An Investigation into the Problem of Character Generator Ringing or Second Image on Cable Systems

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Abstract

Waveform testing is performed on a CATV Modulator–Home Receiver modem to investigate the problem of "ringing" or "2nd Images" which sometimes occur when video signals having non-standard baseband formats such as alpha-numerics are carried on the cable system.

Past attempts to solve the problem through the use of Data Filters is discussed as well as a different approach utilizing the technique of Time Domain Correction. A block diagram of the Time Domain Correction scheme is given along with a discussion of its operation.

This new technique is applied to the Modulator–Home Receiver modem and waveform testing is once again performed indicating the degree of improvement that might be achieved using this scheme.

Introduction

The increased use of alpha numerics on cable systems the past few years has brought with it an increase in the number of complaints describing a "second image" following the characters as viewed on the home receiver. The majority of character generators on the market today produce white displays on a dark or multi-colored background and all are capable of excellent "sharpness" and legibility when viewed on a wide bandwidth video monitor. However when this same information is converted to a standard television type RF signal in a CATV modulator and ultimately viewed on the home receiver the legibility may be impaired, the worst situation being when the white characters are followed by a distinct "second image" of the character and this "second image" is also lighter than the surrounding background. In many cases this "second image" has all the characteristics of a ghost; however as we shall later see, no reflections due to poor return loss are necessary to create the problem. Attempts in the past to solve this problem have taken the form of phase equalized 4.2 MHz low pass filters placed on the output of the character generators as well as various types of data filter modules placed at the input to the modulator. It is the purpose of this paper to determine why these past attempts to solve the problem have proved only marginally successful and finally to consider an entirely different approach to solve the problem utilizing the technique of time-domain video waveform correction.

Waveform Testing of a CATV Modulator–Home Receiver Modem

In an attempt to determine the cause of the "2nd Image" problem a CATV modulator was carefully checked for proper alignment and then subjected to video waveform testing when operated back to back with a precision television demodulator. The particular modulator used contained both the pre-distortion delay equalizer required by the FCC for color transmission on broadcast stations as well as baseband delay correction circuits to compensate for delay errors generated in the vestigial filter. The results of this back to back test is shown in Figure 1. The test waveforms chosen for these tests were the Multiburst signal because of its obvious sensitivity to response flatness and the 2T Pulse signal because of its sensitivity to delay errors.

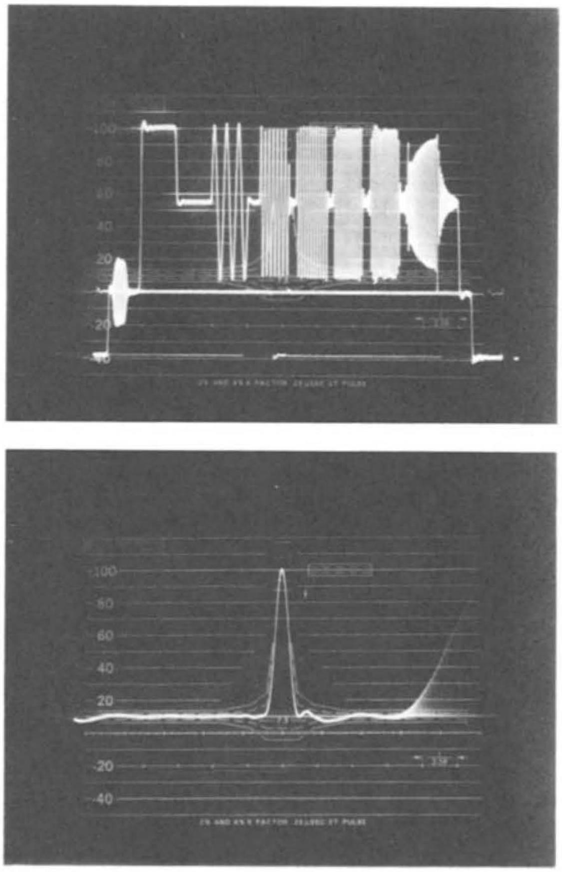


Figure 1. Multiburst and 2T Pulse Response – 6300 Modulator – 6250 Demodulator

From the photographs it can be seen that the overall amplitude response is flat to within a few tenths of a dB and the units produced a "K" factor of approximately 3%. The purpose of this exercise is to convince the reader that although the modulator is not perfect it certainly would be considered to be of good quality and at least typical of many modulators in operation in cable systems throughout the country.

