Secrets Of Doing Surround Sound On Your Existing Console

Martinsound REPORT
Helping You Stand Out

Introduction

The following is not intended as an exhaustive report on surround sound mixing, but rather provides suggestions on how any studio might make the transition from stereo to surround sound operation without a significant financial outlay.

The mixing console often represents a studio's single largest capital expenditure. This guide suggests how your stereo mixing console, with the addition of a monitor controller, will be capable of producing surround sound mixes in a variety of formats without requiring costly modifications or total replacement. It offers suggestions on working around the apparent shortcomings of the average mixing console, highlights the features that you should look for when choosing a monitor controller, and provides basic advice to get you started on the road to successful and creative surround sound mixing.

There are plenty of business opportunities available to studios wishing to diversify into surround sound production. The 5.1 surround sound format has been adopted, in some cases mandated, for a wide range of applications, including digital television (DTV) and cable, direct broadcast satellite (DBS), DVD-Audio, DVD-Video, DVD-ROM, laser discs and Super Audio Compact Disc (SACD).

There seems to be an ever-increasing demand for surround sound music production, for back catalog music re-mixes, and audio for video games, interactive multimedia and Internet distribution. The convergence of this wide range of audio media means that multichannel surround sound mixing is no longer the exclusive domain of a small number of dedicated motion picture studios with expensive, highly specialized equipment.

Teaching Old Consoles New Tricks

Surround sound mixing places specific demands on your studio equipment. To produce surround sound mixes in all of the current formats, including those for the theatrical release of motion pictures, you ideally need a console with at least 8 mix buses. With some forethought you could get by with the main stereo mix bus, 4 group buses and some auxiliary sends. But the majority of audio mixing consoles, including some current models that are sold as 'surround sound capable,' do not include all of the essential monitoring functions.

The stereo monitor section of a standard console cannot provide you with the means to check the compatibility of your mix, whatever the format, as it will be reproduced on all professional and consumer presentation systems. It cannot provide comprehensive control, including level, mute and solo functions, of a multichannel speaker system. There is usually no quick and easy way to insert and monitor encode/decode processors. Calibration functions, downmixing coefficients, bass redirection and filtering are beyond the scope of a standard console.

So what are your options? Many mixing console manufacturers offer surround sound mixing and/or monitoring upgrades for at least some of their console models. These may be available as standard, as an option, or maybe as a retrofit. Other consoles are simply limited to stereo operation and offer no possibility of an upgrade path. The manufacturer of your console may no longer be in business. Your only choices as a studio owner may be to spend a large amount of money on a console upgrade from the manufacturer, pay someone to custom-engineer a solution for you, or replace the console.

Multichannel Mixing With A Modest Outlay

There is an alternative. Whether you are looking for a temporary solution to meet your immediate requirements or are planning to diversify into the world of surround sound, an add-on multichannel monitor controller can offer the means to preserve your investment in your mixing console. Third-party solutions will augment your existing console's monitor section, add the facilities necessary to handle the complexities of surround sound mixing, and allow you to very quickly be mixing in surround sound, with only a modest financial outlay.

'Quickly' is a key word, too. Some multichannel monitor systems can take up to one full day to setup and calibrate ready for a session. That is fine if you can bill the time to your client, but is not so good if it means a day of lost revenue for the studio. The monitor controller must also provide you with all the tools for the job to be cost-effective, so you need to choose yours carefully.

The Martinsound MultiMAX monitor controller is designed to assist recording studios, broadcast facilities and post production houses in making a smooth transition from stereo to surround sound production by providing a comprehensive yet cost-effective solution. A console is not even necessary: MultiMAX may be integrated with a workstation to provide production, mastering and quality control for music and multimedia authoring in surround sound.

Console = Source

The monitor section on your console may provide some useful features but they are probably limited to stereo or mono operation. Some consoles offer 4-channel capabilities, either in quadraphonic or LCRS format. In order to monitor the entire signal chain you are going to need more source selections than are available on your existing console's monitor section. The complexities of surround sound monitoring dictate the augmentation of the console with a monitor controller.

Although third-party solutions can add comprehensive monitoring features to the console there are also certain functions that you need to retain. You need your console to be one of your monitor sources, as that is the only place where your AFL/PFL/APL solo bus(es) appear. The monitor controller should thus be able to select the stereo or quad/LCRS speaker outputs of your console as a monitor source, allowing you to use all of the features of your console and monitor the result on any of your speaker systems, including stereo and mono.

Logical, Captain

When you press a non-destructive solo switch on the console you want the convenience of hearing the selected signal without having to press more switches. You will want to interface the console's non-destructive solo sense bus to the monitor controller so that the activation and deactivation of a solo switch automatically selects and deselects the console as the monitor source.

You will also want to retain the operation of the console's mute and level dim functions when talkback is selected. Just like the console's solo function, you will want to interface these logic lines to the monitor controller. If, for technical reasons, you are not able to access your console's solo, mute or dim logic lines, you may be able to add some switches to your console for remote control of these functions in the monitor controller.

Alternatively, the mute and dim functions of the monitor controller may be interfaced to other machines. For example, if you are using a video tape recorder that does not unlace the tape from the heads in fast wind, you may want that machine to automatically dim the control room monitor system when it is put into fast forward or rewind.

Level Control

The level control on your console's monitor section is fine for whatever speaker system it is currently feeding. Once the speaker outputs from your console become just another source to be monitored, you must not alter the console monitor level control after it is calibrated and set. A +4 dB input to the stereo monitor section should result in a +4 dB level at the console monitor output. The same is true for the carefully calibrated levels that you will set feeding the recorder, encoder, and so on. Changes to the listening level must be made without affecting any of these levels.

