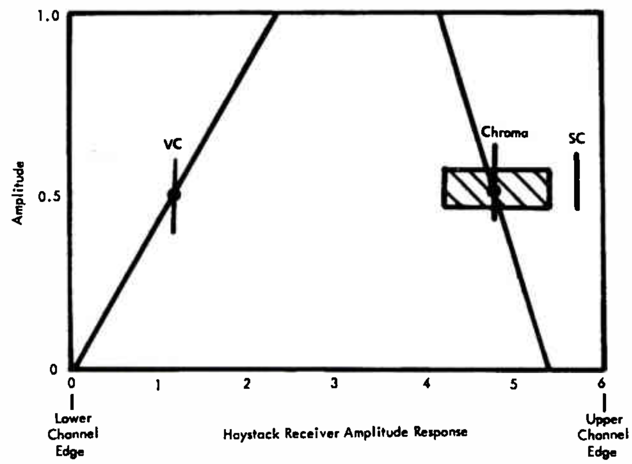


Figure 9

susceptible because: 1) Video spectrum power decreases greatly at the higher video frequencies, and 2) at the receiver or demodulator, Nyquist flank filtering further attenuates these frequencies.

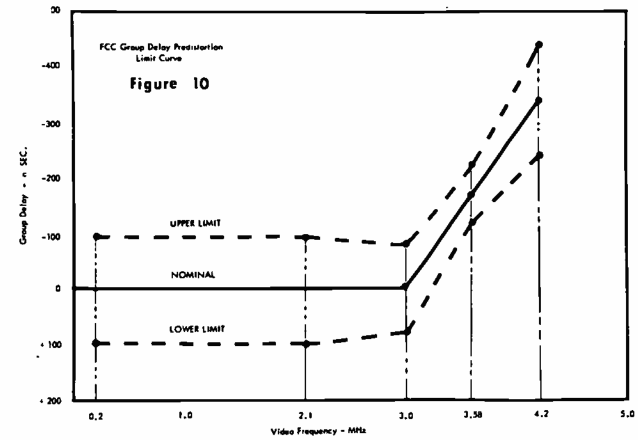
An exception is noted to 1) above when non-bandwidth limited video sources are used. In this case, the necessary filtering is more easily obtained at baseband than in RF or IF circuits.

Modulator Vestigial Sideband Filter. From the above considerations, an overall modulator passband characteristic can be outlined, consistent with the requirement to deliver a quality color signal to the cable or microwave link, and which will also assure noninterference to adjacent channels.

- Passband flat within 0.5 dB from f(video carrier) to f(video carrier +4.18 MHz).
- A vestigial sideband flank attenuation characteristic which develops a diode detected video signal within Figure 4 limits.
- A lower band edge attenuation of 20 dB minimum, increasing to 40 dB minimum at the lower adjacent channel chroma frequency f(video carrier -2.42 MHz), then to 60 dB minimum at the lower sideband chroma frequency f(video carrier - 3.58 MHz).
- The upper band edge attenuation requirement of 20 dB will be met with normal bandwidth limited video signal sources.
- Stop band attenuation greater than 3 MHz from upper and lower band edges should be greater than 40 dB. Normal roll-off of higher video frequency energy will insure that transmitted spectrum will be 60 dB minimum below video carrier.

Group Delay

Frequency dependent timing variations, or group delay occurs in all filter networks. These errors result in degraded pulse fidelity and a relative shift in the luminance and chroma information. Group delay errors are greatest near the corners of the passbands within the modulator and demodulator. These are greatest at the lower passband edge due to the modulator vestigial sideband flank, and at the upper sideband slope due to the demodulator sound traps.



Typical group delay curves obtained with a 5 pole modulator vestigial filter design are shown in Figure 6A and 6B, and for a 5 pole synchronous tuned demodulator Nyquist filter, no sound traps, in Figure 7.

The corresponding attenuation curve of the vestigial filter is also shown on Figure 6A. Group delay at the upper video frequencies with sound traps in circuit will reach large positive values approaching the 4.5 MHz trap frequency. Measured group delay for a single bridged T sound trap similar to those used in a TV set is shown in Figure 8.

Most current TV set designs use the haystack IF response, Figure 9, to reduce these sound trap related errors, by providing a smoother transition from the chroma passband to the sound trapping frequency. The resulting skew in chroma amplitude is then made up by shaping the chroma amplifier filters.

Delay equalization is accomplished with all pass networks, which may be inserted in baseband video circuits, or at IF or RF. Equalization is normally accomplished at baseband because the required element values are more realizeable, although slightly different results are achieved by the two methods due to the unequal transmittance of upper and lower sidebands within a vestigial sideband system. This effect can be noted in the two examples of group delay given in Figures 6A and 6B.

High frequency delay precorrection to compensate receiver delay errors is required of transmitters. The delay precorrection specified is shown in Figure 10. Some disagreement exists as to the appropriate amount of precorrection since delay errors are a function of the particular type of passband shaping used within the receiver. However, TV manufacturers optimize performance of receivers using this established precorrection curve. Low frequency precorrection of receiver error is not a requirement of transmitters since this error is smaller than the high frequency errors.

The overall group delay characteristic of modulators used as cable distribution signal sources should conform to the standards of TV transmitters since the home receiver is optimized for signals having this group delay characteristic. Modulators used in microwave links may require other than this delay characteristic in order to more exactly match the delay characteristics of the demodulator used. For this reason, some flexibility in the delay network section is desirable.

Subjective Effects of Group Delay. The subjective effects of group delay errors in a TV system have been well documented. A recent study by A.M. Lessman of Bell Laboratories relates the subjective effects on standardized test pictures to varying amounts of both shaped delay, Figure 11, and flat delay. The flat delay characteristic was introduced by delaying color camera luminance information varying amounts relative to the chrominance signals prior to combination and distribution to the viewing monitor. A seven point comment scale, Table 1, is used to develop a family of curves relating the amount of group delay and the resulting subjective degradation.

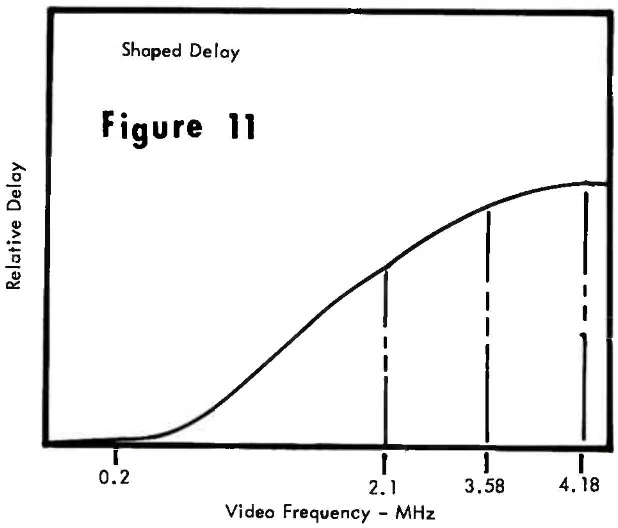


Figure 11

Table 1 The Seven-Point Comment Scale.

