The Dolby Surround Mixing Manual is available in two formats: Vertical pages and horizontal pages. The vertical format, publication S98/11932, is designed for printing to US letter or A4 size paper. The horizontal format, publication S98/11931, has been created to facilitate on-screen viewing. Both versions are available on the Dolby Laboratories website at www.dolby.com/tech/.
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Dolby Surround is a format that enables the production and delivery of multi-dimensional soundtracks for television, cable, consumer video, compact disc, video game and other stereo media. Once created, Dolby Surround soundtracks can be recorded, broadcast and reproduced in the same manner as any conventional stereo programs, including compatible monophonic playback. Consumers equipped with Dolby Surround systems will experience the full measure of spatial dimensionality built into these programs, just as they do from thousands of Dolby Stereo movies currently available on home video media.

Many aspects of producing soundtracks in Dolby Surround are the same as producing soundtracks in stereo. The main difference is that the mixing console must have at least three and preferably four outputs to feed the Dolby Surround encoder. To complete the surround system, additional speakers and amplifiers are needed to monitor the Center and Surround channels via a Dolby Surround decoder.

In most cases the finished two-channel encoded soundtrack is all that will be recorded or broadcast. However, in some cases it may be desirable to record the four-channel stems (Left, Center, Right and Surround encoder input signals) onto separate tracks when further elements are to be added later, such as with music pre-mixes for movie soundtracks.

This manual covers the information needed by production personnel to properly produce soundtracks in Dolby Surround.


Chapter 2
Technical Guidelines

2.1 Equipment from Dolby Laboratories

2.1.1 Dolby Model SEU4 Surround Encoding Unit
The SEU4 receives four input signals (Left, Center, Right and Surround) from the audio console and matrix encodes them into two output signals (Lt and Rt). The Lt and Rt signals are then treated as any stereo signal would be for transmission and recording.

2.1.2 Dolby Model SDU4 Surround Decoding Unit
The SDU4 decodes the two-channel encoded signal (Lt and Rt) into four output signals (Left, Center, Right and Surround) using Dolby Surround Pro Logic decoding technology. The unit also provides switchable stereo and monophonic monitoring modes for evaluating mix compatibility. A ganged master fader allows all four monitor output channels to be varied together, allowing variations in listening level while maintaining playback balance and calibration.

![Figure 2-1 Dolby Model SEU4 and SDU4](image)

It is important to listen through the decoder while mixing in order to hear any subtle changes that may be created by the Dolby Surround matrix encoding process.

Both the SEU4 and SDU4 are available for purchase from Dolby professional products dealers and for rent from several studio equipment rental houses.
2.2 System Information

2.2.1 Room Layouts

The various room possibilities for working with Dolby Surround encoding all conform to a basic standard. They all require the typical Left and Right speakers we have grown accustomed to for stereo production. In addition to the stereo speakers, a Center channel speaker and two or more Surround speakers are needed, Figure 2-2. Individual room requirements will determine exactly what is needed for the Surround channel.

![Figure 2-2 Typical Room Layout](image)

2.2.2 Control Rooms

Because of the need for even Surround channel dispersion, Dolby Laboratories recommends that room layouts such as shown in Figure 2-3 use two Surround speakers.

![Figure 2-3 Sound Field Pattern with Two Surround Speakers](image)
For rooms similar to Figure 2-4, four Surround speakers will better serve both the mix engineer mixing and the clients listening in back. Attempts to share two Surround speakers with this configuration have proven that both listening positions are compromised. When the balance is correct for the engineer, it will usually be too loud for the client. When a compromise in balance is necessary, rooms should always be optimized for the engineers listening position. However, the better solution is for both the engineer and clients to have their own set of Surround speakers.

2.2.3 Remote Trucks

Remote trucks producing live shows offer a challenge for Center channel speaker placement. Usually the position desired for the Center channel speaker is either already occupied by equipment and video monitors vital to production, or is occupied by the window to the main production area. In this case a Center channel speaker would block the line of sight view to the director. Neither of these scenarios are desirable and the only reasonable solution is to not use a Center channel speaker. Because the mixer is in close proximity to the Left and Right speakers, mixes can be successfully created using this arrangement. This is not an ideal situation, and assistance by those at the station who can check the mix with a proper monitor setup is usually required.

2.2.4 Critical Listening Rooms

Critical listening rooms, mastering rooms, television master control rooms and screening rooms are similar to control rooms. For larger rooms, several Surround speakers may be used in an array much like a movie theater as shown in Figure 2-5. In
these applications, the SDU4 is ideal. However, many facilities also set up separate Home Theater rooms complete with a typical living room atmosphere. In these situations, a living room environment with a complete consumer system including a Dolby Surround Pro Logic receiver, VCR, laser disc player, CD player, etc. and consumer grade speakers will give clients a good idea of how the project will translate when played back at home.

