xpanded band capability. There is still a great deal f information needed before a real decision can and hould be made, and we would like to introduce some f our thoughts into the discussions that are going on oday.

EXPANDED BAND CATV CAPABILITIES

By

Dr. Leon Riebman and Mr. Walter Wydro

Of all the conventions that AEL participates in throughout the year, certainly the NCTA CONVENTION is by far the most dynamic and exciting. CATV is still in its infancy. New ideas for applications and a rapidly changing technology are the order of the day. The buildup for the Convention starts many months ahead with whispered rumors as to magical new equipment and new system approaches that are being prepared for the Convention by all CATV manufacturers. The pressure of these rumors cause the engineering departments of all the major manufacturers of CATV equipment to put in many extra nervous hours in order to bring to the show advanced equipments ahead of schedule. Of all the fields of endeavor that AEL's 250 professional scientists and engineers are engaged in, certainly CATV is the most exciting and rapidly moving, technologically speaking.

CATV is our Number One commercial effort today! It is presenting a tremendous challenge to every technical discipline within our organization.

The CATV Industry today is in the painful throes of changing from an art to more of a science. When a field of endeavor is an art, decisions are based on emotions and judgments. In a true science, decisions are based on experiments and physical laws.

CATV will always be a mixture of art and science. The art will be the visualizing of future possibilities for applications of this new means of signal transportation. At the present time, the applications appear to be unlimited and the requirements on the system should be primarily the users' responsibility. The system owner should provide the specifications, in qualitative terms, for the requirements and the purpose of the system that he wants to build. Once the decision is made as to the ultimate purpose of the system, it becomes possible for systems designers and manufacturers to scientifically optimize design and cost for the most effective system based on existing state-of-the-art equipment.

The topic of our paper today is, "Expanded Band CATV Capabilities."

In the beginning, the first systems were only one or two channels. Then, low channels only came into being followed by a combination of low and sub-channel systems. Many of these original systems are still in existence.

More recently, interest developed in all-band or twelve channel systems. As a result of this requirement, broadband tube amplifiers were developed and the modern CATV industry took shape and began to grow.

Incidentally, during the first fifteen years of the CATV Industry much was done by intuition or cut and try. It was mainly art -- very little science. During 1964, 1965, and 1966, many very capable engineers working independently and building on the work of others worked out the ingredients of a theory for a fully integrated CATV System. This was the first time that various design parameters could be related and optimized for a particular system requirement. The theory is now being extended and perfected and will greatly accelerate the pace of developments and open new opportunities for new applications of CATV systems.

During January of 1966 AEL first discussed with a CATV user the possibility of building an Extended Bandwidth System (extended to 270 MHz). In October of 1966 a detailed proposal was written and equipment development started.

At this, the 1967 NCTA Show, AEL is offering a trunk extender amplifier and remote bridger amplifier with 270 MHz bandwidth -- a minimum of twenty channel system capacity.

In some geographical areas such as the corridor between Boston, New York, Washington, and Philadelphia or the corridor between San Francisco and Los Angeles, viewers can now receive twelve channels off the air. Thus, the need for more channels in CATV.

Let us review the various approaches to a system of more than twelve channels. Essentially five methods are being explored as feasible transportation systems.

1. The Sub-channel method -- this approach places twelve channels between the frequencies 5 MHz and 95 MHz.

2. The Mid-Band Method -- this method uses the spectrum between Channel 6 and 7. In particular, the frequency spectrum between 108 MHz and 174 MHz.

3. The Dual Coaxial Cable Method -- this method uses two coaxial cables each carrying twelve channels.

4. The Octave Band Method -- this method places 20 channels between 120 and 240 megacycles.

5. The use of the spectrum above Channel 13 -- this method - The AEL Method-uses the frequency band between 220 - 270 for extra channels.

Let us examine each of these signal transportation methods and explore strengths and weaknesses.

