B T S C S T E R E O

Implementation on Normal and Scrambled Channels

William F. Arnold

WARNER CABLE COMMUNICATIONS, INC.
Houston, Texas

ABSTRACT

The decision to begin transmission of stereo programming to subscribers involved a process that required several years. Construction of the Houston system began in 1980. In 1982 we began to review the options available for carriage of stereo programming, including the choice of not transmitting stereo in any form. One important factor was the impact that stereo would have in the areas of increased subscriber satisfaction and retention.

BTSC, introduced in 1984, was determined to be the most practical choice due to:

1. the capability to deliver an acceptable stereo product, and
2. maximum convenience for the subscriber.

Remaining to be answered was whether BTSC was viable in an environment that includes scrambled channels. If we were to begin transmitting stereo, we wanted to go beyond the usual practice of limiting stereo to music services, and include all premium channels; the premiums being scrambled using a gated sync suppression system. Evaluation began at the Houston system in April, 1986.

Our efforts culminated on December 10, 1986 with the commencement of BTSC transmissions on nine (9) satellite services, and retransmission of BTSC from the three (3) local TV stations carrying part-time stereo. Marketing surveys have since indicated that not only are present subscribers more satisfied with our service, but many people have become subscribers because of the availablility of stereo.

BACKGROUND

There are presently more than 400 television stations utilizing BTSC stereo, and an increasing number of cable systems are distributing stereo in this format. Add to this the emphasis of the consumer electronics market on stereo television sets, stereo VCR's, and separate TV stereo decoders and it is easy to see the direction cable system operators will be forced at least to consider if not fully implement.

Our desire is to qualify the use of BTSC in an environment that includes a majority of scrambled channels on which stereo service must be provided. At the time our research began, no definitive information as to the advisability of utilizing BTSC on scrambled channels was available. As is usually the case, there were many 'theories' about this application, but few 'realities' seemed to exist in this area.

METHODS OF DELIVERING STEREO

Before deciding to use the BTSC system, the alternatives were considered. Those determined to be viable were:

1) FM broadcast band

Using the 88-108Mhz standard FM band, stereo signals are generated at the head-end and transmitted through the cable system to a subscriber's FM tuner. At that point, the subscriber tunes to a frequency carrying the stereo audio which corresponds to a channel that has been tuned on the television set. This is one of the simplest ways to transmit stereo to subscribers since most cable systems do not use the FM band for anything but delivery of FM radio signals; however, in Houston these frequencies are utilized for distribution of video channels. While this method will deliver very good stereo, it is inconvenient for the subscriber and virtually impossible to secure.

2) Out-of-band FM

The stereo signal is transmitted on frequencies that cannot be tuned by an FM tuner; i.e., a channel that is otherwise restricted for the area, or a channel assignment for which there are no other plans. A converter is installed at the subscriber's home to change the frequency back to the 88-108Mhz FM band to

enable tuning the stereo as described above. This provides some additional security, but the converter is easy to build or purchase as a black market item.

3) Out-of-band FM with 'MTS' adaptor

Similar to (2), but additional head-end equipment is required to encode the normal TV channel with an identifier which will cause the MTS adaptor to tune automatically to the out-of-band signal and provide the subscriber the left and right audio signals to be fed to a stereo system. The adaptor also has volume control. Black market converters as described in (2) will also work with this system.

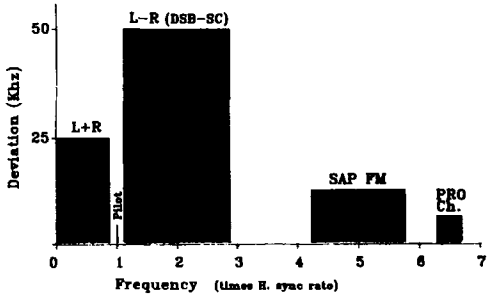
4) BTSC Stereo

This most recent development transmits the stereo information as subcarriers on the normal TV sound carrier, and has been implemented by many broadcast television stations throughout the nation. In addition, it is being utilized by a number of cable television systems on basic services such as MTV. The convenience of transmitting stereo information on the associated channel, rather than occupying additional bandwidth, along with the increasing number of stereo-capable television sets makes BTSC an attractive method for use in cable TV. The system requires a BTSC generator at the head-end location and a stereo TV or adaptor at the subscriber terminal.

