ADVANCED AUDIO FOR HDTV

Systems including Data Requirements

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ABSTRACT

The FCC Advisory Committee's Planning Subcommittee Working Party 1 defined the attributes of high definition video. The Commission has placed a channel bandwidth limitation of 6 mHz for the terrestrial broadcasting system. Working Party 1 has described HDTV audio quality requirements as being CD like. The HDTV testing laboratory in Alexandria, Virginia is measuring only two-channel stereo systems. Many papers describing studies that compare two-channel and multi-channel stereophony have been written by CBS in the U.S. [1], NHK in Japan [3], BBC in the United Kingdom [8], and IRT in Germany [7]. The studies agree that with two-channel stereophony the center signal (phantom or virtual) image is distorted by listening position. As screen size increases, the problem is exaggerated.

All four organizations recommend that additional channels (speakers) are necessary to produce a stereophony image that can be viewed from a wide angle without distortion. This paper proposes that HDTV audio use a center channel to stabilize the audio image.

Introduction

The purpose of this proposal is to provide a starting point for the ATSC T3/S3 Specialist Group on Digital Services to define the non-video related objectives for HDTV systems. After committee review the document may be sent to proponents, existing video users and providers of ancillary services, and others for comment. This draft defines the program audio, other program-related audio services, audio program control, and ancillary services. The document does not address the ghost canceling training signal. This signal is part of the HDTV video system.

With the imminent introduction of simulcast high definition television, the North American television industries have the opportunity to introduce an advanced digital audio system that will match the viewing experience of the new video service. Recent advances in low bit rate coding techniques make it possible to achieve state of the art quality audio with bit rates as low as 128 kbit/s for each program audio channel. The low bit rate digital audio systems make it possible to transmit the number of discrete audio channels necessary to complement the high definition video.

Proposed Program Audio Attributes

1. The quality of the HDTV program audio will complement the full potential of the new video service.

2. The system will be designed to produce a stable audio image and enhance the ATV visual image.

3. Discrete audio channels should be used. The matrix process is not used in the four channel system. Linear transmission systems will be incorporated, preventing the distortion of the audio image.

4. Viewers will have the option of controlling the dynamic range of the reproduced audio.

5. The four channel simulcast audio system will also accept for transmission: three channel stereophony, two channel stereo, and monophonic programs.

6. The four channel program audio will be convertible to

BTSC stereo for NTSC simulcast.

7. A stereo second language audio program is provided (two channel). Alternately, these channels can be programmed as two separate monophonic channels.

8. A dedicated DVS channel for the visually impaired is provided.

9. The audio system should be more robust than the video to bit errors. Audio should not fail prior to video.

Ancillary Service

1. Teletext service is provided.

2. Conditional access channel is provided.

3. Expandable digital services is provided.

4. Closed Captioning is provided.

5. Program Guide channel is provided.

DESCRIPTION OF SERVICE

Main Program Audio

The main program audio consists of four discrete state of the art digital audio channels. The channels are center, left, right, and rear (surround). The center channel is a discrete channel similar to the center channel used by the film industry. The rear channel, a surround sound channel, is viewer optional. Audio production techniques are the same or similar to those used in the film industry. A programmer-originated control signal will allow the receiver to be switched to a viewer preselected mode of operation. Industry operating standards and recommended operating practices should be developed for the SAP switching nomenclature and logic to prevent the confusion that exists today with BTSC receivers.

Program Audio Expander (Viewer Optional)

To avoid viewer complaints of loudness, program providers have had to limit the dynamic range of the audio signal. A digital expansion channel is provided to allow viewers the ability to expand the audio to its original dynamic range. This channel will control a digital audio expander in the receiver that will restore the original dynamic range to the program channels. Care in implementing this service must be exercised to maintain integrity of the audio image. Twenty kbit/s of data is available per audio channel for the expander control.

Separate Audio Program (SAP)

A two channel full quality stereo service primarily for second language programming is provided. Alternately, the stereo service can be used for two separate monophonic program channels. With user preselection and a programmer-originated control signal, the receiver will switch on command from stereo SAP to one of the preselected monophonic SAP channels.

Descriptive Video Service (DVS)

DVS is a monophonic audio channel that provides program descriptive information to the visually impaired. Because of the growing interest in this service and of possible scheduling conflict with other SAP services, a channel dedicated to DVS is provided.

Teletext

Teletext service of 100 page cycle and 1000 characters per page (8 bits/character) transmitted in 20 seconds requires a bit rate of 40 kbit/s. It should be noted that in some situations teletext may be a program related service.

