SYSTEMS AND ANTENNAS

THURSDAY AFTERNOON - JULY 22, 1965

MR. CAYWOOD C. COOLEY: I hope you will give some consideration to the fact that I knew this about ten minutes ago and to the best of my ability I'll try to serve as your Moderator this afternoon.

Our first subject today is entitled, "Color TV--From Studio to Your Customer". And the gentleman that's going to deliver this is an engineer from the Collins Radio Corporation with more than 27 years of experience in radio communications, television, photography and optics. He is a member of the Society of Motion Picture and Television Engineers and he attended Wright Junior College, the Armour Institute, the Lewis Institute of Chicago, and the Bell Telephone School for War Training. I see he's got quite a bit of paraphenalia and slides and talks so I'm going to sit down and enjoy the program with you. We have half an hour and at about the 25 minute period interval, we will stop and hope we have an opportunity to attempt to answer your questions. Mr. W. P. Kruse. Am I saying it right, sir?

MR. W. P. KRUSE: You pronounce it right, but it's the wrong enunciation. Thank you, Mr. Cooley. The name is Kruse if you don't mind. Subject: "Color TV from Studio to Your Customer." First of all, in introduction, color TV is a permanent part of our economy at this day and age. The quantity of our programs is increasing monthly. We are not here to discuss the quality of programming. We're here to improve the transmission of the available techniques. At one end, our source of signal is the Color TV camera at the studio. On the other end, we have a customer looking at his color TV receiver. We and the broadcasters are between these two ends. The broadcaster will produce a program from any of the following switchable sources: 1) A local color TV camera, which may come from a live remote scene using FM microwave relay, coax cable or twisted shield repair. It may also come from a localized studio scene. It may come from film and slides. 2) The program may be coming from a video tape which does use FM record and play back techniques. The third source of our studio's program is network, of course. The program will get to that given studio via FM microwave relay, coaxial cable or occasionally twisted shield repair. Telephone company has these various methods in their longlines division.

A single building broadcasting plant could directly coax cable from the selected program to the AM TV transmitter system. In many places, there is no room for the transmitter tower and equipment in the downtown location. They would then have a multiple building plant that you would usually use an FM microwave STL. STL in this case is a Studio Transmitter Link between the studio and the AM transmitter site. I hope you will bear with me in my partial emphasis on the difference between the AM and th FM transmissions, because this is an important part of what I'm going to try and bring home to you people.

Our business is handling the signal between the off-the-air broadcast and the cable to our customer. It is our responsibility to add as little technical degradation as economically possible. We add many components to the system; however, you do have control over the off-the-air antenna location, the off-the-air AM receiver, the intervening microwave FM transmitter, its antenna, the following receiving antenna, the intervening microwave FM receiver. You then have your video back. It then goes into your cable-driving AM transmitter, your cable distributing amplifiers and cable to your customer's AM receiver. Already we have two FMs probably and two AMs before the customer gets to his picture.

The many conversions of the TV signal involve numerous possibilities of degraded reception. Our customers are becoming increasingly discerning as to picture quality. Our operating on the signal must be accomplished with great care. There are many factors involved. At times the signal must be predistorted to correct for later and inherent distortions in your customer's receiver.

In color television, as we are going to primarily emphasize this talk, we do have to be concerned with the over-all economic system, what the people are going to see in their homes in their color receivers. We do and will start with the very first item and that is, what can the eye see?

1. The human eye is capable of seeing large objects in full color. As the object viewed is decreased in size, the eye loses perception of greenish-yellow and blueist purple or magenta colors. Your eye continues to see small items in orange-red and blue-green or cyan color. Very small items are seen only in black and white. The exact amount of this color rendition of our eyes depends on individual persons, but there are generalized rules that are met and found quite widely in the various optical magazines and texts.

The above characteristics will, however, allow appreciable simplification of our color TV techniques. The size of the object at a given scanning distance is a given band width required out of that camera. If you can't see certain colors below a certain size, then you don't need band width for that color you can't see anyway.