BTSC TESTING

Before implementation, a variety of tests were performed to insure compatability with our addressable converter system (Pioneer BA5000). At the time we began our evaluation, research into the effects of utilizing BTSC in an encoded-channel environment was not available.

Below is a chart depicting the spectral components of the BTSC system. Let's assume we are familiar with how the system operates and continue into the actual test results.



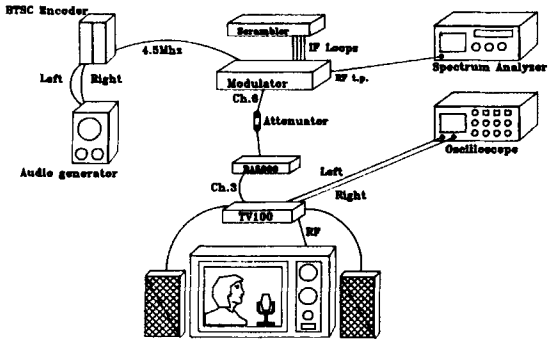
The BTSC system utilizes a pilot signal at a frequency equal to the horizontal sync rate (15,734Hz) as does the Pioneer scrambling system. Theoretically, there should be no interaction between the BTSC pilot signal which is frequency-modulated onto the main audio carrier of the television signal, and the scrambling system 'key' signal which is amplitude-modulated onto the same carrier. Imperfections in the FM detector (TV) and the AM detector (descrambler), however, can create an AM component in the FM detector and an FM component in the AM detector, thus creating concern that interaction between the two could interfere with proper recovery of the scrambled video and with separation of the left and right component of the stereo signal.

Other areas of concern are that the FM component produced in the descrambler could be of sufficient amplitude to activate the stereo circuitry of a BTSC adaptor or television set and open the sound system to noise rather than the expected stereo subcarrier, and that the AM component of the stereo detection process could create a problem with sync buzz in the stereo signal.

Evaluation and measurement of the afore-mentioned effects of BTSC vs encoded (scrambled) channels was vital to the process of determining whether or not to recommend its use. The Pioneer BA5000 home terminal is being used in the Houston system to replace basic converters in order to gain efficiencies in the areas of upgrades, downgrades, non-pays, etc. Scrambling of premium and certain other services is utilized to reduce the problem with illegal connections. Coupled with the operational factors of using the BA5000 system is the increasing desire of subscribers for more programming in stereo.

For testing, following equipment was utilized:
Wegener 1791 BTSC Generator
Scientific/Atlanta 6350 Modulator
Hewlett-Packard Tone Generator
Hewlett-Packard 8569B Spectrum Analyzer
Tektronix 465 Oscilloscope
Radio Shack TV-100 Stereo Adaptor

INTERCONNECTION DIAGRAM
(Evaluation)



Equipment set-up and calibration was performed with a 1 Khz tone feeding the left and right channels of the BTSC generator. This enabled us to make an accurate determination of the input and output levels at each point in the system without regard for variations in program content. All equipment was calibrated to assure proper operation at all points.

Initial measurements indicated separation between left and right channels was in the 10 to 12 db range. Previous subscriber evaluation by other system operators demonstrated that individuals would consider the stereo to be good with as little as 8db separation. We felt the 2-4 db differential to be too small a margin for error, so further investigation was made. Conversations with others who had researched the carriage of BTSC on clear channels revealed that a modification to the audio module of the S/A 6350 modulator might yield an increase in the left-right separation. When this modification was made to our test module, a repeat of our measurements indicated a 50% increase in separation to an average of 18 db.

Test #1 was made with the Pioneer encoder in the standby (unscrambled) mode. For tests #2 through #5 the encoding was activated in various combinations of operating modes; i.e., zero, six, and ten db suppression of sync, in combination with modes 1-4 of the Pioneer dynamic phase shifting.

