divergent approaches, and they have planned to submit this entire problem to the appropriate E.I.A. committee to work toward some sort of standardization.

We are planning to propose in that particular forum a joint working group of set manufacturers, CATV equipment manufacturers, operators, possibly representatives from the FCC -- if they wish to participate -- to attempt to work toward some overall television industry standardization.

I thought some of you might be interested in this particular point of view because I think the last paper just mentioned that there has been some discussion with TV set manufacturers. I am not sure that any people discussed this with our representatives at Syracuse. They are, however, very much aware of it and very concerned about it.

MR. WYDRO: I have one comment, and the only comment that I can say is, amen.

CHAIRMAN CLEMENTS: Thank you very much.

I know that many of you must have other questions concerning these addresses, and if we have additional time when the panel is completed we will possibly get back to some of the more pertinent points in connection with expanded band use.

Our next speaker is Argyle Bridgett, from Spencer-Kennedy Laboratories, Inc.

He is now Manager of Design Engineering for S-KL. He started with them in 1951.

Without any further introduction, I present Argyle W. Bridgett. (Applause)

MR. ARGYLE W. BRIDGETT (Spencer-Kennedy Laboratories, Inc.): For those of you reading the paper, the first sentence does not sound like anything.

Actually, if you get down to the basics, they are probably two in number, but there are a large number of problems that develop from these.

AUTOMATIC EQUALIZATION AS A FACTOR IN SYSTEM LEVEL CONTROL

BY

ARGYLE W. BRIDGETT

BASIC PROBLEM

The basic problems of CATV are really only two. First is obtaining a sufficient number of high quality TV signals and second is transmitting these signals through coaxial cable without degrading the original quality too much. The cable which is obtainable today does only one undesirable thing to the signal to any major degree. It attenuates the signal. It also causes a delay, but the delay, in general, is not a type which degrades the signal and the amount of delay is small. In a system of 1000 db, of cable attentuation the cable delay will be approximately 100 micro seconds.

The attenuation, however, is enough to completely lose the signal in snow and must be compensated for by providing amplification at close enough intervals to avoid losing the signal. It is in providing this amplification that most of the problems originate, since any amplifier will degrade the signal in several ways. First, if the total response of the amplifiers does not match the loss of the cable fairly well the picture quality will suffer. Second, it will add some noise to the signal. Finally, it will add distortion signals to the desired signals. These last two effects, noise and intermodulation are usually the factors which limit either picture quality which can be attained or system length.

I believe we are all familiar with the V curves shown in Fig. 1 which show how the amount of noise and intermodulation introduced in a system by the amplifiers depend on signals levels, amplifier gain, and number of amplifiers. The top curve shows the maximum output level at which a given number of amplifiers can be operated with a given amount of cross-modulation. (This will depend on the amplifier, the gain setting and the signal level tilt). The bottom curve shows the minimum input level at which the same number of amplifiers can be operated with a given carrier to noise ratio. The difference between these two curves for one amplifier is what is called by Shekel the "k" factor for the amplifier. The intermediate curve shows the minimum output level at which the amplifiers can be operated without degrading the carrier-to-noise ratio. The distance between these two curves is "system margin" which is the range of output levels at which a system of any number of cascaded amplifiers can be operated without exceeding either limitation. The ideal way to operate a trunk is with all amplifiers operating midway between these limits so that the "system margin" is equally divided between noise and intermodulation.

The important thing to remember about these curves is that the "system margin" obtained from them assumes that all amplifiers are operating at the same levels. In practice this is not always true. There will generally be a difference in levels from amplifier to amplifier due either to measuring equipment errors or variations with temperature.

It would seem at first thought that one could predict results by using the average of the levels throughout the system but this does not turn out to be the case. As an extreme example, suppose that we consider a system of 2 amplifiers and set one at the highest operating level for one amplifier. The amplifier which is at the high level will contribute a very small amount of noise and the amplifier at low level will contribute a small amount of intermodulation. Our system of 2 amplifiers will have exceeded the system limits by a small amount regardless of the "k" factor.

