BTSC: THE STEREO FOR CABLE

by

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ABSTRACT

Stereo programming is presently available to the cable operator. The enhanced entertainment value of stereo video programs should be provided to the cable subscriber as soon as possible in order to stay competitive. BTSC is the best choice of stereo formats for video program audio because of the ease of interface and compatibility, both in the headend and the home. Video buzz interference has been the major drawback to BTSC stereo, but it has been eliminated with the dual detector system. Other limitations such as bandwidth and separation are minimal and turn out to be audibly insignficant. BTSC stereo has a better dynamic range than the typical FM stereo receiver. BTSC requires no separate tuning system as out of band FM systems do, which makes BTSC the easiest to operate and the least expensive alternative.

INTRODUCTION

Quality stereo audio is a significant enhancement to the entertainment value of any video source. Cable television should be no exception. In a time when competition from video tape rentals is strong (many of which are in a hi-fi stereo format) cable must move quickly to provide stereo. The BTSC format is compatible with broadcast, cable, and home equipment. Broadcasters in many areas are presently transmitting in BTSC stereo, but their source of stereo programming is still limited. Cable operators have an advantage over broadcasters, in that many pay services are already available in stereo.

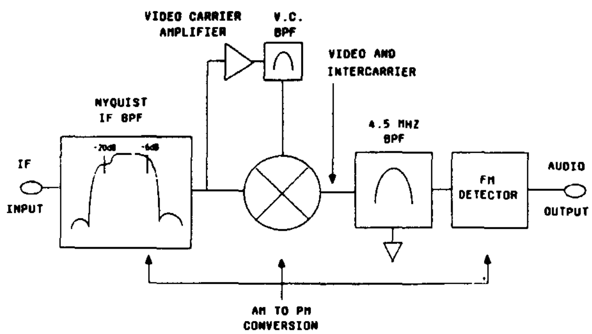
BTSC is the most convenient means available to the cable system operator for providing multi-channel television sound. Passing the BTSC signal through to the subscriber on broadcast channels usually requires no changes. To put a satellite channel in BTSC stereo requires a subcarrier receiver and a BTSC encoder/modulator. The result of this small addition to the headend is an enhanced service which requires no truck rolls and no additional subscriber equipment provided by the cable operator. The subscriber interested in stereo may purchase a stereo TV or stereo adapter. The cable operator may choose to sell or lease stereo adapters. BTSC adapters do not require tracking tuning or separate tuning by the subscriber as out of band stereo systems do. BTSC provides increased customer satisfaction and an opportunity for increased revenue and pay service retention.

BTSC SYSTEM PERFORMANCE

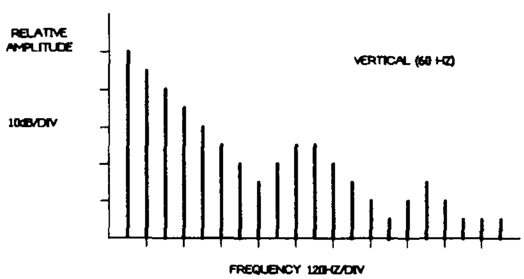
BTSC has been criticized by some in the industry for being a system with inferior audio quality. I contend that the BTSC system is the best choice in a backward compatible environment. The poor quality claimed is a result of early non-optimum encoders, modulators and inferior receiver designs, as well as improper equipment alignment and operation.

Video Interference

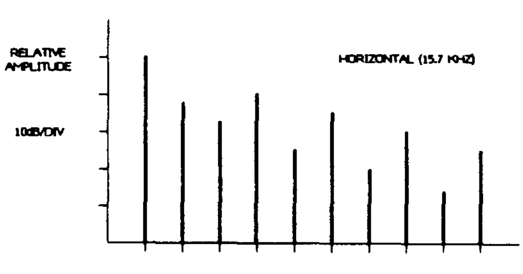
Video Interference has been the major limiting factor in most BTSC measurements and listening tests. The primary problem area is in the BTSC receiver, which exhibits high buzz interference levels. The buzz is a result of AM to PM conversion in the Nyquist intercarrier detection system commonly used (see Figure 1). Some of the AM video modulation present on the video carrier is converted to phase modulation of the sound carrier in the detection process which results in video spectra overlapping the audio information. This overlap occurs at video vertical rate (see Figure 2) and harmonics, as well as horizontal rate (see Figure 3) and harmonics. The horizontal interference also has vertical rate sidebands (see Figure 4). Monaural TV receivers with small speakers were usually not bothered greatly by intercarrier buzz, having most of its energy outside the TV sound systems' bandwidth on both ends.



