HIGH QUALITY TELEVISION DELIVERY SYSTEMS

Clyde Robbins

General Instrument Corporation
Jerrold Division

ABSTRACT

Looking forward, signal quality will be increasingly important. A minimum performance target of 50 dB C/N is suggested. A method of improving cable system performance is outlined. Two alternate modulation schemes are presented for extended definition and picture quality over existing cable systems.

INTRODUCTION

The advent of Super VHS (S-VHS) VCRs has caused many people in the cable TV industry to take a renewed interest in picture quality. S-VHS VCRs are capable of delivering substantially better picture quality than the original VHS VCRs. Soon the same movie titles will be available to rent in the S-VHS format as are carried by cable operators on pay per view and premium channels. This will provide the discriminating cable subscriber with a direct A/B comparison of picture and sound quality over cable vs. rented tape. Unless steps are taken, the cable quality will most likely be the clear loser in this comparison.

Although the growth of S-VHS owners in the next year may not be cause for great concern, the longer term trend of improved signal quality is certain. Sony will enter the high end video market this year with ED-Beta, which promises to provide significantly higher quality than S-VHS. Laser discs, another medium capable of very high picture and sound quality, could make a comeback.

S-VHS vs. VHS

Table 1 compares performance characteristics of S-VHS and VHS. S-VHS is clearly better in terms of luminance resolution (detail). Note that the chroma S/N is nearly equal in the two systems and is nothing to boast about. The VHS chroma S/N problem may be more a result of mechanical limitations than electronics. The poor chroma S/N results in poor color purity. Chroma bandwidth is also not changed in the S-VHS format, resulting in soft color edges, but some of Faroudja's (1) techniques may be incorporated by manufacturers in the future to enhance the sharpness of chroma transitions.

		VHS	S-VHS
Weighted Luminance S/N		52 dB	51 dB
Chroma S/N	AM	38 dB	38 dB
	PM	37 dB	40 dB
Resolution		200 lines	400 lines

Table 1: Measured Video Performance Parameters

Y/C vs. NTSC

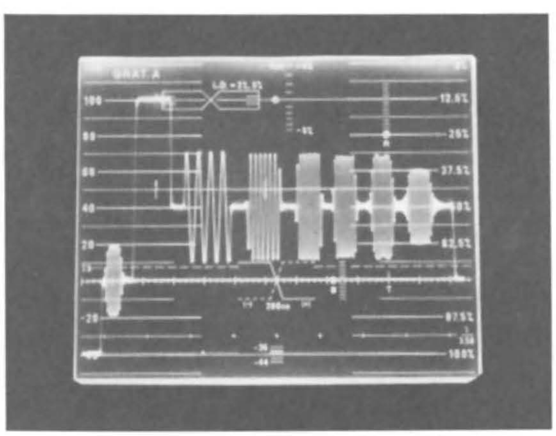
The Y/C (luminance/color modulated) connector feature of S-VHS VCRs and monitors has been widely publicized. It should be noted that the new connection is not in itself a reason for superior picture quality. If an NTSC composite signal is properly encoded (combined Y and C) and then properly separated, the artifacts (i.e., cross color and cross luminance), are minimal and do not significantly degrade picture quality. A properly encoded NTSC signal (with proper decoding) on a monitor is nearly indistinguishable from a Y/C presentation on the same monitor. However, not all monitors with Y/C connections have good NTSC decoding.

