

# LIVE PRODUCTION AND TRANSMISSION OF LARGE-SCALE MUSICAL TV PROGRAM USING 22.2 MULTICHANNEL SOUND WITH ULTRA HIGH DEFINITION VIDEO

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## ABSTRACT

The world's first production and transmission of a live Ultra High Definition Television (UHDTV) program was carried out in 2006. The sound system was a 22.2 multichannel system that satisfies requirements for Ultra High Definition TV such as stable localization of frontal sound image on the entire screen, and it consisted of three layers for reproducing three-dimensional sound.

The program was a live musical variety TV show that is broadcasted every New Year's Eve from the NHK hall in Tokyo. Ultra High Definition video together with 22.2 multichannel sound was transmitted over a 1-Gbps IP network to the NHK Osaka station, 500 km west of Tokyo. This transmission included the uncompressed 22.2 sound signal (28 Mbps) multiplexed with a compressed Ultra High Definition video signal (600 Mbps), whose uncompressed transmission rate is 24 Gbps.

This paper outlines this live production and transmission of Ultra High Definition TV and describes 22.2 multichannel sound recording, reproduction, and transmission.

## INTRODUCTION

A high-definition television (HDTV) system that provides high-resolution images to viewers in their homes is being used in digital broadcasting in Japan. HDTV produces more realistic images than conventional standard definition television can.

Our research has found that the sensation of reality increases as the viewing angle increases and becomes saturated at a horizontal angle of around 100 degrees [1]. An Ultra High Definition video system with about 4000 scanning lines that gives a 100-degree horizontal viewing angle was recently developed [2]. The system has 16 times the resolution of HDTV and more than twice the resolution of 70-mm motion picture, and its viewing distance is 0.75 H (H: picture height).

A 5.1 surround sound system is also being used in digital broadcasting in Japan, and it can provide two-dimensional spatial impressions to viewers in their homes. We have developed a 22.2 multichannel sound system for Ultra High Definition television to reproduce an immersive and natural three-dimensional sound field that creates a superior sense of presence and reality [3]. The 22.2 multichannel sound system was developed for the extra large screen of Ultra High Definition video and with the intention that it should produce the highest sensation of immersive presence.

The 22.2 multichannel sound system debuted along with Ultra High Definition video at the World Exposition 2005 in Aichi, Japan [4]. The system's improvement of various spatial impression attributes has been demonstrated in subjective evaluation experiments using

Ultra High Definition video programs. These experiments were described in previous papers [5], [6].

The development of 22.2 multichannel sound and Ultra High Definition video has reached the stage of verifying the possibility of live transmissions. In the transmission experiment described here, three-dimensional sound of a musical variety TV program was mixed live by using a 22.2 multichannel sound system.

This paper focuses on the live recording, production, transmission, and reproduction of 22.2 multichannel sound. It also introduces the IP transmission system of Ultra High Definition TV employing MPEG-2 based video coding system.

## 22.2 MULTICHANNEL SOUND SYSTEM

The horizontal viewing angle is around 100 degrees in the front row and around 40 degrees in the back row in a typical Ultra High Definition TV theater. Therefore, the horizontal and vertical angles of movements in the visual image are extremely wide. The sound system for such video therefore has to provide a sound field that surrounds viewers with various sound sources. The ability to localize sound content over the screen images should be so that the horizontal and vertical direction of sound matches the visual image. The sound system of an Ultra High Definition TV should thus have the following attributes:

- stably localize frontal sounds over the entire screen area,
- reproduce sound images in all directions around a viewer including elevation,
- reproduce a three-dimensional spatial impression that augments the sense of reality,
- create a wide listening area with exceptional sound quality, and
- be compatible with existing multichannel sound systems.

The 22.2 multichannel sound system was developed to have these attributes. As shown in Figure 1, it consists of loudspeakers with an upper layer of nine channels, a middle layer of ten channels, and a lower layer of three regular channels and two low frequency effects (LFE) channels. Figure 2 shows the loudspeaker arrangement.

Previous research has shown that the system can reproduce a greater sensation of presence over a wider listening area compared with a conventional multichannel audio system and that the upper layer of loudspeakers is essential for reproducing better presence [3].