A basic level control function is what the majority of people look for in a monitor controller. Once the monitor speaker system level is calibrated for the project (more on this later) listening levels need to be easily referenced and accurately governed by the monitor controller. A visual display of the SPL allows for fast, accurate and repeatable level adjustment. MDAC technology provides a highly accurate method for controlling the monitor levels, with precise tracking and consistency between all channels, crucial when controlling up to 8 speaker channels simultaneously.

Check, Mate

But a monitor controller should provide much more than simple level control. You need to check quality control at each step of production, regardless of the format. To ensure the optimum performance of the encoder and decoder you must monitor every stage in the signal path to check for artifacts or lost information during the encode/decode process. This involves monitoring the multichannel mix at the console bus outputs, the recorder outputs, the sends to the encoder, the matrix-encoded mix and the discrete decoded mix. In the right monitor controller this process should be simplified to a series of button pushes, requiring no additional patching or cabling.

You will need to monitor up to 8 console buses, whether mix, group or auxiliary. These buses will feed the monitor controller and the 8-track recorder. You will also need to monitor the outputs from the recorder. If there is switching for playback (recorder outputs) and direct (console bus outputs) on the monitor controller then it is a simple matter to quickly switch between either source with the push of a button. This is still referred to as PEC/Direct switching in film mixing. PEC stands for photoelectric cell, which was the only method available to the engineer to monitor the optical audio tracks in the early days of film production.

Similarly, you will want to monitor the decoded outputs from the processor (in the correct 8-, 6- or 4-channel format) to check them against the inputs to the encoder. Either source should be selectable at the monitor controller with a push of a button. Connections on the monitor controller for a 'wide' processor send (up to 8 channels), with the ability to define the surround format, are obviously essential. The processor send should be 8 channels, for SDDS or IMAX formats, and therefore also able to handle 6-channel (5.1) DTS (Digital Theater Systems) or Dolby Digital formats.

So Many Choices

There are several common surround sound formats for motion picture theatrical release: Dolby Digital and the new Surround EX, DTS and SDDS (Sony Dynamic Digital Sound) (see sidebar). A movie may be released with its soundtrack in all, or a combination, of these formats, for presentation in cinemas with a variety of playback equipment. These multichannel formats must also be compatible for playback in cinemas equipped with stereo speaker systems and non-digital presentation equipment, and will also be released in a variety of formats on assorted media for the home entertainment market. Alternative professional multichannel systems like the RSP Circle Surround and Ultra Stereo processors only add to the need for comprehensive compatibility checking facilities in the monitor controller.

Although some surround sound formats are used only for the theatrical release of certain motion pictures, 2 of them – Dolby Digital and DTS – have migrated into other media types, specifically television broadcast, computer gaming and music. DTS, in particular, has gained prominence among music producers as the only 5.1 system currently available for the production of music-only discs (released on DVD-Video). The recently agreed standards for DVD-Audio will allow either encoding system to be used, in addition to MLP (Meridian Lossless Packing), the data compression system mandated for DVD-A.

The home entertainment market is presented with a variety of media, from broadcast television to videocassette to DVD, encoded in DTS, Dolby Digital, Dolby Surround or Stereo format, as well as standard stereo and mono. High end home entertainment equipment permits the consumer to listen to your multichannel mix in a variety of formats, including downmixed to stereo or even mono, so you will need to check the compatibility of your mix in all of them. Also, bear in mind that the finished product may be automatically downmixed by playback systems with fewer channels than your original mix.

The Development of Multichannel Surround Sound

From Mono To Many

Let's take a look at the development of the multichannel motion picture presentation systems that led to the surround sound formats we know today. The dictionary defines stereophonic as:

> Recording or reproducing sound, as by use of separate microphones or loudspeakers, to enhance actuality by giving effect of direction.
> (Little Oxford Dictionary, 4th Edition)

Although now synonymous with 2-channel recording and reproduction, the majority of the public became acquainted with stereophonic sound in the early 50s with the introduction of a number of multichannel formats by the motion picture industry. Stereophony in the motion picture industry involved multiple channels from the very beginning, and to this day it continues to use at least 4 channels.

These days we are used to sitting in a movie theater and seeing loudspeakers along the walls, even behind us. A large number of readers have a similar, scaled-down setup at home. Many motion pictures make spectacular use of these surround speakers, which are most often used for sound effects and ambient noises to provide the audience with spatial information or to create movement. Multichannel surround sound is a part of the motion picture experience that we now take for granted, yet many readers probably grew up with movies that were presented in mono.

Movie Multichannel Pioneers

As many readers may be aware, Bell Labs conducted a series of pioneering experiments with stereo sound in the early 30s. These were followed by demonstrations of a 4-track stereo system by Western Electric in 1940. But these efforts were conducted largely for the benefit of the recording industry.

The first motion picture to be shown publicly with stereophonic sound was Walt Disney's Fantasia, which was released in 1940. The soundtrack was reproduced by utilizing 3 optical tracks, each on a separate 35mm film played in sync with the movie, feeding 3 sets of loudspeakers: one behind the screen and one on either side of the screen. Walt Disney referred to the system as 'Fantasound.'

Despite this pioneering effort it was not until the 50s when first Cinerama, then CinemaScope and Todd-AO, brought multichannel sound to the wide screen. These first stereo systems were configured with multiple channels across the front. Because of the width associated with these presentation formats, all of the front speakers would usually carry the dialog. Generally a single channel fed speakers at the rear of the theater for special effects. Music would usually be in mono or 2-channel stereo.

Cinerama made a huge impression on the public and the movie industry with the 1952 release of This is Cinerama. The movie used 7-channel sound and was billed as 'Stereophonic.' The soundtrack was recorded on 35mm film, which was played in sync with the 3 simultaneously projected films. Cinerama had an unusual feature. Channels 6 and 7 were fed to speakers on the left and right walls of the theater. These were switched manually during the performance by the 'Cinerama engineer' who, with the aid of cue sheets, would throw a switch to route channel 6 to both side walls and channel 7 to the rear.