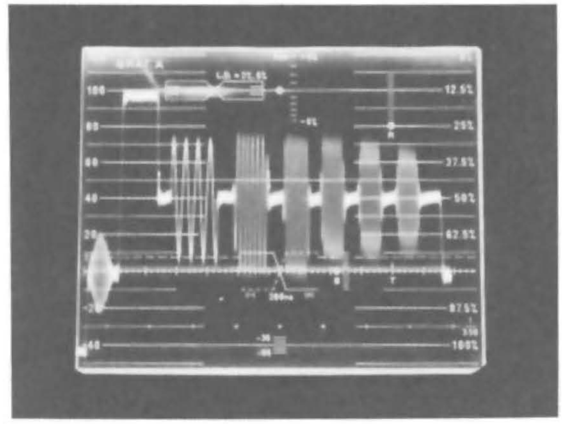
VSB-AM NTSC vs. S-VHS

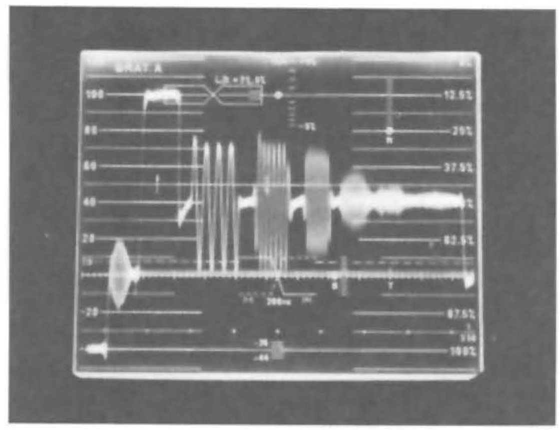
The 6 MHz spaced AM vestigial sideband system for transmitting NTSC pictures and sound limits resolution to 330 lines or less, depending on receiver and display performance. Already available on the market are TV Monitor/Receivers with Y/C connections which have display capabilities of only 330 lines, regardless of whether the NTSC or Y/C video input is used.

A clean 330 line picture can be an excellent and pleasing display, even on large screen CRTs (25 to 36 inches). The difference between a 330 line and 400 line picture is not a dramatic difference, but a subtle improvement. If the 330 line picture is clearer (higher S/N) than the 400 line picture, then the choice of better picture quality will go to the 330 line version. In a broadcast environment, a properly encoded/decoded and displayed NTSC picture is truly an excellent picture.

Photograph 1 shows a multiburst video test pattern AM-VSB modulated and demodulated. Photograph 2 shows the same pattern recorded and played back on an S-VHS VCR, and Photograph 3 shows original VHS. The AM Mod/Demod pair is clearly more transparent than the VCRs. These photographs show that cable TV has been using a modulation and channel allocation format which is capable of providing superior pictures than that of new S-VHS VCRs for many years. The question then is "what quality of pictures and sound is actually being delivered"? A further question is "what can be done within the constraints of existing cable TV systems to improve the delivered picture and sound quality"?. It is beyond the scope of this paper to discuss new distribution system design approaches. Techniques which can be applied to existing systems to deliver better quality signals will be presented.







Boosting C/N

Cable system operators and equipment manufacturers have historically been conservative on signal levels for distortion parameters at the expense of noise. Signal levels at the input of trunk amplifiers and converters are often too low. A simple and effective means of improving trunk and converter noise performance is to reduce system AGC pilot signal levels by 3 dB or more. The effect on S/N can be substantial and make a dramatic picture improvement. Boosting system levels should not be done indiscriminantly. An experimental approach to finding the best system operating levels can be used to "fine tune" the system for minimum noise with acceptable distortion. Observing pictures at the end of the longest system cascades and decreasing pilots until distortion is just noticeable on live pictures, then increasing the pilots back about 3 dB for a safety margin will yield the optimum picture quality.

Low Noise Pre-Amplifiers

As system C/N is improved the converter noise performance becomes more important. In situations where the C/N is relatively high (i.e., 47 dB) and the drop level is low (i.e., 0 dBmV) a low noise pre-amplifier installed before a converter can improve the C/N presented to the TV by 3 dB. If in this example the converter noise figure were 12 dB, then the system cascade length would actually be doubled by the converter. A low noise amplifier built into the converter solves this problem. AGC is required to prevent overload of the converter mixer where input levels are normal or high. Fixed gain pre-amplifiers suffer from the problem that they shift the dynamic range lower, but do not extend it. AGC'ed pre-amplifiers built into the converter can widen the input operating range over which high C/N pictures can be presented to the TV receiver.