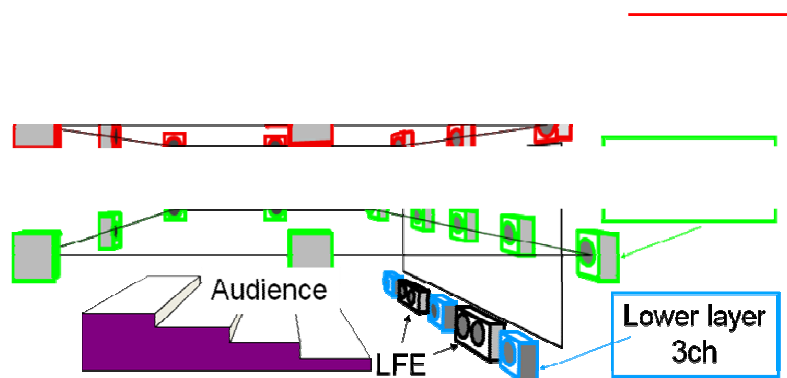


Figure 1 - 22.2 multichannel sound system

## LIVE PRODUCTION AND TRANSMISSION OF 22.2 MULTICHANNEL SOUND

The live transmission experiment was carried out using a 1-Gbps IP optical network on New Year's Eve 2006. While several programs of Ultra High Definition TV had previously been produced, at that time, the sound engineers and sound designers did not have any experience with live mixing of 22.2 multichannel sound. The experiment was also the first time to attempt a transmission of three-dimensional sound for such a large-scale musical variety program. The program, called "Kou-haku Uta-gassen" and held on every New Year's Eve, is one of the most famous Japanese pop music TV shows. The 2006 program lasted about five hours, and featured performances by many singers and bands. "Kou-haku Uta-gassen" is usually recorded with more than 250 microphones. From these microphones, about 150 channel audio signals consisting of individual microphone outputs and sub-mixes of musical tracks for components such as brass instruments and vocals were sent in digital format through the optical fiber link from the show's venue ("NHK Hall"), to the Ultra High Definition TV theater in Tokyo ("NHK Fureai hall"), which had a 500-inch Ultra High Definition video screen and a 22.2 multichannel sound system. These input feeds were directly mixed to 22.2 multichannel sound at the theater, and the mixed 22.2 multichannel sound was transmitted to Osaka over the IP optical network.

### System configuration for live production

Because so many singers and bands performed in this program, the stage was used exclusively for their performances; there was no space on or around the stage for the main band (consisting of a jazz band, a string orchestra, and a chorus) that accompanied the singers and played the opening and finale of the show. Therefore, the band performed in one of the large music recording studios of the NHK broadcasting center. The sound of the band was pre-mixed at the studio and transmitted to NHK Hall.

To live mix the 22.2 multichannel sound, microphone feeds from both NHK Hall and the music studios were sent to the Ultra High Definition TV Theater through optical fiber links, as shown in Figure 3. The sound of the main band was transmitted from the studios and the sound of vocals and bands performing on the stage and sounds from ambience microphones in the NHK Hall were transmitted from NHK Hall. The theater was located a few hundred meters away from both the music studios and NHK Hall. Many audio channels had to be sent simultaneously to the theater in which the AES10 digital interface, known as MADI, was used for the transmission from the music studios. Microphone signals were amplified to the line level by pre-amps and converted into digital signals by an analogue-to-

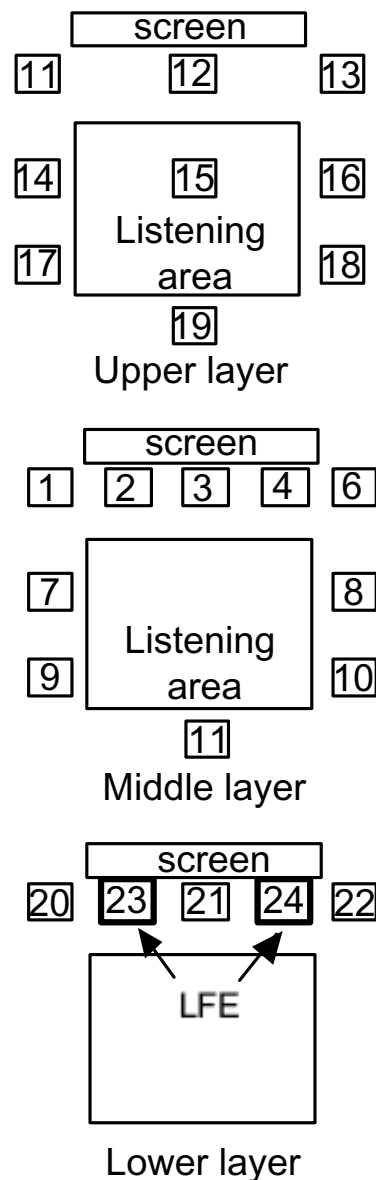


Figure 2 - Loudspeaker arrangement for channels in 22.2 multichannel sound system

digital audio converter. Fifty-six digital signals were multiplexed to one MADI, and the MADI signals were sent via optical fiber network in the NHK center. MADI is an adequate digital interface on which to send many channels of digital audio for advanced multichannel sound production, which needs more channels than conventional sound production does.

