TECHNICAL SESSION NO. 1:
CATV Head-end Engineering

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"R_x: Signal Processing"

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INTRODUCTION

The one place where a CATV Technician can still really be an individualist is inside his head-end. Some head-end installations get the floor scrubbed twice a week while others in the industry are virtually rats nests. Recently I called a Chief Technician's attention to the disorderly tangle of wires behind his head-end equipment racks. He said, "Oh, no man, I'm not going to do anything about that! That's my job security. They don't dare get rid of me because no one else could ever figure this mess out."

Every CATV Technician has his own special way of processing off air signals. I would like to pass on some of the methods which I have learned from helpful associates and many long nights spent in head-ends.

Nowhere in a cable system can money be more wisely spent than on well engineered and properly installed antennas. Antennas are an involved subject in themselves so I will not attempt to cover them in this paper.

Every piece of signal processing equipment should be checked for proper alignment prior to installation. This is especially important for equipment that is frequency selective. Although processing equipment may be carefully aligned at the factory it is often received in poor alignment after a few thousand miles of bouncing around in a freight truck.

1. PREAMPLIFIERS

Preamplifiers are designed to overcome downlead loss where weak signals are encountered. The benefits of using UHF and FM preamplifiers are often overlooked.

(a) BROADBAND PREAMPLIFIERS

Preamplifiers that pass all 12 channels are not recommended for CATV systems. However, preamps that cover either the low or the high band alone do have a limited place in a modern head-end. Broadband log periodic antennas are very popular now partly because several channels can be received from one antenna therefore saving valuable tower space. Broadband preamps are very handy to use with these broadband antennas. Cross modulation may occur however if all the channels received from a broadband antenna are not near the same level in signal strength. It has been my experience that input levels should be within at least 10 dB of each other to avoid visible cross modulation. Of course this problem is worse if the signal levels are high. It is possible to use only those stations received from the broadband antenna at near the same level and build a separate

(a) BROADBAND PREAMPLIFIERS Continued

high gain array for the weak stations with single channel preamplifiers. For example at one of our head-ends we receive channels 7, 9, and 11 at +3 to +8 dBmV and channel 13 at only -10 dBmv. All stations are transmitted from Mt. Wilson and received with the same high-band log periodic antenna. We have installed a broadband high-band preamp to overcome our downlead loss but only use channels 7, 9, and 11 from this antenna. We have built up a separate higher gain array for channel 13 with a single channel 13 preamplifier.

(b) SINGLE CHANNEL PREAMPLIFIERS

Preamplifiers are available with resonant cavity preselectors which are similar to a bandpass filter just ahead of the first stage. These preamplifiers can take more abuse from interference than broadband preamplifiers. In the presence of strong adjacent channel interference it may be necessary to cascade preselectors. Before cascading preselectors be sure the input and output impedance of the cavities are both 75 ohms. At times it may be necessary to supplement the preselectors with a narrow band trap to attenuate lower adjacent sound or upper adjacent picture carriers. Particular attention should be paid to the quality and temperature stability of traps for this purpose.

(c) UHF PREAMPLIFIERS

Do not overlook the possibility of improving UHF reception by using a good preamp ahead of converters. Many popular UHF converters have a 12 dB or higher noise figure. In weak signal areas it is common practice to mast mount UHF converters and follow them with a post amplifier to overcome downlead loss. It is a much healthier situation to place a UHF preamplifier with a low noise figure ahead of the converter and do away with the post amplifier.

(d) FM PREAMPLIFIERS

A good FM preamplifier can often mean the difference between providing a distant station or not. This is particularly true because FM stations are generally operated 15 to 20 dB below the level of the TV channels in CATV systems. Even though FM signals are inherently noise immune, noise builds up fast in a long system at these low levels.

2. UHF TO VHF CONVERTERS

(a) CRYSTAL CONTROL

UHF converters are one of the weakest links in CATV head-ends. UHF to VHF converters should have crystal controlled local oscillators to avoid being plagued by adjacent channel interference due to local oscillator drift.