The output of the modulator was disconnected from the input to the demodulator and then fed into the input of a home TV receiver. The home receiver used in these tests was a popular model of recent vintage. Although it certainly can't be argued that his particular receiver is the "average home receiver" it should at least be representative of the units in the field. To perform waveform testing on the TV receiver the back cover was removed and a buffer amplifier exhibiting a high input impedance and a 75 ohm output impedance was placed between the receiver luminance signal prior to being fed to the kinescope and the input to a waveform monitor. The receiver channel selector was set to be the same as the output of the modulator and then carefully fine tuned while feeding the receiver the modulator channel plus a lower adjacent channel sound carrier. The sound carrier was then removed and this modulator–"demodulator" pair was subjected to the same waveform testing as described for the modulator–precision demodulator pair. The results are shown in Figure 2.

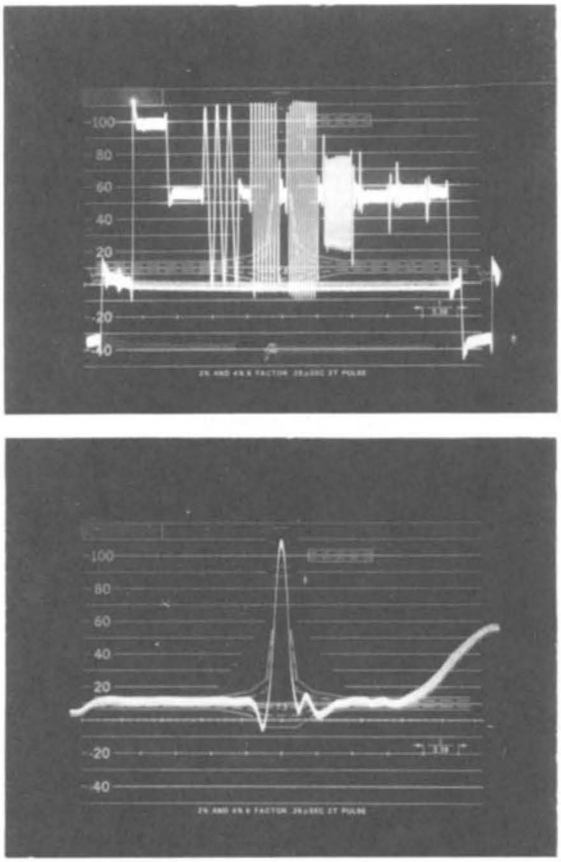


Figure 2. Multiburst and 2T Pulse Response — 6300 Modulator — TV Receiver

The multiburst response indicates a gradual peaking of about 1.5 dB from low frequencies to 2 MHz and a sharp cutoff between 2 MHz and 3 MHz. The 2T pulse response shows a leading undershoot and trailing overshoot giving a "K" factor of approximately 5%. Had the overall modulator-demodulator delay response been flat we would have expected fairly symmetrical ringing on either side of the 2T pulse having peaks displaced from the 2T pulse maximum amplitude by 1/cutoff frequency or about 400 nanoseconds. The combination of non-flat delay plus to a lessor degree some quadrature distortion has produced un-symmetrical ringing at the cutoff frequency. Careful viewing of even the 2T pulse on this receiver begins to show a trailing "2nd image."
As is well known the shape of the 2T pulse is carefully controlled to produce an energy distribution versus frequency which is approximately 6 dB down at 2 MHz and essentially zero above 4 MHz.