Thus, if we operate alternate amplifiers a few db. above and below the average level we find that we have reduced our system margin. Fig. 2 shows the reduction in "system margin" which would result from this type of operation. Notice that the degradation is very small if we do not deviate a great deal from the central value but becomes very great when the deviations from average are large. This can be very important when the system is long enough to provide very little "system margin".

FREQUENCY EFFECTS

The cable attenuation is not a constant value for all channels but varies almost directly as the square root of requency. The loss at channel 2 is approximately one half of that at channel 13. In a system having a total cable loss of 1,000 db. this requires 500 db. less gain at channel 2.

TEMPERATURE EFFECTS

Probably the most annoying problem in maintaining a system and operating it so as to obtain the best system margin is that the cable losses (and to a lesser degree the amplifier gains) vary with the temperature. If the temperature varies from + 140°F to - 40°F the cable loss will decrease approximately 16%. Thus, if the total high temperature cable loss in a long run is 1000 db. at channel 13 there can be a change in loss of 160 db at channel 13 and a slope change of 80 db. in the system from a summer day to a winter night.

It is obvious that it is impossible to obtain a system margin large enough to accommodate such a wide swing in levels. Therefore, it is necessary either to adjust amplifier gains and slopes every time the temperature changes, or to provide some automatic method of level adjustment. Automatic Level Control Amplifiers by themselves can only correct for one half of the cable variations. It is necessary to provide some method of automatic slope correction.

AUTOMATIC EQUALIZATION METHODS

A. Temperature Operated Equalizers

These are designed and built in the same manner as ordinary fixed equalizers using resistors, capacitors and inductors. However, one or more of the elements uses a temperature sensitive element such as a thermister, selected in such a way that the transmission response varies with temperature in a way as to be complementary to that of cable. Fig. 3 shows the characteristics of a typical equalizer. These are placed in the system at intervals so as to minimize the variations in slope at all amplifiers. Their only disadvantages are:-

1. As with any lumped-constant networks, an exact match to the square root of requency response of cable cannot be obtained. However, the errors in shape can be made very small and once a considerable number have been cascaded, and the errors measured a thermally operated mop-up equalizer can be designed to correct them.

2. The cable is spread out over an area in such a way that some of it is in direct sunlight and some is in the shade. On the other hand each equalizer is in a fixed location. Therefore, an exact match to the cable variations is difficult to achieve. However, if a sufficient number of them are used, and they are suitably located this effect can tend to average out.

3. If exact control of level at every amplifier is to be achieved, each equalizer should be designed to exactly match the span of cable preceding it. This would require that every equalizer be custom designed or that the system be built with spans which exactly match the equalizer. In practice this is usually undesirable for other reasons. As Fig. 2 shows, however, a slight deviation from desired signal levels will not lower the system margin very much and some errors can be tolerated. It is, however, desirable to calculate the location of each thermal equalizer quite accurately using accurate measurement of cable spans. This type of equalizer has been proven to work very well in systems over a period of 6 to 7 years.

B. Compensated gain controls with ALC

Some automatic level control amplifiers have been built with a slope variation designed into the gain control circuit in such a way that the amplifier slope is reduced with the gain. While absolute control of amplifier output level at the operating pilot frequency is obtained, this system also suffers certain disadvantages.