![Figure 2-5 Large Listening Room with Surround Speaker Array](image)

2.2.5 Consumer Decoders

Consumer Dolby Surround Pro Logic decoders operate in an identical fashion to the Dolby model SDU4 professional decoder, but they include foolproof circuitry such as auto-balance to correct left/right balance errors. This function is undesirable when mixing or checking for quality as it could cover up the problems being checked for. Features such as this are needed at the consumer level to correct imbalances between channels introduced during transmission or tape duplication. Consumer decoders also do not normally have enough time delay for studios or a simple way to compare Mono, Stereo and Surround compatibility. While they are fine for small listening rooms, consumer decoders should never be used in control rooms as part of the mixing process.
2.3 Additional Equipment Required

2.3.1 Speakers and Amplifiers

The speaker setup for front speakers may be accomplished two ways. Either add a Center speaker that matches the acoustic characteristics of the existing Left and Right soffit speakers or install three identical near-field monitors. In either case, it is important that the design of all three front speakers be identical or panning from one type of speaker to the other will cause great differences in the sound. This does not mean that they all have to be the same size. It is quite acceptable to use large Left and Right speakers and a smaller Center speaker from the same product line. If possible, the Center speaker should have the same high- and mid-frequency drivers as the Left and Right speakers.

When placing the speakers, it is important to keep the distance from all three of the front speakers equal with respect to the mixing position, Figure 2-6.

![Figure 2-6 Front Speakers Equidistant from Engineer](image)

Using soffit-mounted Left and Right speakers with a Center speaker sitting on the console overbridge is not acceptable, Figure 2-7, because the Left and Right speakers will be too far from the mixer.
The Surround speakers can be smaller bookshelf-type speakers. The actual frequency response of the Surround channel is 100 Hz to 7 kHz so large speakers for bass reproduction and extended range tweeters for ultra-high frequencies are not necessary. It is important, however, to choose Surround speakers which sound similar to the front speakers throughout the 100 Hz to 7 kHz range and a smaller speaker from the same product line is usually the best choice.

If all three speakers in the front are identical, the power amps for each should be rated equally. If the Center speaker is smaller, and the Center channel bass is being redirected to the Left and Right channels, see Part 2.3.3, the power rating of the center amp should be at least 75% that of the left and right amps. The total power provided for the Surround channel should not be less than the power provided for one of the Left or Right channels. If separate amps are used for each Surround speaker (the preferred method), each amp should have at least 50% of the power of the left and right amps. If one amp is used for the Surround channel (all right to do, but not as desirable), it should be rated the same as left and right amps. For example, three identical front speakers with three 100-watt amps and two 50-watt amps for the Surround speakers.
2.3.2 Center Channel Speaker

The Center channel speaker is used to anchor dialog and other sounds to the screen. In conventional two-speaker configurations, the listener can only hear a balanced mix when seated exactly in the center or sweet spot, Figure 2-8. This configuration provides a good phantom image.

Figure 2-8 Listener in Sweet Spot

If the listener moves to either side of this sweet spot the mix will become heavy on that side. This results in the listener perceiving the Center channel as coming from a point which is not halfway between the Left and Right speakers as in Figure 2-9. In this configuration, the phantom image is displaced, off the screen.

Figure 2-9 Listener Shifted to Side
This produces an eye/ear conflict, the visual image doesn't match what is heard. By adding a Center speaker, the center information, such as dialog, will stay locked on the screen no matter where the listener is seated, Figure 2-10.

![Figure 2-10 Defined Image](image)

Also, because most engineers are used to mixing with a phantom center, it is easy not to realize how much mono or center information is in a typical mix. When the center speaker is added, all mono information will be reproduced by it. The result is usually a narrower mix than most people are accustomed to. This further supports the need to have a Center speaker in the studio in order to hear what people will hear at home with a Center speaker.

The Center speaker should be placed in the same horizontal plane as the Left and Right speakers whenever possible, Figure 2-11. In near-field applications, this is usually a simple task.

![Figure 2-11 Front Speakers in the Same Horizontal Plane](image)

When soffit mounted speakers are used, this task may be more difficult due to the conflicts with video monitors. If it is not possible to put the speakers in the same horizontal plane, the Center speaker should be placed either above or below the video screen, as in Figure 2-12 or Figure 2-13.
The goal is to place the high frequency drivers, tweeters, in a straight line. This may require turning the Center speaker upside down or sideways, Figure 2-14. Make sure that the high frequency driver is oriented for the correct dispersion characteristics if you use it in any position other than its normal one.