The Robe was the first film to be seen in 20th Century-Fox's CinemaScope, which offered 4 audio tracks, configured as left, center and right behind the screen, with a channel at the rear. These were recorded as magnetic stripes on the 35mm print film.

The 6-track 70mm Todd-AO system premiered with Oklahoma! in 1955, adding a left-center and a right-center channel to previous 4-track configurations. In Europe the second Todd-AO release, Around the World in 80 Days,

Dolby Surround

If you are mixing a project in one of the matrixed or encoded multichannel formats the monitor controller should include facilities to monitor the processor's 2-channel Lt Rt output, to check stereo playback compatibility. The Dolby Surround process matrix-encodes the 4-channel LCRS mix to a 2-channel mix. When the discrete channels of the surround mix are downmixed to a stereo-compatible, matrix-encoded mix it is referred to as Lt Rt (left total, right total). This 2-channel encoded signal is what you hear played back, in stereo, from Dolby Stereo videocassettes or TV.

The Dolby Surround Pro Logic decoder found in the majority of home entertainment systems can output a number of formats from Dolby Surround encoded material, including a recovered LCRS mix, a stereo compatible (Lt Rt) mix and a mono downmix compatible with mono television playback. It can also produce 3-channel downmixes, in LCR or LRS (with phantom center) formats.

The Dolby Surround encoding process utilizes phase relationships to produce the Lt Rt mix. Information for the left channel is encoded to Lt, the right to Rt, and the center channel to both Lt and Rt. Surround channel information is phase shifted +90 degrees to Lt and –90 degrees to Rt, and is also bandwidth limited. If this 2-track encoded Lt Rt mix is played back through the Pro Logic decoder it will be heard in LCRS format. For obvious reasons Dolby Surround is also known as a 4-2-4 process. According to Dolby there are 80 television series, plus sports events and special programming, transmitted regularly in Dolby Surround.

During decoding out-of-phase information is sent to the surround channel, including information that you did not intend to appear there. A by-product of this is that when listened to it in mono the surround channel can disappear. Also, highly uncorrelated material will be sent to the left and right channels during decoding, but correlated information will be sent to the center channel. This means that information found equally in the left and right channels will appear only in the center channel. When you mix with a Dolby Surround encoder you will need to check how the Lt Rt mix sounds and you will want to closely monitor the recovered LCRS mix from the decoder.

Dolby Digital

Dolby Digital encodes 6 discrete channels: left, center, right, left surround, right surround and a low frequency effect (LFE) channel. Like the Dolby Surround system, Dolby Digital encoded material may be played back by the consumer in a variety of formats, including both a full dynamic range 5.1 mix and a reduced dynamic range version designed to not disturb the neighbors. Domestic Dolby Digital decoders are also capable of producing a Dolby Surround Pro Logic (LCRS) downmix, an Lt Rt downmix, an Lo Ro standard stereo downmix (suitable for headphones, for example) and a mono compatible downmix, as well as a Dolby 3 Stereo mix (LCR, or LRS with a phantom center). You will want to check compatibility with all of these.

A standard stereo downmix of a surround mix is known as Lo Ro (left only, right only). It is not matrix-encoded and cannot therefore be decoded satisfactorily as a surround mix, but is suitable for stereo loudspeaker or headphone playback. In fact, if played back through a Pro Logic decoder it will produce a 'wide' stereo image. The monitor controller should therefore offer the ability to monitor your mixed multichannel inputs in standard Lo Ro stereo format, and it is very useful if it also provides output connections so that a 2-track reference recording may be created of the Lo Ro mix.

Downmixing

During Dolby Digital encoding, downmix coefficients are selected by the mastering engineer to provide a comparable balance between downmixed and non-downmixed playback. Excessive levels at the input to the digital processor would result in the digital-to-analog converters being overloaded. The decoder utilizes a gain ranging process and applies downmix coefficients to maintain the selected balance yet prevent overload, based on the worst case peak level of the material.

A good monitor controller will allow the engineer to check stereo compatibility by applying the exact same downmix coefficients that are also available in the Dolby Digital processor to the Lo Ro stereo mix. Applying the coefficients corresponding to the downmix level bit settings recommended by Dolby for DVD production to the center and surround channels at the monitor controller allows the mix engineer to maximize his balance

The Development of Multichannel Surround Sound continued

was, for financial reasons, released on 34mm film, locked to a 4-track 35mm mag film that provided the soundtrack. Their proprietary Perspecta control tone was used to dynamically move effects between the 2 side channels and the rear channel.

Two Steps Forward, One Step Back

Rick Altman, in his article 'The Sound of Sound' (Cineaste, Vol. 21, 1995), suggests that Hollywood's notion to provide audiences with high fidelity sound in movie theaters in the early 50s ran contrary to the standard of reference of the average consumer, which was monaural television and monaural playback of phonograph recordings in the home. There was a long history of focussing the movie-going experience directly on the screen, which was reinforced by the placement of the speakers – and the positioning of the dialog, mixed in mono - behind the screen.

The use of surrounds was not easily accepted by the public, nor by many motion picture studio executives. Columbia Pictures apparently never used the surround channel at all during this period. In trying to match the standard of mono audio reproduction in the home, the movie industry abandoned the surround channel for the time being. Stereo, except for some music reproduction, was also largely discontinued. This was further reinforced by the evolution of the multiplex. As screen sizes became smaller there was less need for 5 behind-the-screen channels.

In 1958 2-channel stereo records became available for the home and were quickly followed by stereo FM radio broadcasting. In the early 70s there was an ill-fated attempt to promote quadraphonic sound to the consumer market. The quality of domestic sound equipment began to improve, keeping pace with the improvements in the quality of sound that was being produced by music recording studios. Similarly, the quality and sophistication of sound reinforcement systems improved, as consumers demanded that their favorite bands reproduce in concert the sounds they were used to hearing on record at home. By the late 70s consumers were demanding the same sound quality at the cinema.