The results were as follows:

Test	Mode	Separation
1	Standby	20 db
2	Pioneer 1	
	Clear	17.8 db
	6 db	17.8 db
	10 db	17.8 db
3	Pioneer 2	
	Clear	18.3 db
	6 db	17.6 db
	10 db	17.3 db
4	Pioneer 3	
	Clear	18.3 db
	6 db	17.6 db
	10 db	18.9 db
5	Pioneer 4	
	Clear	18.3 db
	6 db	18.1 db
	10 db	18.9 db

Termination of both inputs to the BTSC generator allowed observation of the residual components of the scrambling signal. Total distortion from these components ranged from 0.8% to 1% depending on the mode of operation.

Also of concern was the possibility of activation of the BTSC stereo detector by the key signal component on the audio carrier of scrambled channels. The key signal being a horizontal rate pulse might be interpreted as the BTSC pilot signal. This was not a problem on the receivers used in our evaluation. Since introducing stereo to subscribers, we have encountered a very small quantity of devices exhibiting this characteristic, and these also appear to trigger their stereo circuitry on clear, non-stereo channels.

LISTENING TESTS

In order to determine the end result of the entire process in a typical subscriber setting, listening tests were made in the homes of several employees and at a TV/Video equipment retail outlet. For evaluation in employee homes, the Radio Shack BTSC adaptor was used as both a stand-alone item and a supplier of left and right audio signals to larger stereo systems; different addressable converter/descramblers were used in each home to add to the variety of conditions for evaluation.

Perfection was not expected in the final product delivered to the subscriber considering the various forms of degradation of the original signal that can occur. But in all of the situations utilized for listening tests, the end product was determined to be acceptable.

LONG-TERM TESTING

Both laboratory and cable system environments were utilized during the evaluation process. The final test of the BTSC system began June 1, 1986 with the full-time transmission of stereo on The Movie Channel. We felt it was important to have an opportunity for feedback from a larger audience before the decision to proceed could be made.

Contacts were made with operators of stereo retail outlets to encourage them to evaluate our product and provide their comments. Cable company employees also began to provide information from their experience as well as from other contacts. Most of the information received was of a very positive nature. Only rarely did we hear any negative comment about stereo.

DECISION TIME

In October, a final decision was made to proceed with implementation of BTSC on the seven premium channels, two music channels, and the local off-air channels offering a stereo product. Stereo is now available on the following services on Warner-Houston:

Off-air:

KPRC-TV	NBC
KUHT-TV	PBS
KHOU-TV	CBS

(the ABC affiliate does not offer stereo)

Satellite-delivered Services:

MTV	VH1
HBO	TMC
Showtime	
Cinemax	
Disney	
Viewer's Choice 1	
Viewer's Choice 2	

The locals, MTV, and VH1 are transmitted in the clear. All seven of the premium services are scrambled.

CONNECTING TO THE SYSTEM

Interfacing the BTSC generation equipment to the cable system can be fairly simple in the basic configuration. In our case, we had to modify Scientific/Atlanta 6350 modulators to accept the external 4.5Mhz subcarrier from the BTSC generator. This process required approximately 20 minutes per unit with about $2 in materials.

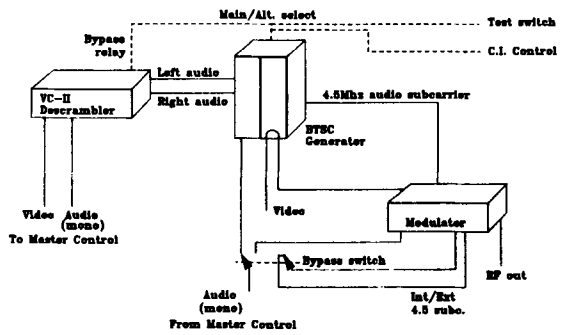
Stereo is available directly from the VideoCipher II descrambler on the services whose satellite feeds are scrambled. Subcarrier demodulators are used to recover the stereo signals on services that are not scrambled.

Another factor in Houston was the requirement for support of commercial insertion on MTV and VH1. We also wanted the capability to switch away from the stereo source to an alternate audio source (such as a tone) for testing.