Consider the results of replacing the 2T pulse with one representative of those produced in some character generators. Such a pulse is shown in Figure 3. This pulse has rise and fall times of 15 nanoseconds and a width of 75 nanoseconds. It was produced by feeding the output of a Hewlett-Packard Model 214A Pulse Generator into the External Video In of a Telemet Model 3508 Test Signal Generator. It has an energy distribution which is flat across the 4.2 MHz video bandwidth of the modulator.

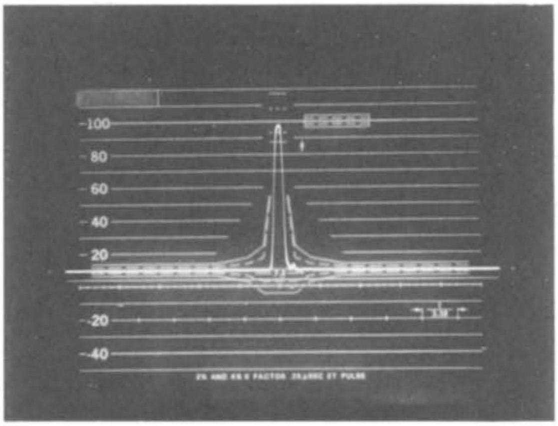
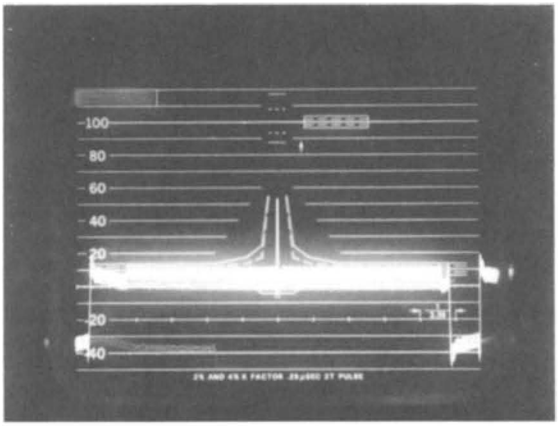
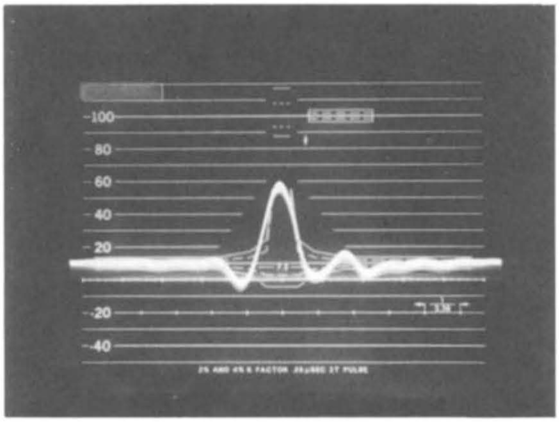


Figure 3. "Character Generator Pulse" — 75 Nanosec Wide — 15 Nanoseconds Rise and Fall Times



One Horizontal Line



Expanded View of Pulse

Figure 4. "Character Generator Pulse" — CATV Modulator — Home Receiver

The results of feeding this "Character Generator Pulse" through the CATV modulator–home receiver is shown in Figure 4.
In many respects it is similar to the 2T pulse response except

the amplitude of the undesired trailing transient response is a much larger percentage of the desired response. This increased amplitude of the "2nd Image" is due to the larger energy content of the "Character Generator Pulse" at the cutoff frequency of the system. Before we are too quick to judge the home receiver at fault let's replace it with the precision demodulator used to produce Figure 1. The results of passing the simulated character generator pulse through this pair is shown in Figure 5.