Dolby To The Rescue

In 1976 Dolby Laboratories introduced Dolby Stereo, a matrix-encoding system that utilized the photographic (optical) method that had been used for mono film sound since the 30s, rather than magnetic stripes. The 4 channels - left, center (to localize dialog for anyone seated to the sides of the movie theater), right and surround (for special effects) - were recorded in the space of 2 tracks with the Dolby Stereo 4-2-4 encoding system.

The next step was an adaptation of the 6-track 70mm Todd-AO configuration. The 3 center channels had typically been used for dialog up to this period. With dialog mixed in mono to the center speaker it freed up the left- and right-center channels to take a specialized role as 'bass extension' or 'baby boom' channels. These channels provided low frequency effects that could be felt by the audience, emulating the experience that many people had from rock concerts. The first movie to use the 'baby boom' channels was Star Wars, in 1977. The majority of features were still being mixed largely in mono but the 70mm release of Superman in 1979 used stereo surrounds, a trend that began to catch on in the industry. Stereo surrounds were later used to great effect in Apocalypse Now.

Rapid Change In The 80's

By 1980 stereo videocassettes were commonplace in the home. The audio quality improved with the development of Hi-Fi FM stereo tracks. The laser disc was introduced around the same time, offering the highest quality home video and audio to date. The Dolby Surround consumer system released in 1982 allowed videos of theatrical releases produced

between multichannel and stereo playback before encoding.

When producing a surround project for cinema release the surround channels are mixed at a different level to the front speakers, unlike a video or music project where all speaker levels are identical. (This is explained in more detail in a later section.) The monitor controller should be capable of automatically applying the correct summing coefficients to the surround channels when downmixing from a wide format once it has been programmed for 'film' or 'music' format.

The monitor controller should be able to output a 7.1 or 5.1 format downmixed to LCRS format in addition to stereo and mono, and a fully-featured unit will include a 4-2-4 send for that purpose. You may wish to check compatibility of an SDDS 7.1 mix on a 5.1 monitor speaker system. The monitor controller should be able to dutifully perform the necessary operations, 'folding down' the left-center and right-center channels to left, center and right and applying correct coefficients to sum the levels.

But Wait, There's More

The console monitor section provides a number of external stereo monitor sources like tape, CD or DAT machines. You may still require these when mixing in surround sound, but you will need more external sources, and they will be wider than 2 channels. If you are premixing the dialog tracks for a feature film, for example, you will want to hear how they sound with the effects and the music premixes, preferably without having to use up any console input channels. More importantly, these premix inputs to the monitor controller will need to be formatted by the unit to match the multichannel configuration in which you are working.

In a similar manner, if you are producing a music scoring session you will want to introduce the production dialog track to ensure compatibility. The monitor controller should ideally offer a production track input that is for reference only, with separate level control. This track will normally be fed to the center speaker (or phantom center on a nearfield pair).

Got Speakers?

When mixing in surround sound you will need more monitor speakers, of course. But you won't just need more loudspeakers - and amplification - to cope with the increased number of channels, you will probably need to control more speaker systems as well. Many mixers travel with their own set of 3 identical speakers (LCR) to provide themselves with a familiar reference. These are generally nearfield monitors, so you should be able to switch between these and the larger LCR monitor speakers you have installed in your control room. You will still also need to be able to select your NS-10s and the Auratone.

There will be more surround speakers, too. You may have installed a set of surround speakers in the control room but a visiting mixer may want to bring in an alternate set, or you may want to switch between a set of diffuse and a set of direct radiating surround speakers. Direct radiating speakers are generally preferred for music mixing. The monitor controller should therefore allow you to switch between 2 sets of surround monitor speakers.

Diffuse speakers such as dipole or tripole monitors are used to more accurately replicate the non-directional soundfield that is produced in a typical movie theater surround array, and are also the speakers that are used in home theater THX systems (THX Ultra). A dipole monitor comprises two or more drivers pointing in opposite directions and utilizes reflections off the front and rear walls to create a diffuse soundfield that does not distract the viewer from the screen as a directional source will tend to. A tripole monitor uses multiple drivers in 3 planes and combines both diffuse and direct radiating technology.

OBE Or LFE?

If the monitor system uses limited bandwidth speakers it may be necessary to augment their response by redirecting the low frequency information to a subwoofer, or to speakers that can handle and reproduce those frequencies. This feature is available in the Dolby CP-65 cinema processor where it is known as OBE, or Optical Bass Enhancement.

When this feature is provided by a monitor controller such as MultiMAX it is not intended to replace the custom bass management systems supplied with many satellite speaker systems. You should refer to the literature accompanying your system for the correct setup of satellite and subwoofer speaker systems. (See also the sidebar on page 5)

The Development of Multichannel Surround Sound conclusion

with Dolby encoded soundtracks to be played back at home with a left, right and surround channel. Dolby Pro Logic, released to consumers in 1987, added the ability to decode the center channel.

By the mid-80s manufacturers of home entertainment systems were supplying very high quality video and audio products. Compact discs were introduced, and personal, portable audiocassette and CD players were becoming more affordable and widespread.

Dolby Digital was introduced in 1992 with the theatrical release of Batman Returns. The Dolby Digital system utilizes Dolby's AC-3 compression technology to fit data for 5.1 channels onto an optical track. Dolby Digital is configured with left, center, right, stereo surrounds and a limited frequency sixth channel for additional bass information (the .1).

