ZEN AND THE ART OF SURROUND

You're likely aware of surround-sound and how it has impacted motion picture sound tracks since the 80's. And during the 90's it has had some impact on music, with many remixes of popular stereo tracks being done with varying degrees of artistic and commercial success. During the last decade, it's also been making real inroads into home theater systems for broadcast television sound tracks, and it could potentially replace stereo as our de facto television-listening standard, especially since the popularization of flat-screen televisions with bundled 5.1 surround systems. Surround sound just seems to be everywhere, and indeed it is.

But "surround" is a new format compared to stereo, and there are lots of myths, hearsay information, and misconceptions floating around about it. So if you're not sure what acronyms like AC-3, DTS, DVD-A, and 5.1 mean, then you're in good company.

It's true that mixing in 5.1 surround requires some extra equipment, and if you want to get into it, you'll have to learn some new techniques. But it's worth the effort; mixing music in 5.1 surround is the most exciting thing I've been involved in. We are witnessing a milestone in audio history.

Virtually every digital television broadcast is capable of surround-sound transmission, while the vast majority of consumers don't even know that they're capable of playing back surround sound. So it's up to you, the content provider, to not only educate, but to provide decent surround-sound material that won't make them hit the stereo downmix button, or change the channel.

Early Birds and Worms

Let's start at the beginning and define exactly what "surround" music is and isn't. I'm sure you're familiar with monaural (a.k.a. "mono") sound and how it works. Mono means there's only one channel of music information to deal with. This can be as simple as a cheap clock radio with a little 1-inch plastic speaker or as complex as a concert sound system with dozens or hundreds of tri-amped cabinets in large speaker stacks.

Next came stereo, our standard listening-format today. In stereo, there are two distinct information channels, and you can position various instruments between two speakers that are typically arranged in an approximately 60-degree spread in front of the listener. This allows for some pretty cool psychoacoustic tricks where the sound actually seems to emanate from a position between the speakers, even though there's no sound source in the center. This is called "virtual" center, and it is a very important concept to understand when we get into the practical details of surround.

Of course, there are a variety of ways to produce this stereo sound field or "soundstage." The simplest way is to simply use a pair of microphones on a naturally spaced music group and direct these two channels out to the speakers. But most music today is recorded in multitrack format, and at mixdown time the channels are panned left, right, or in between, creating an artificial soundstage. In the earliest days of stereo, music producers didn't take advantage of the center mix at all; lots of recordings were made with the vocals panned hard to one side and instruments panned to the other. This gave a ping-pong listening effect to some early stereo mixes, which tended to wow the masses while angering many audiophiles, some of whom insisted that a mono mix was still superior.

As we know, stereo won out and has been king for more than 50 years. There was a brief excursion into quadraphonic (four-channel) sound back in the 1970's, but attempting to squeeze four channels of music into a single record groove pushed the technology beyond its capabilities. A small group of home experimenters actually set up quad systems, and a few soundtracks were released on record and 4-track reel-to-reel tape. Quad died an ignoble death, and many people ended up with expensive gear and nothing notable to play on it. The industry never really recovered from this brief affair with quad, and to this day you can get many record executives to jump by mentioning the "Q" word.

Surround Reborn

The movie industry revived the idea of surround. Discounting the incredibly ingenious multi-channel sound tracks of Disney's *Fantasia*, the first real breakthrough was Dolby Surround, which offered left, center, and right front channels as well as a monaural, limited-bandwidth rear channel for special effects, such as Superman flying overhead. Later this was expanded to include a separate Low Frequency Effects (LFE) channel for sounds like earthquakes and car explosions, both of which the movie industry exploited with great profit.

However, squeezing four channels of sound information onto the two audio channels of 35 mm film was an imperfect solution. Depending on the exact Dolby Surround decoder you were using, the playback could be radically different. More advanced versions, such as Dolby Pro Logic, were designed, but they all suffered from the dreaded "phase" steering problems where a level change in the left channel could affect the mix in the center and rear speakers. Indeed, this is exactly how Pro Logic works, and that's its Achilles heel.

Enter the digital age. The development of the compact disc in the early 1980's provided a way to deliver large amounts of digital data. And since, as I like to say, "bits is bits," the same bits could represent a graphic picture, your accounting information, or more sound tracks. Tomlinson Holman (the "TH" in THX) was one of the leaders in surround sound in those days, and from his experiments with movie soundtracks, the term 5.1 (pronounced "five point one") was born. The 5.1 format defines six separate channels: five channels with bandwidths of 20 Hz to 20 kHz and one Low Frequency Effects (LFE) channel with a frequency response rated from 5 Hz to 125 Hz.
The channels are designated Left (L), Right (R), Center (C), Left surround (Ls), Right surround (Rs), and Low Frequency Effects (LFE).

The bright people at Dolby Laboratories found a system that could digitally compress these six channels of information into a form that would fit within the space of two stereo PCM tracks, and the Dolby Digital codec (coder-decoder) was born. Formerly known as Dolby AC-3, this is the same codec that's on many current DVD-Video movie soundtracks, and it is part of the High-Definition Television (HDTV) standard.