The Rebuilding Decision

If a cable TV system has an end of cascade C/N less than 40 dB and the C/N can not be improved by raising signal levels because of already visible distortion, pictures comparable with S-VHS and other new sources will not be delivered without more major changes. It should be kept in mind that along with improved resolution displays comes the need for higher C/N ratios. Current S-VHS machines measure a weighted luminance S/N of 50 dB. It is reasonable to assume that further improvement will be forthcoming in S-VHS performance. If a cable operator desires to deliver comparable quality and is faced with a 40 dB C/N system, there are two possible approaches which can be considered. One is to redesign and rebuild the system. In this case, 50 dB C/N should be taken as an absolute minimum C/N design target, including the converter contribution. This type of performance target will require a reconsideration of all signal processing aspects of a system. A final resulting picture is the product of all system components, not just the cascade of cable and amplifiers. The antennas, LNA/B/C, satellite receiver and modulator, transportation via cable, microwave or fiber optics, all have a cascading effect.

Non-Standard Modulation Plans

An alternative solution to rebuilding is to use non-standard modulation techniques. If premium picture quality on premium services is desired, an exchange of bandwidth for signal quality can be made. The approach would be to use either a demodulator adapter box connected to a wideband auxillary IF port on a converter, or a self-contained converter/demodulator.

Either AM or FM modulation may be useful, depending on the desired level of signal improvement and the available bandwidth.

AM-DSB

An AM approach which requires a lower adjacent channel, but offers extended definition and 6 dB of S/N improvement is as follows:

1. Synch suppress both horizontal and vertical intervals at composite video.
2. Decode NTSC to Y/C.
3. AM modulate the Y signal and filter with a special DSB filter.
4. Up-convert C and filter at 42.17 MHz.
5. Up-convert BTSC sound to 41.25 MHz.
6. Combine the signal and convert to the desired two cable channels.

Figure 4 is a block diagram of this DSB-AM modulator with a composite two channel IF output. Figure 5 shows a typical modulated spectrum. Figure 6 is a block diagram of the receiver which receives Y, C, Mono and Stereo Audio, all separately. The S/N improvement of the Y signal is as follows:

1. The IF level is boosted by 3 dB so that peak channel power matches adjacent channels (+3 dB).
2. DC to 2 MHz is received as a double sideband signal (+6 dB).
3. From 2 MHz to 6 MHz the sidebands are single, but at twice voltage (+6 dB).
4. The Y receiver bandwidth is 8 MHz (-3 dB).

   S/N (DSB) = S/N Adjacent + 3 dB (IF level) + 6 dB (sideband power) - 3 dB (BW).

   S/N (DSB) = S/N Adjacent + 6 dB.