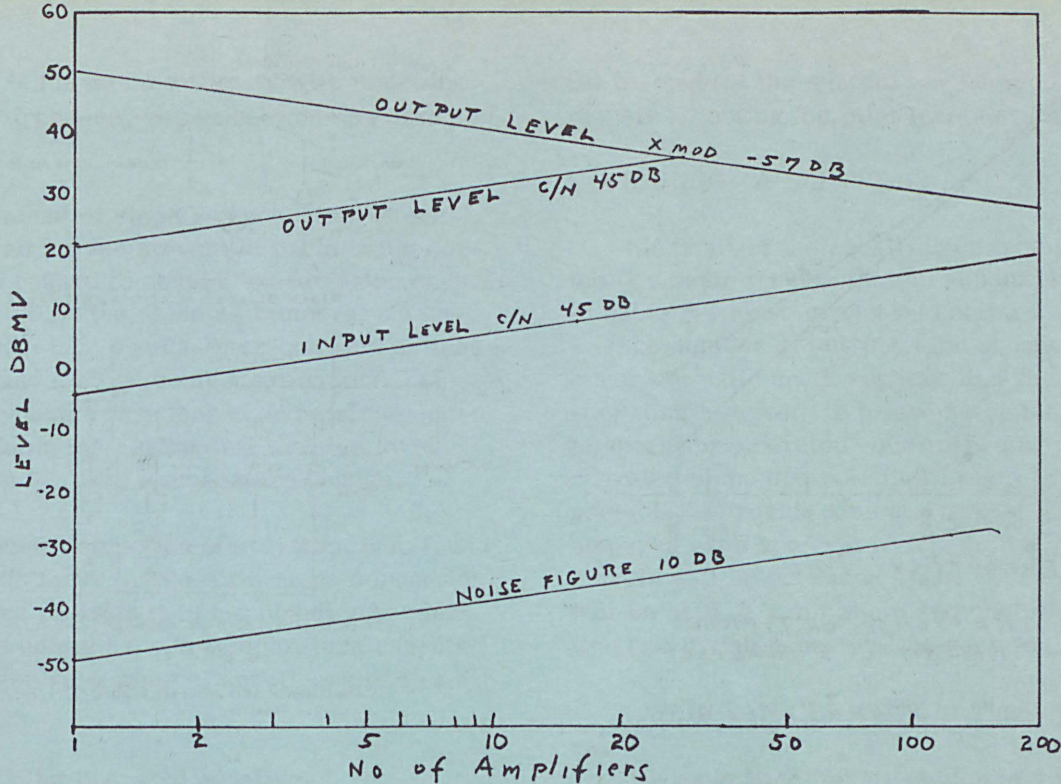
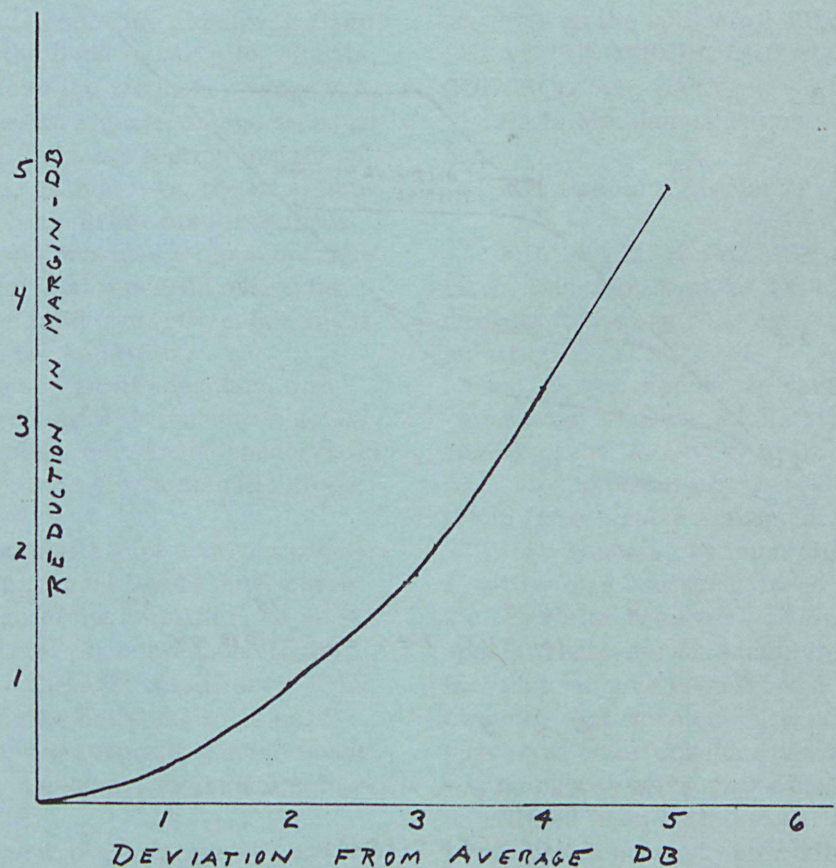
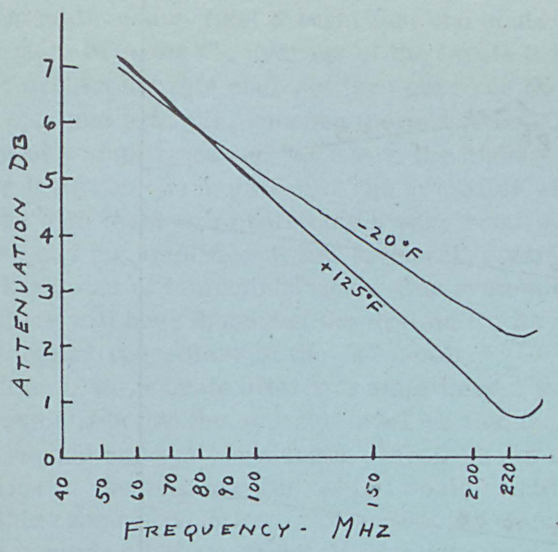