The situation was static for a few years, but with the release of the movie *Jurassic Park*, another competing codec format was introduced by Digital Theater Systems (DTS). The DTS codec uses less data compression and requires more bandwidth and data-storage space than Dolby Digital, so some DTS soundtrack movies don't quite fit on a single DVD disc. The benefit is that the tracks potentially can sound more like the discreet PCM tracks from which they were derived than is currently possible with Dolby Digital. Note that DTS is also the name of the data format, as well as the record label.

In addition, in the late 90's DTS pioneered a release format that uses the same disc format as a Red Book CD, but with compressed DTS data in place of PCM stereo music. DTS then formed a record label to produce remixed 5.1 surround versions of stereo releases. Many of these remixes were done by the engineers that had done the original mixes. Currently you can buy hundreds 5.1 DTS music titles, including everything from Sting, Steely Dan, Lyle Lovette, Dianna Krall, and the Eagles.

Back To Basics

Let's start at the beginning of the mixing chain and take it step-by-step. You'll need some special items to mix 5.1 surround, but believe it or not, most studios already have 90 percent of the needed equipment. By adding a few select pieces you could be mixing surround music in your own studio. Currently, no magic surround processor will turn an existing stereo mix into a proper surround mix. Most home-theater systems have some sort of "hall ambience" setting for this function, but it's the worst sounding effect you can imagine. As with most things, doing it yourself is the right way.

As noted earlier, you will need six separate playback speakers, arranged in a circle around the monitoring position (see **Fig. 1**). These channels are labeled L (left), C (center), R (right), Ls (left surround), Rs (right surround) and LFE (Low Frequency Effects). More on this later, but the channel definitions are something to keep in mind as we discuss patching options.

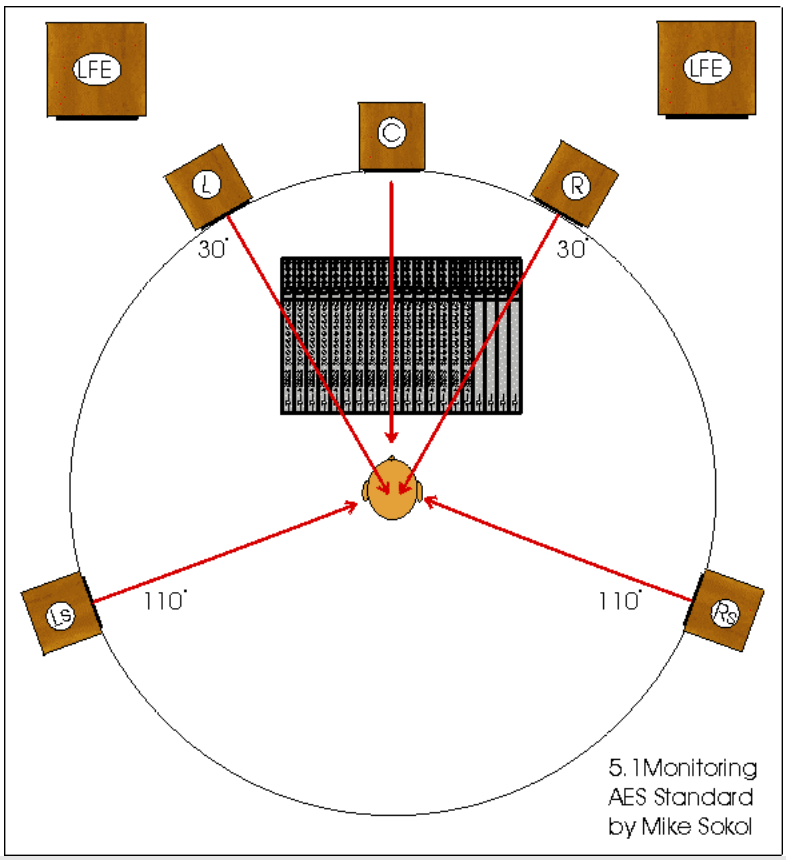

FIG. 1: Following the AES proposal for 5.1 monitoring, your left and right channels should be at 30-degree angles from center and the two surrounds should be at 110-degree angles.

The next thing needed is a multitrack master of the song you want to mix (see **Fig. 2 below**). The initial multitrack format is not an issue; it can be as simple as an 8-track analog tape, or as complex as a pair of 48-track digital decks. I've done some really cool 5.1 surround mixes using 16- and 24-track ADAT systems as well as computer based editors such as Pro Tools and Nuendo. The source tracks can be in any digital or analog format, including a computer workstation. Of course, you'll want tracks with excellent production values, since 5.1 panning won't help a bad melody or poor recording techniques. Nope, it will just be 5/2 times as bad.

Mix Me Up

You'll need to route the tracks into a mixing console that allows you to pan the input tracks between five output channels. If you have a Yamaha O2R or DM2000, Panasonic DA7, Sony DMX-R100, or Mackie Digital 8-bus, then you're already in business. Each of these digital consoles has a setup that will allow you to patch the outputs from the surround mixing matrix to a 6-channel recording deck (more on that shortly).