The system was quickly adopted for standard resolution and high definition television (HDTV) broadcasting as part of the ATSC digital TV standard developed by the FCC for the US. Dolby Digital audio is standard in countries using the NTSC format. Digital cable and direct satellite broadcasting systems are utilizing Dolby Digital, and it is increasingly being used by DVD-ROM game and interactive material producers. Dolby Digital is mandatory for DVD-Video releases, and may also be used on the forthcoming DVD-Audio format.

DTS, SDDS & SEX

Dolby is not the only company to develop a multichannel digital recording and playback system, however. Digital Theater Systems (DTS) launched their system in 1993 with the release of Jurassic Park. Unlike Dolby Digital, data is not encoded onto the film. The film is instead printed with a timecode stripe, which is used to synchronize CD-ROM drives on which the soundtrack data is stored. DTS offers a 5.1 configuration identical to Dolby Digital except for the frequency range of the subwoofer (20 Hz - 80 Hz instead of 20 Hz - 120 Hz). DTS has also been adopted for music-only releases on DVD-V by numerous record labels.

Introduced in 1994 with the release of City Slickers II, the Sony Dynamic Digital Sound (SDDS) system offers the largest number of channels. The multiplexed information is printed optically onto the film, providing 8 tracks of playback. SDDS adds left-center and right-center channels to the 6-track configuration offered by the other 2 digital formats.

The most recent innovation is Dolby Digital Surround EX, which debuted in May 1999 with the release of Star Wars: Episode 1 - The Phantom Menace, and was a joint development by Dolby Laboratories and THX specifically for the movie. The new system modifies the surround system to provide not only left and right rear channels, but also a center rear. The extra surround track is not discrete; instead, the 3 tracks are matrix-encoded into the 2 previously existing surround tracks.

Back To The Future

The process has now gone full circle. The film industry provided the impetus for the development of multichannel sound, but was eventually overtaken by advances in the home entertainment market. Those advances in turn led to technological developments in movie theater presentation sound, and that technology has been adopted for consumer equipment. It is now possible to experience a movie in your home theater exactly as you would in the cinema, and regular TV programming and many special broadcast presentations are available in multichannel formats.

But while music on film soundtracks remain in stereo, mixing for new music production, and the re-mixing of artists' back catalogs, is providing the impetus for studios to upgrade and re-equip for surround. Now that the DVD-Audio 1.0 standard is in place this trend can only accelerate.

Low Frequency Redirection

If your surround speakers are of limited bandwidth they may require augmentation of their low frequencies when mixing for certain formats. The two surround channels in the Dolby Digital format are designed to cover the frequency spectrum from 20 Hz to 20 kHz. As mentioned earlier, in the Dolby Surround process the single surround channel covers only a limited bandwidth: 100 Hz to 7 kHz. It is unusual for the frequency range of the main front speakers in a movie theater to extend below 40 Hz.

There are several standard practices for bass augmentation: (1) Redirection of low frequencies of some or all of the speakers to a dedicated subwoofer speaker or speakers; (2) Redirection of the low frequencies to the main left and right full range speakers from the other speakers; (3) Redirection of bass frequencies to the LFE subwoofer. For example, a bass-deficient center channel speaker may have its low frequencies redirected to the left and right speakers or a subwoofer or the LFE subwoofer.

The ability of the monitor controller to handle all combinations of bass redirection is extremely useful. You should be able to choose to redirect low frequencies to a subwoofer, to the main left and right speakers or the LFE speaker. You should also be able to choose which channels will have their low frequencies redirected: left and right, LFE, center, left- and right-center, left- and right-surround and the alternate left- and right-surround system channels.

Low Frequency Effect

Bass redirection to a subwoofer is not to be confused with the LFE channel. The Low Frequency Effect is a separate, band-limited channel that is used by the engineer to produce special bass effects. Signals can be sent to the LFE channel via a mixing console bus, though a more common practice is to use an auxiliary send, allowing better control of individual signal levels. An efficient subwoofer, or possibly 2 to better handle room modes, is recommended.

The LFE channel is normally 10 dB louder than the other channels, but covers only $1/10^{th}$ the frequency range, hence its description as '.1' in 7.1 and 5.1 formats. The LFE channel is limited to an upper frequency of 120 Hz in the Dolby Digital format, 80 Hz in the DTS format and is full range in the SDDS format. SMPTE (the Society of Motion Picture and Television Engineers) has agreed to set a common upper limit of 80 Hz for consistency in all formats. For this reason it is helpful if the monitor controller allows the engineer to insert an 80 Hz filter into the monitor path of the LFE channel so that the effect of the bandwidth limiting may be auditioned.

Speaker Placements

More has been written on the optimum placement of speakers for the variety of surround sound applications than can be discussed here. In a perfect world, the 3 front and 2 surround speakers in the control room should be identical full range speakers of the same model from the same manufacturer. This is not always possible, in which case the 3 front monitors should be identically matched, sharing the same sonic signature. It is also accepted practice for the left and right speakers to be identical full range models, and for the center and surrounds to be smaller matching speakers from the same manufacturer, preferably from the same series.

The front and surround speakers should all be equidistant from the engineer. It is widely accepted that the left, center and right speakers need to be in the same horizontal plane or, if that is not possible, their high frequency drivers should be in the same plane. This can be a simple matter when using nearfield monitors, but may be more difficult if there is a video monitor located where the center speaker needs to be.

Physical positioning of the subwoofer in the control room is not as critical as for the other speakers as the frequencies produced are non-directional. One other important consideration, however: the LFE and center channel speakers should be phase aligned.