Other Digital Services

This channel is reserved for the possible interconnection with home digital devices, like computers. The channel could be used for educational or interactive services.

Program Guide

The proposed program guide should be capable of transmitting text accompanied by graphics. For viewer channel scanning, six lines of text identifying the on air show and the next up-coming program are provided. This receiver scanning menu will be refreshed at a one second rate. The data for a complete multi-page program guide is interleaved

with the receiver scanning data.

Closed Captioning

Closed captioning is transmitted at a rate of 500 bit/s. To allow for the expansion of this system, a 2 kbit/s channel is provided.

Conditional Access

Because conditional access systems' specifications are usually proprietary for security reasons, detailed specifications on the signal may not be available. The ATSC Specialist Group on Interoperability and Consumer Product Interface T3/S2 is discussing standardization issues relating to scrambling and conditional access.

Capacity Objectives

It is clear that sufficient capacity needs to be allowed in Simulcast ATV systems for advanced audio and data services. When allocating the bit rates for the video, audio and data channels it may be necessary to make tradeoff in channel performance in order to stay within the 6 mHz. Based on information supplied by the ATV proponents, it appears that the 6 Mhz channel has the capacity for transmitting just under 20 Mbit/s of digital data. With overhead, the non-video service should represent less than 9% of the 6 Mhz digital channel's capacity.

The services can be broken down into two categories; program related and program unrelated.

Table 1. Advanced Audio Simulcast HDTV		
	Service	DATA RATE kbit/s
PROGRAM RELATED SERVICE	Main Program, Four Channels	512
	SAP Stereo, Two Channels	256
	DVS, One Channel	128
	Expander Control Data	140
	Program Guide	10
	Closed Captioning	2
	Program Mode Control	2
	Conditional Access	400
PROGRAM UNRELATED SERVICES	Teletext Services	
	Other Digital Services	
	Overhead	To be determined by System Proponent
Total Bits		1450

BACKGROUND ON FOUR CHANNEL SYSTEM SELECTION

Many papers have been written about the problems with two channel stereo television audio [1,2,3,4,5,6]. Papers from the BBC and IRT (FDR) [7&8] all characterize the image distortion experienced with two channel stereo, including recommendations they have submitted to the CCIR. From the data in the IRT paper [4], Figure 1 was drawn illustrating the image distortion that will be experienced when listening to stereo audio with two speakers spaced by 6 1/2' and listening at distances of 2' to 8'. This illustration shows that when listening to the stereo at a distance of 8', while 20" off the center line, the audio image will be shifted by 40%. At the price of separation most BTS receivers have the speakers installed adjacent to the screen to minimize image distortion as illustrated in Figure 2.
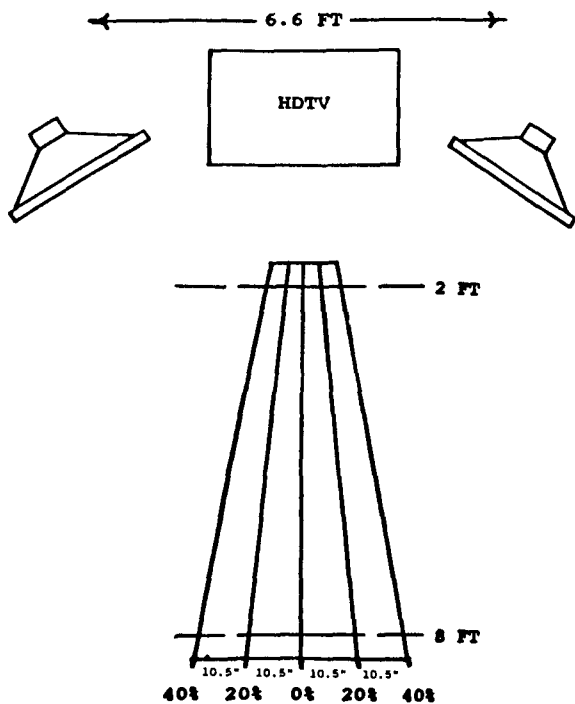