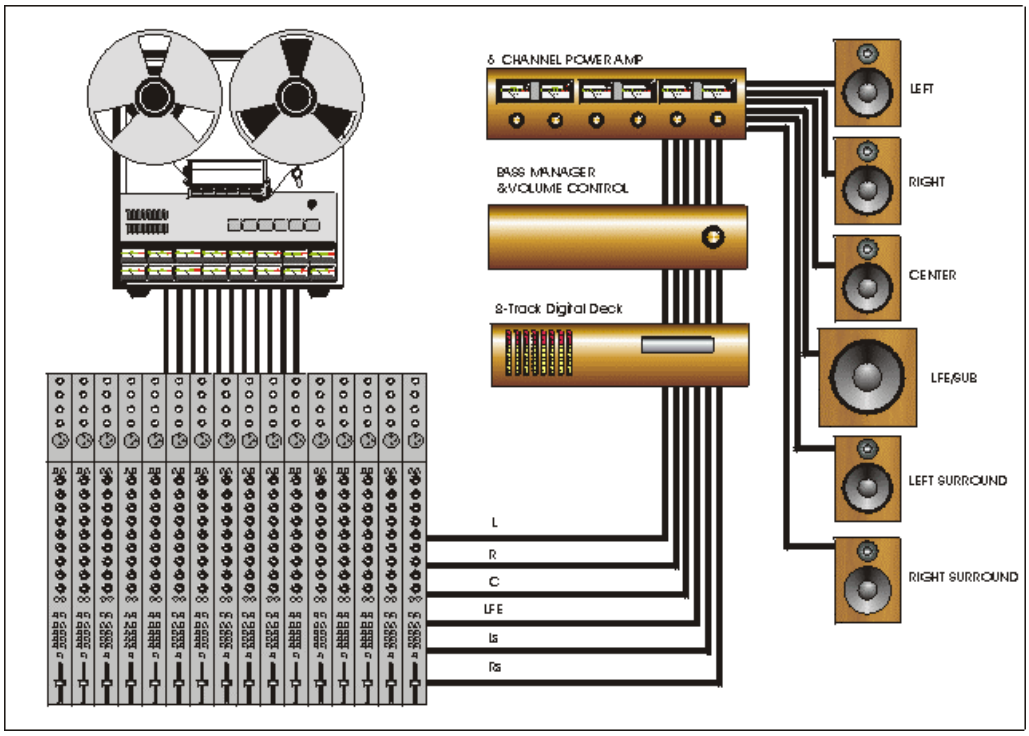

FIG. 2: You'll need two multi-track decks, one for source tracks and the other for your five full-bandwidth tracks and Low Frequency Effects (LFE) tracks. Note that the Bass Management processor comes after the mixdown deck, so it only affects the monitors, not the recording output.

If you don't have a console with built-in surround panning, it's relatively simple to patch in the equivalent using subgroups or auxiliary sends (see the sidebar). But for ease of mixing, nothing beats having a screen in front of you that shows a picture of the surround room and a cursor that shows where the sound ends up. Some earlier consoles, like the DA-7, allow you to use a pair of controls on the work surface to pan left/right and front/rear, while others, like the Mackie D8B, use a trackball or mouse to accomplish the same thing. Either way, we're basically looking for panning that can extend all the way to the rear and a center speaker that can be used in special ways that don't exist in stereo. If you have a modern version of Pro Tools, Nuendo, Digital Performer, or Logic, you're already in business for the actual mixing. You just have to monitor what's happening via a surround monitoring system.

Overpatching a Console for Surround

Even if your console has only stereo outputs and some extra auxiliary sends, you can get into the surround mixing game. Of course, doing fancy spins around the room becomes challenging, if not impossible, without a true surround panner with a joystick or a mouse. But some of my first experiments with static surround mixes were done as follows:

SIDEBAR

On a console without subgroups, if you have four extra aux outputs, you can patch them directly to the Center, Left Surround, and Right Surround Channels. For instance patch the stereo bus to the tracks for the Left and Right channels, Aux 1 to the Center Channel, Aux 2 to the LFE channel, Aux 3 to the Left Surround, and Aux 4 to the Right Surround. The LFE output should be filtered with a low-pass filter somewhere around 80 Hz so that it's completely out at the 120 Hz brick-wall filter limit of 5.1 encoders. This patching works fine for static mixes such as symphonies, where you're only setting the relative levels in each channel for the duration of the track. But getting an audio source to pan across the sound field takes a few tricks with subgroups.

On a console with at least four subgroups you can assign buses 1 and 4 to the front left and right front channels, with bus 2 assigned to the left rear and bus 3 to the right rear channels. Patch separate aux buses for the Center and LFE channels. Now by panning between odd and even buses you can perform front to back moves in the surround sound field. Also, by selecting a combination of buses, such as 1, 2, and 4, you can even manage a diagonal pan. This system can work out quite well with consoles that have pan and subgroup automation.

Patch the output of the console to another 8-track deck, where your surround tracks will reside (see **Fig. 2 above**). The Tascam DA-88 has been the standard multi-track deck for surround due to its popularity in the film industry, but any common 8-track format will work, including a computer workstation. You don't even need a Dolby Digital or DTS encoder to mix surround tracks; encoding is the last part of the process. But whatever you record your mix on, the track assignments must be carefully noted, because unlike stereo, there are many different track-assignment methods to choose from. **Table 1** below shows a list of the most common track-assignment systems.