2.3.3 Smaller Center Channel Speakers

Many speaker product lines contain different sized models of the same design. In these cases, the midranges and tweeters are normally exactly the same while the woofer will differ in quantity and size. In cases where soffit space is limited, a smaller version of
the main Left and Right speakers may be the only option for the Center channel. The Dolby SDU4 will allow for the smaller Center speaker, with its reduced low frequency capabilities, by redirecting the Center channel low frequency information below 100 Hz to the Left and Right speakers. For further information on implementing this function, please see Part 3.6.1 Bass Splitting Modification.

### 2.3.4 Surround Channel Speakers

For normal Dolby Surround installations, small bookshelf speakers will suffice. However, you may wish to consider planning for the future. The 5.1-channel mixing format is currently the format of choice for mixing motion picture, Figure 2-15.

![Figure 2-15 5.1-Channel System Room Layout](image)

This format uses the same three full range front channels, two full range Surround channels and one Low Frequency Effects (LFE) or boom channel. The LFE channel is band limited from 3 Hz to 120 Hz in the Dolby Digital format. A subwoofer, separate from any other front channel subwoofers, is normally connected to this channel with an appropriate amplifier. Since the Surround channels are independent (stereo) and full range, a little extra expense, wiring and thought may save headaches down the road.

To be 5.1-channel ready, full range speakers should be used in each location. If a smaller Center channel speaker is used, the same model may also be used for the Surround speakers. A separate power amplifier should be used for each Surround speaker. Home runs, direct individual runs, should be used for the audio wiring from each speaker to the amp rack or patch bay (for self powered speakers).

### 2.3.5 Surround Speaker Location

For installations using one pair of speakers for the Surround channel, the speakers should be placed on the side walls approximately two feet behind the engineer’s seating position and at least two feet above the engineer’s head. They should be pointed to an imaginary spot two feet above the engineers head as in Figure 2-16. If
four or more speakers are used, the same guidelines apply for each set of speakers. In any case, a Surround speaker should never be pointed directly at the listener or below their seating position.

Figure 2-16  Vertical Location of Surround Speakers in Control Room

2.3.6   Audio Consoles
The flexibility of the console will greatly affect surround mixing capability. While it is possible to create a Dolby Surround mix on a console with as little as a stereo buss and one auxiliary send, the ability to do complex mix moves will be virtually nonexistent. A console with film-style panning will allow the greatest flexibility in placing sounds exactly where they are desired. Console automation will also help in creating complex mixes. The exact needs for each particular application will depend on how complicated the mixes will be. When making decisions on new equipment to purchase, it is a good idea to think about future needs and not just those of today.

2.3.7   Monitor Path
The normal audio path is from the console to the encoder to the recording device to the decoder to the speakers, Figure 2-17.
In most cases, this configuration will disable console functions such as solo and source selection. To continue to use these functions, it is necessary to install the decoder in the monitoring path of the console, Figure 2-18. A few manufacturers have installed patch points in the proper place for this purpose. If you have this feature, follow the console manufacturers instructions for installing the decoder. If you do not have this feature, some wiring or modifications may be required.

The easiest way to add the decoder is to simply connect it to the control room monitor outputs of the console. If this is done, three things must be checked. First, the control room monitor level pot will need to be set in a fixed position and then left there. The decoder requires a calibrated reference level which will change if the control room level pot position is changed. While operating in this way, the level control fader on the decoder (which can be remoted) becomes the new control room monitor level control. Second, the insert point for the decoder needs to be prior to any speaker switching circuitry for alternate speakers. In most consoles, this will require a bit of modification to add the insert points. Third, you may need to add switching circuitry for the extra speakers that are part of the surround monitoring system.
Figure 2-19 Modified Monitor Section of 2-Track Console

The other alternative is to only feed one set of speakers, usually near-field, when doing a Dolby Surround mix. In this case, the control room monitor output is fed to the decoder, which in turn feeds the speakers as was shown in Figure 2-18.

2.3.8 Speaker Sound Pressure Level

Speaker level is adjusted using the decoder's internal pink noise generator. For film work, the industry standard is to set the gain of each channel so that pink noise at 0 dB reference level reproduces at 85 dB SPL, C-weighted, slow. If projects are being mixed for theatrical release, the system should be calibrated to this level.

For music mixing, the 0 dB reference levels should be set for the same SPL in each channel. However, some engineers like to mix more loudly than others. As long as all channels are calibrated at the same level, the overall volume setting is not as important.

For remote trucks and very small mixing rooms, the Surround channel is generally set 2 dB lower than the front channels, e.g. 85 dB in front and 83 dB in back. This takes into account the closeness of the Surround speakers and has proven to make the sound at home very close to what the mixer heard while mixing in this small environment.
For home video releases the 0 dB reference level is usually set to 79 dB. This lower level is used to ensure that dialog will not be lost in a typical, somewhat noisy, home environment.