The sub-channel Method does not lend itself to more than twelve channels and has the usual difficulties of a multi-octave system. Such systems, historically, present tremendous design difficulty in the building of the required amplifier with sufficiently low and acceptable harmonic distortion. There are some of these systems in use today which have beats and harmonics that usually interfere severely. To minimize the harmonic problem, low signal levels are utilized or balanced but very expensive amplifiers can be designed to correct the problems and permit operation at higher signal levels.

There is much discussion today about the Mid-Band approach, using the spectrum between Channel 6 and 7. The NCTA Engineering Subcommittee is studying the many unanswered questions about this band. For example, must the FM band 88 - 108 MHz be excluded? But the more important problem is, can allocations be designed to avoid the danger of direct pickup interference from air navigation or air communication services between 108 - 136 MHz, or from space tracking services at 136 - 138 MHz, or from various mobile, space, and amateur services between 138 - 174 MHz. Also, there are the usual harmonic problems because of the multi-octave nature of this approach.

I have permission to quote from an unpublished paper by Isaac S. Blonder, Board Chairman of Blonder-Tongue Laboratories, Inc. as follows: "The region between 108 - 136 MHz should be avoided since radiation from a system into the aircraft communication and guidance frequencies will be impossible to completely control. The CATV operator may believe he can monitor the cable systems to prevent radiation but the same cannot be said of the home environment." We agree with Mr. Blonder's statement.

The Dual Coaxial Cable Approach has both economic and technical problems. The installation costs are virtually double but of greater concern is the problem of cross-talk between cables. It will require tremendous care and tight shielding to keep cross-talk in any extended system to a reasonable level. Tests made with reasonably short systems may not be sufficiently accurate to predict the effect of extended mileage systems.

The Octave Band Approach from 120 - 240 MHz is a hybrid mid-band approach and has disadvantages and problems similar to the mid-band method.

AEL is recommending the approach utilizing the spectrum above Channel 13. Based upon available transistors and other considerations, we feel that 270 MHz should be the next logical spectrum plateau for system designers. The spectrum from 54 - 108 MHz would cover Channels 2 to 6 and the FM band. The spectrum between 174 - 216 MHz would cover Channels 7 to 13 as is now the case for twelve channels. Additional synthetic channels would be created between 216 - 270 MHz. The spectrum between 108 - 174 MHz could be used in the future for special services not requiring high-level modulation signals; perhaps facsimile, delivery of telegrams, transmission of computer data, control of traffic signals, or local interest FM cablecasts. The type of modulation at the level of the modulation would be controlled so that low channel harmonics would not interfere with the signals to be transmitted nor would the signals themselves generate significant higher harmonics to interfere with the higher band signals.

Some of the advantages of the spectrum above Channel 13 are as follows:

1. The system can be laid out with conventional twelve-channel techniques.

2. Proper planning and attention to detail at time of initial construction will permit conversion to expanded band at any time by installing repeater amplifiers utilizing the modular concept. The initial cost involved in preparing your system for expanded bandwidth can be very minimal; e.g., cable manufacturers are now sweeping cables to 300 MHz. We urge you to specify 300 MHz swept cable now for any new installations. The very small hardware such as directional couplers reflectometers, splitters, tap-offs, etc., are either available or present no technical difficulties.

AEL has introduced at this 1967 NCTA Convention a trunk extender amplifier and intermediate bridging amplifier meeting all specifications expected of the highest quality 220 MHz equipment, yet including extended bandwidth of 270 MHz.

We are actively proceeding to round out the line of 270 MHz equipment by improving the current 220 MHz colorvue modularized trunk line amplifier to handle the 270 MHz bandwidth. Also, under active development, are compatible headend equipment and the necessary test equipment needed to install and maintain the 270 MHz system.

Incidentally, engineering models of new trunk line amplifiers are easily achieving +52 dbmv for -57 db cross modulation when used in a twelve channel configuration; therefore, we can expect to meet the usual twelve-channel cross modulation specification at 48 dbmv but with twenty channels in operation. In effect, we have gained some system performance with added bandwidth.