(b) INPUT STAGE

For use in a low signal area another important feature to look at in UHF converters is the r-f input stage or absence of one. Many popular UHF converters have no r-f input stage. The input signal simply passes through a preselector filter and right into the mixer diode. The noise contribution of this type of converter is usually quite high. For weak signals either a UHF preamplifier or a converter with a built in low noise preamp is recommended. UHF converters that have post amplification built into them make external post amplifiers unnecessary.

(c) SPURIOUS OUTPUTS

UHF converters are notorious for unwanted spurious outputs that are difficult to filter out. Either a spectrum analyzer or a field strength meter should be used to check for spurious outputs that may cause beats in other channels. When using a field strength meter for this purpose it is wise to insert a trap tuned to the desired picture carrier between the converter and meter. Most meters will conjure up their own spurious image readings when hit with a strong carrier. If troublesome spurious outputs are traced to a converter check alignment and install necessary bandpass filters or traps on the output of the converter.

3. SIGNAL PROCESSORS

(a) STRIP AMPLIFIERS

The old 7 channel systems are quickly becoming a thing of the past. For the small systems that still don't have adjacent channels single channel strip AGC amplifiers are still a good economical choice. The main disadvantage of strip amplifiers is the difficulty of reducing the sound carrier level to protect an upper adjacent picture without also distorting the color information. This problem becomes more difficult in the high band as traps become more critical at higher frequencies. If deep fades are experienced the ALC range

(a) STRIP AMPLIFIERS Continued

of some strip amplifiers may also leave something to be desired. If you plan to run adjacent channels, but your budget is tight, by all means only operate strip amplifiers on channels that have no upper adjacent channel or have a guard band, such as 4, 6, or 13. You may get some trouble calls from color set owners complaining about sound modulating their color on these channels because they are used to tuning closer to sound on the other channels. All strip amplifiers that are operated adjacent to another channel should have an automatic noise silencer installed to render them inoperative when a channel leaves the air. If a strip amplifier is allowed to run wide open it will often noise up the adjacent channels and sometimes kill the color or sound of the lower adjacent channel.

(b) HETERODYNE SIGNAL PROCESSORS

Heterodyne processors are one of the most complicated and troublesome parts of a head-end. They represent a substantial portion of the head-end budget. However, they are very necessary for good color processing, especially in the high-band. I can not over-emphasize what was said during the introduction about checking frequency selective equipment for alignment upon receipt, especially when it comes to signal processors. The main advantage of processors is their ability to control the sound level and trap adjacent carriers with very little disturbance of picture and color information. This is possible because the incoming VHF channel is down converted to a lower i-f frequency (41-46 MHz) where control and trapping are done in less critical circuits before it is up converted to the desired output channel.

If your system receives frequency selective fading, evident by the picture and sound carriers fading independently of each other, consider processors with separate sound limiting and video AGC circuits.

When looking at processors check for access of controls such as substitution oscillator level control and substitution oscillator sensitivity control. The sensitivity control sets the minimum signal that will keep the substitution oscillator biased off. If the sensitivity of this circuit cannot be set a small amount of noise or co-channel interference can keep the substitution oscillator off and the processors gain will turn wide open and blast the system with noise.

(b) HETERODYNE SIGNAL PROCESSORS Continued

One of the nice advantages of heterodyne processors is being able to do switching at i-f frequencies. They are a real boon where systems must comply with non-duplication requirements or channels must be operated off-channel.

Processors can be used to switch more than 12 stations into a regular 12 channel system by utilizing the off-air time of part time stations. In our area we have a stock market station that only broadcasts in the mornings and a multi-lingo station that only broadcasts in the evenings. We inserted a miniature relay coil in series with the signal off light of the prime stations signal processor. When activated this relay operates an external solid-state coaxial switch. Just before the i-f enters the up converter we route it through the coaxial switch and back to the up converter input. On the other side of the switch we insert the video i-f output of another processor that contains all the necessary modules except the up-converter. When the prime station leaves the air the signal off light voltage activates the miniature relay which in turn controls the solid state switch. The secondary station will stay on until the prime station comes on the air again turning the signal off light out.