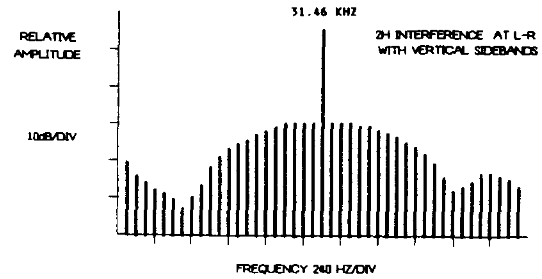
INTERCARRIER DETECTOR FIG. 1



VIDEO INTERFERENCE FIG. 2

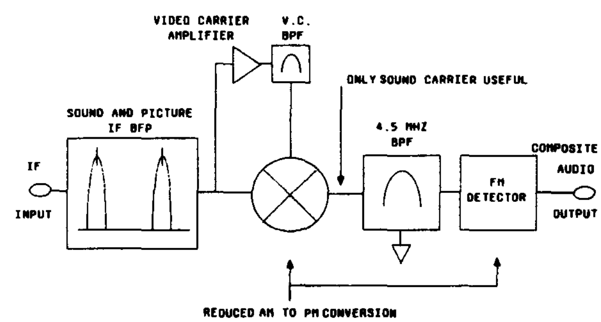


VIDEO INTERFERENCE FIG. 3



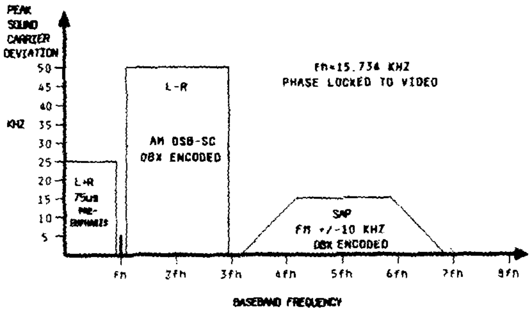
VIDEO INTERFERENCE FIG. 4

There are techniques which reduce the level of the intercarrier buzz components. The Quasi-Parallel (Q-P) sound system (see Figure 5) is significantly better than the Nyquist system because of the reduced AM to PM conversion of the video carrier due to the symmetrical filtering. The choice of FM detectors can also have a significant impact on buzz level. AM rejection is very important.

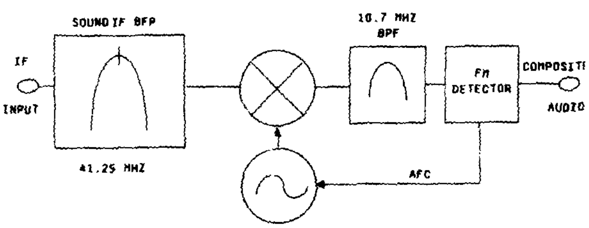


QUASI PARALLEL DETECTOR FIG. 5

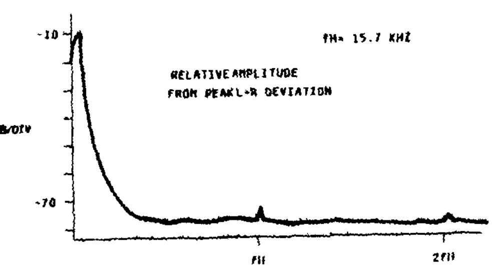
Although the Quasi-Parallel technique is an improvement, it does not eliminate the video interference at horizontal frequency and its harmonics. Both the TV transmitter or modulator and the Q-P intercarrier receiver have residual levels of AM to PM conversion. The BTSC spectrum (Figure 6) Pilot, L-R, and SAP carriers are centered exactly where the highest level of video interference falls. In order to achieve buzz free stereo sound, another detection scheme is required. The obvious way to eliminate video interference is to detect the sound carrier independent of the video carrier. This approach is known as separate sound detection (see Figure 7). This system works extremely well for high frequencies (i.e., Pilot, L-R, SAP - see Figure 8), but exhibits a severe problem at low frequencies, i.e, L+R (see Figure 9). The low frequency noise is a result of the oscillators used in the converter's tuning process. The separate sound detection system is unacceptable except where oscillators of instrument grade phase cleanliness are used. This is not the case in CATV converters, TV receivers, and sometimes TV modulators.