Table - 1

Track	1	2	3	4	5	6	7	8
Mode 1	L	R	Ls	Rs	C	LFE	Lt	Rt
Mode 2	L	C	R	Ls	Rs	LFE	Lt	Rt
Mode 3	L	Ls	C	Rs	R	LFE	Lt	Rt
Mode 4	L	R	C	LFE	Ls	Rs	Lt	Rt
Mode 5	L	C	Rs	R	Ls	LFE	Lt	Rt
Mode 6	C	L	R	Ls	Rs	LFE	Lt	Rt

Key: L = Left, C = Center, R = Right, Ls = Left Surround, Rs = Right Surround, LFE = Low Frequency Effects. Lt and Rt = left and right stereo mixes.

Surround Track Assignments

No standard has been established for assigning channels to tape/disk tracks for surround mixing. However, these six modes are the most commonly used. Make sure to mark every mix tape or file so the track assignments are clear to all who need to work with them. Note that tracks 7 and 8 can be used for recording a separate stereo mix. That way, if the end users choose to listen in stereo, they will hear a real stereo mix rather than a downmixed version of the 5.1 mix.

But, many times you won't have a real choice in which channels end up on what tracks. For instance, small format mixers are often set up to patch their surround outputs in Mode 4, whereas many large-format consoles and some mixing programs (such as Logic) are designed to be used in Mode 1. Lots of consumer products use Mode 2 or some variation of it. So try to pick one output format and label it on every 5.1 file or tape you make. Eventually, someone will have to figure out your track assignments in order to encode them to a DVD or DTS disc or broadcast system, and you don't want your sloppy work habits to jeopardize a project.

Speaking Of Speakers

Obviously, you will have to upgrade your monitoring system to include five speakers and a subwoofer so you can hear what you're doing in 5.1 surround. The simplest and perhaps best setup for music mixing is to use five matched near-field reference speakers. Which speakers you use is up to you; I favor the Tannoy System-800 speakers with the Supertweeters added on, but I've also heard some great mixes on the little Alesis Monitor Ones and Yamaha NS-10s. The key is to match the speakers as closely as possible, because the relationships between the center channel and the left and right levels are critical, and the relationships between the front and surround speaker levels affect the final mix much more than you would imagine. You could mix and match speakers, and many excellent surround mixes have been done on oddball center and rear surround speakers, but I recommend that you use a matched set and not risk putting yourself at a monitoring disadvantage.

The physical speaker layout can be pretty simple. Just put a mic stand in the center of the mix position and run a string around the room like a compass. Now mark off the center speaker position and go 30 degrees to the left and right for the front L/R speaker positions. Next, go 110 degrees from the center each way for the Ls and Rs (surround) channels. This is the AES standard for monitor placement.

There are various ways to place the rear speakers. Some of them make more sense for cinema mixes, while others work better when you have a client in the room with you rather than doing a solo mix. Don't cast the rear speaker platforms in concrete just yet, because you'll probably change your mind a few times and move the speakers around after your first few mixes.

There are lots of other surround speaker options, especially if you're mixing for the cinema. The details are beyond the scope of this article, so for now I'll just note that these options mostly involve creating a diffuse rear-field, either with banks of small, direct-radiating speakers or by using some sort of dipole push-pull, side-firing speaker.

More Power

You'll probably need to upgrade your power amps, too. Many big studios can afford separate amplifiers and a monitor controller to run them, but personal-studio owners should consider buying a big, consumer home-theater integrated amplifier instead. These can be had for less than a few hundred dollars and can provide in excess of 100 watts per channel. They also offer a single level control that will work on all six speakers

simultaneously, but make sure the receiver has separate analog inputs with its master volume control downstream of those same inputs. Generally speaking, if the receiver has separate 5.1 to 7.1 analog inputs, then the volume control should come after those inputs. However, don't count on bass management to operate on those same analog inputs. But more on that later.

Make sure the home-theater amp you choose has discrete analog inputs, as well as Dolby Digital and DTS decoders, so you can hear your mix from the console. These features allow you to compare your discrete mixes directly against commercial mixes from DVDs or DTS CDs. Moreover, if you're doing your own DTS or Dolby Digital encoding, the analog outputs provide the only way to listen to your final mix as the consumer will hear it. These integrated amps may also provide bass management (more on that later) and speaker-calibration options. Just be aware that most (if not all) of these receivers disable the Bass Management for the discrete analog inputs, so you'll need to add some sort of external bass management filter for these such as the BMC 5.1 Mini ($300 from Miller & Kreisel), or use the bass redirection functions included in many workstations such as Pro Tools Woofie and MOTU's Digital Performer. These applications do the bass management for the monitor outputs feeding the speakers, while keeping the output track full-bandwidth for the internal bounce to 6 tracks.