A. The Standard

There is an internationally recognized standard for the placement of the left, center, right and surround speakers, determined by the International Telecommunications Union (ITU). The Surround Sound Forum of the MPGA (Music Producers Guild of the Americas) has adopted the ITU recommendation as the basis for their on-going discussions. Rec.775, as it is known, requires the left and right front speakers to be positioned +/-30 degrees from

Hearing Perceptions and Bass Management

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In small studios/monitoring rooms (generally defined as rooms less than 12,000 cubic feet in volume), the frequency response of a speaker system in the region below 100Hz is dominated by the modal response of the room. Room modes, also known as standing waves, occur in all rooms at frequencies where the wavelength of sound is an integer fraction (i.e. 1/1, 1/2,1/3,1/4, etc.) of the distance between two walls, or the distance between the ceiling and floor (this is a slightly over simplified explanation). This means that invariably, some frequencies are reinforced and some frequencies are canceled, resulting in peaks and dips in the frequency response at the listening position. These peaks and dips are affected by the relative position of the speakers to the boundaries in that room. Because of this, it is virtually impossible to get consistent bass response from multiple full-range speakers located around a room (such as in a 5.1 monitoring setup).

One solution to this problem is to employ a method called Bass Management, also referred to as bass redirection. Bass Management uses electronic filters to extract the low frequency information (typically below 80Hz) from the main five channels and then reroutes that information to a single subwoofer channel (reproduced by one or more subwoofers). Since the low frequencies will now originate from a single source (a subwoofer) this source can be placed in the optimum location for bass reproduction in that room. And, because the main speakers are not required to handle frequencies below 80Hz, they can be reduced in size and easily placed for best imaging and coverage. The end result is that the overall frequency response of the entire audio system is considerable improved, without any sacrifice in performance or imaging.

One might ask, won't I perceive a difference in imaging if the sound of one channel originates from two sources (subwoofer and satellite)? The answer is actually no. Bass Management works by taking advantage of the ear's inability to determine the direction of frequencies below approximately 150Hz. Provided there is no audible distortion or sonic artifacts at higher frequencies (port noise etc.), and the sound emanating from the subwoofer is limited to below 100Hz, it will be impossible for the listener to identify the location of the subwoofer in the room.

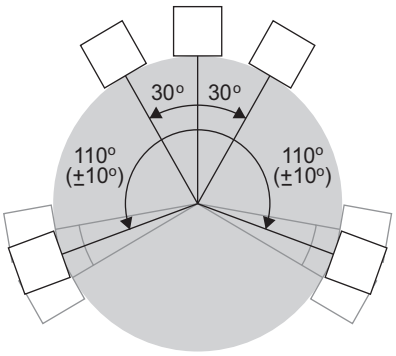
This lack of auditory acuity is based on the fact that the wavelengths of frequencies below 100Hz are much greater in length than the distance between the listener's ears. However, our ears can easily identify the source of high frequency information as coming from the main speakers. Because the sound of the main speakers is the listener's primary audio location cue, the listener's brain believes that the bass is actually emanating from the main speakers and not from a separate subwoofer (even when it is behind the listener).

With a properly designed satellite/subwoofer speaker system using Bass Management the response and overall accuracy of a monitoring system can be greatly improved. These benefits apply to any type of monitoring, whether two channels, 5.1 and beyond.

One additional point that is important to understand is that Bass Management is done as a function of the monitoring system and in no way affects the actual encoding of the mix.

the center relative to the listener. This is based on a well-established equilateral triangle layout, forming a 60 degree spread that provides an optimum stereo image. Some engineers prefer to narrow or widen this angle.

If the center speaker must be closer, for example if it is soffit-mounted in the same plane (i.e. the control room wall) as the left and right speakers, the signal to the center channel will need to be time-delayed.



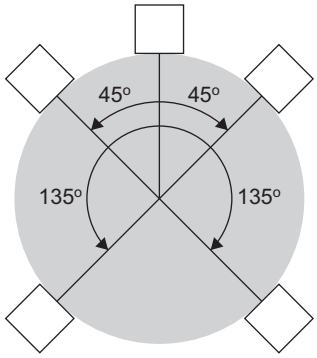
Rec.775 also recommends that the left and right surround speakers be placed at +/-110 degrees, +/-10 degrees, from center. With +/-10 degrees tolerance there is some room for experimentation. Some engineers advocate the positioning of the surrounds near the side walls in a plane 2 feet behind the listener's head, which also fits the Rec.775 model.

Again, if the surrounds must be positioned closer to the listener than the front speakers they should be time-delayed. Diffuse surrounds may be positioned higher than the front speakers, which should be near to the engineer's ear height when seated. The MPGA recommends that the front speakers be positioned at a height of about 4 feet (1.2 m) off the floor.

The Rec.775 layout is considered to be similar to the average home setup. At home the listening position is generally close to a rear wall, precluding the possibility of adopting a layout, such as that preferred by opponents of the arrangement offered by Rec.775, that places the surrounds further behind the listener.

B. An Alternative

Some engineers prefer a squarer spread, with left and right front speakers at +/-45 degrees from center, and left and right surround at +/-135 degrees. This layout places the 4 speakers at 90 degrees to each other and at an equal distance from the listener.



The center speaker may be added, but many proponents of this basically quad layout favor a phantom center and use the center channel very little. A 90 degree separation between surrounds is considered by supporters of this layout to provide better rear phantom images than the 120 degree spread of Rec.775 when using direct radiating speakers. An alternative is to use dipole surrounds with the ITU layout in order to generate a more diffuse and enveloping surround soundfield.

On The Level

To ensure predictable and repeatable results in the finished product the motion picture and television industries have developed standard monitoring levels which have been adopted by SMPTE, their professional organization. A number of tools are necessary when calibrating the speaker system to these standards: a source of pink noise, a sound pressure level (SPL) meter, a real-time analyzer (RTA) meter if at all possible, and individual level trim and mute/solo control of each speaker channel. Radio Shack (Tandy) offers an inexpensive SPL meter that has become widely accepted in the audio industry.

A fully featured monitor controller such as MultiMAX should make this process as manageable and simple as possible, by incorporating protection via the dim/mute controls, comprehensive speaker control, a built-in pink noise generator, etc.