The 22.2 multichannel sound was live mixed in the Ultra High Definition TV Theater, where around 100 viewers watched the show. Because the conventional mixing system can only adapt to up to 7.1 surround sound mixing, a customized mixing system that could adapt 22.2 mixing buses was designed and installed in the theater. The mixed 22.2 multichannel sound was converted again into MADI and sent to the venue where the encoders of the Ultra High Definition TV transmitting system were located. The MADI signal was again de-multiplexed to 12 AES3-id signals and fed to the encoders of the Ultra High Definition transmitting system. Sampling frequency and bit rate in this experiment were 48 kHz and 24 bits, respectively. The sound engineers and sound designer seemed to use the channels of the 22.2 multichannel sound system effectively to mix the three-dimensional sound [7].

The Osaka station had set up a temporary 22.2 multichannel sound reproduction system and Ultra High Definition video projection system with a 400-inch screen in a TV studio. The 22.2 system had a mixing desk that could adjust the level of each channel sent from Tokyo. The differences in room acoustics between NHK Fureai hall and the Osaka studio were also compensated by adjusting the reproduced sound to the common frequency characteristics.

The 5.1 surround sound mixed at NHK Hall in Tokyo for conventional HDTV live broadcasts was also transmitted from Tokyo to Osaka using the same IP optical network. 5.1 surround sound was mixed by a large-scale analogue mixing console and the left, center, and right channel audio signals of 5.1 surround were converted to 96-kHz, 24-bit digital signals, and the surround left and surround right signals were converted to 48-kHz, 24-bit signals and transmitted to the NHK Osaka station, where an exclusive 5.1 surround sound monitoring

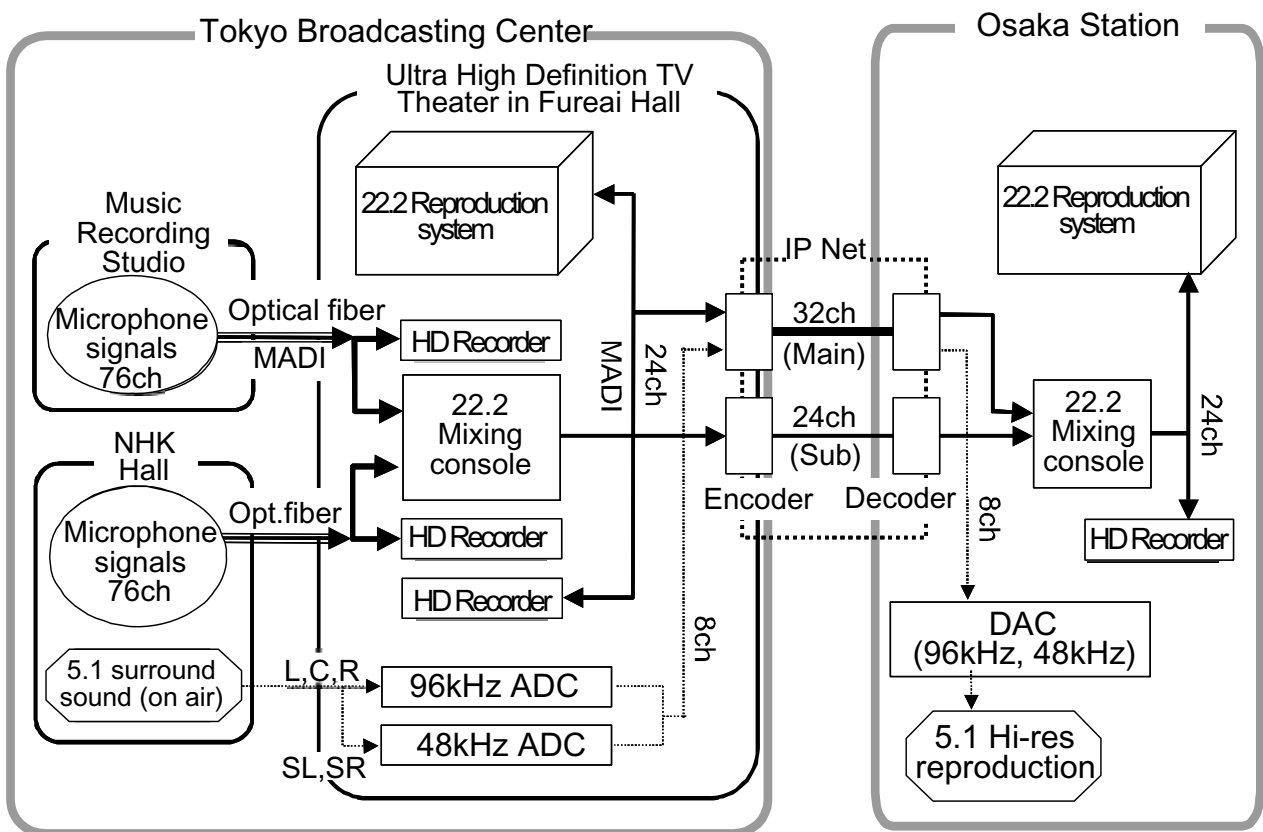


Figure 3 - Audio system for live production and transmission of 22.2 multichannel sound