Comment No.	Comment Description
1	Not perceptible
2	Just perceptible
3	Definitely perceptible, but only slight impairment to picture
4	Impairment to picture, but not objectionable
5	Definitel
5	Somewhat objectionable
6	Definitely objectionable
7	Extremely objectionable

These curves for flat delay and shaped delay are reproduced in Figures 12 and 13.

Test Measurements

The measurement of amplitude response and group delay in a modulator or demodulator is complicated because of the interacting responses of transmission

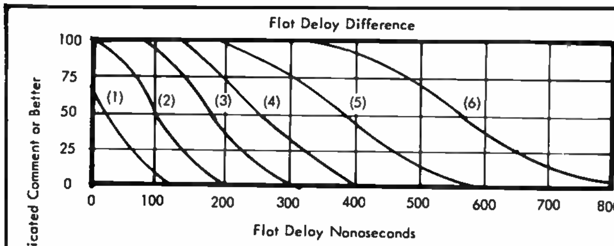


Figure 12

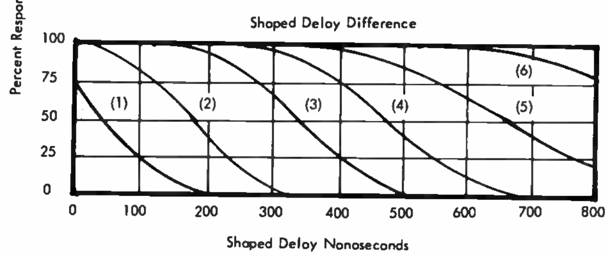


Figure 13

and detection of the test signals in a vestigial sideband system. The following test methods minimize this interaction in testing these parameters.

Vestigial Sideband Characteristic — Modulator. The vestigial sideband transmission characteristics can be conveniently measured with a sideband response analyzer which provides a swept video test carrier, and has provisions for selectively detecting and displaying the resulting sideband energy of a modulator or transmitter. In the absence of this equipment, point by point measurements of the sideband characteristics can be made using the test setup of Figure 14.

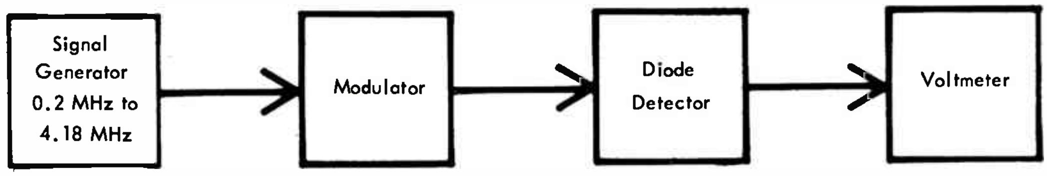
Band Stop Characteristic — Modulator. Attenuation characteristics outside the modulator passband are most readily measured with a spectrum analyzer, and a composite video modulation signal. Carrier modulation should be 87.5%.

Nyquist Slope Response — Demodulation. The Nyquist response of the demodulator is most readily measured with a double sideband modulated signal from a test generator, or from a modulator with the double sideband output brought out for test purposes. Test setup is shown in Figure 15. Ideally, the recovered video output from the demod should be flat across the video band up to 4.18 MHz. See Figure 3.

Group Delay — Demodulator. Group delay characteristics of a demodulator can be measured by using the non-bandwidth limited double sideband output from a modulator as the test carrier. This eliminates any significant delay error contribution from the modulator. Any group delay compensation within the modulator should also be removed. The test setup is shown in Figure 16. The ideal resulting delay characteristic will have the inverse curve of Figure 10 when used to demodulate off-air signals.

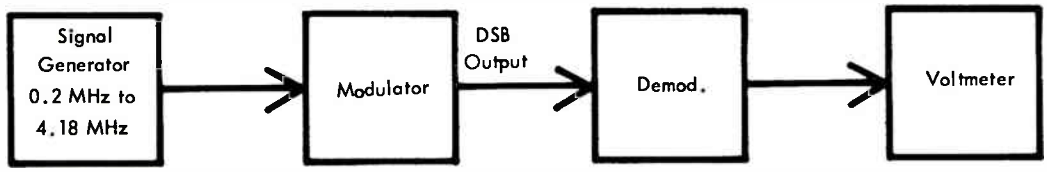
Group Delay — Modulator. Modulator group delay characteristics should be made using a vestigial demodulator for detection. This measurement can be made following the determination of demodulator

Figure 14



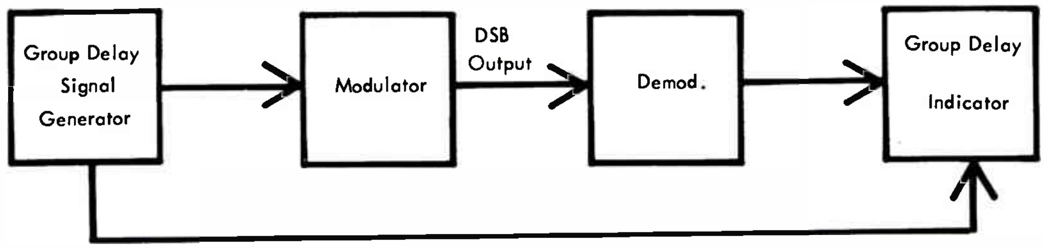
Vestigial Sideband Modulator Response

Figure 15



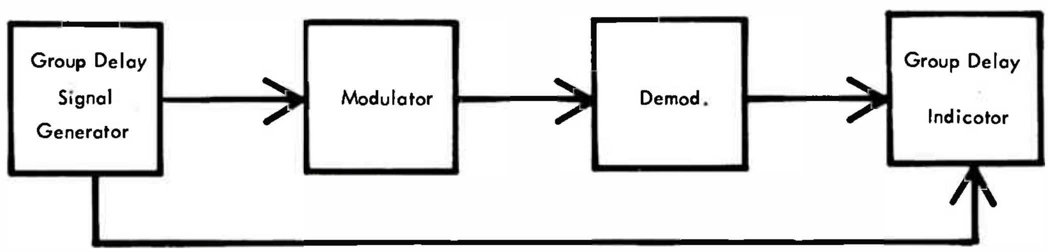
Nyquist Slope Demodulator Response

Figure 16



Group Delay Measurement - Demodulator

Figure 17



Group Delay Measurement - Modulator

group delay, then subtracting the known demod. errors from the result. A test setup is shown in Figure 17. The resulting corrected delay curve should follow the limits of Figure 10.