2. We have a few terms to make sure we agree on our wording before we go on into the main portion of our text. The advent of television produced new meaning for some ordinary words and many new words. As an example, a grouping of words that apply to a subject follows: The following are in groups essentially meaning about the same thing. 1) Brightness, intensity, luminous perception of light, or we may even say the cathode ray tube current that produces that light they were going to look at. 2) Contrast, picture, video level are some of the terms we may use. The ratio between the maximum and minimum brightness in the picture. Often we'll say the video amplitude. Those factors are a group on the same subject. Item 3) Color may be called by tint, its hue and into electronics we'll say its color phase or color angle. The angle represents a specific hue as calculated by the TV color formula. 4) We have chroma or color gain or some receivers will mark it in for the customer to use and call it color brightness. These words essentially mean one in the same thing.

In this direction, a further explanation of chroma, color gain or color brightness, the physicist, the opticians will say saturation, purity of color, compared to gray or white. Black is the absence of color. The amplitude of the color information, or color gain. These in item 4 are all in the same direction.

The number of different terminologies for a given subject in these four listings here can lead to confusion unless we do agree upon what words you're going to call them. Unfortunately sometimes for variety we may go on and call them different names and make our speech try and sound a little bit better.

3. Now, the main part of the text. Color signal generation. The present US FCC standards follow the recommendations of much of the TV industry. The color band pass requirements are to provide full color to all images of large area. This corresponds to televized items producing a video spectrum response from DC to about 0.6 of a megacycle for full color. Objects that are smaller than given size that would produce a video spectrum higher frequency than 0.6 of a megacycle would then not be seen in certain colors. Green-yellow or purple color items are transmitted in black and white from 0.6 through 4.2 megacycles. Green-blue and orange-red color items are transmitted in black and white when a TV scan size is small enough to produce a video spectrum above 1.5 some megacycles. In other words, the band pass requirements are: 1) high definition black and white 0 to 4.2 megacycles; 2) Partial color. Green-blue and orange-red from 0 to 1.5 megacycles; 3) Full color including gree-yellow and purple-magenta, 0 to 0.6 megacycles. These three different band widths are in use in the broadcasting of our color in our present TV standards.

Means have been found for inserting the color information into the normal band width of the black and white signal. The camera outputs are various amplitudes of the harmonics of only the horizontal and vertical scanning frequencies. All the spaces between the horizontal frequency harmonics can be called the "Vast Wastelands of TV."

Clever engineers have found ways of using this space in the TV camera output spectrum. They placed a subcarrier at the 455th harmonic of one-half of your horizontal frequency, which for color is 15,734 cycles. This is between a 227th and 228th harmonic of the color, horizontal scanning rate. This odd value of horizontal frequency is due to the need for low visibility of the color subcarrier itself and also of the beat note between the color subcarrier and the sound inter-carrier spacing. The spacing between the color subcarrier and the sound intercarrier is 920,455 cycles or exactly 117 times half of 15,734. These numbers are fairly important. The signals are actually generated with these numbers in mind, so that the two beat notes, one from the color subcarrier itself, one from the color subcarrier beating against the aural intercarrier will both be of a very low visibility. They will average out in a normal viewing angle in a reasonably linear system.

The intercarrier spacing of 4.5 megacycles was maintained and the tolerance of the transmitter operation was tightened from plus and minus 4 KC to plus and minus 1 KC. Now, I say the intercarrier spacing, not the fundamental aural carrier frequency itself. The intercarrier is what really counts. That's where we're going to have a little problem in the color receiver with our 3.6 odd megacycles beating with the 4.5. Therefore, the 4.5 tolerance is tightened, but not locked together. It was found unnecessary.