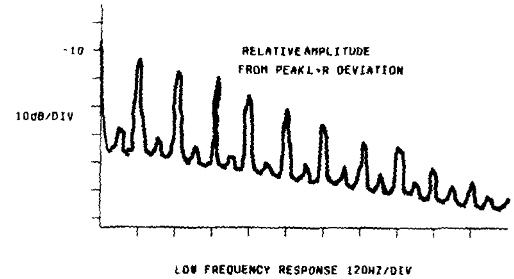
BTSC SPECTRUM FIG.6



SEPERATE SOUND DETECTOR FIG.7



SEPERATE SOUND DETECTOR OUTPUT FIG. 8



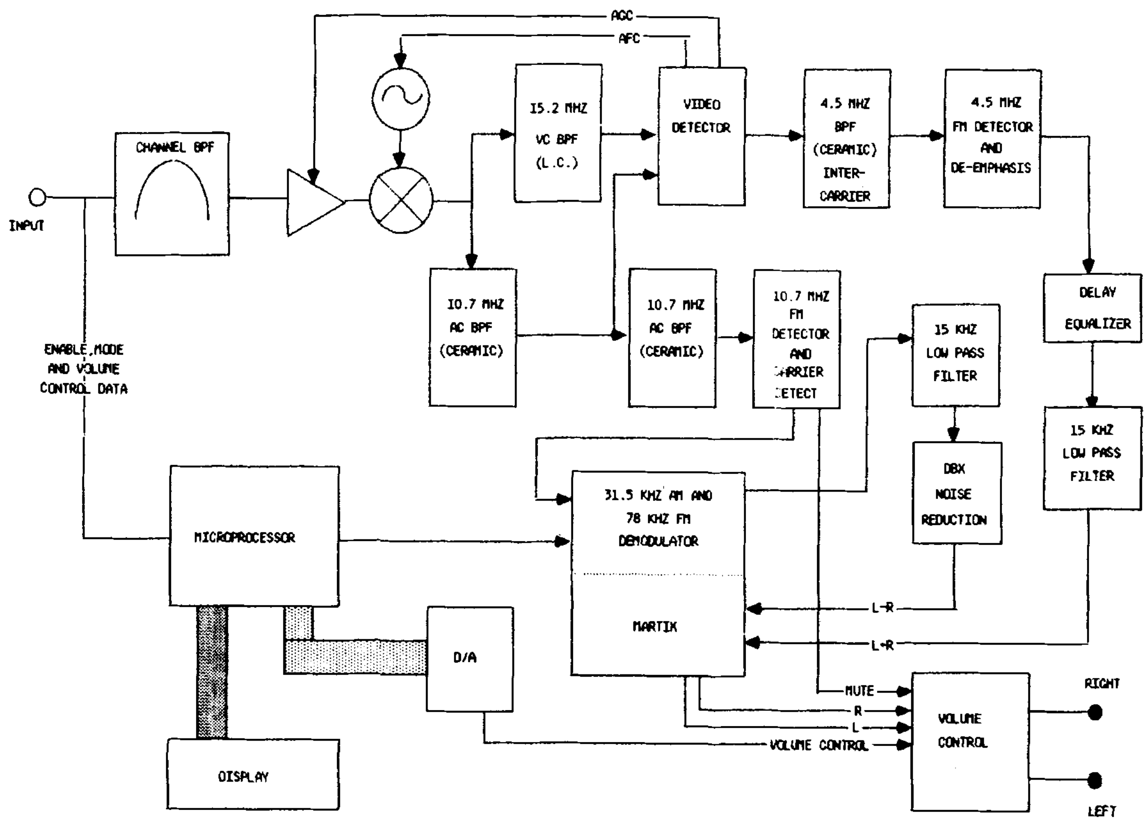
SEPERATE SOUND DETECTOR OUTPUT FIG. 9

Dual Detector System

A Dual Detector System is the solution to the conflicting problem of either high or low frequency noise by using both types of detectors simultaneously. A dual detector system consisting of a Quasi-Parallel detector for the L+R component and a separate sound detector for the Pilot, L-R and SAP components gives superior performance. Not only is the buzz problem eliminated, but channel separation is also improved. Because there is no interference component falling on the pilot, its phase relationship to the L-R subcarrier remains unaltered. In addition, the bandwidths of the two receivers can be independently tailored for matched L+R and L-R delays. Figure 10 is a block diagram of one implementation of a dual detector BTSC stereo receiver.

