Ultra Stereo Labs, Inc.

USL Accessibility Solutions Best Practices

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Introduction

This document summarizes issues in providing cinema accessibility along with possible solutions. The accessibility solutions provided are hearing impaired audio, visually impaired – narrative audio, and closed captioning.

Hearing Impaired Audio

In the U.S., requirements for cinema provision of hearing impaired audio (HI) are listed in 2010 ADA Standards for Accessible Design and Guidance on the 2010 ADA Standards for Accessible Design. Hearing impaired audio is generally a "dialog-centric" copy of the main audio with reduced dynamic range. It is transmitted to patrons using magnetic induction, radio frequency, or infra-red. The patron can hear the audio directly using headphones or hear the audio through a hearing aid via magnetic induction or a direct (electrical) audio interface.

HI Audio Source

Cinema processors have provided an HI audio output for many years. This output is a mix of the left, center, and right channels of the main audio. This audio is passed to the "transmitter" (which may be inductive, IR, or RF) for delivery to the patron. Many transmitters, such as the USL IR emitters, include an audio compressor to reduce the dynamic range of the audio prior to transmission.

Some digital cinema packages (DCPs) include an HI audio track. On Interop packages, the HI audio is to be on track 7. In many cases this track consists of an LCR mix with compression, very similar to that provided by a cinema processor and compressor. Not all DCPs include an HI track. This is especially the case for trailers, which are created with very tight deadlines. Further, DCPs are not the only content played in an auditorium. An auditorium often shows pre-show content that is not delivered in a DCP and may also show live content not delivered in a DCP. Currently, it appears the most reliable source of HI audio is the LCR mix provided by the cinema processor instead of using a track from a DCP.

All USL cinema processors provide an HI output that is a mix of left, center, and right. Recent processors (JSD-60 and JSD-100) allow the source of HI audio to be determined on a per-format basis allowing the track in the DCP to be used, if desired.

HI Audio Transmission

Three methods are commonly used to deliver HI audio to patrons within an auditorium. These

are magnetic induction, radio frequency (RF), and infra-red (IR).

With magnetic induction, a several turn "loop" around the auditorium is driven by a power amplifier with HI audio. The audio magnetic field induces the audio into the telecoil ("T-coil") within a patron's hearing aid. A T-coil is designed to receive the stray AC magnetic field from a telephone receiver. In this manner, the audio is inductively coupled to the hearing aid instead of acoustically coupled. Loop systems allow the transmission of one audio channel per auditorium and may suffer interference from AC power wiring and adjacent auditoriums.

With radio frequency transmission, a small radio transmitter is placed in or near each auditorium. These transmitters have traditionally been analog transmitters, but more recent transmitters use digital signals, sometimes encrypted. RF transmission is a proven technology, but may have a couple disadvantages in cinema applications. These disadvantages are due to the radio signal not stopping at the walls of the auditorium. It is quite possible for a user to select the wrong radio channel and get the audio for a movie showing in a different auditorium. The large number of channels possible complicates the user interface when compared with loop and IR systems. RF systems with a small number of channels may create frequency reuse challenges due to the limited distance between auditoriums using the same channel. RF systems that use unencrypted audio are subject to interception outside the theater, possibly assisting in movie piracy.

With infra-red transmission, the HI audio is emitted into the auditorium by an emitter panel on the rear wall of the auditorium or in the projector port window. The IR emitter is aimed towards the screen such that the signal reflects off the screen to cover all areas of the auditorium. Since viewers can see the screen, the IR receiver can receive the IR signal reflected from the screen. Also, other surfaces in the auditorium reflect the IR signal creating a coverage area of the full auditorium. The IR signal can carry multiple audio channels (and generally carries two, one for HI audio and the second for VI-N audio). Since the IR signal does not escape the auditorium, the user interface is much simpler than that of an RF system. The user can only hear audio for the appropriate auditorium.

HI Audio Delivery

Once the audio is transmitted into the auditorium using magnetic induction, RF, or IR, it needs to be received and delivered to the user.

Magnetic induction systems may use T-coil equipped hearing aids as the receiver. As such, patrons with these hearing aids arrive with their own HI receiver. As noted previously, hearing aid T-coils are designed for use with a telephone. A telephone receiver radiates a DC magnetic field (from its permanent magnet) and an AC magnetic field (with the audio). Some current hearing aids automatically enable the T-coil by the presence of the DC magnetic field. Since a loop system only creates an AC magnetic field, this automatic activation does not work. If the hearing aid does not have a manual switch to enable the T-coil, the loop system does not deliver the audio directly to the hearing aid. In this case, headphones, as with the other systems described below, are required. Magnetic loop receivers are available to drive headphones under these circumstances.