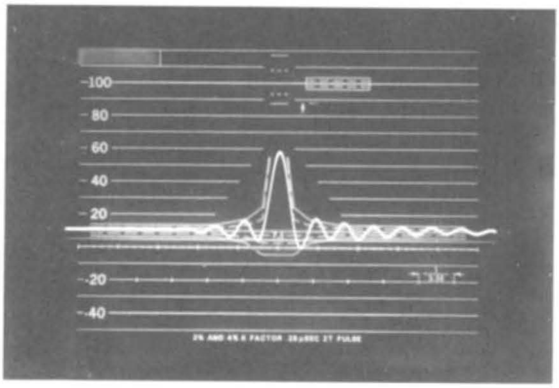


Figure 5. "Character Generator Pulse" – CATV Modulator – Precision Demodulator

As expected we have a more symmetrical ringing on either side of the desired response producing multiple images both proceeding and following the desired image. These undesired images are displaced from the desired one by 1/cutoff freq. = 1/4.2 MHz = 238 nanosec. Viewing the output of this demodulator on a high quality video monitor will produce multiple images which are even more difficult to read than when viewed on the home receiver. If we conclude that the modulator is not at fault and the demodulator is not at fault we must ultimately arrive at the conclusion that the problem is one that can best be described by the Theory of Information Rates. Simply stated: When the transmission bandwidth is less than the signal bandwidth some degradation of the signal always results. This degradation may or may not however result in the loss of information depending upon how the information is ultimately utilized. One solution to the problem would be to slow the rise and fall times and lengthen the width of the pulses produced by the character generators. This obviously would reduce the number of characters that can be displayed at any given instant and is highly unlikely since in many instances the character generators are fed directly to video monitors where the bandwidths and therefore information rates are not nearly so restrictive.

Frequency–Domain Waveform Correctors

In the case of bandwidth limited television channels past attempts to solve the problem have taken various forms. One such attempt was to remove the unusable high frequency energy content of character generators by placing a phase equalized 4.2 MHz low pass filter on their output. This solution can have little or no effect on the problem because as shown in Figure 2 signal frequencies above 2.5 MHz are not passed by the luminance channel of the home receiver.

There have also been developed by some modulator manufacturers a variety of "Data Filters" which basically was some form of low pass filter placed at the input to the modulator in an attempt to roll-off the high frequency energy content of the character generator signals. Usually their effect was only minimal or if anything produced a smearing effect as viewed on the home receiver. Later when colored backgrounds became popular these filters were rendered useless because of the loss of color saturation they produced. Further attempts to design data filters produced results such as that shown in Figure 7.

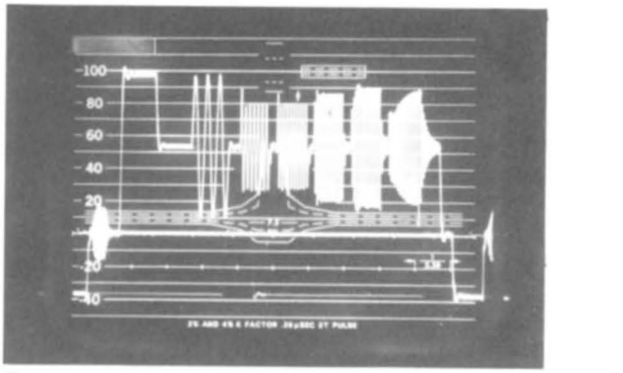


Figure 6. Data Filter Multiburst Response

This filter was designed to produce a more gradual system cutoff response but yet not reduce the color saturation of the background. The results of this filter proved to be more beneficial than that of the low pass type but there were still situations where this filter produced little or no results.