Summary

The demodulation/remodulation process of applying an off-air signal to the cable system offers several advantages over the heterodyne signal processor. The recovered baseband video signals can be processed and enhanced unlike an all RF system. Group delay errors and amplitude inequalities created in bandpass shaping circuits can be measured and corrected at video baseband.

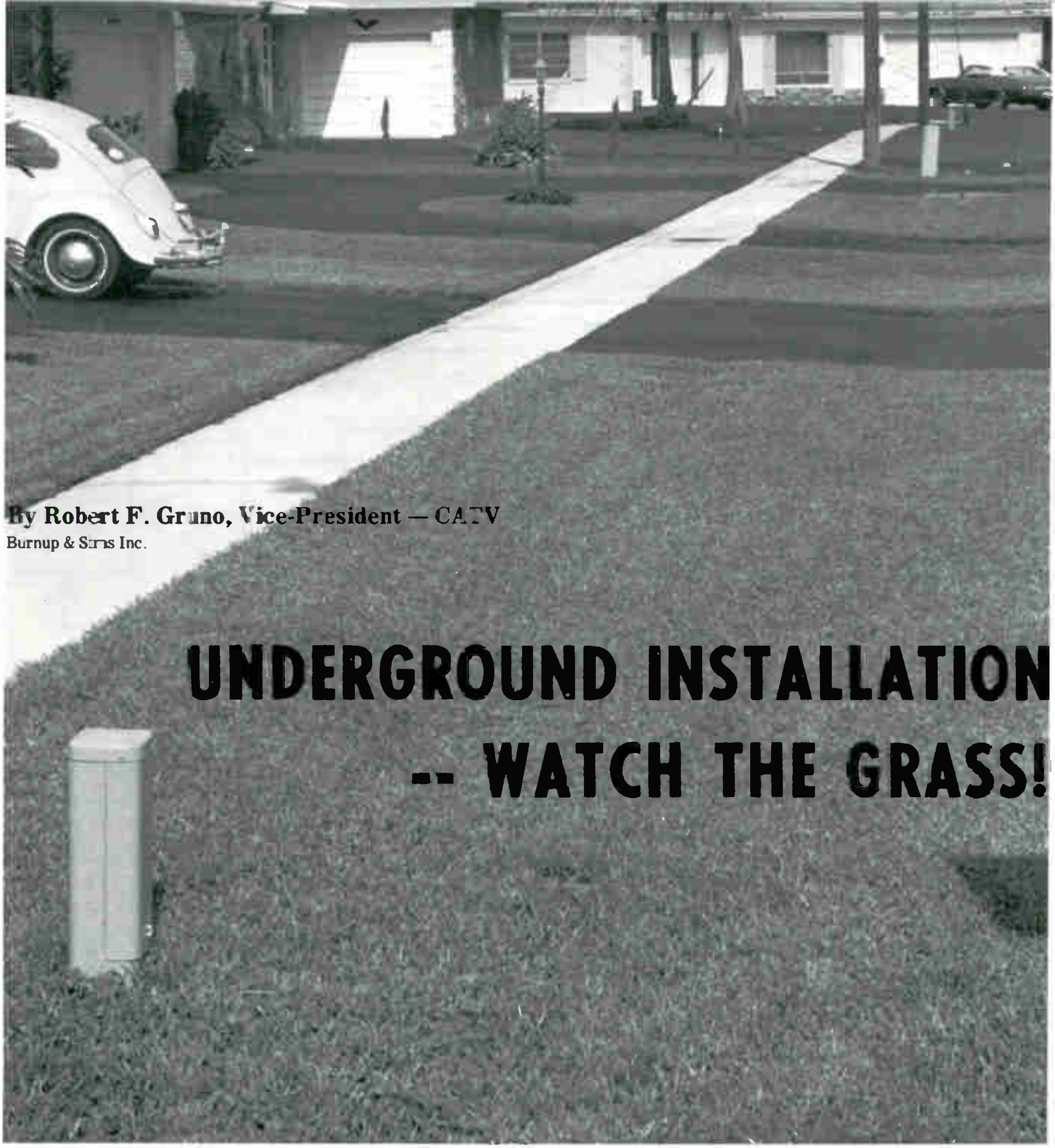
These errors are more difficult to correct at RF or IF (and are usually not) in the heterodyne signal processor. Synchronizing waveforms can be regenerated, additional video sources can be readily switched into the system, and the video waveforms which are available for measurement can be used to evaluate picture quality. Vertical interval test signals (VITS) are used on most network programming, and are a powerful tool in evaluating system distortion.

The problems attributed in the past to the demodulation/remodulation process were primarily: 1) distortions caused by non linear transfer functions of the detection and remodulation process, 2) quadrature distortion produced in envelope detection of a single sideband signal, and 3) off-air co-channel beats. Synchronous detection demodulators are capable of reducing differential gain and phase, quadrature distortion, threshholding non linearities, and the 920 KHz intermodulation product of the chroma and sound carriers. Enhanced carrier techniques of signal detection can achieve some measure of improvement in these amplitude distortions by effectively decreasing the modulating depth.

Modulators using integrated circuit modulator stages are capable of generating a signal with extremely low differential gain and phase and a modulation depth capability in excess of the original transmitted signal.

Off-air co-channel beats are reduced by use of optional phase lock circuitry within the modulator which locks the modulator carrier frequency to the off air carrier.

The remaining potential distortions and errors are related to the various filtering requirements of demodulation and remodulation, and amplitude nonlinearities of the necessary amplifiers and mixers which are well recognized.



By Robert F. Gruno, Vice-President — CATV
Burnup & Sims Inc.

UNDERGROUND INSTALLATION -- WATCH THE GRASS!

Everybody who has ever installed a cable or a conduit in a residential utility easement should know that the homeowner may be seriously disturbed about some aspects of the operation. It's amazing how quickly we who are contractors and engineers seem to forget that fact; and even tend to forget some of the long range consequences which can follow if proper action is not taken.

Put another way, this means that between the problems associated with installation and the problem of selling hook-ups, the system operator is under considerable pressure in two directions at once. He can relieve quite a bit of the pressure by being fully aware of the things that can go wrong when he first enters a community. In addition, he must be aware of the fact that although it is the installer whose crews are in actual contact with the community, it is the system operator who will likely be held accountable.