RF and IR systems both deliver the HI audio to headphones. The receiver may be built into the headphones (as the USL receivers are) or may be separate (common on RF linked systems). All receivers have the 1/8 inch monaural output jack currently required by the ADA Guidelines.

Headphones can serve hearing impaired patrons with and without hearing aids. For those without hearing aids, the louder dialog-centric audio allows them to enjoy the movie. For those with

hearing aids, the headphones emit both a DC and AC magnetic field, so the automatic T-coil in a hearing aid can be enabled. In this case, the headphones are placed over the hearing aids instead of over the ears, just as a telephone would be when driving a T-coil. Placing the headphones over the hearing aid improves the magnetic coupling to the hearing aid and reduces the acoustic transmission into the ear where it may interfere with the audio created by the hearing aid.

As mentioned above, all HI receivers include a 1/8 inch monaural jack carrying the receiver audio output. This may drive the Direct Audio Input of hearing aids or implants. It may also drive inductive neck loops. An inductive neck loop creates an AC magnetic field, similar to that emitted by a room loop or headphones, carrying the audio. However, as with room loops, there is no DC magnetic field, so automatic T-coils will not be enabled. Neck loops can be used if the hearing aid has a manual switch to enable the T-coil.

One concern with headphones is sanitation. Several methods of handling this issue exist.

1. Headphones can be wiped with an anti-bacterial wipe.

2. Headphone ear pads can be replaced.

3. Users can purchase the headphones for their own use. Note that 2.3MHz IR headphones are compatible with consumer IR headphone systems such as the TV-Ears 3.0 system, so patrons can use their headphones both at the theater and home.

Visually Impaired – Narrative Audio

In the U.S., the Department of Justice published an Advance Notice of Proposed Rulemaking in 2010. This Notices describes the proposed requirements for VI-N audio and closed captioning. VI-N audio is a verbal description of the image on the screen to aid those whose vision is not sufficient to see the image in detail or at all. VI-N audio is delivered with much of the feature content produced today. In Interop DCPs, the VI-N audio is on audio track 8. Some HI/VI-N transmission systems accept AES/EBU audio directly from the server while others accept analog audio from the cinema processor. USL offers the DAX-202 digital to analog converter for those installations where the VI-N transmitter requires analog audio but the cinema sound processor does not provide a VI-N output.

VI-N audio can be transmitted over any system that supports an adequate number of audio channels. Since an inductive loop only supports one audio channel, and that is generally devoted to HI audio, VI-N transmission is generally restricted to RF and IR transmission.

Closed Captioning

The the Department of Justice 2010 Advance Notice of Proposed Rulemaking discusses the use of closed captions in cinema. Closed captions are delivered with most feature content. The captions are XML data files within the digital cinema package. These captions are synchronized with the playing content and transmitted to displays used by the hearing impaired patrons that need them. The displays may be a "public display" that is not visible to the rest of the audience or "private displays" for the individual users.

A typical "public display" is the Mopix Rear Window display. A Rear Window display is an LED sign placed on the rear wall of the auditorium. The text is inverted right to left so it appears correct when viewed through a reflector. Users orient a reflector on a goose-neck that sits in the seat cup holder such that the reflected captions are visible while viewing the screen. The Rear Window

system has a very low "receiver" cost (since it's just a reflector). It also provides minimal distraction to nearby patrons since the position of the viewer and the reflector are critical. Patrons not aligned perfectly with the reflector will not see the captions. This critical alignment, however, limits how much the patron using the Rear Window display can move in his or her seat. Though multiple simultaneous language systems would be possible through the use of several Rear Window displays, this is rarely done, if ever.

"Private displays" take the form of seat mount receivers (receivers on a goose-neck that fit the cup holder, similar to the Rear Window reflector) or glasses with a special display and receiver. These systems receive their captions over RF or IR. They generally support more than one language. The additional language feature allows closed captioning to serve both the hearing impaired and those who do not understand the language of the soundtrack. If the movie is delivered with captions in other languages, the user can select an understood language to view along with the movies. The advantages and disadvantages of RF and IR transmission discussed above also apply to closed caption transmission. It is simpler for a user if he/she does not have to select an RF channel to get the captions for the appropriate auditorium.

The available seat mount (cup holder) receivers are similar. On the RF linked displays, the user must select the auditorium. On both RF and IR linked displays, the user may select the language, but generally the default language is the appropriate one. Seat mount receivers are designed to minimize the distraction to other patrons caused by the appearance and disappearance of captions throughout the movie. One system uses louvers to limit the vertical angle of visibility (assuming the person behind the user is above the user, the louvers prevent that person from seeing the captions). Another system uses a Fresnel lens that limits both the horizontal and vertical angles of visibility and also makes the display image appear distant to minimize the amount of refocus required of the eye when viewing the closed caption display and the main screen. In all cases, the seat mount receivers (or reflector) are typically positioned such that the text appears immediately below the main screen image.