Time–Domain Waveform Correctors

Television transmitters, to a large extent, have identically the same problems in producing high quality alpha numerics on the home receiver as we do in cable systems. Their use however has been limited to producing station call letters, emergency messages, sports scores, etc. To provide improved legibility for these applications of alpha numerics as well as improve their overall transient response to normal video signals transmitter engineers have been utilizing a tool which we basically have overlooked in CATV. This tool is the Video Time–Domain Waveform Corrector. The time–domain approach to waveform correction aims directly at restoring a particular point in a waveform at a given time to the amplitude level it should be at that time, without recourse to frequency–domain considerations[1.]. Normally these devices were designed to correct distortions which had occurred in processing the video signal prior to being modulated on the RF carrier. To do so a correction signal is generated from the incoming distorted signal and then added to the distorted signal to produce a corrected outgoing signal. There is nothing however, to prevent these devices from taking a correct input signal and producing a pre-distorted output signal to correct for errors generated elsewhere in the system[2.]. One reason such techniques have not found widespread use in the CATV industry is due to their excessive price, usually costing many times more than the modulator itself. It should be pointed out that these machines provide a variety of signal conditioning functions and the use of such a device to produce increased legibility of alpha-numerics in cable systems would be an inefficient use of its overall capability.

I would now like to describe what I consider to be a novel approach to a solution of the problem utilizing time–domain pre-distortion techniques as described before but at a fraction of the cost. The system will only work with character generators producing white letters on a dark, colored or multi-colored background. It will not function with normal transmitted video signals. Such is not the case for the more expensive machines described above. The block diagram of the Character Generator Pre-distortion Waveform Corrector is shown in Figure 7. The input video signal from the character generator takes two paths. One path is through a buffer amplifier and finally an adder circuit where it appears at the output. This path provides no signal conditioning of any form to the input signal. The second path passes the input signal through a second buffer amplifier and then a 3.58 MHz notch filter which removes any color subcarrier energy which may be present on the signal. The sync negative video signal is then clamped at the sync tips to a positive dc

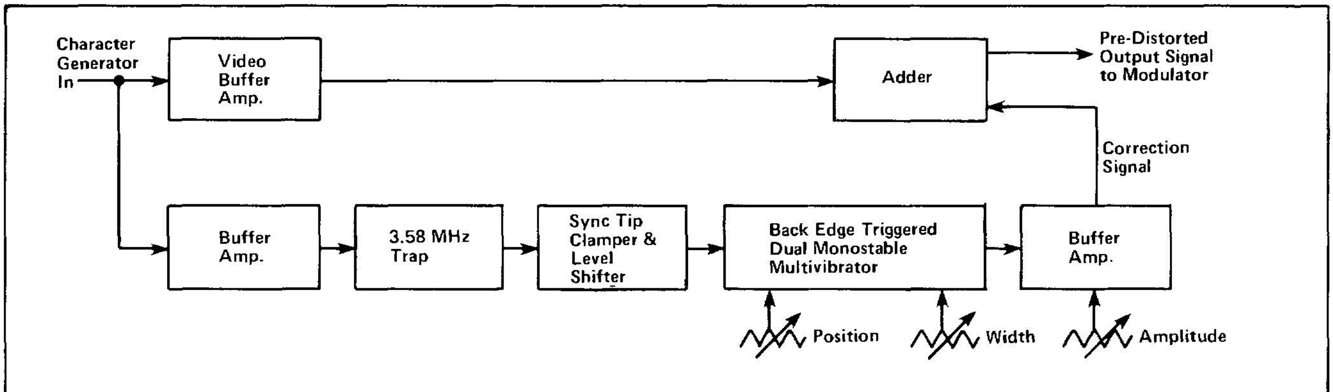


Figure 7. Block Diagram of Time Domain Character Generator Pre-Distortion Waveform Corrector

level set to cause the dual monostable multivibrator to be triggered only by the pulses which produce the alpha-numerics. The dual monostable multivibrator is configured to produce an output pulse every time a negative transition occurs on its input waveform. This output pulse is variable in its position, width and amplitude relative to the pulse which triggered its initiation. This output pulse is added to the unaltered character generator output signal to form the pre-distorted signal which ultimately is fed to the input of the CATV modulator.