All the preceding considerations produced a color subcarrier frequency of a nice long number. I know you've seen it in print. Let me tell you what it is once again. Three megacycles, 579 KC, 545 cycles. And, they try and maintain that within 10-11 cycles. There's an even tighter change of frequency, rate of change speck (specification) on it. This subcarrier is then modulated in amplitude and phase by the color camera signals. The blue-Purple or megenta colors amplitude modulate the subcarrier in an angular direction we will call Q. The green-yellow color amplitude modulates the same subcarrier near an angle we can call minus Q or 180 degrees away from the first set of colors. This Q signal has two sets of colors. They have been previously filtered down to zero, through 0.6 megacycles. The red-yellow colors amplitude modulate the same subcarrier near an angular direction we will call I. The green-blue cyan colors amplitude modulate subcarrier near an angle we call minus I. These two sets of colors, I and minus I, have previously been filtered to 0 through 1.5 megacycles. The output of the Q signal is 3.6 megacycles plus or minus .6, or 3 through 4.2 megacycles. The output of the I signal is 3.6 plus .6 minus 1.5 or 2.18 through 4.2. Any one color is seen at a given instance by our color camera. It will see red here, green there, yellow over there. So It's going to actually phase and amplitude modulate this subcarrier at a given direction depending upon what the color is. Any one color that is seen by the red, green or blue sensitive camera tubes is computed and band passed to be a single amplitude and one angle of a subcarrier.

The different colors seen by the camera will be another amplitude and another phase angle of the subcarrier. The various amounts of color purity or saturation produced proportional amplitudes of the subcarrier. The various tints or hues of color produced a computed angle of the subcarrier. A fixed phase reference color sinc burst is generated and added immediately after all horizontal sinc pulses. This burst is used to synchronize the color of the monitors in the studio, perhaps in your locations as well as your customer's receivers.

4. We have a factor which is rather important in color and this is called envelope delay. Envelope delay in AM broadcasting. The important concept here is that color is an amplitude and phase sensitive signal. It is added to the monochrome signal at 2.18 through 4.2 megacycles. The sound intercarrier and later subcarrier at 4.5 megacyles is perilously close to 3.6 and 4.2 megacycles. The AM receiver sound IF and video traps are generally narrow band, high Q tuned circuits. Their very action causes a serious delay in the passage of the 3 to 4.2 megacycle color and monochrome high frequency or small area components. Each and every AM TV receiver use these traps. Experts have found that the resulting delay curve is very consistent

in relation to trapping used in many different manufacturer's models of TV receivers.

The AM broadcaster is required to have a delay equalizer to predistort for this effect. The result is any AM transmitter and any AM receiver should therefore be compatible. This delay is often referred to as the funny paper affect.

The Sunday color comics are often printed out of register in any direction, being a low-cost color printing process. In TV, however, a color misregistration can be to the left or right only. The excellent paper this morning on envelope delay had a very good slide, showing a man in the boat with a color about half to an inch away from where it belonged compared to his brightness components.

Color to the left is caused by insufficient phase delay or a leading phase. To the right is excessive phase delay. This phase can be most sensitively measured with the concept of envelope delay.

Envelope delay is defined as the change of phase in degrees per change of frequency or the mathematicians will say DΘ/Df, the change of phase with relation to frequency.

Now, this frequency I'm referring to is that of the video; the microwave boys will say the base band or the telephone company may say base band. It will also, however, be including the AM side band of our AM transmitter and our AM receivers.

This delay of the envelope is that of the high frequency monochrome and all color components compared to the low frequency components. After all the low frequency components or the monochrome signal should be at the same TV screen location as the low frequency color components.

Commercial test equipment and finished design equalizers are available for envelope delay usage. Every color AM TV transmitter is required to correct for the color AM TV receiver's envelope delay. The receiver's envelope delay is caused by the sound trap for one and partially due to the vestigial side band transmission of the receiver and transmitter acting together.

Observable improvements are made when this correction is made. The main part I wanted to show is (this page of a paper which was available at our booth) is this chart saying, Overall envelope delays shown with AM transmitter powers.