FIG 1



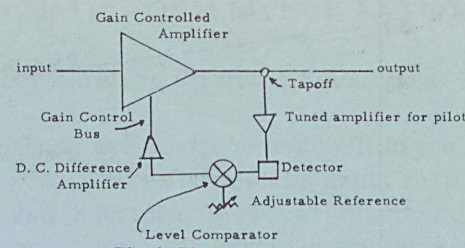
REDUCTION IN CASCADABILITY
WHEN ALTERNATE AMPLIFIERS ARE
SET HIGHER & LOWER THAN AVERAGE

FIG 2

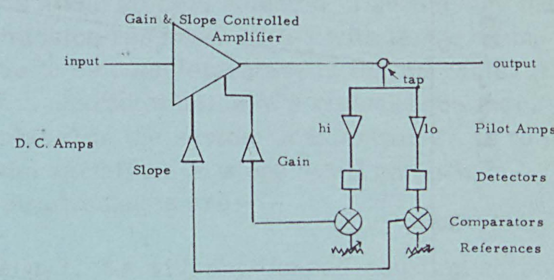


RESPONSE OF TYPICAL THERMAL EQUALIZER

FIG 3



Block Diagram - ALC Amplifier



Block Diagram - ALC/ASC Amplifier

Fig 4.

Comparison of ALC Amplifier & Pilot Controlled Equalizer

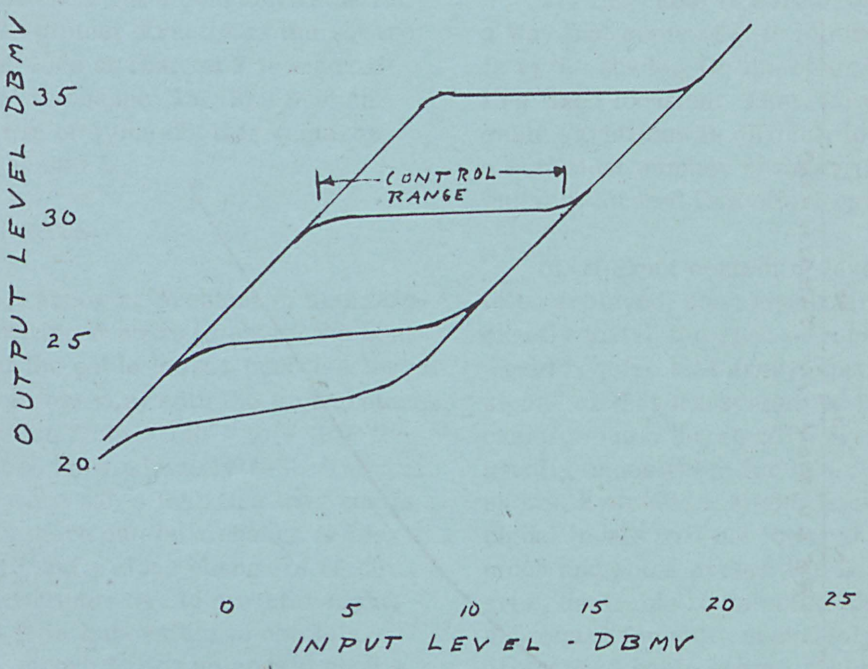


FIG 5

TYPICAL AUTOMATIC CONTROL CHARACTERISTICS

1. There is the same difficulty with matching square root of frequency response common to any of the methods.

2. The amount of slope compensation should be custom designed for the amount of cable being corrected for. In regard to correction for slope changes this method is about the same as temperature operated equalizers. In one case, temperature is measured directly and a slope compensation made. In the other, a level change is measured and a slope compensation made on the assumption that the level change was due to cable temperature change.

3. If, after construction of a system it is found that there is too much or too little slope correction for temperature changes it is not possible to make corrections as easily as with temperature operated equalizers, when relocation of equalizers can easily be made.

C. Automatic pilot operated equalizers

These have been in use in CATV systems since 1957. They operate in somewhat the same way as an ALC station except that the level of two pilot signals located near the two ends of the frequency range are used. If the levels of the two signals change an equal amount, the amplifier makes a correction in gain only to maintain signal levels. If, however, the two pilots do not change equally, the amplifier also measures the difference in levels and provides a slope correction in much the same way that a person observing the slope with a sweep or field strength meter might adjust the tilt control on the amplifier.

This system has the one great advantage over the other two methods that, since it measures actual signal levels, errors in slope correction cannot build up but will be corrected at the next automatic slope control amplifier.

However, just as automatic gain controls require that the range of incoming signal levels must correspond to the control range of the amplifier, so must the range of incoming signal tilt correspond to the slope correction range of the ASC amplifiers. This of course requires that if the units are to be used under normal conditions when preceding cable spans may be different from one another, the initial setup be made carefully.