2.3.9 SPL Meters

In order to properly calibrate speaker levels, a sound pressure meter is necessary. The most readily available units in the US are from Radio Shack, Figure 2-20. These units are also very inexpensive. Because we are usually more concerned with level relative to each channel rather than absolute level, the accuracy of this meter is sufficient for level balancing. For greater accuracy, more expensive meters may be used. It is recommended that an inexpensive meter be left in the control room for quick calibration checks.

![Radio Shack Analog and Digital SPL Meters](image)

Figure 2-20 Radio Shack Analog and Digital SPL Meters

2.3.10 Phase Scope

To assist in mixing, a phase scope can be very helpful. When the display is rotated 45 degrees counterclockwise from the traditional display, as is available on the Tektronix 760 audio phase scope, the mixer will see graphically what is heard in the Dolby Surround sound field. Figure 2-21.
The Left, Center and Right channels will appear across the top and the Surround channel will appear at the sides. Information that is in all channels will appear somewhat circular as in Figure 2-22. Individual channel information will appear on the appropriate vectors.
3.1 Signal Routing Audio Connections

Both the SEU4 and SDU4 are feature +4 dBm XLR connectors with pin 2 hot. The built-in trim pots allow operation within the range of -10 dBm to +8 dBm and may also be configured for unbalanced operation as necessary. For unbalanced operation, it is important that the connections be made with either pin two or three as the hot and pin one as the ground. The additional unused pin MUST be connected to ground or excessive noise from the unit will result. Figure 3-1 shows the pin out for both male and female XLR connectors.

![Figure 3-1 XLR Connector Pins](image)

3.2 Signal Flow Options - Encoder

3.2.1 Basic Recording Setup with Auxiliary Buss Surround Feed

The most basic setup possible uses the encoder with a stereo output from the console feeding the left and right inputs and auxiliary busses feeding the center and surround inputs. The encoder then feeds to the recorder input. The recorder output feeds the decoder, which in turn feeds the amps and speakers. While this is the simplest way to encode, it is also the most limiting in terms of panning effects. This arrangement works best with live broadcasts and simple music mixes.

![Figure 3-2 Signal Routing - Stereo Buss and Auxiliary Sends](image)

**Troubleshooting Tip:**

Many consoles currently in production do not maintain consistent polarity on their outputs. (Many industry professionals refer to this polarity inversion as phase. In addition, many console manufacturers have included phase buttons for each input channel which will allow the
Polarity of the signal to follow the wiring connections or, by enabling the switch, will reverse or invert the connections via the switch contacts and, as a result, will invert the polarity of the signal. The auxiliary outputs of the console may not be in phase with the main stereo outputs of the console. When connecting reverb units, delays and other effects processors, absolute phase of these signals may not be a concern since it will not be exactly maintained after the effect is added. Unfortunately, this is a problem for Dolby Surround encoding. To check the signal polarity to the encoder, apply a 1 kHz signal to the left and right encoder inputs. While observing the encoder outputs, add the same 1 kHz signal to the surround channel. The outputs should both increase in level as the surround input level increases. If one channel goes up and the other channel goes down, the polarity of the surround channel input to the encoder is reversed. If you vary the frequency of the signal, you will get varied results between the two channels depending on the frequency of the tone. To correct this problem, reverse the polarity of the input to the encoder surround channel input by swapping the connections to pins two and three.

### 3.2.2 Basic Recording Setup with Film Panning Console

The most versatile console setup involves the use of a console with film-style (LCRS) panning. These consoles have a pan pot system capable of panning from left to center to right and from front to back. With this system, sounds can be placed quickly and easily. These consoles will have left, center, right and surround outputs for connection to the encoder. The output of the encoder follows a flow similar to the above example.

![Signal Routing - Film-Style Panning](image)

### 3.2.3 Basic Recording Setup with 2 Stereo Buss Output

Some consoles have multiple stereo busses. This is common with broadcast consoles. In this case, one stereo output can be used for left/right panning and a second used for center/surround panning. Although not as flexible as a film style panning setup, this configuration will serve the needs of most applications with few limitations.

![Signal Routing - Dual Stereo Buss](image)
3.3 Signal Flow Options - Decoder

3.3.1 Recording Setup with Monitor Section of Console

All of the above connections involve feeds to the encoder. They assume a signal path from the encoder output to the recording device. The recording device then feeds the decoder that in turn feeds the amps and speakers.

For installations where the console contains a monitor section, all monitoring functions such as solo, dim and source selection will be lost. It is possible to connect the units as shown in Figure 3-5 to restore the monitor operations in the console.