Now, you see that across here we do have a straight line. This is the transmitter and receiver together properly compensated. Just for emphasis of the tolerances of the system, I included the dotted lines to show the AM transmitter tolerances of its filtering. Its filtering is supposedly from the camera terminals to an ideal demodulator off the transmitter's transmission lines.

We have a chart here in frequency in megacycles going as far as video is concerned from 0.2 megacyles, 1, 2.18, 3. At 2.18 our color starts. At 3, all of our colo is started, 3.58 is our color subcarrier and all over at 4.18 MC. Tolerance is tightened progressively through the exact part of subcarrier frequency.

We have the vertical components here of this chart in microseconds of envelope delay. It is given in time, in tenths of a microsecond and the existing AM transmitter broadcasting tolerance is plus and minus .1 microseconds from .2 megacycles up. Then the tolerance gets increasingly tighter as you get to the 3.58 MC color subcarrier where the tolerance is only plus or minus .05 microseconds or we can express that as plus and minus 50 nano-seconds.

A major item list for observing envelope delay includes a video sweep generator, envelope delay generator, a video envelope delay equalizer, a video vestigual side band filter, an AM transmitter with amplifier either set for VSP or a passive filter, your AM TV receiver, your envelope delay receiver and an oscilloscope.

5. Now, to go on, once we have used the AM transmitter's radiations into a head-end receiver, that head-end receiver has sound traps. We have then used up the correction; the straight line is now available to us at that head-end receiver. We pass it into the FM microwave, either STL or your CATV microwave. The video amplifiers in FM as well as AM that lead to modulation and those following demodulation are both equally susceptable to producing envelope delay. The microwave and IF band pass components can influence envelope delay in FM as well as AM; however, it is

easier to maintain an excellent phase versus frequency through 4.2 megacycles in an overall pass band that is nominally flat through 7 to 8 megacycles. It's the action of the traps at the aural intercarrier 4.5 that cause trouble in the 3 to 4 megacycle region.

There is no trapping of 4.5 in microwave equipment unless our customers do that on his own head end or terminal equipment. This lack of trapping at 4.5 megacycles precludes most phase shift at 4.2 megacycles. In general, the envelope delay will be negligible in the FM microwave.

6. Envelope delay in AM CATV. Your customers' AM receiver has sound traps at IF and at 4.5 in video amplifiers. It should be preceded by an envelope delay filter at the CATV AM transmitter or your name for it is a cable modulator.

7. We have spectrum conservation in our AM TV transmitters, AM receivers - therefore your customers' receivers - your head-end cable driving transmitters. In order to get your 6, 8, 10, 12 channels in some applications onto one cable, you are definitely using adjacent channel operation. You will, therefore, have to essentially adhere to the vestigial side band transmission that the broadcasters use. Their problems and your problems in that direction are one in the same.

Vestigial side bands. Vestigial means remnant or partial. The vestigial lower side band in the case of the AM broadcast TV transmitter has a flat response from carrier to .75 megacycles instead of 4.2. That's speaking of the lower side band. Using 200 KC as a zero db reference, the vestigial side band response is down 20 db at 1 1/4 megacycles on the low end instead of 4.75. Subtracting, 4.75 minus 1.75 you have a spectrum saving of 3 1/4 megacycles for every 5 megacycles channels in use. This saving of actual spectrum space has been in use for 15-20 years or better. You are using it.

The vestigial side band's amplitude response is accomplished at the carrier frequency. The attenuation may take place either by passive filters or the tuning of linear amplifiers. This carrier is transmitted without attenuation.

The solid line is that of the AM transmitter. The carrier sitting here at fv. The response goes out flat to three-quarters of a megacycle and then goes to better than 20 db down, 1 1/4 meg out. This is for the lower side band. The upper side band is still flat to 4.2 megacycles. The transmitter is used with a passive filter or tuning procedure. Your corresponding AM receiver then has its IF response running along the dotted line. Your visual carrier is 6 db down from the normal flat reception, ideally flat to 4.2 and sound traps at 4.5 megacycles.

