DESIRED SPECIFICATIONS OF PAY CABLE TRAPS

Dan Pike

United Cable Television Corporation
Tulsa, Oklahoma

ABSTRACT

A list of desired specifications is developed, with a discussion of each, for a trap on channel A (121.25 MHz). The specifications are intended to describe a filter whose performance will be predictable over a wide range of environments and with many different TV receivers. Also discussed are the differences to be expected in operating parameters of filters for channels higher and lower than channel A.

Considerations discussed are: the critical portions of the signal to be trapped, the parameters needed to effect scrambling action in the receiver, specifications geared to insure time stability, and specifications intended to cause poor to indiscernible audio in most receivers.

NOTCH FREQUENCY: Desired visual carrier ±2 KHz
TEMPERATURE: -40°F to 140°F
DEPTH OF NOTCH: 45 dB at room temperature
INSERTION LOSS: Adjacent visual carrier 2 dB; all others 0.75 dB
RETURN LOSS: All channels outside 3 dB points 16 dB
FREQUENCY STABILITY: ±75 KHz
3 dB BANDWIDTH: 10 MHz
3 dB NOTCH WIDTH: 32 KHz minimum; 100 KHz maximum
POWER PROTECTION: Withstand 250 VAC from center conductor to sheath
SHOCK: Withstand 20-foot fall to concrete
MECHANICAL CONFIGURATION: Not removable with common hand tools
WARRANTY: One year

INTRODUCTION

The rapid growth of pay cable has resulted in a heavy demand for a device previously unknown to the cable industry: an inexpensive (relative to other filters in use in the industry), highly stable, weatherproof filter (or trap) designed to render a pay signal unwatchable, available in large quantities to accommodate any given channel line-up found in the industry. Such a device is difficult to specify, and consequently not all filters are purchased under the same specifications. It is to the benefit of the operators and manufacturers if both describe the unit by the same manner of specification, with changes in absolute values to accommodate special circumstances found in different CATV systems. The desired specifications are listed here with the appropriate discussion of each one.

NOTCH FREQUENCY: Desired Visual Carrier ±2 KHz

The notch frequency should be specified as the assigned visual carrier frequency of the pay channel with a tolerance of ±2 KHz to allow for slight variances between equipment. This specification is intended to insure that the center and deepest portion of the notch lies in the area of its maximum effect. Other parameters will deal with the shape of the notch.

TEMPERATURE: -40°F to 140°F

The temperature range commonly specified for most CATV equipment lies from -40°F to 140°F, and these units should be compatible with other equipment operating in the industry. Certainly southern coastal areas might wish to relax these somewhat for their particular needs, but filters with good stability and temperature compensation generally have little difficulty meeting the -40°F to 140°F temperature range.

DEPTH OF NOTCH: 45 dB at Room Temperature

The depth of the notch can be specified to satisfy one of two desires: either to effect scrambling action in the receiver or to reduce the visual carrier and consequently the carrier to noise value of the signal displayed on the receiver to that which is generally accepted to be unwatchable. Most late-model color receivers will not reliably synchronize when the video carrier approaches an absolute level of -35 dBmV.

The maximum drop levels found in most systems rarely exceed 10 dBmV such that a notch depth of 45 dB is adequate to effect scrambling action in most receivers. If the notch, however, does not retain that value through the channel of interest but rather only very near the visual carrier, as is the case in a pay cable trap, there are appreciable energy components within the desired channel (particularly within the areas of the color subcarrier and sound carrier).

In addition, most receivers develop AGC voltage by reference to the horizontal sync information, which is located within 15,750 Hz of the visual carrier. With the gain of the receiver circuitry at a relatively high value, these added energy components may aid scrambling effect by the generation of intermodulation products in the receiver IF circuitry and detectors. Also aiding this effect are any adjacent channels that lie in the bandpass of the tuner and IF response of the receiver.

These added effects may be used as a basis to modify the 45 dB specifications at room temperature to include a tolerance for the temperature extremes of 5 dB to allow a 40 dB specification at the two temperature extremes of -40 and +140 provided that the filter returns to 45 dB at room temperature. The depth of notch specification, then, should read 45 dB at room temperature, 40 dB at the temperature extremes.

If the goal is to simply provide a snowy picture that may be considered unwatchable, then the value of the notch does not necessarily have to be so high since a 40 dB trap in conjunction with a converter with a 13 dB noise figure and 10 dBmV input leaves a carrier to noise ratio of 16.1 dB, excluding the effects of the noise contribution of the TV tuner and the system itself as being negligible. A poor picture has been defined as one whose carrier to noise ratio is 30 dB or less. A barely viewable picture has been defined as one having a 27 dB carrier to noise ratio such that any value below 24 dB could be considered unwatchable. For the protection of the premium channel, however, specifications written for a scrambling effect would be advisable.