Figure 1. Stereo Image Distortion

The BBC in its recommendation to the CCIR suggested that a three channel system be used as the most practical approach to reduce the image distortion problem [6]. NHK in a study of eight different speaker combinations settled on a four speaker system; left, center, right and surround [2]. IRT in their papers concluded that four front and four surround speakers should be considered [4]. In a paper published by Torick of CBS, a three speaker system was recommended to resolve the image distortion problems [1].
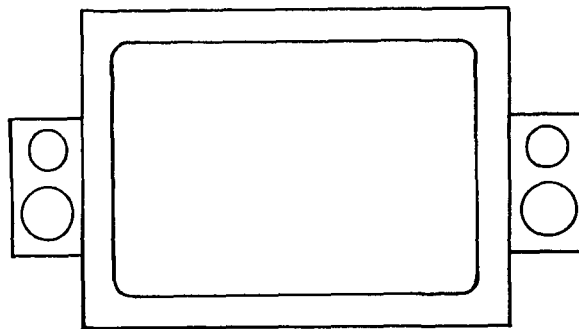

Figure 3. BTSC Stereo

Based on the literature published by the major international broadcasters and the experience of the film industry, a four channel system with a center channel and surround sound is proposed. Figure 3 illustrates the speaker configuration for this system. This proposal is a practical combination for image stabilization, viewing experience enhancement, and transmission channel numbers.
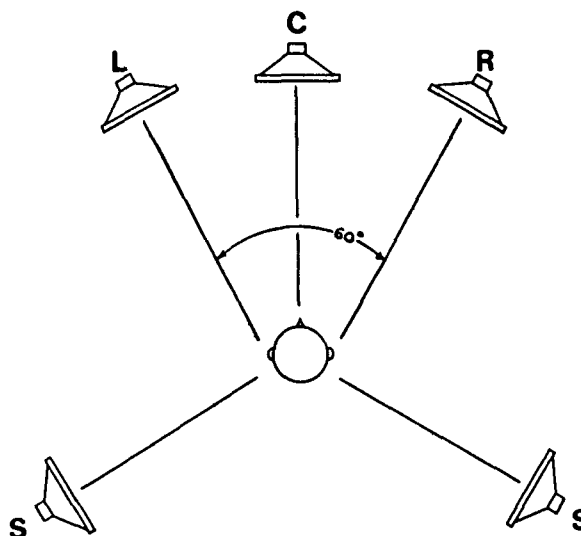

Figure 3. System Speaker Placement

TABLE 2. CHANNEL ACTIVATION WITH TRANSMISSION MODE

TRANSMISSION MODE	CH1	CH2	CH3	CH4	CH5	CH6	CH7
1 4 Channel	on	on	on	on			
2 3 Channel	on	on	on	off			
3 Stereo	off	on	on	off			
4 Monophonic	on	on	on	off			
5 SAP Stereo*					on	on	
6 SAP/1*					on		
7 SAP/2*						on	
8 DVS							on

CHANNEL DESCRIPTION

Ch-1 Center
Ch-2 Left
Ch-3 Right
Ch-4 Rear (Surround)
Ch-5 SAP Left or SAP #1
Ch-6 SAP Right or SAP #2
Ch-7 DVS

TABLE 3. LOUDSPEAKER ACTIVATION BY CHANNEL

TRANSMISSION MODE	CENTER	LEFT	RIGHT	REAR
1 4 Channel	on/ch-1	on/ch-2	on/ch-3	on/ch-4
2 3 Channel	on/ch-1	on/ch-2	on/ch-4	off/ch-4
3 Stereo	off/ch-1	on/ch-2	on/ch-3	off/ch-4
4 Monophonic	on/ch-1	on/ch-1	on/ch-1	off/ch-4
5 SAP	off	on/ch-5	on/ch-6	off
6 SAP/1	on/ch-5	on/ch-5	on/ch-5	off
7 SAP/2	on/ch-6	on/ch-6	on/ch-6	off
8 DVS	on/ch-7	on/ch-7	on/ch-7	off

References

[1] Torick (CBS), "A Triphonic Sound System for Television Broadcasting," SMPTE, 1983.

[2] Ohgushi Kengo (NHK), "Sound System Suitable for HDTV," NHK Laboratories publication, 1988.

[3] Komiyama (NHK), "Subjective Evaluation of Angular Displacement between Picture and Sound 'Directions for HDTV Sound Systems," J AES, 1989.

[4] Theile (IRT), "On the Performance of Two-channel and Multi-channel Stereophony, "AES reprint, 1990.

[5] Holman (Lucas film and USC School of Cinema and Television), "Surround Sound Systems Used with Picture in Cinemas and Homes," AES Conference Proceedings, 1990.

[6] CCIR 10/215 (United Kingdom), "Sound Systems for HDTV," 1989.

[7] CCIR 10/267 (Federal Republic of Germany), "Suitable Number of Sound Channels to Accompany Wideband HDTV," 1989.

[8] Meares (BBC), "HDTV Sound Systems: One Broadcaster's View," a contribution to the CCIR IWP 10/12, 1989.