![Figure 3-5 Signal Routing - Console with Monitor Section](image)

The only caution here is that the console monitor level must be set and the decoder level calibrated. Once this is done, the console monitor level control must not be moved. The level control on the SDU4 must be used or a remote level pot must be installed. It may be possible to physically insert the SDU4 remote pot in place of the current monitor pot. Because every console is different, this may not be possible for all consoles. See Part 2.3.7 for further information.

3.3.2 Recording Setup with Surround-Ready Monitor Section of Console

Some newer consoles have been equipped with a multichannel volume control and monitor loop insert points for inserting the SDU4. In this case, installation is very simple and the monitor level control is post the insert point. In this case, the console pot can be used to control overall gain, Figure 3-6.
3.3.3 Live Broadcast Setup

Setups for live broadcast are the same as studio setups with one exception, generally, the signal is fed to the station instead of to a recording device. This is not to say that the event could not be recorded locally at the same time. In these cases, any of the above encoder wiring schemes are possible. The decoder is normally fed from the distribution amp system used to feed the transmission path. See Figure 3-7.

![Figure 3-7 Signal Routing - Live Broadcast](image)

3.3.4 Live Broadcast Setup with Fail-Safe

Because of the addition of patch points to insert the Dolby Surround encoder in the final outputs of the console for typical live broadcast applications, many mixers have adopted the use of a fail-safe connection. To do this requires a larger console, usually one with multi-track outputs, to accommodate both the extra outputs and inputs required to use this method. See Figure 3-8.
The premise is that if a patch or the encoder should fail while on the air, the modules that are assigned to feed the encoder can easily be reassigned to the stereo buss of the console and audio can be re-established very quickly. Although the signal will no longer be Dolby Surround encoded, at least there will be audio on the air. Once the program goes to a commercial or break, repairs to the problem can begin. Either connection system will work, but one has redundancy for the unexpected, while the other does not. While it is very rare for a Dolby product to fail, patch bays and patch cords are another matter.

### 3.3.5 Monitoring Music Premixes for Film

4-2-4 monitoring is used primarily in the production of music soundtracks for film work. Because these tracks are normally sent to the final mix as separate elements rather than a complete mix, these signals are not actually encoded when preparing the elements for delivery to the mixing facility. In order to make sure that there are not any surround compatibility problems with the elements, they are mixed through the console and fed through an encoder and decoder to the speakers in the room. In this case, the output of the encoder feeds directly to the decoder. Both units are in the monitoring chain, not the recording chain. This method of monitoring can also be used when tracking a music session that will be mixed later in Dolby Surround.
3.4 Dolby Model SEU4 Setup

Normal operation of the SEU4 requires no modifications to the unit as it comes from the factory. There are two modes which should be checked if problems are encountered.

3.4.1 Surround Active LED

The Surround Active LED on the front should be lit as in Figure 3-10. If it is not, most likely a jumper inside the unit has been changed (there is no reason to do this under normal operation) or there is a jumper wire (or closed switch) between pins 5 and 15 of the DB15 connector on the back of the unit which is disabling the function. Open this switch or remove the jumper to restore operation.

![Figure 3-10 SEU4 Front Panel with Surround Active LED On](image)

**NOTE:**

IF YOUR UNIT IS MODIFIED FOR GAME MODE (Section 7.5) THE SURROUND ACTIVE LIGHT INDICATES NORMAL OPERATION. IF THE LED IS NOT ILLUMINATED, THE UNIT IS IN GAME MODE.

3.4.2 EPL Loop Switch

The SEU4 can be used with an external processor inserted in a loop before the final output stages of the unit, Figure 3-11. In normal operation, this loop is unused. The processor would be placed after the encoder outputs and before the next device in line such as the stereo master fader on the console. The EPL loop output is a separate output with its own level controls. Should you desire to use the loop as an insert point, there is a switch inside the front cover to enable it or bypass it. Set this switch as your installation dictates.
Figure 3-11 SEU4 with EPL Highlighted

**Troubleshooting Tip:**

*IF YOU ARE FEEDING SIGNALS TO THE UNIT, BUT THERE ARE NO OUTPUT SIGNALS FROM THE MAIN OUTPUT CONNECTORS FOR BOTH CHANNELS, CHANCES ARE THAT THE LOOP IS SWITCHED IN AND YOU DON'T HAVE ANY EPL CONNECTIONS IN PLACE TO COMPLETE THE SIGNAL PATH. MOVE THE EPL SWITCH TO THE OUT POSITION TO RESTORE OUTPUT FROM THE MAIN OUTPUT CONNECTORS.*

### 3.5 Dolby Model SDU4 setup

#### 3.5.1 Internal Switches - CAT 344 information

There are several switches and jumpers on the right card inside the SDU4 that may need to be checked for proper settings. These switches cover the wake up mode, Center speaker status, local or remote fader and external processor loop. From the factory they are configured with Dolby Surround as the wake up mode, Center speaker on, remote fader disabled and no external processor loop. Should one of these options require changing, remove the card, make the changes accordingly and replace the card.
3.5.2 Center Speaker Switch

When using the SDU4 with a Center speaker, the switch should be in the **yes** position, Figure 3-13. This is the recommended configuration. In this configuration there will be Dolby Surround decoded Center channel audio information from the Center speaker when in the Dolby Surround mode, no audio in the Center speaker when in the Stereo mode (conventional two channel stereo from the Left and Right speakers), and a Mono summation of the audio in the Center speaker when in the Mono mode.