To gain a better understanding of how such a system might operate in actual practice, consider the problem indicated in Figure 4 which shows a distinct "2nd Image." If we now feed the "character generator" pulse through the Time–Domain Pre-distortion Waveform Corrector before going into the modulator, careful adjustments of its controls would allow almost complete elimination of the "2nd Image." Examination of Figure 8 which is the demodulated output of the home receiver under these conditions indicates a much improved transient response with a complete elimination of the trailing "2nd Image" response. Shown in Figure 9 is the pre-distorted output of the Time Domain Waveform Corrector under these conditions.

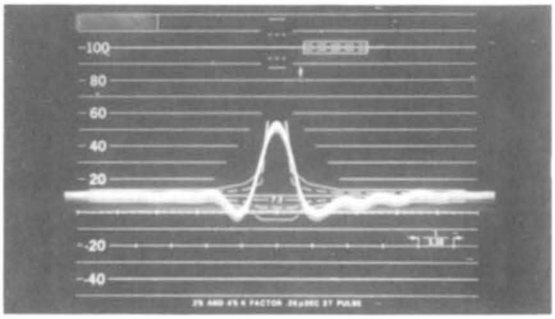


Figure 8. 75 Nanosecond Pulse – Character Generator Waveform Corrector – CATV Modulator – Home Receiver

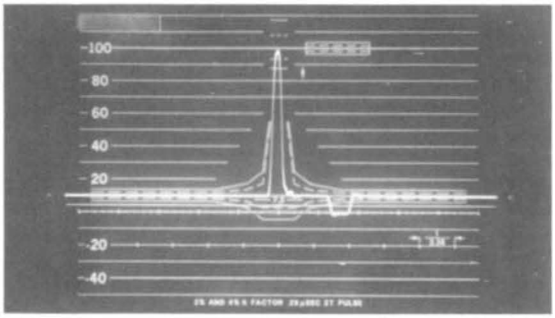


Figure 9. 75 Nanosecond Pulse – Character Generator Waveform Corrector – Waveform Monitor

The correction pulse follows the main pulse by about 400 nanoseconds and is opposite in polarity to the main pulse. Its width is about 100 nanoseconds. This correction pulse is generated each each time during the scanning of a horizontal line that a pulse is produced by the character generator. Since the correction pulse is initiated by the negative transition of the character generator pulse, its position relative to the back edge of this pulse will not vary, regardless of its width.

Conclusion

Past attempts at improving the legibility of alpha-numerics being viewed on home receivers fed from CATV modulators have generally been in the form of Data Filters. These attempts to improve the system transient response operate by altering the system in the frequency–domain.

This paper describes a technique whereby the overall system transient response is improved by altering the system characteristics in the time–domain. In our example the output of the character generator has been pre-distorted before going to the modulator by adding in a correction signal which ultimately cancelled the "2nd Image." It may be argued that the receiver used here was not an "average home receiver" and that different receivers would require a different amount of pre-distortion correction. This may well be the case, however my experience with this form of correction has indicated that receivers with greatly impaired legibility of alpha-numerics are much improved whereas receivers which had good legibility to start with have not been impaired.

The real advantage of this technique may well lie not in its ability to compensate for the "average home receiver" as indicated here but its ability to compensate for errors generated within the cable system itself. Differences in performance between character generators, CATV modulators, as well as system configurations which may include sub-lo runs from office to headend plus reprocessing all enter into the system performance. The time–domain correction technique can easily be adjusted to optimize the performance of any particular system. Such is not the case with Data Filters.

(1.) Mervyn W. Davies, "A Versatile Video – Waveform Corrector for TV Transmitter and Studio Applications," IEEE Transactions on Broadcasting, Vol. BC-19, No. 2, June 1973.

(2.) T. M. Gluyas, "TV Transmitter Luminance Transient Response," IEEE Transactions on Broadcasting, Vol. BC-20, No. 1, March 1974.