BASEBAND TERMINALS APPLIED TO CATV

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The possibilities with baseband CATV terminals are significant, but implementation must be tempered with caution. While the advantages are certainly attractive, implementation is not problem free and before one considers the advantages it is wise to reflect on the fundamental purpose, define the criteria for that purpose and insure that the purpose is met.

THE FUNDAMENTAL PURPOSE IS ACCEPTABLE TELEVISION ENTERTAINMENT. CRITERIA IS THAT A BASEBAND TERMINAL SHALL NOT CREATE ANY SUBSCRIBER DETECTABLE DEGRADATION WHEN COMPARED TO A TRADITIONAL RF TERMINAL.

The above definition may appear vague. The intent is not to demonstrate that a baseband terminal does not create additional degradation. But, the additional degradation is controllable within acceptable limits and is transparent to the subscriber.

INTRODUCTION

Although the reason for implementing a baseband system is to allow for enhanced features, this paper will concentrate on the signal path, categorize and rank distortions relative to functional blocks, analyze the cause of the distortions and present methods of controlling these distortions within acceptable limits.

TYPES OF DISTORTION

Within a CATV converter there are three (3) basic categories of signal degradation or interference. For the purpose of this paper the degradations will be referred to as Type One (1), Two (2) and Three (3) ranked in order of threshold of perception. One being most critical, and Three being least critical. Refer to Figure 1.

Type 1

Multiple Signal Interference: a degradation of a desired signal due to the presence of other signals in a non-ideal system.

This is the most objectionable, as it adds continuous undesired distracting information to the desired information. The level of perception is typically between Ø.1% and Ø.2%.

Type 2

Random Interference: thermal noise degradation of the desired signal. This interference is spectrally evenly distributed, and the brain acting as a correlator rejects substantial amounts of random noise. Acceptable interference levels are typically 1%.

Type 3

Single Signal Distortion: change in the desired signal due to non-ideal processing.

This distortion does not present additional extraneous information to the desired signal. It is entirely synchronous with the desired information and, as a result, distortions from 1Ø% to 2Ø% are not readily perceived as a degradation.

In the above three types of distortion, Type One and Two are inherent to both RF and baseband terminals, while Type Three is typically inherent to baseband only. It is the utilization of the basic fact that Type Three distortion is two orders of magnitude less severe than Type One, and that Type Three distortion can be maintained well within these limits which allows the criterion to be met within the limits of a consumer product.

FIGURE 1

DISTORTION TYPE BY FUNCTION

RF TUNER	
DISTORTION	**TYPE**
SPURIOUS SIGNALS	1
CROSS MODULATION	1
THIRD ORDER	1
SECOND ORDER	1
NOISE FIGURE	2
FREQUENCY RESPONSE	3
IF DEMOD VIDEO	
VIDEO FREQ. RESPONSE	3
920 KHz BEAT	1
DIFFERENTIAL GAIN	3
DIFFERENTIAL PHASE	3
TRANSIENT RESPONSE	3
CHROMA DELAY	3
CHROMA LUMINANCE INTER-MODULATION	3
SIGNAL TO NOISE	2
IF DEMOD AUDIO	
FREQUENCY RESPONSE	3
INTERCARRIER BUZZ	3
HARMONIC DISTORTION	3
SIGNAL TO NOISE	2
VIDEO MODULATOR	
FREQUENCY RESPONSE	3
920 KHz BEAT	1
DIFFERENTIAL GAIN	3
DIFFERENTIAL PHASE	3
TRANSIENT RESPONSE	3
CHROMA DELAY 3	
CHROMA LUMINANCE INTER-MODULATION	3
SIGNAL TO NOISE	2
MODULATION DEPTH	3
FREQUENCY ACCURACY	3
AUDIO MODULATOR	
FREQUENCY RESPONSE	3
HARMONIC DISTORTION	3
SIGNAL TO NOISE	2

SIGNAL PATH

Baseband converters are really RF converters with demod/remod systems attached. This can be seen by comparing the signal path block diagrams of Figure 2 (RF) and Figure 3 (Baseband). The major differences between the tuner sections is the addition of a low noise broadband AGCed RF amplifier and a variable AFCed second local oscillator.