With the switch in the **no** position the Dolby Surround decoded Center channel audio information will be added equally to the signals for the Left and Right channels and will be heard from the Left and speakers as a phantom image for the Dolby Surround mode, no audio in the Center speaker when in the Stereo mode (conventional two channel stereo from the Left and Right speakers), and a Mono summation of the audio in the Left and Right speakers for Mono mode.
**Troubleshooting Tip:**

*If a center speaker is not being used and left and right information can be heard, but no center information when in either the Dolby Surround mode or mono mode, the center speaker switch is probably set to the yes position. This results in all of the center information being fed to the center output of the decoder (which, in this case, is an open unconnected output). To correct this, remove the card and move the center speaker switch to the no position or add a center speaker and amplifier.*

### 3.5.3 Wake-up State

The unit is set at the factory to wake up in the Dolby Surround mode when power is applied. If you want the unit to wake-up in the stereo or mono mode, remove the card and move the jumper to the appropriate position, Figure 3-14.

![Figure 3-14 Wake-Up State Jumper Detail](image)

### 3.5.4 Local/Remote Fader

The master volume control on the front of the unit controls the four outputs of the decoder. Alternately, this fader can be remoted to an external location by using a 100kΩ pot which is connected to the DB25 connector on the back as shown in Figure 3-15. To activate the remote fader, move the remote fader switch, Figure 3-16, to the remote position.

![Figure 3-15 Remote Fader and Connector](image)
**Troubleshooting Tip:**

If the volume control on the unit does not appear to control the monitor level, check the remote fader switch. The unit will output audio at full volume with the switch in the remote position and no pot attached.

### 3.5.5 EPL Switch

As with the encoder, the decoder contains an EPL switch as shown in Figure 3-17.

The connections are made via the DB25 connector on the back. The connections are as follows:
To activate the loop, move the switch to the **on** position.

**TROUBLESHOOTING TIP:**

*If audio is being sent to the unit and the master level control is set correctly, but no audio appears at the outputs, check the EPL switch. It is probably in the in position and no wiring is connected to the EPL loop to complete the signal path. Remove the card and move the switch to the out position.*

### 3.6 Cat 150E Card Settings

#### 3.6.1 Bass Splitting Modification

In most studio applications, all three front speakers will be identical. In some applications, however, this is not possible and a smaller version of the Left and Right speakers will have to be used for Center. It is important that the midrange and tweeters in the three speakers be identical if possible. In this case, the center woofer will be smaller. Because most bass information is normally found in both the Left and Right channels, panned center, the decoder will place these low frequencies in the Center speaker. The decoder contains a special feature that can be implemented to take the Center channel low frequency information below 100 Hz and redistribute it to the left and right outputs where the larger woofers exist. To enable this feature, a jumper wire needs to be installed, soldered, between pin T of the Left card (CAT 150E) and the unbanded end of the diode (D401) adjacent to pin T, Figure 3-18. It is important not to get solder on the gold edge card pin except at the very end away from the edge of the card.
3.6.2 Time Delay Calculations

In addition to the switches mentioned above, there is a rotary switch for setting the time delay to the Surround channel, Figure 3-19. On older units, the switch is behind the removable front panel cover. On newer units, the switch is visible through the round hole in the front panel.

To calculate the proper delay you will need to measure the distance in feet from the seating position to the front speakers, and from that subtract the distance from the seating position to the nearest Surround speaker. Add 10 to the result and this will be the proper time delay in milliseconds. The minimum delay available is 20 ms. If your answer is less than 20, use the 20 ms setting. Always round up to the next available delay time. For example, 18 becomes 20 ms and 22 becomes 30 ms. For most trucks and small studios, 20 ms will be the proper delay time.

If using metric measurements, measure the distance in meters from the listening position. Subtract the distance in meters from the listening position to the nearest Surround speaker. Multiply this number by 3 and add 10 to that answer. This will give the correct delay time.