It is, of course, poor operational practice not to be concerned with all aspects of system installation. However, community relations are often a problem of less pressing urgency than the making up of work crews, the scheduling of a delivery, or the repairing of a vital piece of equipment. Community relations is an intangible factor that is easily ignored, yet can significantly affect the financial rewards of the investment in the system.

The time to start thinking about the community effects of system installation is when the contract is put out for bids. You will already be aware of some

Third stage of cosmetic restoration is a perfect blending of the old and the new. As shown in the photo on the left, other than the junction boxes, all signs of excavation have vanished.

of the problems: you will have looked over the neighborhoods covered by the franchise, you will know something of the political climate, and you will have an idea of what the community's attitude towards CATV is likely to be. In addition, however, you will have to develop plans for dealing with individual property owners — particularly in conjunction with underground installation.

Before awarding the contract, the contractors should be evaluated in terms of their ability to establish and maintain good relationships with a community's inhabitants. Make it your business to find out how efficiently a contractor has handled restoration work: it may become necessary for you to contact system operators for whom the contractor has worked in the past.

While restoration work may represent as much as 50 per cent of the cost of an underground installation, this is also the area in which a contractor may be most likely to pick up some extra dollars for himself. A successful low bidder who discovers that his costs are running far ahead of estimates may be tempted to skimp on restorations in order to recoup his losses — at untold cost to the system operator.

Now you may say that you have trouble enough trying to design a system, purchasing equipment, building a tower, trying to keep costs from going out of sight, without having to worry about a homeowner's rhododendron bushes. Yet, if you don't worry about such very small details it may not matter whether you build the tower or not. Naturally, it is always understood that shrubs will be replanted, sod will be replaced, driveways repaired, and utilities put back into operation. Even the homeowner understands this. But don't forget, the homeowner has spent time, energy and money to put his yard in order. Even when he has been prepared for the event he feels helpless when trucks pull up and machines begin to dig up the flower beds. He may well understand that a utility easement across his property exists, but he will feel exploited on the slightest provocation. All too often, the resentment mounts until he feels that the system operator and city hall have banded together and somehow sold him down the river.

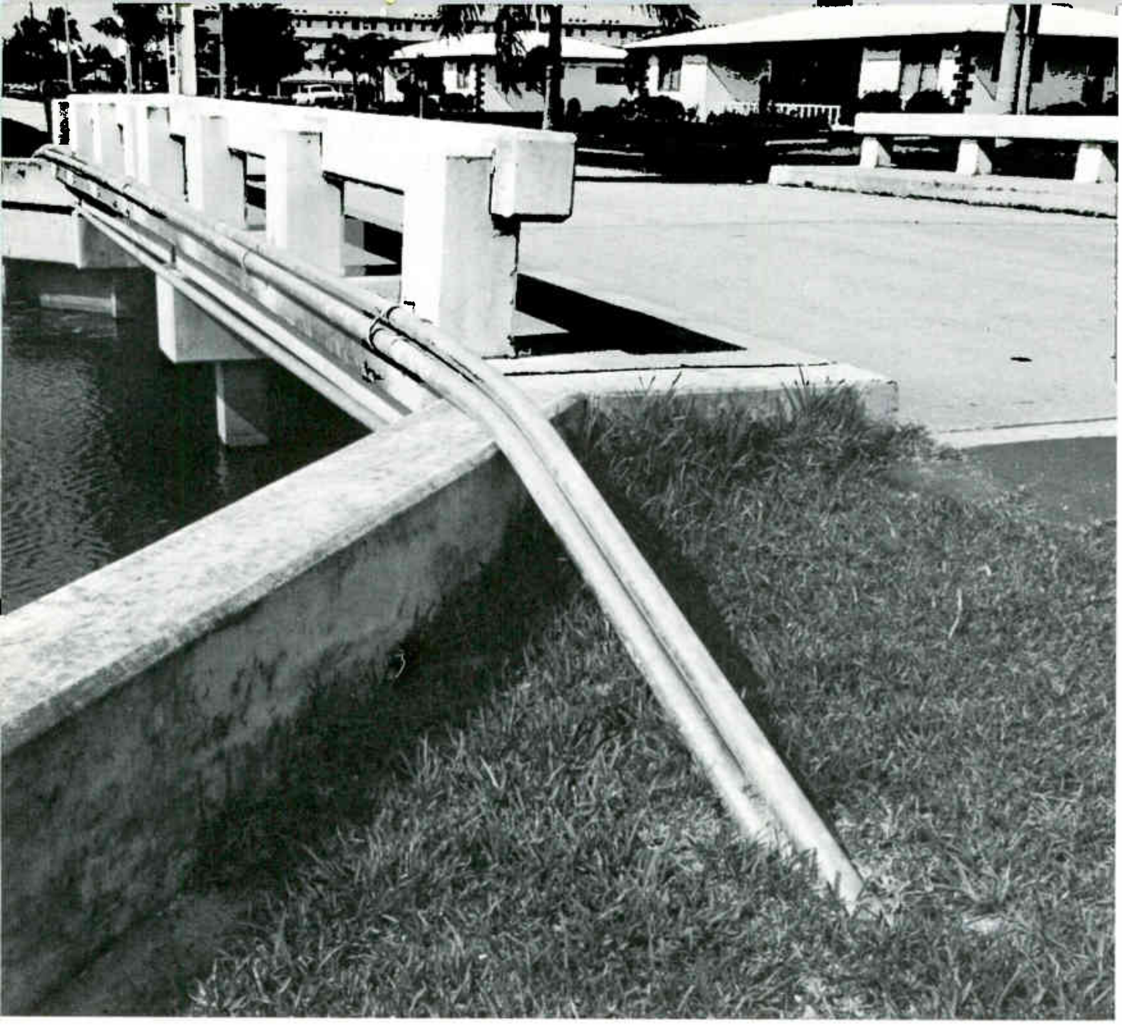
Not infrequently, an underground installation may temporarily deny him access to or exit from his own house. Under normal circumstances this is hard for a homeowner to take, but when it is added to the irritation of having uninvited men and machines on his property his good will may be lost permanently. At this stage, it makes little difference what agreements and signed papers the operator can wave in the air: the burden of making the underground installation pallatable rests squarely with the system operator and his contractor.

So, here are some thoughts on what can be done:

1) Make frequent contact with the residents of communities where you plan to operate. This can be done through direct mail pieces — telling the reader exactly what to expect and approximately when to expect it. When individual homeowners have to be inconvenienced, they should be told why, and how long for, and every effort should be made not to extend the estimated time.

Before. Immediately after closing of trench. Some contractors may leave the surface in this condition, but most will place sod over it.