While there is no technical reason for not implementing these features in an RF terminal, a baseband terminal inherently has all the drive signals available and the incremental cost is justifiable, while in an RF terminal it is not.

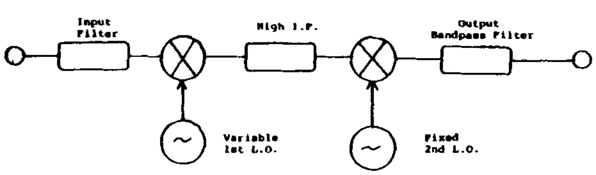


Figure 2 RF

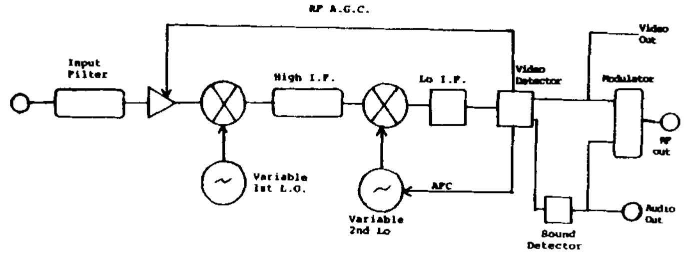


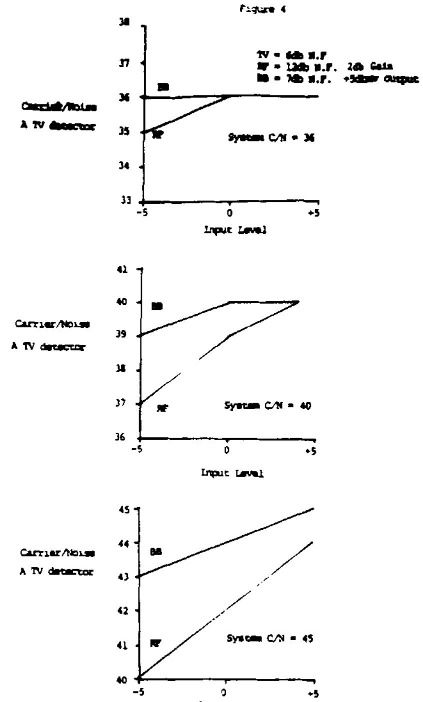
Figure 3 Baseband

TUNER

With careful design, RF AGC can be used to increase the usable input operating range. RF terminals typically have a 12 dB noise figure and small net gain, while a baseband terminal typically has a 7 dB noise figure and fixed output level. At low input levels and high C/N this will result in a direct decrease in Type Two distortions. Refer to Figure 4.

While the above is possible, a reduction in random noise must not be offset by an increase in Type One distortion. If the addition of an RF amplifier reduces the maximum input level for acceptable Type One distortion by 5 dB, while improving the C/N by 2 dB, the dynamic range has not been increased. If this condition occurs, this feature is best left out since the problems it will create will negate any performance improvement. However, by careful design techniques, utilizing today's manufacturing technological and strict process control, it can be reliably accomplished.

Figure 4



IF DEMOD

While the tuner is an integral part of the sytem and careful attention must be taken, especially in the areas of dynamic range and frequency control, it is this section that is either going to make the terminal a success or a failure. The areas that particular care must be taken are:

- Adjacent Channel Rejection
- 92Ø KHz Beat
- Dynamic Range
- Frequency Response
- Transient Response
- Differential Gain
- Differential Phase
- Chroma Delay

Also, one should remember that with the exception of 92Ø KHz beat, the above are Type Three (3) distortions and significantly more distortion can be tolerated.