There is one problem in the proposed system and that is the requirement of a top of the set converter, which converts the synthetic channels above Channel 13 into channels that the TV set can utilize. Such converters are available from several manufacturers today and this field is actively being pursued.

One interesting solution to the problem is to put complete conversion directly into the TV receiver; manufacture a TV set especially for CATV. AEL has discussed this possibility with several set manufacturers and they are very receptive.

There is a tremendous need at the present time for standardization within the TV industry. Standardization will bring with it many benefits to the CATV owner. The equipment costs will go down and the dangers of obsolescence will be greatly reduced. We strongly urge that NCTA take the lead in recommending which approach to a twenty-channel system should be recommended to CATV owners. Once one system has been accepted, the manufacturers will be able to plan ahead and modularize compatible equipment that can at minimum cost be expandable in the future.

Another problem area in the proposed system as it is in every wide-band CATV system is the effect of temperatures on system performance. Thermal equalizers are not a satisfactory solution for reasons all too familiar to you. AEL is currently developing a system called Auto-Tilt that will automatically compensate for temperature in a frequency selective manner. It involves, sensing, pilot carrier signals at both ends of the spectrum and adjusting the tilt. The key to success of this system is a frequency flat AGC system. AEL's current AGC amplifiers use a novel pin-diode attenuator (the diode is manufactured by AEL) that is frequency flat considerably higher than the 270 MHz required and, in addition, is voltage controlled. Auto-Tilt should be available from AEL within the next six months.

Thus, all the equipment for an extended band 270 MHz system is either available or under development to provide you with upwards of twenty-channel capability within the next twelve months. Today, we equipment manufacturers need and solicit your ideas and suggestions as to what you want future CATV systems to be capable of doing. Don't worry about whether, or how, what you want will be accomplished -- that is our job! Knowing what you want, we will stretch our imagination, achieve and push the state-of-the-art, and surprisingly -- in most cases -- come very close to what you originally might have considered impractical. It does not take much foresight or risk or courage for us to predict a very rapidly changing technology in the CATV industry during the next few years. We, at AEL, are proud to be participating with you during this pioneering period. We find it very exhilerating, very challenging, and very satisfying. In addition, let's all hope we will all reap the rewards that pioneers who take risks well deserve.

Thank you!

Thank you very much. (Applause)

CHAIRMAN CLEMENTS: Thank you, Dr. Riebman.

I am glad that someone else is working with the equipment manufacturers and the television receiver manufacturers to try and get them to become cognizant of our needs for multi-channel use beyond the present 12-channel system we are now utilizing.

I must agree with him, personally, because equipment manufacturers have been telling me for 15 years that if we tell them what we want and can make up our minds as to what we desire, they will come up with the product. I believe we are seeing this come true.

We have perhaps three or four minutes for questions, and I will ask now if anyone has a question?

MR. MIKE RODRIGUEZ: I think my question is of a rather general nature.

We have heard many comments about using various portions of the spectrum for banded channel use, but one thing that does not really get mentioned too prominently is, if we do utilize the upper portion of the spectrum, what about the systems that are being constructed now? Will it be required that they be re-spaced?

What sort of problems do the system owners who are presently constructing systems face in this regard?

Is this going to be a slow transition?

This is one of the questions I have in mind; and another is, what use is the modular concept in the housing where you have taken the outer space? It is not just that simple, replacing the module. If you have to take the housing and change the system layout, this is another consideration. I wonder if you have any feelings about that?

DR. RIEBMAN: Let me ask my colleague to give you the answer. He is much more familiar with this phase of the situation.

MR. WALTER WYDRO (American Electronics Laboratories, Inc.): Mr. Rodriguez, as we have looked over the situation, and the way the hardware was developed, the current hardware, as we have introduced it here, does go to 270; but it is utilizing a system, as you now use it, through a 220 or 216 megacycle amplifier. If you were to design for a 22 db spacing, it would have, again, at 216 and something higher than 22 db, at 270, something taking care of the rise in tilt.