On another channel which carries a UHF station that broadcasts only a few hours a day, we switch in a message center channel. This is done with an i-f modulator in place of the secondary processor I mentioned earlier. Because we lose the stripping action of the i-f strip in the processor we found it necessary to install a custom i-f bandpass filter on the output of the modulator.

Most TV processors and strip amplifiers operate best with an input of +10 dBmV, gain of 40 to 44 dB and an output of +50 to +54 dBmV. Many technicians operate their processors and strip amplifiers at very low gain and output, especially in the low band. By doing this they often lose much of the AGC action and wonder why they have to set levels every day. By operating processors near their rated output you improve the desired to undesired spurious output ratio. If you operate your processors at +10 dBmV in and +50 dBmV out you will have a few dB's in reserve for inserting a bandpass filter or trap before mixing if necessary.

(c) FM PROCESSING

FM radio service is often neglected by CATV systems. If at least as much money is allocated for the FM band as you would spend for processing one TV station you

(c) FM PROCESSING Continued

will be well rewarded for your investment in the years ahead.

If you only receive a few FM radio stations in your area you probably can get by with a strip amplifier followed by a leveling trap. In a metropolitan area there are so many stations available it becomes nearly impossible to level out the strong stations without killing the weak adjacent stations. Why is it that the FM station everyone wants is always some weak sister right along side the strongest station on the dial? FM heterodyne processors have the selectivity and noise limiting to provide fade free reception under these conditions.

I am anxiously awaiting the production of the new solid state FM processors. If you are in an area without FM reception available don't neglect the possibilities of modulating your own music station or bringing FM stations in on your microwave system.

4. MIXERS

(a) ACTIVE SIGNAL COMBINERS

Reliability is a consideration when using active mixers. I don't know why, but if anything is likely to blow when you experience a power surge at the head-end it will be the electronic mixer, especially if you don't have a spare.

Electronic mixers should only be used where a high output level is required to traverse some inaccessible area out of the head-end. Active mixers are available with an output capability of about +57 dBmV. These could drive as much as 4800' of 3/4" cable, or 6700' of the new 3/4" dyna or ultra foam cable before the first amplifiers. With an overhead trunk line spanned this far the input to the first amplifier will swing several dB's with seasonal changes. This has the effect of seriously reducing the dynamic range of a system at the very start. It is a good practice to operate the head-end at the same output level as the amplifiers used in the trunk line. This will also facilitate sweeping the system from the head-end without the need for special setups.

(b) PASSIVE MIXERS

It takes at least 16 inputs to combine a typical 12 channel head-end. Passive mixers are usually comprised

(b) PASSIVE MIXERS Continued

of hybrid splitters, directional couplers or a combination of both.

(1) HYBRID SPLITTER

One of the oldest and most efficient mixers is made up from two 8 way hybrid splitter networks fed into a high-low splitter. This setup allows for 5 low-band channels, 2 FM inputs, a low-pilot, 7 high channels, and a high pilot. If good hybrid splitters are used and the trunk is well matched it is possible to develop as much as 30 dB of isolation between channels with only 11 dB of insertion loss. It will be necessary to install an appropriate pad on the low side of the high-low splitter to obtain proper tilt leaving the head-end.

(2) DIRECTIONAL COUPLERS

Directional couplers are very popular now for mixing. A series of directional couplers are installed backwards for each band and joined in a high-low splitter. With good directional couplers and a well matched trunk line you can expect 30 dB of isolation between channels and about 17 to 21 dB of insertion loss depending on the channels. The lowest channel of each band must be mixed in with a low value tap and the tap value raised on higher channels. Otherwise, you may experience too much tilt within a band because of through line insertion loss building up. Mixers made up from directional couplers allow additional channels to be installed later.

(3) FOUR WAY DIRECTIONAL TAPS

Many operators use a combination of the two methods mentioned above by using regular four way subscriber taps. Two taps for each band are installed like the directional couplers above. You have about the same insertion loss as directional couplers but lose some isolation because most four way directional taps have only 18 to 25 dB of isolation.