After. Photo of same location with junction box covering the distribution and drop cable terminals and sod in place.



The cable is neatly carried over a culvert. Homeowners may be sensitive to the excavation even when a utility right-of-way exists.

Also, keep in mind that during the day most homeowner contacts by the contractor will be with housewives. One system operator found that some serious confrontations were avoided by using smart, well-informed young women as goodwill ambassadors. They not only helped the operator to avoid embarrassing situations during the construction phase, they were also highly successful in signing new subscribers.

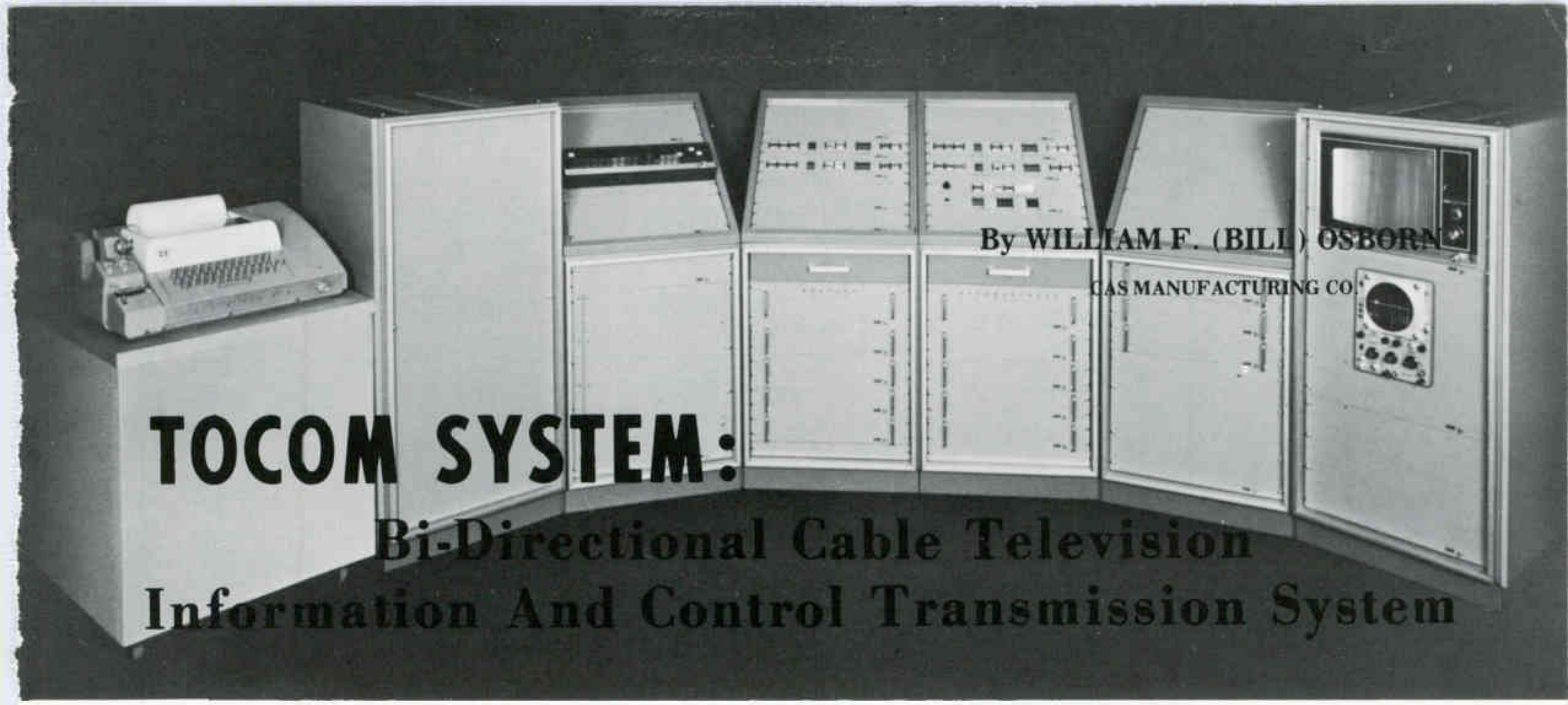
2) Maintain constant contact with the contractor and provide a liaison man to receive complaints. If the contractor's crew, through no fault of theirs, cuts a utility line during an underground installation, make sure the homeowner is contacted. (How many times has it happened that a water pipe or a power line turns up somewhere other than where the utility company said it should be?) It is always better if the homeowner learns the bad news from those responsible than if he discovers it for himself.

A good deal of trouble can be avoided in this area by working with an experienced contractor. You will need to be able to assure yourself that he and his crew will treat residents with courtesy and that he is sufficiently diplomatic to handle some pretty tricky situations without making them worse. The contractor will obviously have to have a serious interest in doing a good job as well as an appreciation of the long term effects of doing a bad job. Again, experience is all important.

By keeping in constant touch with the contractor you will know immediately when a homeowner has been inconvenienced. And keep in mind that even when you respond instantly to a complaint you may not calm the complainant. Accidentally cut a sewer line and the owner may demand replacement of his entire plumbing system. Take comfort in the knowledge that if you had not reacted as quickly it might have been very much worse.

3) For all of the above reasons, it will pay you to research your contractor. Find out how he handles himself, particularly in underground installation since that is more likely to cause adverse reaction than overhead. When considering a contractor, check not only his records of conscientious restoration, but also his credit rating — since obviously he will be doing business with local suppliers. More likely than not, he will have to bring some of his skilled people into town with him. Satisfy yourself that they will not meet the community with a "here today, gone tomorrow" attitude, since such an attitude is certain to affect their behavior. You cannot afford a contractor who possibly will offend community residents regardless of how low his bid.

In conclusion: The way you, your contractor and his men appear in public is at least as important as the quality of the installation and the hook-up. Without doubt, the future of your underground system may well depend on the ability of the contractor to replace the grass.



TOCOM SYSTEM:

Bi-Directional Cable Television Information And Control Transmission System

By WILLIAM F. (BILL) OSBORNE
CAS MANUFACTURING CO.

TOCOM is a broad band, single cable, bi-directional CATV communications system providing conventional 26 channel forward transmission, a 26 channel converter receiver, a crystal controlled subscriber identified digital transmitter built into the converter, a hub located computer interface interrogator and master computer memory bank.