The result is you design the system with 220 megacycle concept, totally; in fact, with the current

amplifiers, if you put those in, you have automatically a system properly spaced and properly equalized.

Now let us assume the condition where you are designing a 270, but you want to run 220 temporarily through it. By the same token, we are preparing on the amplifiers a dual specification. These are paper specifications. You cannot change the gain of the amplifier. The amplifier has a certain gain and a certain equalization. This is true. Whatever the frequency cutoff is, this is a fixed value. It has nothing to do beyond the fixed content of the amplifier.

If you take the amplifier and write a set of specifications at 220, based on its tilt values, write a duplicate based on the 270, allowing for the cost of difference in the gain, you can now design a system with current technology; install it; and your spacing is automatically handled.

We are not advocating changing spacing to a 270. What we are saying, however, is design for 220; current practice; and install the amplifier, and automatically it has the spacing to offset the cable drop.

DR. RIEBMAN: As Fred Schulz was presenting his fine address, you noted the compatibility problem between the MATV system and the CATV system, and again to re-emphasize, the sooner that CATV standardizes, the quicker you are going to have to stop worrying about changing equipment in the future.

As far as the manufacturers are concerned, they will sell more equipment the longer it takes you to settle that problem. There will have to be changes made.

We are doing our best, however, to build compatibility into the system that we are producing today. So, again I say, it is up to you to standardize.

MR. DON SHIELD (Vancouver): I do not know whether I fully understood your discussion concerning the use of some of the areas in the mid-band. I believe you said the use of low-level modulation carriers could possibly be effected in this area.

What I am concerned about is that the harmonics in the low-band television signals in the 54 to 108 level will probably wipe out the use of this mid-band.

The facsimile or data processing character, because of the obscurity and the harmonics, rather than the fact that the mid-band signals are not usable because of what they may do to the television in the low or high band areas, would represent still another consideration.

MR. WYDRO: I do not think this is quite the case, and here is why: First of all, we are indicating that the mid-band should be delegated or relegated, and this I should not say, to service low-level modulation, but those that require low signal noise and ratios, not as high as television requires.

Secondly, most of the pulse-type signals that we are referring to, and I say "pulse", or the use of low-level FM modulation, for example, will render complete immunity to amplitude interference caused by the harmonics of the low band.

The use of sub-carriers or FM modulation would entirely take care of it. Also, the fact that you are occupying the low band is no worse than you now have in a 12-channel system where Channel 6, for example, in the FM band, will reflect that harmonics do appear in Channels 10 and 11.

MR. SHIELD: My final question I wanted to ask concerns something similar in the area above 200, where you are proposing to put selectors/ carriers. I would presume you have a similar problem with octaves. If you continue to use the standard television band between 54 and 108, and you have a computer program giving you some clear channels in this region, would this not be true?

MR. WYDRO: Yes; but they do not have to be clear by the very statement I made previously.

There are 12 channel systems today; 88 megacycles appears right in the middle of Channel 10, and this is not causing any major problem in the current 12-channel-system practice.

Yes, I know a number of systems that require Channel 5 and Channel 6 and the FM band downgraded inband by a few db. In most systems, however, the harmonic problems in most of these channels are relatively minor.

By putting the rest of the channels above Channel 13, we have eliminated the need for harmonics falling within the band. They are not there, and they are not falling within the bands not occupied.

The suggestion for the non-occupied band is to use it for service that can be handled by a form of modulation such as FM that can be made interference-free.

CHAIRMAN CLEMENTS: Thank you very much. We have time for one additional question.

MR. WILLIAM HENCHE (General Electric Cablevision Corporation): We have been watching this development of the extra channel concept here with considerable interest, and a little concern. I have been in frequent consultation with our television receiver people, our Television Receiver Department, on this same subject; and I can tell you that they are very much concerned about the divergent approaches to the extra channel concept.

They have had CATV in mind for some time. I think most of you are aware that General Electric does make a standard line of television sets with 75 ohm inputs. I repeat, they are concerned about these

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 emplifiers 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.