Adjacent Channel Rejection

Adjacent channels must be carefully filtered out to prevent this interference from becoming Type One interference. This is accomplished by tightly controlling the frequency accuracy of the double conversion tuner to ensure the adjacent channels fall within the traps located in the tuner and SAW filter. With commercially available SAW filters and proper frequency control, only 1Ø dB of additional rejection is required in the tuner itself to ensure that no unwanted signals reach the detector. This requirement is easily met with present technology.

Dynamic Range

In a baseband converter, the low IF section must amplify the desired signal to a fixed level for demodulation. If, at any point along the signal path, the signal falls within 1Ø dB of the input level, then the amplifier may have a significant contribution to the total system noise figure. Also, if the desired signal exceeds the signal handling capacity of the IF amplifiers, Type One distortion occurs. This distortion, commonly called "92Ø KHz beat" is caused by intermodulation between video, chroma, and aural carriers. The balance between noise and overload is additionally aggravated by high loss in the IF SAW filter.

The 92Ø KHz beat is overcome by use of a SAW filter that reduces the sound carrier approximately 18 dB, in conjunction with heavy negative feedback in the pre-amp, preceeding the SAW and differential drive to the AGCed IF amplifier.

The low end noise problem is solved simply by maintaining proper signal level to the detector, however, implementation is not so simple. The area where particular care must be taken is again in the pre-amp prior to the SAW filter. This amplifier must have high gain, low noise and wide dynamic range, therefore, particular attention must be paid to this area of design. Once the basic design is achieved, performance can be very repeatable over an input dynamic range of -1Ø dBmV to +15 dBmV, while maintaining proper noise performance and less than Ø.1% 92Ø KHz beat.

Frequency Response

A change in video frequency response is inherent in all baseband systems. The RF tuner passband contributes to this type distortion. The major changes are caused by the IF SAW filter. The SAW filters used are TV receiver Nyquist filters with sound carrier shelves, approximately 18 dB below the passband maximum. Due to the finite slope of the SAW filter response, 3.58 MHz and 4.2 MHz video is attenuated. Attenuation at 3.58 MHz is typically 3 dB and is easily corrected by the color AGC of the TV receiver or monitor connected to the converter. 4.2 MHz is significantly attenuated and for all practical purposes not present. This particular parameter cannot be corrected economically. It is my contention that it need not be. For all practical purposes it can be viewed as not being part of the video spectrum. I realize that this point can be debated at length, but I contend that the absence of 4.2 MHz video signal does not now, nor will in the future, present information a subscriber can discern. Therefore, it does not violate the original criterion.

Transient Response

Transient response distortion is also a result of the IF SAW filter. However, by careful selection and specification of the SAW itself and particular care taken in proper matching between input pre-amp and IF amp, this type distortion can be maintained well below 1Ø%. This is significantly better than the typical TV receiver.

Differential Phase Gain and Luminance Non-Linearity

This type of distortion is the result of imperfect demodulation and possible non-linear IF and video amplification. While this distortion cannot be eliminated, it has been shown that distortion can reliably be maintained below 5 percent and 5 degrees. This performance is accomplished by optimizing the AFC, setting the detector input level for optimum linearity, and compromising between limiter and detector bias adjustment for optimum performance. This is not the normal method of aligning demodulator systems, but experience has shown that careful alignment of these parameters results in a substantial performance improvement over the typical TV receiver.

Chroma Delay

Chroma delay is an incorrect time alignment of the luminance and chrominance portion of the displayed video. Since chrominance and luminance are both part of the same picture, it may be considered Type Three distortion. But, in reality, its visual effect more closely resembles Type One in terms of threshold of perception. Tests have indicated that Ø.3% of the active video scan line is visible on typical video. Therefore, of all baseband video degradation, chroma delay is the most important to minimize.

Chroma delay results from filtering in two places, the IF SAW and 4.5 MHz sound carrier trap. Fortunately, both are very consistent by the nature of their construction, and proper design results in a very close compensating match with the FCC standard pre-distortion curve.