While a 45 dB notch may render a video signal viewed on a television set unwatchable, it most likely will not have a discernible effect on the audio portion of that signal since a filter designed not to suppress the visual carrier on the adjacent channel by more than 2 dB will not suppress the aural carrier by more than approximately 10 dB. In cable systems where the aural carrier is operated 15 to 17 dB below the visual carrier, the audio will still be quite discernible.

Virtually every television set used in the U.S. today makes use of the 4.5 MHz difference between the aural and visual carriers with the use of an intercarrier sound technique whereby after IF detection there follows a 4.5 MHz sound detector to recover the aural information. The level of the 4.5 MHz carrier is directly dependent upon a level of the visual carrier, so it is possible to place a value on the visual carrier at which or below which the value of the 4.5 carrier produces a garbled audio component. This absolute value has been established to be on the order of -45 to -50 dBmV, which means that a 55 or 60 dB trap is necessary if the maximum subscriber levels are 10 dBmV.

The reduction of the visual carrier is, however, not absolutely certain to produce garbled audio since the pay aural carrier can beat with any adjacent carrier or even with high level luminance components if the trap is very sharp in the IF detection process and produce a 4.5 MHz component that the FM detector in the receiver will receive. Since the gain of the receiver circuitry is relatively high, many more distortion products will be presented to the FM detector and, depending on the alignment and fine tuning range of the receiver, it may be possible to fine tune to receive discernible pay channel audio even when the pay visual carrier has been attenuated 90 dB or more. The only sure way to reduce the audio to an indiscernible level in every receiver is to reduce the aural carrier level before IF detection. This may present a problem to upper adjacent visual carriers, particularly for operation above the low VHF channels.

It is very important that the depth of the notch specification be considered in conjunction with the other frequency and bandwidth specifications since it is entirely possible that a 60 dB notch can be placed in a channel in such a frequency position as to be barely noticeable. A 45 dB trap is not effective unless it attenuates the information within ±15.75 KHz of the pay visual carrier by 45 dB.

INSERTION LOSS: Adjacent Visual Carrier 2 dB; All Others 0.75 dB

Insertion loss for all channels other than the adjacent channel to the trapped channel should be 0.75 dB maximum. This should include any peak to valley or other variations in the response. The adjacent channel carrier should not be attenuated by any value more than 3 dB for the average home receiver to be unaffected, and the figure of 2 dB provides adequate margin for variance between receivers.

While the trapped pay TV channel is not offered to the subscriber and by yet-unqualified opinions doesn't have to be tested to meet the FCC standards, the adjacent channel does have to meet them, and a value of 2 dB at the visual carrier is intended to provide a reasonable variance in that channel. Since the filter response will return to about its insertion loss value above the visual carrier and will also drop another dB approximately to the lower channel limit, the recommended FCC limits of ±2 dB may be met if the 2 dB insertion loss specification is observed for the adjacent channel.

Also, tests have shown (see photos 1A-4A) that the trained eye can begin to determine differences in the transient response (where the picture contains sharp transitions) but cannot determine variances in the color saturations or hues at this level of adjacent channel attenuation.

Photographs 1-4 show the variance in test waveforms through a demodulator that may be considered equal in quality to those of the average home receivers. Since the AGC voltage is developed from the 15,750 Hz components lying within 15.750 KHz of the visual carrier, the difference in the amplitude of the upper and lower 15.75 KHz sidebands is very slight and can be neglected. However, there is a discernible difference in attenuation between the components of appreciable energy content at the lower end of the lower vestigial sideband and those of the same corresponding frequencies away from the carrier in the upper sideband, resulting in a reconstituted signal having variances in this response relative to equal amplitudes of components not passing through a trap having non-linear attenuation throughout the adjacent channel. Since the gain is corrected using reconstituted lower frequency components, which are attenuated by the value of the slope of the incoming RF response, the corresponding value of the slope of the higher frequency components will be greater.

Photos 1-4 show the effects of a reconstituted signal for values of carrier attenuation given in Table 1. Also shown in Table 1 are the values of attenuation at the lower limits of the vestigial sideband.