Diagrammed are the two arrangements we utilize for stereo in Houston. The first shows the connections for operation with the VideoCipher II; the next shows connections for operation with subcarrier demodulators.

INTERCONNECTION DIAGRAM

(Operation with VC-II Descrambler)



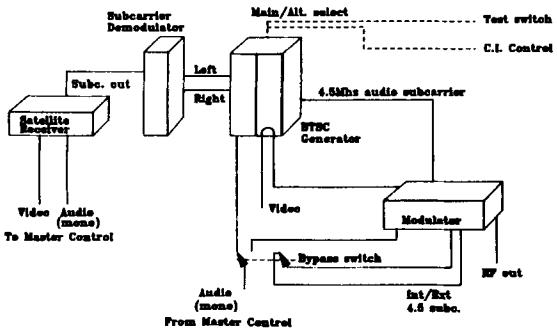
Stereo left and right audio is fed from the VideoCipher II directly to the BTSC generator. Program video and mono audio are routed through Master Control. Video is looped through the BTSC generator and terminated at the modulator.

A manual bypass switch normally supplies the mono audio (program or commercial) to the alternate audio input of the BTSC generator. It also supplies the closure to the 6350 modulator to cause it to choose the external 4.5 Mhz stereo subcarrier. For testing, or in the event of failure of the BTSC generator, the bypass switch can be toggled to the bypass position which places mono audio on the modulator and selects the internal 4.5 subcarrier.

Control lines are run from the main/alternate select connection on the BTSC generator to the VideoCipher II bypass relay, the commercial insertion controller, and a test switch. A closure from any of these sources causes the BTSC generator to change from the stereo inputs to the mono audio input.

INTERCONNECTION DIAGRAM

(Operation with subcarrier demod.)



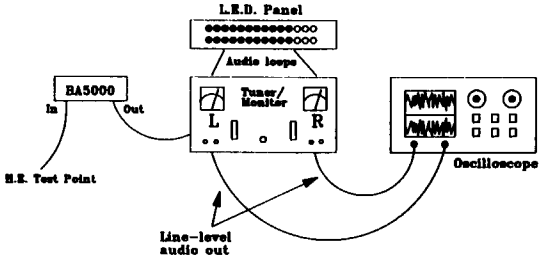
Connections when using a subcarrier demodulator are similar to the VideoCipher II connections except for the source of the left and right audio signals.

MONITORING

Maintenance of proper operation of each of the components of the stereo system is aided by the following equipment:

Marcom 730 Metered Stereo Receiver
Audio Technology 510 LED Display
Hewlett-Packard 1222A Oscilloscope

Head-end Monitoring



Output signal from a test converter is fed to the stereo receiver. High-impedance line-level audio output is routed to the LED display and to the oscilloscope. Modulation levels of both the left and right channels can be adjusted very accurately by observing the LED display. The oscilloscope is used for checks of separation and any scrambling components that may be present.

Adequate monitoring must be available. However, the stability of each component in the chain has, thus far, required little time to be spent making adjustments.

SUMMARY

Delivery of stereo sound to subscribers via the BTSC system will not be void of problems. However, with proper monitoring and reasonable maintenance, it is capable of providing an acceptable final product. When compared to the various other methods, it is certainly the most convenient for the subscriber. Initial investment in head-end equipment ($2,500 per channel) is higher than other systems, but no company-owned equipment is required at the subscriber terminal. The subscriber is required to provide his own means of recovering the stereo signal, whether it be a stereo television set or a BTSC adaptor. Long term, because of the influence of consumer electronics retailers, we believe this method of stereo delivery to be the most viable to our subscribers.

RESULTS

We must do all we can to maximize the perceived value of our product since we are in a market with competition from four VHF and four UHF television stations, along with MDS operations and videotape outlets. Entry into stereo was viewed as a step in that direction. Retention of existing subscribers was a primary goal.

Marketing surveys indicate a greater impact than we expected. Not only are present subscribers more satisfied with our product, the availability of stereo has had a positive effect on sales to new subscribers. In the sampling of subscribers interviewed, 28% are TV stereo capable. Of those equipped for TV stereo, 23% said stereo availability was a major factor in their decision to become cable television subscribers.