AUDIO DEMODULATION

Ignoring the stereo issue, sound detection systems in all baseband converters are typically intercarrier types with adequate performance, which do not add noticeable additional distortion. In fact, given today's performance in sound detection systems (and assuming that baseband outputs are connected to Hi Fi audio equipment), sound quality is impaired to a much greater extent by TV network transmission than by the baseband converter. If stereo is addressed, all baseband terminals will require redesign; the redesign will entail more than implemention of a demux system, but also requires a complete redesign to the video and audio demodulator. Since the presently approved system employs an AM subcarrier system, true high fidelity can only be achieved by implementing a quasi-parallel detection system. While implementation of this system adds significant cost, it improves both video and audio performance.

While Quasi-parallel solves the performance issue, volume control remains a dilemma. Since implementation of a stereo modulator is cost prohibitive, stereo compatibility will most likely be accomplished by passing the 4.5 MHz aural carrier directly to the modulator and volume control will only be available via the baseband outputs. This may seem a poor compromise, but present indications are that stereo compatible TV receivers will also include baseband interfaces for use with external high quality audio equipment. If this, indeed, turns out to be the case, then the dilemma is solved.

REMODULATOR

Up to this point, we have dealt with the tuning path and demodulation process. If the interface to the television set was at baseband, there would indeed be a performance increase over the standard RF terminal. The reason for this is that baseband CATV terminals typically outperform even the best TV receivers and an additional conversion process has been eliminated. However, we are not yet at the point where the whole world is using component video equipment. The majority of receivers require an RF input, therefore, an additional modulation process must be included. While all the same Type Three distortions must be dealt with, the solutions are more straightforward since we are starting with baseband.

TYPES OF MODULATORS

Today there are two modulators in use. The first uses a 4.5 Mhz audio modulator whose output is summed with the video. The composite signal is used to AM modulate the video carrier. The second modulates the video separately and mixes the 4.5 MHz modulated audio with the unmodulated video carrier. The first modulator is prone to 92Ø KHz beats, while the second is not. Since this is Type One distortion, good design practice mandates implementation of Type Two.

Frequency Response

Video frequency response can be essentially perfect (Ø.5 dB ripple) because filtering, if used, is channel filtering; this does not separate video and audio as required in the demodulation process.

Signal to Noise

This parameter is insignificant due to high signal level. However, if an output SAW filter is used to provide vestigal sideband - rather than a double sideband output - care must be taken to prevent the RF level from dropping below the output to prevent noise addition.

Differential Gain, Phase and Chroma Luminance Intermodulation

While modulators add differential phase and gain, this distortion is usually less than that of the demodulator, because the carrier is generated rather than recovered. The only critical parameter is depth of modulation, which can be easily controlled if the demodulation is done correctly and the input video constant.

Chroma Delay

As with the demodulator, this parameter is most critical in the modulator also. Typical modulators do not include standard FCC 17Øns group delay pre-distortion. Therefore, if the baseband video is correct the RF output will be off by 17Øns, visible to the trained eye. To correct this, pre-distortion should be added, preferrably in the output channel SAW filter for repeatability.

Audio Modulator

As with the demodulator, audio performance of all modulators is well within required performance. Since the percentage of deviation from center frequency is very small less than 1% total harmonic distortionn is easily achieved. While distortion or noise performance is not a problem, volume control may be.

Reduction of deviation of the sound carrier is the method of volume control used in baseband converters. This method is effective; however, decreases the signal to "buzz" ratio in the TV receiver since the buzz level remains constant. Best performance is obtained by deviating more than the standard +/-25 KHz and operating the unit near the top of its volume control range. This can be quite effective, but requires education of the subscriber to insure the subscriber sets his TV receiver at the optimum point.

CONCLUSION

If the reader agrees with the given criterion and the ranking of distortion presented, it is obvious that with proper care the baseband terminal can effectively perform equivalent to the traditional RF terminal and even improve Type Two distortion performance to the subscriber.

Now you can start adding features, letting your imagination and pocketbook be your guide. It is all possible once the signal path is designed correctly.