TABLE 1

Photo	Attenuation, dB at Visual Carrier	1 MHz Below Visual Reference
1	Reference	Reference
2	1.4	2.1
3	2.3	3.0
4	2.6	4.5

Photos 1A-4A show responses through the same demodulator with 2T, 12.5T and window test signals. Since most of the energy of the 2T pulse lies in the low-frequency areas of the video signal, its amplitude is affected less than that of the 12.5T pulse. The 12.5T pulse shows a relative chroma level increase in photos 2A, 3A and 4A with relative chroma delay in photo 4A. The 2T pulse reveals that the transient response as well as the amplitude is affected, as may be predicted by the change in phase relationships for those frequencies reconstituted from components above and below the visual carrier since the components on the lower edge of the vestigial sideband are on the lagging edge of the filter and are affected more by any phase difference. The low to high frequency phase variance is apparent by the observation of the 12.5T pulse. These phase relationships, amplitude, variances and transient response differences will be determined largely by the alignment of the subscriber's receiver, but the effects of the trap will be additive in any case. The fact that the trained eye may begin to see the effects on using an average representative receiver with a filter whose upper adjacent is attenuated beyond the values given in Table 1 is used as a basis for the specification.

RETURN LOSS: 16 dB

Since taps commonly used in CATV systems have return loss specifications of 15 dB or better, the trap used in conjunction with these should have at least an equal return loss except, of course, within the effects of the notch. All channels other than those within the 3 dB points of the trap should exhibit a return loss of 16 dB or better. Of course, systems with taps that have better or worse return losses may wish to alter these numbers slightly.

Tests at United Cable have shown that a feeder line with traps on roughly 50 percent of the tap spigots exhibiting return loss of 11 dB does not result in a measurable difference in the response of that feeder line, nor does it result in discernible impairment of the adjacent color picture or any other channel when viewed by trained observers. The tap values on the tested feeder line ran from the high 20s to 8 dB, and the minimum isolation specification of the taps was 26 dB.

FREQUENCY STABILITY: ±75 KHz

The frequency stability of the notch is important to insure that the critical components remain at the attenuation value that has been chosen. To insure that a notch retains its position in the frequency spectrum a specification of ±75 KHz across the temperature extremes has been shown to be a valid specification. Measurement of frequency for any attenuation value chosen should not vary more than ±75 KHz over the -40°F to 140°F extremes.

3 dB BANDWIDTH: 10 MHz

The 3 dB bandwidth has long been a standard measurement of filter performance and indicates that value at which the frequency response is 3 dB below its incident value. It is referenced as a basis in a great deal of filter design information and should serve a similar purpose in the description of its use in a trapping effort. Spectrum lying above and below the 3 dB points of the filter will be considered available for program use for any purpose. Spectrum lying with the 3 dB points should be considered incapable of carrying useful information to cable subscribers not choosing to subscribe to pay cable.

Notch filters, for most practical purposes, will be symmetrical about their deepest point. There are special conditions where, to favor lower adjacent sound carriers, skewing techniques have been incorporated; but the majority of these filters have been in the low-band channels. Filters in use in the mid-band channels utilize designs that do not generally lend themselves well to this technique. Since the upper adjacent video carrier lies at 6 MHz above the carrier to be trapped and its lower sideband cannot be attenuated more than 3 dB, and the appreciable energy components of this lower sideband extend 1 MHz below it, then we may establish the 3 dB point of the filter to be 5 MHz above and below the carrier to be trapped (assuming a symmetrical filter). To include those situations where the filter may not be symmetrical about its deepest point, the specification for 3 dB bandwidth should be 10 MHz with no indication of its variance of the visual carrier.

3 dB NOTCH WIDTH: 32 KHz Minimum; 100 KHz Maximum

A 3 dB notch width can be used also to describe the performance of the filter in that the points 3 dB less than the maximum attenuation figure must remain a given width in order for the synchronization components contained in the video signal to be attenuated to the value that has been previously determined to effect scrambling action in the receiver. Since sync components lie as far as 15.75 KHz above and below the visual carrier, the 3 dB notch width should be greater than 31.5 KHz and is limited on the high end by the shape factor of the filter. However, in order for appreciable energy to lie in the color burst and aural components to help in the scrambling effect, experience has shown that this value should be limited to 100 KHz. The 3 dB notch width should be specified at greater than 32 KHz but less than 100 KHz and may be specified at 50 KHz nominal if desired to effect maximum scrambling action and allow a slight tolerance for temperature drift. This specification, coupled with the frequency stability specification, is designed to insure that the notch retains its most effective shape at its most effective portion in the frequency spectrum throughout the temperature range.

POWER PROTECTION: Withstand 250 VAC from Center Conductor to Ground

In order to resist intentional damage by subscribers who introduce common house voltages from center conductor to ground in an effort to destroy the trapping effect of the filter, the unit should be designed such that there is no degradation in the trapping action with 250 VAC introduced from center conductor to ground in its normal operating environment. A normal operating environment is, of course, between the subscriber and the tap.