BTSC receivers which do not use dual detectors still offer a substantial improvement in sound impression over the typical monoral TV receiver. The L-R buzz is usually well masked by the dBX [TM] noise reduction. The buzz is, however, audible, especially in intermittent quiet situations such as drama, sports dialog, or orchestra concerts. For BTSC to reach high fidelity standards, a dual detector system is required.

The BTSC system has been compared with high fidelity systems in the cable press, but the BTSC receivers used were not high fidelity types. A high fidelity BTSC receiver requires the same care as a high fidelity broadcast FM receiver. Multiple ceramic filters for high frequency video rejection, advanced quadrature or pulse count FM detectors for high linearity and a linear multiplier for clean L-R detection would be required in order to compare apples to apples. However, BTSC, even in its inexpensive implementations, does exhibit one advantage over the majority of FM stereo



DUAL DETECTOR BTSC RECIEVER

FIG. 10

receivers. The hiss level is much lower due to the dBX noise reduction. This reduced hiss is usually apparent even to the casual listener.

BTSC Measurement

BTSC Measurements are greatly enhanced by the use of a Fast Fourier Transform (FFT) spectrum analyzer. An FFT is superior to analog audio spectrum analyzers because of the very narrow resolution bandwidth achievable while maintaining rapid display updates. An FFT spectrum analyzer is much more useful than a distortion analyzer because individual signal components are immediately distinguishable rather than receiving one summation number. Hum, buzz, harmonic distortion, spurious signals, and random noise are immediately obvious on the FFT analyzer, but often are disguised by a Total Harmonic Distortion Plus Noise (THD+N) reading. A THD+N of 0.5% may have pleasing sound quality or be annoying depending on the source of the 0.5%. Spurious signals 46 dB down are quite obvious against rather pure tones such as piano notes, but second harmonic distortion at the same level is not. For BTSC receivers THD+N numbers don't tell the story. FFT spectrum analyzer photos say a lot.

Channel Separation

Channel Separation capabilities are limited in the BTSC system because only the L-R component is dBX processed. Any tracking errors in the noise reduction processing reduces channel separation when the components are recombined to recover the L and R channels. Separation in practice will generally be greater than 20 dB over the frequency range where separation has significance, roughly 100 Hz to 8 KHz. This does not seem to be a very impressive number by comparison with other systems, but fortunately the audible difference between 40 dB and 20 dB separation is rather insignificant.

Dynamic Range

The Dynamic Range of a currently available dual detector BTSC receiver is 65 dB at 1 KHz. This is by no means a theoretical system limitation. A higher cost implementation could certainly achieve further improvement. For cable applications with limited carrier to noise ratios (C/N), further improvement may be a bit academic. The signal to noise ratio (S/N) of the L+R component at 1 KHz with a video C/N of 40 dB and sound carrier 15 dB down should theoretically be 70 dB. The L-R component, however, would have only 43 dB S/N for the same conditions. The dBX noise reduction system has a masking effect which generally provides about a 20 dB apparent improvement, giving the sound quality of 63 dB S/N.

Bandwidth

The Bandwidth of BTSC audio must be hard limited to 15 KHz to prevent interaction of audio with the fH pilot. The net system -3 dB bandwidth, including the decoder, can easily achieve 13 KHz. Again, there is very little difference between the sound quality of the BTSC 13 KHz and the 15 KHz available in other systems. On the low frequency end BTSC audio is not limited in comparison with other systems.

SUMMARY

It is very important to realize that although BTSC does not challenge the specifications of compact disc players, it can provide good stereo sound for a theater style effect. BTSC sound, in fact, is better than the audio reproduction capabilities in the vast majority of subscriber homes. BTSC stereo is intended for video program related audio rather than separate premium audio services. The ease of interface and low cost cannot be beat. If you are still not convinced that BTSC stereo is a major improvement to the entertainment value that can be delivered by cable, may I suggest that you perform the following experiment. Connect a BTSC stereo receiver to a quality stereo system. Watch and listen to Miami Vice broadcast from a stereo transmitter. You will most likely come away from the test wishing your TV screen was larger to match the depth and impression of your sound.

Acknowledgements

Thanks to General Instrument for supporting an extended investigation of BTSC receivers.

Thanks to Alps Electric Company, Ltd. for an economical implementation with superior performance.

References

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2) Multichannel Television Sound Transmission and Audio Processing Requirements for the BTSC System, OST Bulletin No. 60, April 1984, FCC, Office of Science & Technology, Authorization and Standards Div.