I'll Level With You

It's extremely important to set the relative volume level of each speaker properly. Although it's very easy to tell when the left and right levels are wrong in a stereo mix—you can hear the sound leaning one way or the other—it's not simple to hear the balance with a surround system. You'll need to purchase at least an inexpensive SPL meter to do this properly, and it's amazing to see how many $50 Radio Shack meters are used in this way. Oh, and by the way... if you have an iPhone, you can get a pretty decent SPL meter app for less than a dollar. It's a great time to have new technology in your pocket.

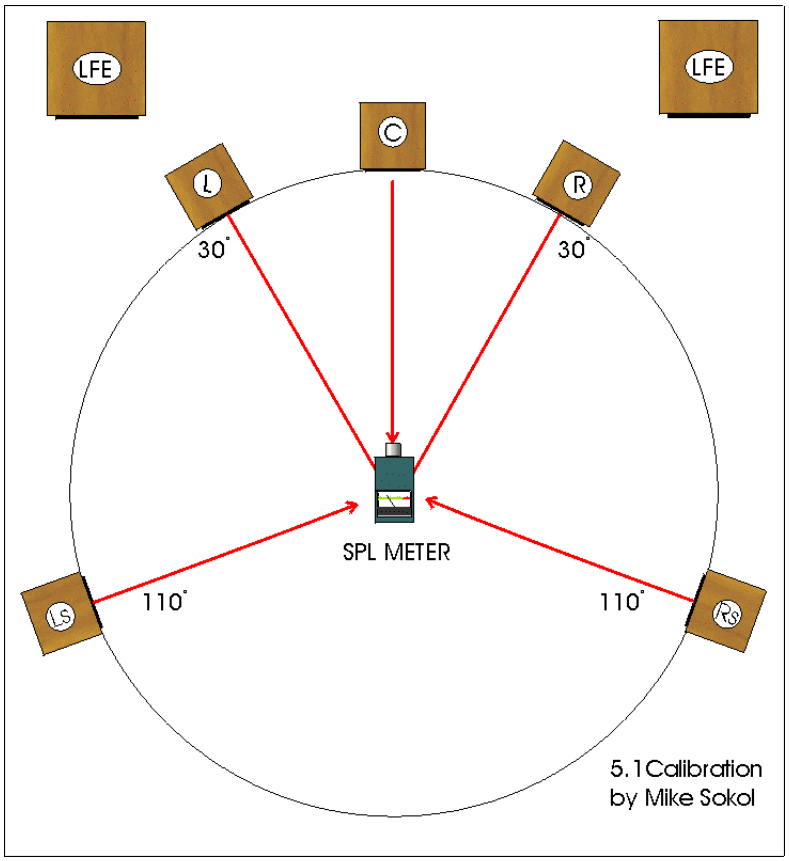

FIG. 3: Calibrating your speakers to ensure that their levels match is absolutely critical to 5.1 mixing. Feed pink noise through each speaker and check the level on an SPL meter, keeping the meter in the same spot. Full-bandwidth speakers should output 85 dB SPL, and subwoofers should deliver 95 dB.

I could write a whole book just on speaker placement and calibration, but for now, here's the quick and dirty. Grab some limited-band pink noise—100 Hz to 10 kHz—either from a mixing-console noise generator, a home-theater receiver, or a test CD and patch it into an input channel on the console. Pink noise is also available from http://whirlwindusa.com/support/downloads/downloads (Pink Noise_DTS.WAV). Make sure the output gains of whatever surround matrix you're using are set to unity. Set the input strip on the console so that the output level going to the mixing deck is at –20 dB (below zero) on the meter. This is the standard reference level for surround mixes being done for Cinema and Movie DVD discs.

Feed the pink-noise through one speaker at a time and point the SPL meter in the speaker's direction while holding the meter in the same center location (see **Fig. 3**). Trim the gain of the amplifier so that the meter shows 85 dB SPL. Repeat this process for each full-bandwidth speaker, one at a time, until you have the same output for each.

Next, run low-frequency pink noise (30 Hz to 120 Hz) to the LFE Subwoofer channel. In theory, the gain of the LFE channel should be set 10 dB higher (95 dB SPL) as read by a Real Time Analyzer (or RTA for short), but since the SPL meter is only responding to two octaves of energy from the subwoofer, it will end up reading +4 dB above 85 dB SPL when the LFE speaker level is correct, or approximately 89 dB SPL.

For diffuse surround speakers used in cinema and many broadcast mixes, the rear surround levels are set to 82 decibels (-3 dB relative to the other full-bandwidth speakers), and for really small mixing rooms where you can literally reach out and touch the speakers, Dolby recommends setting the mono-pole surround speakers down by 2 dB to 83 decibels. So it can be a bit confusing. For most music mixing, having all five speakers set the same SPL will be close enough. But you still must get the LFE channel playing back at +10 dB if you're going to use the LFE track at all.

If you don't get these levels correct, then all the mixes you do will have incorrect surround and center channels levels, or the LFE level will be out of control during consumer playback in the home. This will force the home listener to jump up and adjust the levels on their home system, which is a bad way to make a mix.