SHOCK: Withstand 20-foot Fall to Concrete

The nature of the pay cable trap, be it a band stop filter, a trap, or a band reject filter, is such that its operating conditions are somewhat opposite to that of most other equipment found in the industry. It has to operate with very high circuit Qs and very high stability yet over very narrow bandwidth, where the other equipment in the industry operates over a very broad bandwidth. Slight physical displacement introduced by shock may have catastrophic effects on the action of the filter. For this reason the unit must be able to withstand a 20-foot fall to concrete to insure that it will retain its electrical performance during and after installation. It also gives a relatively good idea that the unit will perform well with long-term environmental impacts and gives a good idea that the mechanical exercise caused by temperature extremes over the years will not adversely affect the unit.

MECHANICAL CONFIGURATION

If a unit can be installed with common hand tools, it may quite naturally be removed with common hand tools. Since the pay channel represents an annual worth of approximately $100 to the trapped subscriber, the propensity for him to steal the service is dramatically increased over that of the theft of the normal cable service. Where economically feasible, the filter should lock to the tap mechanically and not be removable except with special tools not normally available. Other alternatives to that, of course, include the use of a locking "F" connector or other arrangement on the subscriber's drop to mechanically lock the drop to the filter rather than the filter to the tap. The disadvantage of this method is the availability of type F connectors at hobby shops and the likelihood a potential pay subscriber may connect himself at a point on the tap side of the filter. In apartment boxes and some underground installations there is the reliable padlock for security. Regardless of the type of mechanical security, he may connect himself to a neighboring pay drop. The inclusion of the mechanical locking specification is to indicate to the manufacturer the desireability of that feature.

WARRANTY: One Year

Cable television equipment operates in environments and over bandwidths surpassed only by a few industries. The inherent nature of this narrow band device suddenly developed for pay cable use dictates the concern for its long-term stability. Component changes, mechanical exercise through temperature extremes, water absorption, potting compound aging effects and countless other factors can affect the long-term stability of the unit. The unit should be warranted to exhibit these outlined specifications for a period of one year.

DISCUSSION

These specifications were drawn for units operating on Channel A and represent reasonable specifications for that spectral area. Filters that are intended to operate at higher frequencies into the high VHF or super band must have relaxations in the 3 dB bandwidth since that parameter may be expressed as a percentage of center frequency and used as a rough estimate of performance for channels above the lower mid-band. For channels in the low VHF area the 3 dB value may be expected to reduce by approximately the same percentage value.

There are many other conditions that come into play in the actual design, and the use of the percentage estimations yields only crude approximations. Certainly with the vacating of upper adjacent and lower adjacent channels units may be used on channels in the high VHF and super band. However, the sacrifice of those two channels involves the sacrifice of an important resource of the system--that of valuable spectrum space that can never be used for distribution of information to all subscribers except when the filters are removed. Units operating in the low VHF band have a spectral opening given them by the FCC in the 4 MHz space between channels 4 and 5. Units on channel 5 have that 4 MHz with which to recover their 3 dB bandwidth without adversely affecting the aural carrier of channel 4. Also, some designs incorporate 3 dB bandwidth sufficiently narrow to be used in the lower four channels without adversely affecting lower adjacent sound or color subcarriers, while keeping the required stability. The spectral area below channel 2, of course, contains no useful information to the subscriber, and units operating in that area have no lower adjacent problems.

The program of trapping non-pay subscribers must be carried through with the highest integrity possible for many reasons. The filter protects a service with an annual worth of $100 or more, and its performance has an effect on the number of pay subscribers since inadequate performance may let a poor signal reach the home. A poor signal relative to the other cable signals offered at a cost of a few cents per signal per month may in the eyes of a subscriber become a signal good enough not to be worth $8-10 more per month to be made better. Also, subscribers paying for the premium channel often fail to see the dollar difference between their good signal and their neighbor's free snowy signal. These undesirable events may be avoided by 100 percent incoming inspection and rigid testing for these specifications presented on a sample lot of units from each production run. Continued observation of filter performance may be carried out by observing the trapped channel on every service call to a non-pay subscriber.

General trends that may be noticed during the testing of filters may be the slight dependency for the scramble effect on the average picture level, depths of modulation and picture information. A test pattern such as the cross hatch and dot pattern where rapid transitions are apparent will effect the scrambling action more so than dark movie scenes since dark scenes have more visual carrier available to the receiver, and any scrambling action introduced by the rapid transitions is not apparent. Also, for systems using converters, a receiver that does not synchronize with the fine tuning at its normal range may synchronize if the fine tuning is adjusted to one extreme partly because of the frequency response of the television receiver and partly because of the response of the converter.

CONCLUSIONS

Perhaps by the establishment of a set of desired specifications with the flexibility to adapt them to every particular situation to be encountered in the CATV industry the industry's needs may be more closely conveyed to the manufacturer, and the manufacturer's response may be more closely correlated with the predetermined CATV operator's need.

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