The zero setting is 20 ms and each number upward adds 10 ms.
Table 3-2  Delay Switch Settings

<table>
<thead>
<tr>
<th>Setting</th>
<th>Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<td>40 ms</td>
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<td>3</td>
<td>50 ms</td>
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</tr>
<tr>
<td>12</td>
<td>140 ms</td>
</tr>
<tr>
<td>13</td>
<td>150 ms</td>
</tr>
</tbody>
</table>
Chapter 4
System Set-Up

4.1 Encoder Alignment

In order for proper surround mixing to take place, correct electronic alignment is a must. The following steps should be performed on initial installation of the equipment and should be checked on a time-to-time basis to verify system integrity.

1. If not already done, connect unit to audio path. See Section 3.2 for further information. If the effects processor loop is to be used, switch it out for the following alignments. You will be instructed when to switch it back in. (To disable the EPL, you need to move the slide switch located front center of the right-hand board as shown in Figure 3-17. Access to this switch requires removal of the front cover).

2. Apply a 1 kHz tone at console reference level (+4 dBr, 0 VU, etc.) to the Left channel input.

3. Adjust the Left channel trim control until both green LED’s on the SEU4 are illuminated. The resolution from left green LED to right green LED is approximately 1/4 dB. In some cases it may be difficult to get both green LED’s to remain lit. Should you find this to be the case, adjusting so that you are at the crossover point from one green LED to the other will be acceptable.

4. Adjust the Lt output trim pot to reflect console reference on the metering employed, console or recorder. If you are returning the signal through the console master fader, be sure the fader is set for unity gain. Once the master fader is set, it should not be changed for the remainder of the setup procedure.

5. Apply the 1 kHz reference tone to the Right channel input.

6. Adjust the Right channel input trim and Rt output trim as in steps 3 and 4 above.

7. Apply the 1 kHz reference tone to the Center channel input.

8. Adjust the Center channel input trim, Figure 4-1, to light both green LED’s. Do not adjust the output trims for Lt or Rt. The left and right meters on the device being fed by the encoder, console or recorder should both read approximately -3 dB and the signal should be in phase.
9. Apply the 1 kHz reference tone to the Surround channel input.

10. Adjust the Surround channel input trim to light both green LED's. Again, do not adjust the Lt or Rt output trims. The left and right meters on the device being fed by the encoder, console or recorder, should both read -3 dB and the signal should be 180° out of phase.

11. If the Effects Processor Loop (EPL) is not used, encoder alignment is complete, proceed to decoder alignment.

12. Switch the EPL in.

The EPL contains send and return levels and is used to interface a piece of signal processing gear after the encoding to Lt/Rt, but before the final output of the SEU4 encoder. These trims are usually set for unity gain at the factory. Should you desire to change them, you should apply the 1 kHz reference signal to the left and right inputs and adjust left and right EPL sends for the proper level at the signal processing device input. Then adjust the left and right returns to produce for proper level at the SEU4 output. To enable the EPL, you need to move the slide switch located front center of the right-hand board (CAT 385). Access to this switch requires removal of the front cover.

### 4.2 Decoder Alignment

The decoder has two parts to align, the input levels and the output levels.

#### 4.2.1 Input Levels

1. Feed a 1 kHz tone to the left and right inputs of the decoder. (This should be fed to the encoder, which in turn should be feeding the decoder as well as the rest of the signal chain.)
2. Adjust the left and right inputs, Figure 4-2, to light both green LED’s. The inputs are now aligned.

![Figure 4-2 Adjusting the Right Input Trim Control](image1.png)

4.2.2 Output Levels

To adjust the outputs to the speakers, make sure the volume control is set to the reference position, about 2 o’clock on the scale, and use the built-in noise generator to send pink noise to each speaker. Adjust each speaker level, usually done at the amplifier, to obtain 85 dB SPL, C-weighted, slow. If you do not have a Center speaker, ignore the setting for the Center speaker and adjust only Left, Right and Surround. The level for center should then be correct. You may see slight level variations which are caused by the acoustical environment. See Part 2.3.8 for further details on modifying the 85 dB calibration level.

![Figure 4-3 Adjusting the Center Output Trim Control](image2.png)

4.3 Room EQ

Mixing room designs always include some form of room equalization. The most common way to achieve this is by using multi-band equalizers. In addition, wall and ceiling treatments may be required. The use of near field monitors has become popular
recently because the near field monitors are not adversely affected by the room environment.

4.3.1 ANSI/SMPTE 202M X-Curve

For film applications, where large mixing rooms are used, the X-curve is used as defined by the ANSI/SMPTE 202M standard. When TV shows are mixed on these stages, the X-curve is also used. This curve is flat from 63 Hz to 2 kHz and then falls off at 3 dB per octave from above 2 kHz. See Figure 4-4. There is a 3 dB roll off on the bottom end also, with 50 Hz being down 1 dB and 40 Hz down 2 dB.