This combination when all amplifiers and filters are properly aligned will give you a 100% modulation output that is level from 0 to 4.2 megacycles. It can be done. Your cable driving transmitter, its tuning, the normal -- I soouldn't say normal but the idealized and proper tuning of the receiver -- can produce an 0 to 4.2 meg flat video response.

8. AM VSB for CATV use. The cable modulator or CATV transmitter today is generally designed to be tuned to a VSB response. The CATV system will generally produce a better overall picture quality when a VSB or low frequency phase filter is used This is used before modulation. It is quite simple to check with a 100 KC square wave or a white window from a TV test generator and a decent scope, a receiver whose IF is tuned properly.

Adjust for optimum rectangular pulse. Another method if not a better way to check the vestigial side band filters, both video predistortion, RF per channel filtering, your receiver slopes, your receiver sound traps, is to use an overall envelope delay response. One commercial test set covers from a .5 to a 4.2 megacycles in one sweep. The AM broadcaster uses a 4.75 megacycle low pass filter. This keeps all his important side bands inside his 6 megacycle channel. It does interfere with the envelope delay but fortunately you are not required to have that filter, neither legally nor technically. The broadcaster has already mopped it up for you. A few exceptions may be for some of your adjacent channel duty.

9. The main portion of the discussion here is color differential phase and gain.

Amplitude linearity and phase linearity is a big factor here. I'm speaking of the phase and gain linearity of our video component as the picture goes from black through gray to white. The phase shall not change, because the phase is what tint our picture will be at any unit area. If a person walks around the studio from dark to light areas of studio lighting, we don't want their face to change color. This can happen if you have poor differential phase. The amplitude linearity should be good and it is called differential gain. The means for measuring differential phase and gain is basically a two-tone test and that has been coming quite widely known. It amounts to our color television procedures taking our 3.5 megacycle sign waves and adding it to a horizontal TV component, 15,750 cycle stairstep sawtooth sign wave. It's not real important what the wave is of the low frequency, the 15 KC signal, so long as it excursions from black to gray to white in some known manner. Test sets are available from several sources. To measure the change of phase as you go from black to gray to white and back, to measure the change of gain, although you can often do that with a scope directly.

10. Your customer's AM TV color receiver is the final end action. We do have to bring the result over to there. We're starting off with the AM transmitter in the broadcaster's equipment building. He has the filters in. Your head end receiver uses up all the filtering that he put in. Those problems do not exist in normal FM microwave either for the CATV operator or the STL connection from studio to transmitter. However, one point that I'm trying to bring across as a main factor in this paper is this. Your cable driving modulator and your home customer's color TV receiver, they are both today running vestigial side bands. They have many aural traps at 4.5 or equivalent. Neither one of which I know of, as far as now, is being corrected for in your CATV head end location. It can be shown that the picture improvement is definitely noticeable. The video vestigial side band filtering is quite inexpensive. The test equipment, most of you have or can actually all but use the off-the-air TV sinc pulse direct.

I'll be the first one to point out that envelope delay procedures can be quite expensive. They are legally required for your AM counterpart and so far they are not in use in CATV procedures, but I'm positive - I'm sure that that time will be coming.

Test sets are available, expensive, yes. Some consultants may eventually be having them to make trips and go around and check things. The actual envelope delay equalizer has to be correlated with the CATV head end modulating unit. Then and then only will we have the optimum picture. When all time delays, which is really what this whole discussion is about, are corrected, the result can produce a show at your customer's home that can approach the use of that same receiver coupled to the AM TV transmitter.

In conclusion, we must give considerable thought, energy and money to the overall concept. It may seem complex, have many apparently conflicting requirements, but each unit is simple. Consider each area separately and "All your problems will be little ones".