(4) EIGHT WAY DIRECTIONAL TAPS

Recently eight way directional taps with low insertion loss and 30 dB of isolation have become available. A 13 or 17 dB value tap can be mounted

(4) EIGHT WAY DIRECTIONAL TAPS Continued

on a blank panel for each band then joined in a high-low splitter.

(c) 20 CHANNEL MIXING

Many systems are contemplating using mid-band soon and make allowances for adding channels later. Three eight way directional taps can be connected in series and backwards to provide 24 inputs. Unused inputs should be terminated until needed. It will be necessary to install bandpass filters or traps on some channels to attenuate local oscillator and other spurious outputs before mixing. An appropriate custom low pass filter must be installed behind each preceding eight way tap.

(1) SEASONAL PAD

After all channels have been combined an inline variable attenuator with 1, 2, 3, and 6 dB steps is inserted in the out-going line. This pad can be used to compensate for changes in cable loss due to seasonal variations. On a cold night this pad can be used to eliminate a case of cross modulation a lot easier than climbing poles all over town. A log should be maintained of pad changes.

(2) SUMMATION SWEEP POINT

The output of the seasonal pad should be routed to a convenient place where a jumper can be removed to insert a sweep generator and pilot traps for summation sweep testing the system when needed. If the pad is front mounted a F 81 can be installed as a bulkhead adapter in the panel. A shelf for test equipment mounted on the front of the racks at this point is very handy.

(3) PILOT GENERATORS

A 17 dB four way directional tap is inserted backwards for mixing in low and high pilot generators. Two pilot generators for each frequency should be mounted in the racks. The spare generators should be set up and ready to operate at the throw of a switch. Some systems use two pilot generators which are continuously operated at the same frequency. They only experience a 3 dB change in system level when one pilot drops out. It is very important that the pilot generators be inserted after all channels have been combined and passed through the seasonal pad. The pilots are necessary to control the system gain when making

(3) PILOT GENERATORS Continued

summation sweeps of the system. If the pilots are inserted before the seasonal pad any attenuation changes would be corrected by the first AGC amplifier in the system so little benefit would result.

(4) TEST POINT

A 20 dB four way directional tap inserted just before the combined signals enter the trunk line is adequate for most head-ends to drive required monitors.

(5) LEVELING

Operate every channel so the mixer receives +50 dBmV picture carrier, +33 dBmV sound carrier and +30 dBmV for FM and other narrow band services after necessary traps and bandpass filters. With 3 dB of seasonal pad thrown in the insertion loss at channel 13 will be about 18 dB. This gives a block tilt output of 26 dBmV lowband, 29 dBmV mid-band, and 32 dBmV high-band. These levels are compatible with most CATV systems and will not restrict the dynamic range of the system as mentioned earlier.

(6) READY MADE MIXERS

This seems to be the year for mixers as several new models have been introduced by manufactures recently. Most of them employ either hybrid splitters or strip line directional couplers consolidated into chassis with 6 to 24 inputs. I recommend you either consider using one of these ready made mixers or neatly mount eight way taps behind blank panels for each band.

(7) DOWNLEADS AND JUMPERS

Semi-flexible aluminum sheathed cables are the best choice for downleads. In the last few years it has been popular to plumb the processing equipment also with aluminum sheathed cable. Many of the CATV Technicians that used aluminum cable for jumpers are sorry they did now and have gone back to flexible cable. They found the ridged jumpers too much of a hassle during everyday operation and breakdowns. As head-end gear becomes more trouble free semi-flexible jumpers will be more practical. Buy the best quality double shield,

(7) DOWNLEADS AND JUMPERS Continued

single jacket, solid dielectric 59/U or 6/U drop cable available for flexible jumpers. Check cable rolls that are planned for jumpers with a bridge before installation. Make all jumpers as short and neatly routed as possible. If ties are used around bundles of jumpers make them as loose as possible so jumpers can be traced and others added later.

CONCLUSION

Ask yourself the following questions:

Can your head-end picture quality use some improvement?

Are you providing your subscribers with all the services available?

Are you proud of your head-end when the manager brings in a guest?

Let's give our processing gear a little R_x and we may find it helps our job security.