Full range speakers will require a full bandwidth pink noise source. Speakers of limited bandwidth will benefit from the application of a band pass filter to the pink noise source. This will correct for the loss of energy in a speaker unable to reproduce the entire frequency spectrum, and should not therefore be used for trimming a full range speaker.

Monitoring Level: Cinema

The SMPTE standard for film mixing is for the reproduction of a reference level of pink noise to be at 85 dB SPL, set to C weighted/slow. In the film industry the level at which the surrounds are mixed is 3 dB higher than the level of the front speakers. This is to compensate for the –3 dB levels in movie theater surround channel speaker systems. A monitor controller that can automatically apply the 3 dB level differential to the surround channels when in 'film mode' is very useful in this application, as the 3 dB difference also needs to be factored into the downmix coefficients, as noted earlier.

In their literature, Dolby observes one other film mixing convention. Motion pictures being mixed for home theater release benefit from an overall mix room listening level of 79 dB. At 85 dB low-level dialog is easily heard in the acoustically treated environment of the control room. At home the release must compete with ambient noise like conversation, domestic appliances and so on. Mixing at 79 dB results in the low-level dialog being mixed at a higher, more consistent level.

Monitoring Level: Non-Cinema

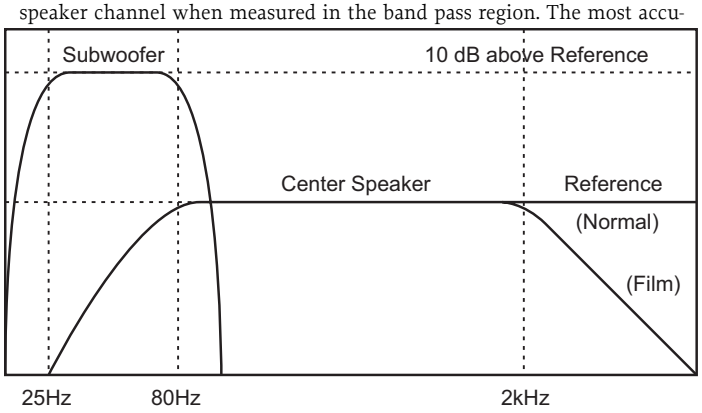
Non-cinema product such as television, DVD-Video, DVD-Audio and SACD should be mixed with the surround speakers calibrated to the same level as the front speakers. In music mixing all channels are set at the same reference level, ensuring uniform calibration regardless of the overall mixing and listening levels preferred by the mixer.

Monitoring Level: Small Room

Dolby makes a further recommendation for small mixing environments. If the surround speakers are within 5 feet of the engineer, the level of the surround speakers should be reduced by 2 dB to better replicate a home listening environment.

Putting The .1 In 5.1

For all forms of surround mixing the LFE channel is calibrated slightly differently. The SMPTE practice is to set the level 10 dB louder than the center speaker channel when measured in the band pass region. The most accurate way to measure this is with an RTA meter. Once the center channel has been calibrated, the average value of the 1/3rd octave bands between 25 Hz and 80 Hz for the LFE channel should be set 10 dB higher than the average value of the mid-range band (100 Hz to 2 kHz) of that channel. A measurement should then be taken with the SPL meter to provide a reference for subsequent calibration when an RTA is not available. The reading should be approximately 4 dB above the SPL of the center channel.



Speaker Controls

The monitor controller should be able to provide individual speaker channel facilities to allow the engineer not only to set up the multichannel monitor speaker system(s) easily but also diagnose audio irregularities while mixing. These facilities should include the ability to individually solo and mute each channel. Automatic muting of all speaker channels when pink

noise is applied is another important feature, protecting ears and speakers. An interlocking solo system, whereby selection of a speaker channel switch deselects the previous selection while muting all other channels, allows a quick and easy method to calibrate each channel in turn.

You also need to be able to listen to a single speaker channel, or a group of channels, in order to isolate irregularities in the audio. You may need to diagnose a problem in the signal path of a specific channel or isolate an anomaly in the output from the decoder. Mute and solo controls provide an efficient method for diagnostic and continuity checks of every channel.

Film mixers regularly use speaker mutes to help them isolate problems in the mix. Bass redirection becomes a factor when selecting a single channel to mute or solo, however. A speaker mute will also mute the redirected low frequencies, altering the overall tone of the mix. MultiMAX avoids this problem by muting each speaker channel at its source in the monitor matrix, so that the channel source, rather than the speaker output, is muted. Muting a single channel will not defeat redirected audio to the associated monitor. Likewise, when monitoring a 7.1 mix downmixed to 5.1, for example, deselecting the left channel on MultiMAX will not mute the phantom image produced by the left-center channel.

Pots & Pans

You may perceive panning as a limitation of your existing stereo console when producing a surround sound mix. What can be achieved may depend on the preferred recorder track assignment configuration for the format. There are a number of format standards:

A. SMPTE/ITU standard
1: left front
2: right front
3: center
4: LFE
5: left surround
6: right surround

B. Film/music alternate
1: left front
2: center
3: right front
4: left surround
5: right surround
6: LFE

C. DTS
1: left front
2: right front
3: left surround
4: right surround
5: center
6: LFE

D. SDDS
1: left front
2: left center
3: center
4: right center
5: right front
6: LFE
7: left surround
8: right surround

Several manufacturers of surround sound equipment, including Dolby and Martinsound, have adopted the SMPTE/ITU layout (A), and it is becoming an accepted standard. Some film and music studios have adopted a configuration (B) that differs slightly from that standard, following instead the physical layout of the speakers in the room. The DTS layout (C) differs from both of these. SDDS (D) uses all 8 tracks, of course, unlike the other options. The 6-track formats allow a 2-track Lt Rt or Lo Ro version of the mix to also be recorded, on tracks 7 and 8.