Bottom Feeding

Bass management is probably the least understood part of surround mixing, but it's very important to understand how it works, lest you make mixes that sound great in your studio but are unlistenable on a standard home-theater system. As noted earlier, in 5.1 surround, each of the main channels is rated at 20 Hz to 20 kHz, while the LFE channel is rated at 5 Hz to 120 Hz. That 5 Hz is not a misprint; such low frequencies could offer surround systems in cars a new way to make your ears bleed.

However, while a program channel goes as low as 20 Hz, very few home-theater speaker systems can produce any reasonable output at that low frequency. So a clever circuit in the amplifier system removes any of the low-frequency energy below 80 Hz that's destined for the L, R, C, Ls, and Rs speakers and reroutes it to the LFE subwoofer. This is exactly how the early subwoofer/satellite systems worked. The manufacturer could make a small bookshelf speaker that sounded great above 100 Hz or so, and the bass would be handled by a coffee-table size speaker on the floor. In the case of THX designed bass-management for 5.1 surround, the subwoofer is now doing double duty: it's handing all the bass below 80 Hz for each of the main and surround channels, as well as the point one (.1) LFE channel on the DVD, which might be an earthquake or gunshot.

But there's something else going on in home-theater systems called *bass management*. Assume you've put up five NS-10 speakers and a big subwoofer in your studio for monitoring. Each speaker is directly monitoring a final output track. Now, the NS-10 has a small woofer in a small cabinet, so it will naturally roll off anything below 60 Hz or so. If your source tracks have any sonic material with extra bass in the 20 to 40 Hz region, you'll never hear it on these small monitor speakers.

Let's also assume a few of your tracks have some undesirable subsonic information — maybe some vocal plosives or air conditioner rumble you weren't aware of. While the natural filtering action of the NS-10s may make you think all is well, when this mix is played back in any home theater system, the bass-management filter in the playback system will faithfully reroute this low frequency garbage into the LFE subwoofer, where it will be available for all to hear. Lately I've been listening to some classic stereo mixes over my NHT Pro monitors with an M&K subwoofer, and it's amazing to hear the traffic rumbles and thumps in the studio. Some of my initial surround mixes weren't monitored with extended bass monitors or bass management, and when I took the mixes into my local hi-fi store, the bass garbage caused the subwoofer to try to jump off the floor. Pretty embarrassing for a live broadcast, and potentially expensive if those mixes had been pressed into thousands of copies and distributed. So if each of your main speakers can't produce down to 20 Hz, you have a potential mixing disaster if you don't have some sort of bass management in place for your monitoring system. And yes, that's vitally important in your recording/broadcast truck for a live sporting event.

What's another reason you need bass management (A.K.A. *bass redirection*) in your studio? It's the law of inverse mixing. A speaker that's deficient in a part of the audio spectrum will force you to overcompensate for the missing frequencies by adding. Try doing a mix with blown tweeters sometime and you'll see what I mean: because you hear fewer highs than are really going on tape, you'll overcompensate with too much high-frequency level in the mix.

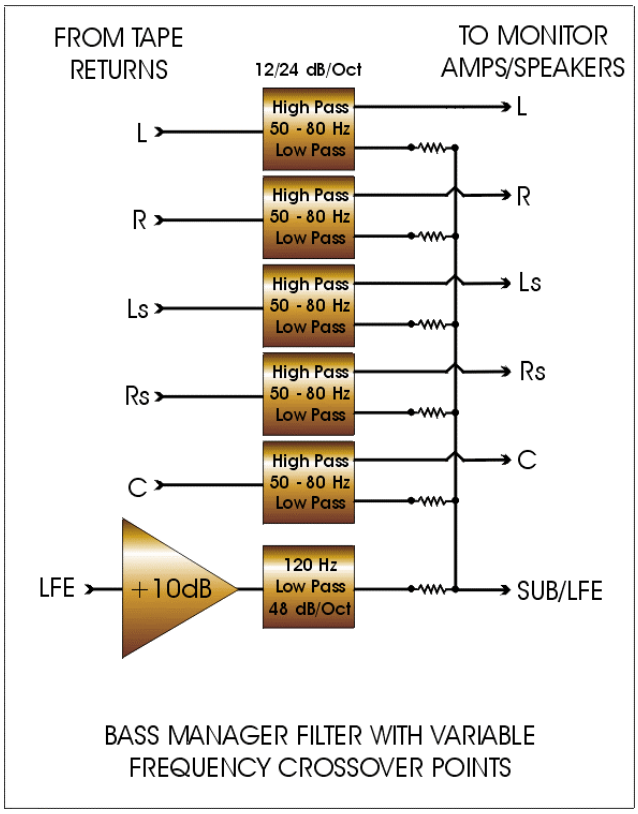

FIG. 4: Although the subwoofer handles the bulk of the low-frequency (below 80 Hz) playback chores, you still need to feed full-bandwidth audio to the other 5 channels.

The bass-management filter shown here only affects the monitor system; the recorded L, R, C, Ls, and Rs channels still contain the entire, unfiltered signal.

Simple enough, right? Yet a lot of mixing engineers think that bass management has something to do with filtering the signal before it goes to the final mix-tape tracks, and that's simply incorrect. In fact, each of the L, R, C, Ls, and Rs channels needs to get the full 20 Hz to 20 kHz program signal. You don't want to cut off some of the lows and put it in the point one (.1) LFE channel. What you want is a bass-management filter in your *monitoring* system that will emulate the home-theater playback system (see **Fig. 4**).