AM-DSB Backward Compatable Extended Definition IF Modulator

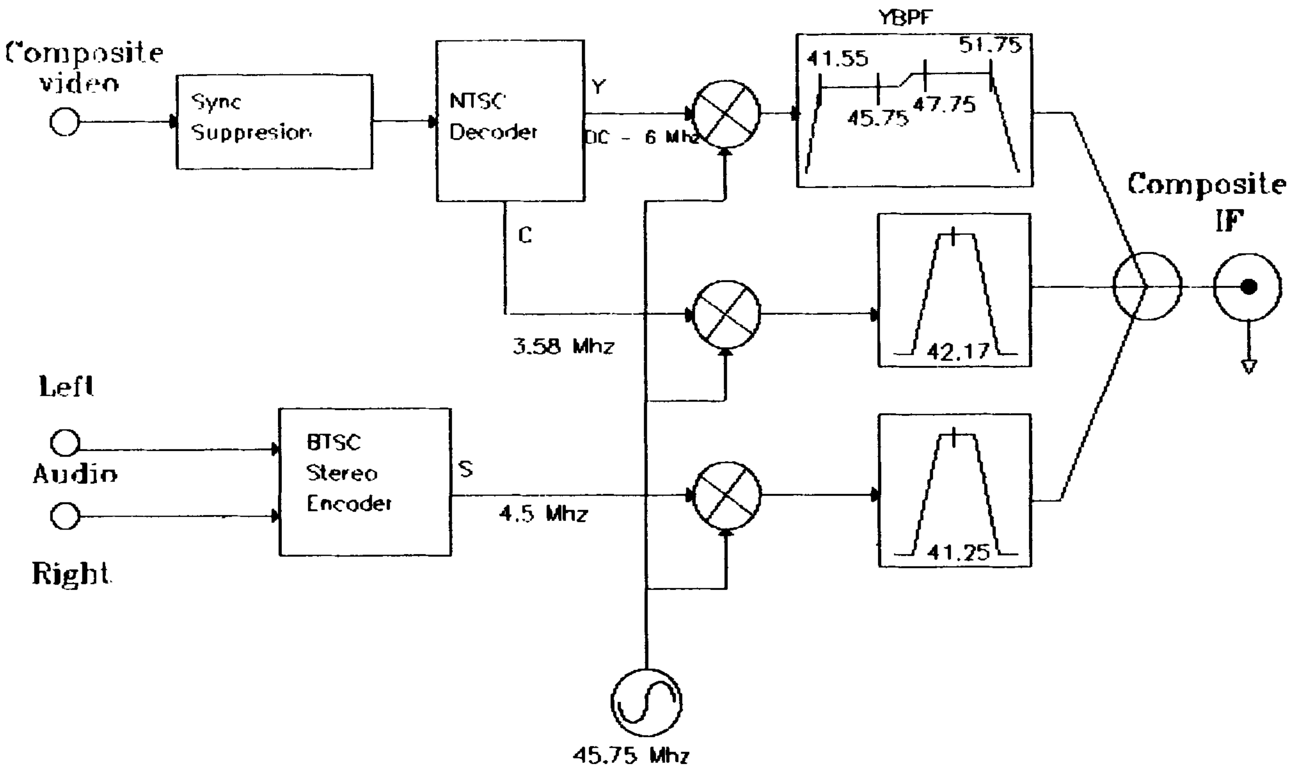


FIGURE 4

Modulated Composite IF Spectrum

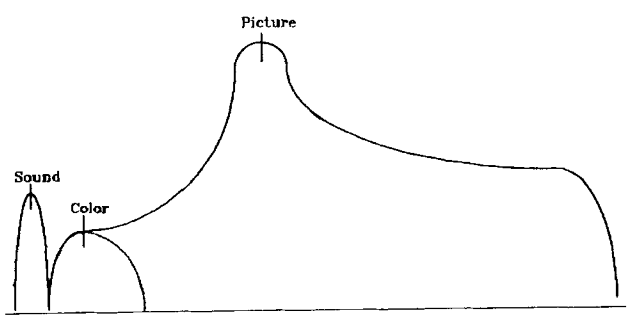


FIGURE 5

Extended Definition AM IF Demodulator With Super MTS Decoding

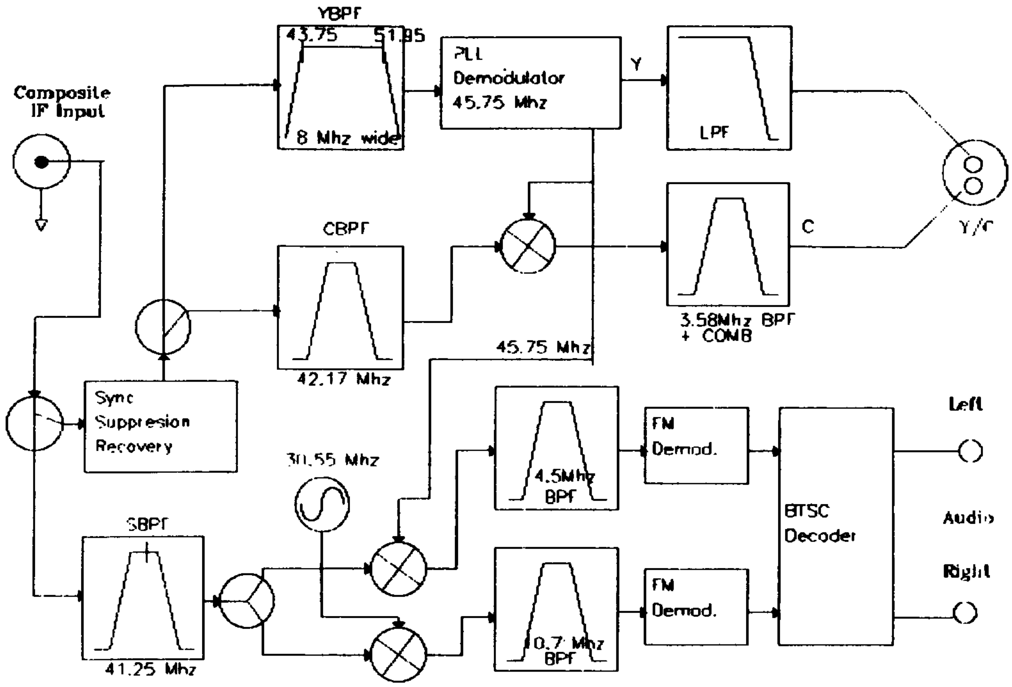


FIGURE 6

3 Channel FM Component IF Modulator

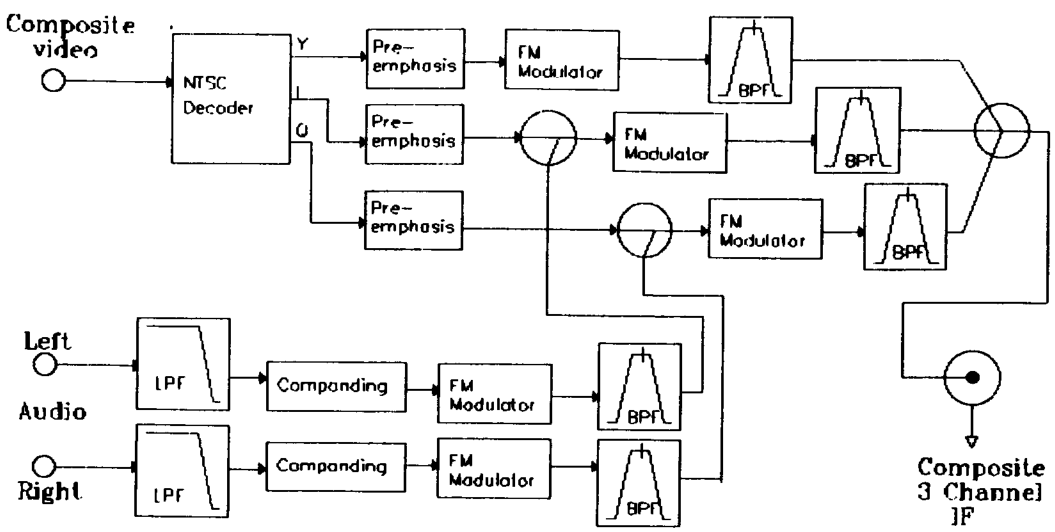


FIGURE 7

3 Channel FM Component Demodulator System

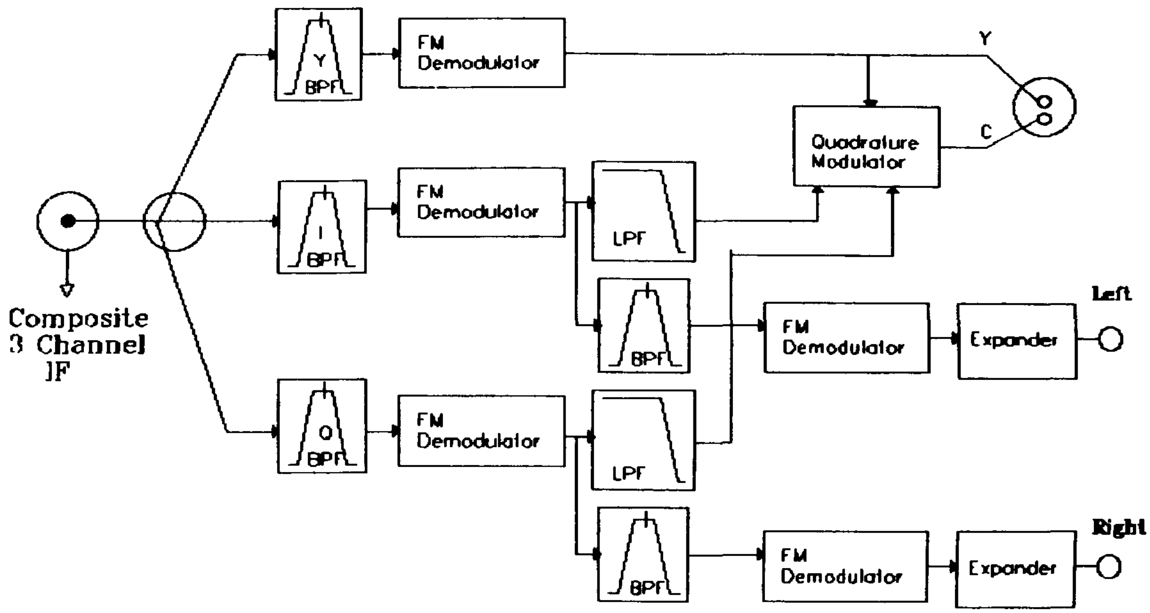


FIGURE 8

3 Channel Component FM Composite Spectrum

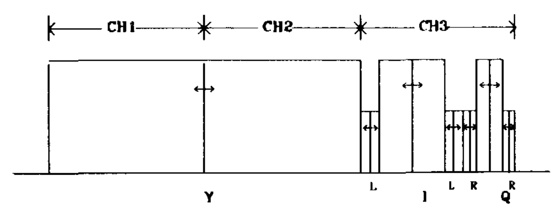


FIGURE 9

FM Component Modulation

If 6 dB S/N improvement is inadequate, FM modulation can be employed. An approach which could yield at least 15 dB S/N improvement is shown in Figure 7. The key features are the optimally matched pre-emphasis