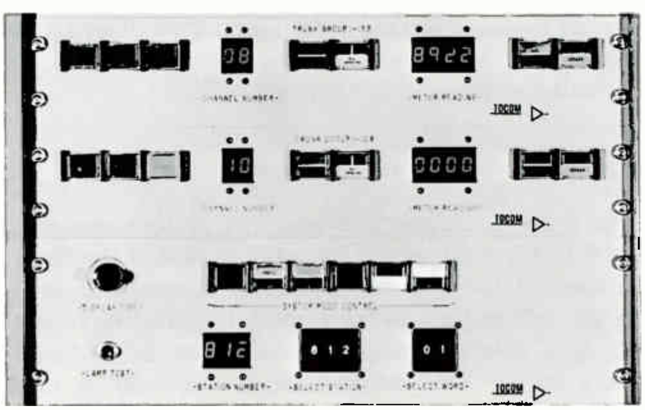
The TOCOM system consists of three primary elements — a central data terminal (CDT), a bi-directional coax amplifier system, and a large number of remote transmitter receiver (RTR) units. In general, the TOCOM system has the capability of transmitting from the CDT interrogation information to one or more selected RTRs. This causes the RTR unit or units that have been interrogated by the interrogation signals to sample certain data and to transmit this information back to the CDT, with all signals being transmitted on a single coax cable.

The system as it is presently designed, though expandable, has the capability at any RTR location of interrogating seven words of information, each word containing 16 bits. In the present system, the seven words of 16 bits are so coded to return certain specific information; however, the seven words of 16 bits could be coded to return any information desired. In addition to being able to obtain the interrogated information, the system also has certain other capabilities which will be discussed later.

What It Can Do

The system as it is presently designed and presently coded at each RTR location, will interrogate the following information. It can determine if there is a fire, ambulance or police alarm activated at the location; it can determine to what channel the set is tuned; it can determine if the selected pay TV channels have been authorized by the user; it can determine the user's opinion on a specific question (in conjunction with video signal the user is asked a question, he then will make his selection by pushing one of three buttons on the RTR, thus indicating that his is No — YES — or No OPINION). Also, the system can determine if the TV set is on or off. In addition, the RTR unit, when connected to a kilowatt hour meter, gas meter, water meter, or any other such type of device, can automatically read the meter or meters. In addition to being able to determine the specific information mentioned above, the system in conjunction with a digital computer that is located at the CDT, can disable or enable select remote units, can determine where faults occur in the line, and determine if any specific RTR unit has failed.

For the future of the system, with very little modification, we see the capability of not only interrogating information from the remote locations, but also the control of devices at remote locations. For example, to turn on or off a heating system or air conditioning system at a given time, feed the cat, wake up a person, turn on the coffee pot, or any number of things that would be desirable to control from a central location on an automatic basis. In general, the system has the capability of control and interrogation of remote units be they located in a CATV system or an industrial complex. It is possible with



Closeup of control panel showing some of the readout information available from the system.

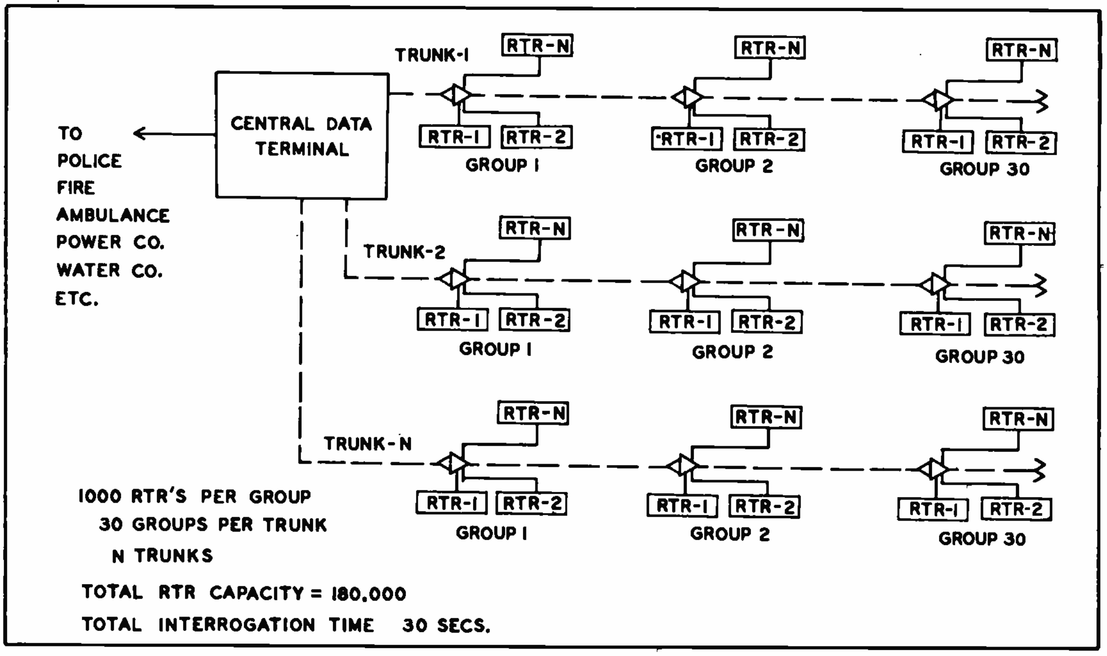


Fig. 1. System block diagram.

very little modification for the system to interrogate more information if desired. For example, we can include parity bits for reliability purposes, we can measure analog signals, we can increase the number of words and bits, and if necessary, we can increase the sample rate considerably over and above the rate at which the system is now operating.

As it is now operated, the system has the capability of controlling one thousand RTRs per group, and it can handle 30 groups, that is 30,000 RTRs, on each trunk line. Since it can include any number of trunk lines, we may say that the system, as designed, has the capability of handling roughly 120,000 to 180,000 RTRs. From a practical standpoint this large number is really in excess of what will be necessary on any one particular system.

The speed of the system is such that to sample up to 180,000 RTRs will only require 30 seconds. What this really amounts to, is that we will sample on a simultaneous basis more than one RTR. It requires approximately 30 milliseconds to sample one RTR and obtain from it one 16 bit word.

Figure 1 is a block diagram showing a central data terminal controlling N number of trunk lines with up to 30 groups of remote transmitters on each trunk line and each group on each trunk line containing up to one thousand RTR units. This diagram indicates that we have information flow to police, fire, ambulance, power company, etc.