Note that this filter is placed *after* the mixdown recording system and directly feeds the monitor amplifiers, as shown in **Figure 2 above**.

Another misconception is that you have to match the 80 or 120 Hz bass-management filter points in home systems to properly monitor in 5.1 surround. Since this is for playback and monitoring only, you only have to do what's needed to extend the low-frequency ability of your own monitoring system. Just as we don't care about the crossover frequency of the midrange speaker in a home system, we don't know (and don't care) what the exact bass-management frequency is for the consumer. We just know that somewhere around 100 Hz, all the bass energy will head to the big subwoofer

cabinet. That's why I think that a somewhat lower crossover frequency than 80 Hz is better in the studio.

Since my playback monitors will go nicely down to 35 Hz, I would like to adjust my bass-management frequency down to 50 Hz or even 40 Hz. This will limit the bass-localization effect—yes, you can localize 80 Hz bass, contrary to popular belief—as well as taking some of the power load off the subwoofer, which is attempting to reproduce the bass for the other five main channels as well as the LFE information. That's why you should buy the largest subwoofer that you can afford and fit in your studio or remote truck. The subwoofer probably needs as much power as all your other speakers combined so that it won't run out of steam before they do. But practically speaking, two to three times the power of one of your other speakers will probably get you by.

TAKING CONTROL

Once you have all of your speakers set up and level matched, it's important to use a controller that adjusts the level up and down equally at each speaker or the positions of the elements in the mix will shift as volume is adjusted. This will give you a false sense of where that particular element is located in the monitoring space.

The Whirlwind 5.1PA controller avoids this by adjusting all speakers symmetrically, with a precision of 0.5 dB from full up to full attenuation, perfectly maintaining the surround image.

Downmixing Basics

There's one other bugaboo that you need to watch out for when doing surround. All 5.1 mixes might be downmixed to stereo at some point. For instance, if the consumer is listening to a Dolby Digital DVD or DTS CD of one of your mixes and selects the stereo option, the six channels of information are mixed down to a pair of stereo channels and played out the main left and right outputs.

In a downmix, the center-channel information gets added into the left and right channels, while the left surround and right surround channels get added into the left and right front channels, respectively. Some systems add the LFE channel into the stereo pair; but the most standard downmix algorithm throws away the LFE information.

All of this would be fine in a perfect world, but in the real world, lots of potential phase conflicts are set up. For instance, if you put some sort of awesome-sounding delay between the left-front and left-surround channel, when those channels are combined into one you could end up with a huge, phasey sound. In such cases, something that sounds great in 5.1 surround can be unlistenable when downmixed to stereo.

Think your carefully crafted 5.1 mix will never be heard in stereo? Think again. Just as we need to check stereo mixes for mono compatibility, we also need to check for stereo compatibility of our 5.1 mixes. At the very least, a stereo version of your songs may be

needed for radio play, and Lady Luck will probably make it the downmix of the one song that sounds like it was mixed in your washing machine. I've heard some very high-end surround mixes done by the most famous engineers on the planet that just sound horrible when auditioned in stereo. Guess what? Those engineers didn't know about or have the tools to understand the effects of downmixing.

What can you do about it? At the least, you need to have a way to monitor the downmixing-cancellation effect. The Whirlwind 5.1PA controller provides a "Stereo Downmix" button which performs the downmix for you and turns off the LFE channel. Use it periodically to check your downmix. Then you can easily hear potential phase-cancellation problems.

Furthermore, you should always do a separate stereo mix of any 5.1 surround mix. That's because certain DVD formats, specifically the new DVD-Audio (DVD-A) format, have enough data room to include both a 5.1 surround version and a stereo version of your mixes. That way, when consumers select "stereo," they hear your original stereo PCM version of the mix rather than a downmixed 5.1 mix. The proper place for this true stereo version to exist is on the same 8-track master tape of the 5.1 mix itself, on tracks 7 and 8 (see **Table 1 above**). So even if you have to do the mix in two passes, one for surround and the other for stereo, you'll be way ahead of the game when someone requests a stereo version of the mix.

Encode Thyself

The final part of making a 5.1 mix is the encoding. **Figure 5** shows where the encoder fits in the mixing chain in a hardware-based system.