Depending on the surround format even the most basic console can cope to a certain extent. Mixing a 4-channel format like LCRS is a relatively simple matter: Use the main left/right stereo output of the console for the left and right channels, and two auxiliaries for center and surround. This solution is less satisfactory for formats with 6 or more channels, and can be cumbersome if dynamic panning between certain channels becomes necessary. The most effective way to achieve dynamic panning anywhere within the soundfield is through the use of joystick panners, or their software equivalent. Hardware panners are readily available, and may be patched for use on specific signals.

Understanding Overpatching

There are a couple of ways around the apparent panning limitations of a stereo console. The first is to overpatch at the patchbay or via the wiring interface. Taking the SMPTE/ITU track layout as an example, panning between the left front and center channels requires you to pan between bus/tracks 1 and 3. Patch console bus output 2 to the input of track 3 on the recorder, and bus output 3 to the input of track 2. Now, when you pan between 1 (left) and 2 (right) on the input module, you will pan between tracks 1 (left front) and 3 (center) on the recorder.

Another way to achieve this is to 'mult' the same input signal to several console channel inputs. Assign each module to different tracks on the recorder and dynamically move the signal by bringing the relevant faders up or down. A fader automation system will make this method even simpler to use. The advantage of this method is that you can move the sound across 3, 4, or more channels.

Oblique Strategies

You can also pan diagonally, and front/back, using a method suggested by Bobby Owsinski of Surround Associates. Assign buses 1 and 4 to front left and front right respectively, with bus 2 assigned to left rear and bus 3 to right rear. Panning between odd/even buses will now permit front/back movement. Selecting a combination of buses – say 1, 2 and 4 – will even allow a workable diagonal pan. Various combinations of the 4 buses will in fact permit panning between all corners of the surround field. The center channel can be fed from a separate bus assignment or, better yet, an auxiliary send.

Against All Odds

Stereo consoles generally only offer left/right panning across odd/even buses. Some consoles offer panning to left, center and right. To pan from one odd numbered track to another, say from 1 to 3, may seem impossible at first, but you can achieve good results with a little planning. It helps if your console has switches to assign to individual, rather than pairs of, buses.

You will also have to get used to panning 'in reverse'; that is, panning from left to right to move the signal from right to left, as well as left to right. If you adopted the film/music alternate format, for example, moving a sound from the right front to the center channel requires you to pan from track 3 (right channel, left pan) to track 2 (center channel, right pan). As you pan from left to right, the sound pans right to left.

The First Rule Is: There Are No Rules

For those of you interested in producing music in surround sound it will be apparent that there are really no rules when it comes to the creative aspects of mixing. If you have no experience mixing in 5.1 the process may seem daunting, but remember that surround sound music production is still in its infancy, and (almost) anything goes. Even those who have some experience in the process do not agree on any number of issues nor do they employ similar methods to each other.

Some engineers place the listener in the center of the soundfield, for example, while others choose to position you as an observer, as if at a concert, reserving the surround speakers for little more than ambiance or audience sounds. There are those who prefer to place voices and instruments statically in the soundfield while others choose to move elements around, often to great effect.

The arguments for and against the different speaker layouts go hand in hand with preferred mixing methods. For example, there are arguments for and against the use of the center channel, especially positioning something like a vocal solely in the center: what if the consumer chooses to listen to that channel on its own? Many music mixers are content to create a phantom center, as is traditional in stereo mixes. But there are also disadvantages to this approach, as it is dependent on the listener being positioned optimally, which is often not possible, and the timbre is not the same as that from a direct source.

Unlike cinema, there is no standard calibrated level for the playback of CDs or music-only DVDs. These media have proven to be capable of handling high levels of low frequency information without affecting the audio quality. The majority of music mixers use full range monitors, and have little need for the LFE channel (except, famously, in the often-quoted example of the cannons in the 1812 Overture), and in any case information solely in the LFE channel will be lost in the downmix to other formats.

It will be obvious even to the casual observer that the creative process of mixing multichannel surround is still very much in flux, offering great challenges and exciting opportunities for the adventurous. Much is being written about the process, so pay close attention to the industry journals, and take some time to investigate the websites listed at the end of this article.

Martinsound REPORT
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MultiMAX 1U Master Unit and Full-function Remote

Shameless Self-Promotion

Having read this far, you will realize that a multi-channel monitor controller must offer very comprehensive features to cope with the complexities of surround sound. The Martinsound MultiMAX monitor controller offers the most comprehensive set of features of any third-party solution. It adds monitoring for 8-channel surround, 7.1, 5.1 and LCRS. It provides solo, mute and dim control. Digitally controlled attenuators give you precise level control of 4 speaker systems. But MultiMAX is more than just a level control. Like your console, MultiMAX can monitor multiple sources. It lets you monitor the mix bus or the mix recorder, 3 additional 8-channel premixes, and the production track, too. You can monitor through an external processor.

And just like your console, you can check the compatibility of your mixes – even in stereo or mono, as MultiMAX offers comprehensive downmixing in all formats to ensure backward compatibility on any playback system. You can check how your 5.1 mix will sound in stereo, or your 7.1 mix in 5.1, or how your HDTV mix will sound on a mono television. No other monitor controller offers all of these features as standard.

The easy-to-read display allows precise, repeatable setups. You can calibrate your speakers using the built-in pink noise generator and individual level trims. DVD production is made easy with MultiMAX's downmix level options, LFE filter and bass redirection features. There's even an optional fully featured remote. And MultiMAX is very affordable.

Contact Martinsound for more information on how MultiMAX can help you start mixing surround sound projects immediately without major investment.

Resources:

You might consider joining the Music Producers Guild of the Americas. There are a number of websites that provide excellent additional information on a variety of topics related to surround sound. These resources are listed in the sidebar at left.