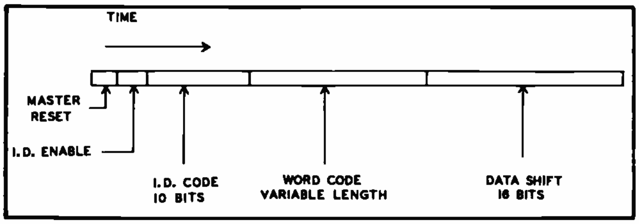
How It Works

In order to understand how this system operates, refer to Figure 2, which gives the format of the transmission of the system. The CDT transmits interrogation information to the remote transmitter receivers with selected frequency coding in the 50 megahertz range. This information is received at each RTR, operated on accordingly, and the RTR then transmits information back to the CDT in the 6 to 30 megahertz region. Each group of RTRs on each trunk line is assigned a specific frequency, for example, 10 MHz, 10.8 MHz, 12 MHz, 13.2 MHz, 14.7 MHz (these frequencies have been selected such that harmonics fall in between the upper channels and we don't end up with birdies in the video system.)

Referring to Figure 2, the operation or interrogation of any one RTR unit is as follows, The CDT transmits a master reset signal. This causes the RTR's throughout the system to come to the initial or reset state. We then transmit an ID Enable signal. This enables all the remote transmitters in the entire system to receive an ID code, which is 10 bits long and is transmitted to all of the RTRs. Each RTR decodes these signals and reacts accordingly. For example, RTR No. 1 in Group 1, and No 1 in Group 2, and No. 1 in Group 3, etc., would all have the same ID code.

When an RTR receives its code, it in effect enables itself to say "OK I am the particular remote unit you are talking to, please send additional information." At this point, the CDT transmits an additional signal which identifies the particular word that we would like to have interrogated from the RTRs which have received and identified themselves from the previous ID code. We then transmit 16 data shift bits from the CDT and this causes the 16 bits of information which have been, in effect, brought into the RTR from the combination ID code and word code, to be shifted out and transmitted to the CDT. The actual transmission is caused by the 16 bits turning on or

Fig. 2. Signal format.



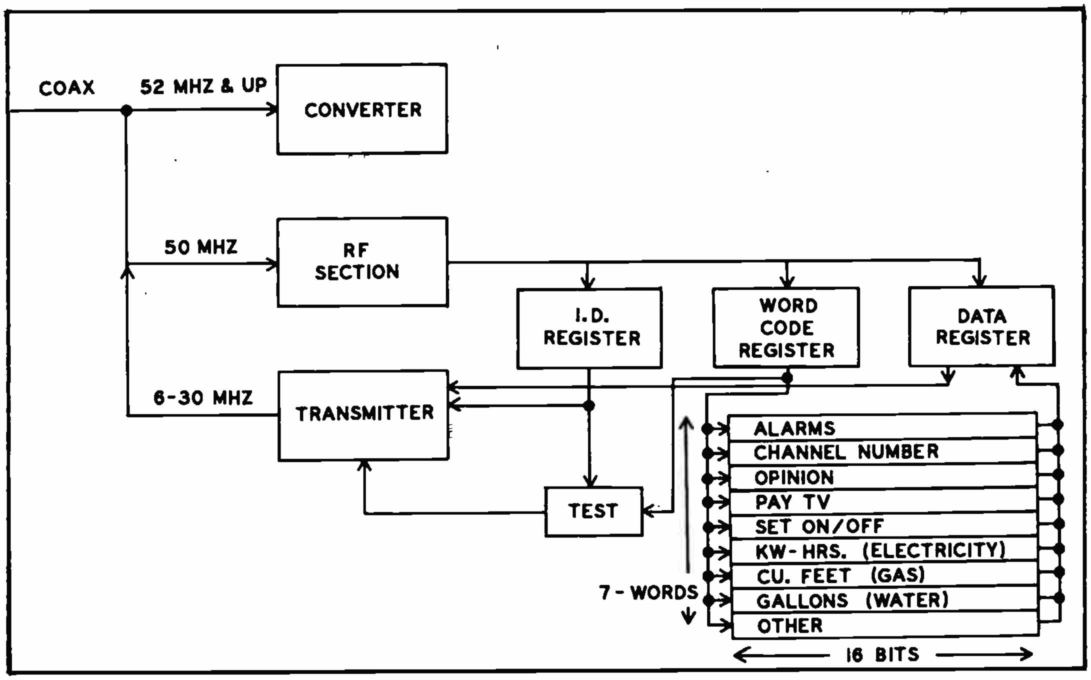


Fig. 3. Remote transmitter receiver.

off the appropriate 6 MHz to 30 MHz oscillator that is contained in the RTR.

In order to better understand the operation of the system, refer to Figure 3, the block diagram of an RTR unit. At the remote unit, any information in the 52 MHz region and up is bypassed through a by-pass filter and transmitted on to a conventional 26 channel converter, which converts the particular channel to Channel 12 for the user's TV set. The 50 MHz interrogation information is brought to an RF section which is a portion of the RTR unit. Here the interrogation information is decoded in such a manner as to cause the appropriate information to be sent to either the ID register the word code register, or the data register.

As previously explained, the ID register, when it recognizes its particular code, enables the output remote transmitter. In addition, the word code enables a particular set of switches or devices. Infornation from these is transferred into the date register and then, in conjunction with the 16 shift pulses, operates on a transmitter to be sent back down the coax to the CDT.

Located on the front panel of the RTR are 3 pushbuttons labelled No — Yes — or No Opinion. The sequence of events of operation of these switches is as follows: From the video portion of the program a viewer is asked a particular question. At the same time, the CDT transmits a particular code to each RTR which causes the opinion circuits in all RTRs to be reset (the purpose behind this is to not obtain an opinion from every set but only those that are properly activated by one of the users). The viewer may, for example, push the Yes opinion button, but a moment later he may decide that he really meant No, and he then pushes the No button. This will cause the internal circuitry to reset his Yes opinion and to set his No opinion; he actually has a short period of time to change his mind if he so desires.

Referring again to Figure 3, there is a certain portion of the RTR which is marked "test". The purpose of this portion of the system is to enable the CDT to send out selected information to each remote transmitter to disable every RTR throughout the system. We can also use this to enable every RTR on the system, or selectively enable or disable particular RTRs. This capability can be extremely helpful in operating the system if failures occur.

The RTR units are so designed that maintenance personnel can in a matter of a few moments change an RTR and have a new one in operation. To accomplish this simply requires one to disconnect the coax coming into the unit from the CATV system, disconnect the cable running to the antenna input on the TV set, and disconnect the connectors going to the remote alarm units, water meter, etc. The only additional job required to install a new RTR is to connect three wires that are in the RTR digital section to certain pins, which sets the identification code for that particular unit. The console at the CDT is so designed that an RTR unit that has failed can be plugged in to determine if the RF section or the digital section has failed.

The Central Data Terminal

Figure 4 is a block diagram of the CDT, which consists of three major elements: 1. the central data processor, 2. a hard wire controller display system and 3. the RF system.