Glasses-type displays project an image of the caption text into one or both eyes of the user. When the image is projected into both eyes, the images must be aligned precisely to correspond with the parallax of the distant main screen. Projecting the image into one eye eliminates this issue. Unless a person has bad vision in the eye the captions are projected in to, the use of the one eye display is not noticed by most people. For those people with bad vision in one eye, the receiver can be flipped to place the caption image in the other eye.

Another concern with glasses-type displays is sanitation. As with headphones, glasses displays can be cleaned with anti-bacterial wipes. In addition, those with removable electronics (such as the USL CCH-100) can be washed in the same manner as 3-D glasses (often in a dishwasher).

Another area of interest with glasses-types displays is their use with 3D movies. Generally, these displays can be worn with 3D glasses. The USL CCH-100 can also have Real-D lenses used in the glasses, allowing viewing of 3D movies with only one pair of glasses.

Server Interface

As discussed above, HI/VI-N audio can be delivered by either the cinema sound processor or as AES/EBU audio direct from the digital cinema server. Delivery from the cinema sound processor allows local generation of HI audio ensuring that HI audio is present for all content. VI-N audio is, if available, delivered in the digital cinema package. The server may deliver that directly to transmitters

that support AES/EBU input or may be converted to analog by cinema sound processors for transmitters that require analog audio.

Some digital cinema servers can drive the Rear Window display directly using an RS-232 port. Others only deliver captions using the SMPTE closed caption protocols, thus requiring an adapter (such as the USL CCE-100) to drive a Rear Window display. All digital cinema servers support the SMPTE protocols for driving closed captioning equipment, though a special license may be required to enable this feature.

Closed captioning relies upon the SMPTE Auxiliary Content Synchronization Protocol. Servers that have this port enabled accept a TCP connection on port 4170. A quick method of testing a server to see if it is configured to support closed captioning is to telnet to the server on port 4170. If the connection is accepted, closed captioning is probably supported. If the connection is refused, the server is not configured to allow a closed captioning device at that IP address.

System Comparison

The table below compares three systems that support HI/VI-N audio and closed captioning.

Feature	Doremi Captiview, AccessLink, and Fidelio	Sony (transmitter and receiver)	USL	Comments
Link	RF	RF	IR	IR link confined to an auditorium.
Glasses Receiver	No	Yes	Yes	
Glasses Removable Electronics	NA	No	Yes	Removable electronics aids cleaning.
Cupholder Receiver	Yes	Yes*	Yes	*Sony compatible receiver is USL CCR-200.
Cupholder Receiver Optics	Louvers	Fresnel lens*	Fresnel lens	Louvers restrict vertical view reducing distraction. Fresnel lens restricts vertical and horizontal view reducing distraction. Fresnel lens creates distant virtual image reducing eye strain. *Sony compatible receiver is USL CCR-200.
Caption Languages	6	6	4	Most content currently delivered with 1 language
Caption RF channels	32	7	See comments	Since the IR link does not interfere between auditoriums, the number of RF channels does not apply. For example, an IR system will support an infinite number of auditoriums

Feature	Doremi Captiview, AccessLink, and Fidelio	Sony (transmitter and receiver)	USL	Comments
				with no "channel reuse" concerns. "RF channel" count includes use of spreading codes over the same band to yield separate data paths.
Audio RF channels	32	7	See comments	Since the IR link does not interfere between auditoriums, the number of RF channels does not apply. For example, an IR system will support an infinite number of auditoriums with no "channel reuse" concerns. "RF channel" count includes use of spreading codes over the same band to yield separate data paths.
Audio Inputs	AES/EBU only	AES/EBU or analog	Analog only	Analog input for HI allows local generation of HI.

Other Notes

Doremi servers require a special license to enable SMPTE compatible captioning. All other servers support SMPTE captioning directly.

Sony servers must be configured with the IP address of the captioning transmitter and only accept a connection from one captioning transmitter (which is usually all you have!). All other servers will accept a number of connections from closed captioning transmitters and include support for closed captioning with no additional license.

GDC servers have a configuration screen to enable SMPTE closed captioning. The enable box must be checked, then the SMS rebooted.

As discussed previously, a server can quickly be tested for support of closed captioning by telnetting to it on port 4170. If the connection is refused, the server is not configured to support closed captioning.

Revision History

April 17, 2013 – First draft

April 18, 2013 – Minor revision

April 25, 2013 – Formatting and minor revision