A knowledge of the control characteristic is very important in planning the use of the equalizers if full advantage is to be obtained from their use. Fig. 5 shows a typical set of control characteristics.

The use of these units will reduce the amount of seasonal adjustments to an absolute minimum. In fact a certain amount of adjustment of both level and tilt throughout the system can be accomplished by merely adjusting the pilot levels at the head end.

COMBINING OF METHODS

Since all of the equalization methods suffer from the one basic trouble that an absolutely exact match to cable response cannot be obtained and cascading a large number of any one kind of unit will allow any errors to build up, it appears that the best way of operating a system is to use a combination of both temperature operated equalizers and automatic pilot operated slope control amplifiers. In this way it is possible to provide almost constant levels at the output of each and every amplifier so that the system margin will be degraded least. Errors in correction will be held to a minimum and cost of both construction and maintenance will be very low.

CHAIRMAN CLEMENTS: Thank you, Mr. Bridgett.

We have time for a question or two.

Apparently there are none at the present time, and we will move to our next speaker, who will address us on the subject of TEMPERATURE, TEMPERATURE DESIGN, AND AUTOMATIC LEVEL CONTROL FOR CATV.

He is Mr. James Palmer, of C-COR Electronics, Inc.

Mr. Palmer. (Applause)

MR. JAMES R. PALMER (C-COR Electronics, Inc.): I do want to make some comments of general interest to the engineering fraternity of the cable industry.

"I am alarmed by the various approaches to the "more than 12 channel" distribution system. They appear to me to be very premature, poorly conceived from an engineering basis and motivated almost entirely from a sales standpoint. Once we exceed the 12 VHF Channels, we must utilize either a special receiver or a converter located in conjunction with the television receiver. Having the converter or the special receiver, we should take advantage of the fact that we have been freed from broadcast frequencies that were established due to spectrum space and other considerations. We should make a very thorough study of the optimum frequencies to be utilized in an optimum system. We should use a total system concept optimizing the frequencies, the amplifiers, the coaxial cable and the converter or receiver. To do otherwise, we are doing ourselves as individual companies and our industry harm."