Under normal operation, the central data processor tells the hard wire controller: I would like to have the information from certain remote transmitter units whose ID code is such and such and I would like to receive words 1, 2, 3, 4, or whatever it may be. The hard wire controller takes over and with this information actuates the 50 MHz transmitter, which sends out the interrogation information to the RTR. The

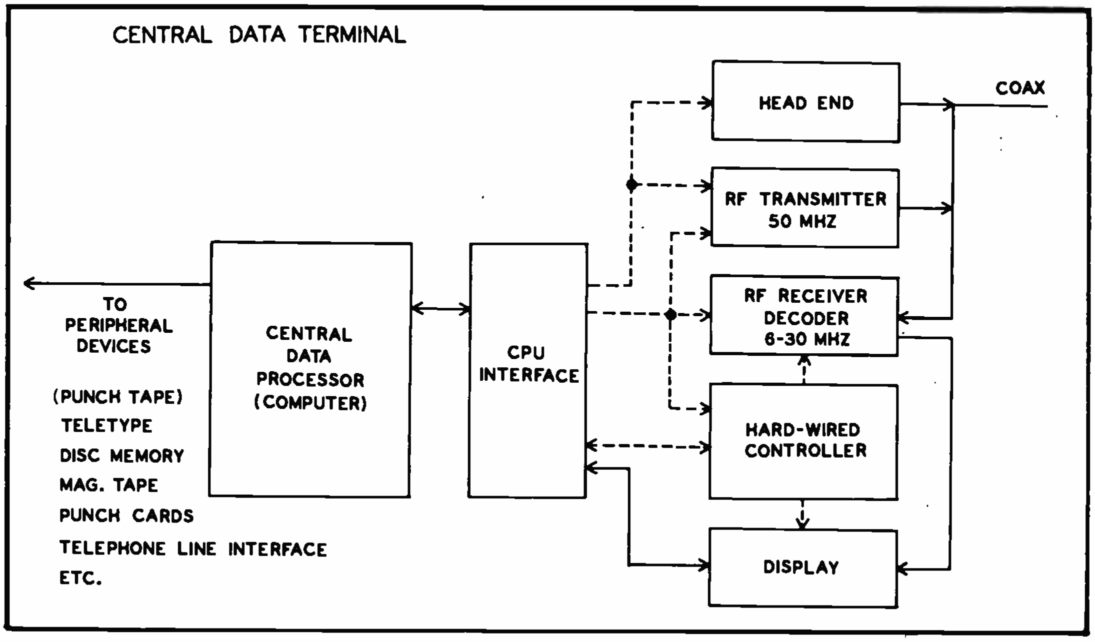


Fig. 4. Central data terminal.

information is returned from the appropriate RTR units and is brought into the display portion of the system. At this time the hard wire controller tells the computer: I have the information — come get it. Then the central data processor will bring in the 16 bit words from each RTR which was interrogated and operate on this particular information.

This normal operation mode permits the central data processor the maximum amount of free time to do other functions, such as bookkeeping, statistical analysis, etc. However, it is possible to operate under two other modes of operation. The second is the direct mode, in which the central data processor bypasses the hard wire controller and directly controls the 50 MHz RF transmitter system. It can also control the head-end system and the display system directly. Under these conditions, the central data processor will then cause the 50 MHz RF transmitter to send out the interrogation pulses, the information will be received back and the central data processor then obtains the information from the display portion of the system.

The third mode of operation of the system is a semi-manual mode. In this case, an operator can take entire control of the system by operating certain switches at the console. This semi-automatic mode was designed into the system to enable it to go off-line from the computer to monitor, for example, alarm conditions on a continuous basis and leave the central data processor free for other purposes. In addition it gives a back-up if the central data processor were to fail.

By using a digital computer in the system, it is possible to do any number of things with the data received. For example, the central data processor can detect when an alarm condition occurs, and via an automatic system call the fire dept., police dept., or ambulance company. In addition, in the case of a fire, some additional information may be transmitted to the fire department. For example, it may alert the fire department that the fire is at a paint factory, an old age home, or a hospital and is a particularly critical situation. Further, we can determine a great deal of statistical information during polling. And in reference to pay TV, we can not only determine who is tuned to what channel on a real time basis, but the computer can actually prepare the billing, so that the customer is billed only for the time he watched, to the closest 30 seconds.

In other words, the use of a central data processor permits us to operate on information in any way we desire. We can bring this information out on telephone lines to remote locations, to another computer, or we can bring information out on punch tape, type it out on a teletype, put it on disc memory, magnetic tape, or punch cards.

The system can be used for maintaining the cable television equipment too. RTRs can be located along the coax system to monitor such things as the AGC, amplifier gain, etc. If the operating parameters change appreciably, this would be detected and we can alert a technician to check the failing amplifier, etc., before it actually fails.

With reference to the cost of the system, we have not at this point determined hard-set costs for the RTR or CDT. However, we feel that the RTRs, which do include the converters, will cost in the neighborhood of $100 each, depending on quantities. The cost of the CDT can range anywhere from $80,000 and up, depending on the requirements, such as the number of RTRs and the amount of programming necessary to program the processor in order to accomplish the functions desired by the operator.

Mr. Osborn has worked for Sandia Corporation, where he was responsible for establishing a secondary standards laboratory for the AEC, and National Data Processing Corporation in Dallas, where he was involved in the design of one of the initial automatic banking and check sorting systems. Before his association with CAS, Mr. Osborn was Vice President of Engineering for the Arps Corp.

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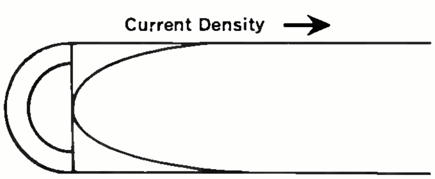

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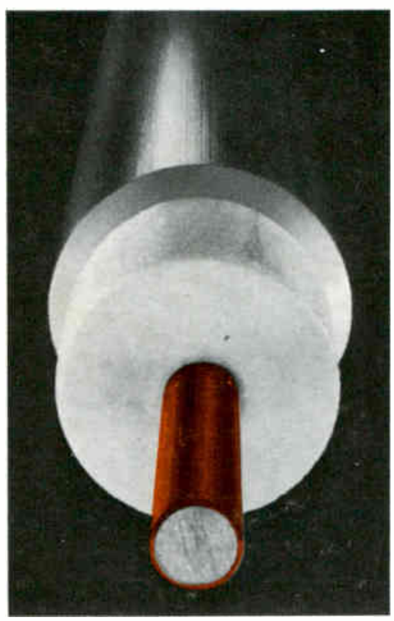

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