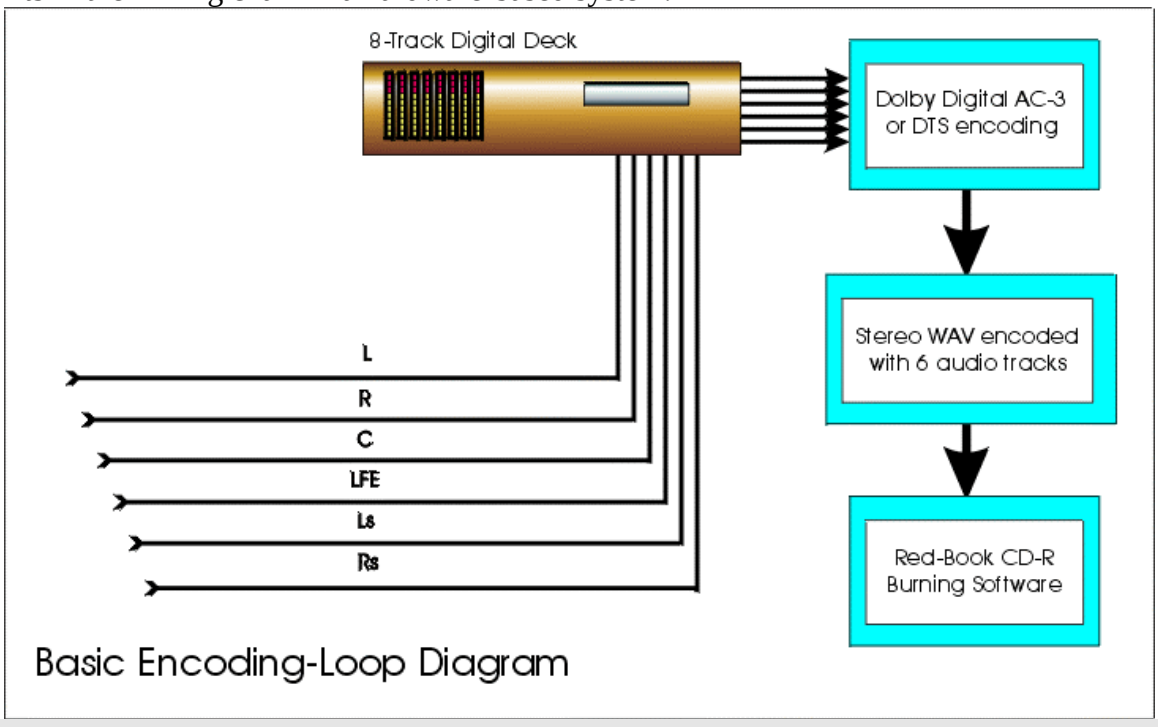

FIG. 5: If you are using a hardware-based system, as against a computer-based system, you need to patch the output of your 8-track mixdown deck to a Dolby Digital or

DTS encoder. With a computer-based DAW, of course, this is all done in software. The system shown here produces files that can be burned to CD-R.

For the first few years of surround, if you wanted to make a one-off DTS disc of your 5.1 mix, you needed to send a six-track tape to DTS, and the company would encode the tracks and send you back a DTS CD-ROM. But now you can get a standalone Dolby Digital or DTS encoder for Windows from Minnetonka Audio as well as plug-ins for Pro Tools and Steinberg Nuendo that will allow you to take your six discrete surround tracks and encode them as a single Dolby Digital or DTS file with a WAV extension. This DTS file can then be stored as a WAV and later burned onto a standard CD-R disc using any CD-burning application. Then your file will play back through any home theater system that has a DTS decoder. You can get plug-ins for Pro Tools from Kind of Loud, and for Nuendo directly from Steinberg.

One other thing to watch out for is that although a "burned" DTS disc acts like a Red Book CD-R—technically, it's an Orange Book disc—the disc might not play back in earlier generation DVD players. That's because the color of the dye and reflective layer in the CD-R media itself may not be seen by the frequency of the laser in the DVD player's pickup. The current generation of DVD players have dual-laser pickups, which allows them to read any color (and chemistry) CD-R. Interestingly, CD-R media that's more "gold" in color (such as the Kodak discs) seem to have a better chance of universal DVD playback when compared to the dark blue or green CD-R discs. Interestingly, a CD-RW (rewriteable) disc will play back on nearly every DVD player, even the old ones. So if you can't get a CD-R disc to play in your DVD player, burn a CD-RW disc and give it a spin. Of course, you can also play back a DTS disc in a standard CD player via its S/PDIF port and a DTS-equipped receiver.

Those of you using Dolby Digital AC-3 encoding for DVD authoring can burn a 44.1 kHz version of an AC-3 file and put it on a CD-R disc for playback in most standard home systems. You can get Dolby Digital encoders from Minnetonka Audio Software. Also, the Dolby Digital AC-3 encoder is bundled as part of the Final Cut Pro editing program from Apple Computer. The encoding procedure is the same: load the six discrete audio tracks into the computer and toss them into the encoding software. By selecting the AC-3.WAV output, an AC-3 file is created that's been padded out to fit in the exact same space as a stereo PCM file. Again, this file can be stored and burned on a standard Red Book CD for playback in most home-theater systems.

This format isn't recommended by Dolby Labs, and it's not 100 percent reliable because some Dolby Digital decoders aren't expecting an AC-3 file to be coming from a S/PDIF stream with the Audio/Data flag bit set to Audio. Nevertheless, it works perfectly on many decoders and receivers. Up until Minnetonka licensed the DTS encoder algorithms a few years back, this was the only way to hear a one-off version of your surround mixes on a home-theater system without dragging a multitrack deck and media around.

Bio: Mike Sokol is a live-sound and recording engineer with over 40 years experience on both sides of the console. Now just when you've got stereo figured out, along comes surround. May you live in interesting times.