We have discussed the many trials and tribulations of the path of the TV signal. Our industry is progressing. There are many things we do today that were laboratory and mathematical concepts only yesteryear. Let us all earn and learn by experience and let's use today's technology today. I thank you. (Applause)

MR. COOLEY: Thank you very much. I wonder if there are any questions from the floor, gentlemen? I'm sure color is going to be more and more important. Yes, please.

UNIDENTIFIED SPEAKER: About the missmatch in the FM transmission between the microwave antenna and, say, a line. Now, I'm talking of a set down in the 2000 megacycle region where you use a line rather than wave guide, say a 50 ohm transmission line. Then, at the bottom you have a load isolator for say as much as 20 db load isolation, with the effect of the missmatch at the antenna. What, if any, what is the effect on the envelope delay?

MR. KRUSE: With the load isolator, I believe, although I have not had any test in this direction, that the load isolator would absorb the reflected signal from the missmatch at the antenna and dissipate it. The result would generally be a change in amplitude response only. That is what I believe should happen. I'd be glad to discuss it further with anyone as far as perhaps some future testing in this direction.

MR. COOLEY: I thank you very much. Let's give him another hand, gentlemen. (Applause)

Our next subject on today's agenda is entitled, "Problems in Using Line Powered CATV Systems", and the gentleman that's going to provide that information is the Plant Manager for CAS Manufacturing Company in Irving, Texas; formerly served as production manager for Johnson Service Company, Electronics Division; also was production manager for Fishbach and Moore. A native of Dallas, he attended the University of Texas and Southern Methodist University and has nine years of management background. Gentlemen, Mr. Preston Spradlin is going to give us a little story on using line powered CATV equipment. Let's give him a hand as he comes up. (Applause)

MR. PRESTON SPRADLIN: Thank you very much, Mr. Cooley. I'd like to express my appreciation in being able to participate in this technician's session.

The title of my presentation is "Problems in Using Line Powered CATV Systems." Since the miracle of electronics, namely the transistor, enables us to use line powering but at the same time it creates problems, the question of why transistors for CATV should be answered first. May I have the first slide, please. (Illustrations next page)

I. AC vs DC Line Powering Line powering, the natural and economical way to power transistor amplifiers in cable systems, is in reality, a relatively simple matter and consequently, not too much thought has been devoted to this "life-line" of CATV. Yet, through experience, the majority of transistor failures and associated maintenance problems may be traced directly to problems in line powering.

CAS Manufacturing Company, as a result of several years of experience in line powering, has determined that adherance to the following procedures make possible maximum transistor performance.

The necessary power requirements of a conventional CATV system utilizing transistors is between 15 and 20 volts DC. In earlier systems, and as recently as 1960, CAS, like other manufacturers, used pure DC for line powering. This approach, being quite easily attainable, simplified standby systems and required little or no filtering networks in individual amplifiers.

The power supply was conventional and a wet cell could be used as a standby reserve.

Using pure DC, no problems were foreseen in the planning stage. However, in actual operation, continuous trouble caused by electrolysis and AC hum made it obvious to switch to AC line powering. A simple experiment demonstrating electrolysis is to fill a fitting with water and apply first AC and then DC and observe the action of each current. The application of DC builds up a carbon path and shorts the fitting or causes a high resistance leakage path. Even a small amount of moisture is sufficient to cause electrolysis when DC voltage is applied.

II. Regulated vs Non-Regulated Supplies In tube systems, constant voltage transformers became a necessity to prolong tube life and to furnish some degree of protection from lightning surges. In transistor systems, a constant voltage supply is normally built into each amplifier by using constant current transistor power supplies. Since this feature is inherent in transistor systems, the importance of having constant transofmrer voltage, although desirable, is not as important as in tube systems. Also, fast transients that may be destructive to transistors can pass readily through a regulated transformer diminishing afforded protection enjoyed so in tube amplifiers.

Basically, there are two types of constant current transformers - a sinusoidal and a normal harmonic. The sinusoidal type normally produces only a 3 percent harmonic