curves for each component and separate FM carriers for Y, I and Q with FM subcarriers for L and R which are companded. A further refinement would be to make the Y, I and Q pre-emphasis adaptive. Figure 8 shows the receiver for this FM scheme which must include a chroma encoder to generate the desired Y/C output. Figure 9 shows the 3 channel allocation. Although this FM component modulation concept is bandwidth intensive, it is a feasible means for providing excellent picture quality over systems which provide poor pictures in the normal format. Looking at this FM format from a different perspective, extremely long cascades could be built with this very robust modulation in mind. Note that this method could have optical fiber applications, such as fiber trunking with short multi-cable runs, without a format conversion. Signal security could be provided by line rotation or other baseband means.

CONCLUSION

Picture and sound quality of competing video mediums are rapidly improving. Depending on the design and condition of individual cable systems, operators may choose to "fine tune" for best picture performance or rebuild in order to provide comparable quality pictures. If spectrum space is available, non-standard modulation formats could provide both extended definition and improved S/N. A DSB AM approach with moderate S/N improvement is backward compatible and requires the lower adjacent channel. For more severe cases, an FM approach is proposed which requires 3 channels and which is compatible with fiber transmission.

(1) "Improving NTSC in a Cable Television Facility", Yves Faroudja and Joseph Roizen, NCTA Technical Papers, 1987.