![Figure 4-4 Standard X-Curve](image_url)

4.3.2 ANSI/SMPTE 222M Modified X-Curve

For small rooms, defined as less than 5300 cubic feet or 150 cubic meters, ANSI/SMPTE 222M calls for a modification of the X-curve with flat response to 2 kHz and then a 1.5 dB per octave roll off above 2 kHz. See Figure 4-5. This curve is useful when a mix is to be played back in a large room, but is mixed in a small room. Some people prefer to use the low end roll off as defined by the standard, some prefer to leave the low end flat. It is generally left it flat. Another variation on the curve is to begin the high end roll off at 4 kHz instead of 2 kHz and roll off 3 dB per octave instead of 1.5 dB per octave.
4.3.3 Recording Studios - Music Mixing

There are perhaps more arguments over what equalization should be used in a recording studio than any other place. Most studio designers have their own opinions about what the curves should be and how they relate to what is ultimately heard by the end user. We suggest that you consult with your room designer to find out what curve was used to initially set up your facility for music mixing. In any case, most designers tend to roll off a little of the top end frequency response. Some prefer to start at 8 kHz and roll off such that 16 kHz is down 3 to 4 dB. Others believe that the system should be flat to 12 kHz and roll off a few dB per octave from there.

No matter what convention you choose, the Left, Center, and Right speakers should all be equalized to match the curve. The only exception would be that if you are using a small Center speaker with the bass splitting modification; see Chapter 3. In this case, the low end of the Center speaker will not be equalized below 100 Hz as this information is carried by the Left and Right speakers.

4.3.4 Near-Field Monitors

Because near-field monitors do not generally interact with the room at the listening position, no room equalization is usually required or used. Several self powered near field monitors include equalization adjustments. Follow the guidelines above for setting the equalization adjustments. The flat position usually refers to a measurement taken at 1 meter from the speaker that reproduces the designers desired response.
5.1 Announcers and Dialog
Traditionally, dialog has been placed only in the Center speaker to keep the on-screen sounds tied to the picture. When a Center speaker is used, all center panned dialogue will appear to come from the screen regardless of where the listener is seated. If the dialogue were to come from the Left or Right speakers, the stereo image would differ depending on the listener’s choice of seat. This is highly undesirable. This does not mean that voices cannot appear in the other channels, but generally only effects or incidental voices should be in any channel other than center.

5.2 Interior Effects
Interior effects are sounds that come from all four channels and appear to surround the listener. Examples of interior effects are wind noise, crowds, and other general ambient sounds that are included within the mix to give a sense of realism. Effects and ambiance sounds will normally appear in the Left, Right, and Surround channels. Common practice is to use Stereo ambiance that is panned left and Surround for the Left channel of the source and Right and Surround for the Right channel of the source. The result is a sound that surrounds the listener, yet still has a front stereo image. The amount of Surround channel signal added will determine how far back the listener is in relation to the front sounds. More surround level produces an image that sounds further back in the room.

Sometimes a mono element is all that is available, yet a surround effect is desired. In this case, the signal can be put in both the Center and Surround channels. This is commonly known as a 2-4 punch. By applying it equally to both Center and Surround, the sound will appear to come from all four channels. Stereo reverb can also be used with a mono sound element to give a slightly wider image. Simply apply the reverb effect to the Left and Right channels while applying the original dry signal to the Center and Surround channels.

Another technique that frequently works is to take the signal and assign it to the Left channel and add an 8 millisecond or so delay of the same signal to the Right channel. This may or may not produce acceptable results depending on the program material.

5.3 Positioning of the Stereo Image
Because of the Center speaker, the stereo imaging in a Dolby Surround system is slightly different than in a two speaker stereo system. Most music engineers find this distracting at first, but adjust quickly. Those used to mixing motion picture sound feel
right at home as do those music engineers who have their own home theater systems. The most noticeable difference in the stereo image is that the perceived image will tend to be narrower when a Center speaker is used. This is because most music mixes contain significant amounts of Center channel information that we are used to hearing as a phantom image produced by the Left and Right speakers. Since all of this information is now being directed to a single point source, the Center speaker, we perceive it as all center. To correct for this in the mix, simply make the image slightly wider than is normally done for a two channel stereo mix.

A mistake that should be avoided is to eliminate the Center speaker in the control room and use the phantom monitoring mode. While this may produce a more familiar sound in the control room, it does not address the listeners at home who have a complete home theater system. The mix produced with a Center speaker will be somewhat different and this the correct listening method.

5.4 Panning Sounds

There are several different ways to pan sounds in a mix. The best way is to have film-style multichannel panners that pan from left to center to right and from front to back. This type of panning system will allow you to position a sound anywhere in the sound field with little effort.

If film style panners are not available, panning from left to right on one stereo buss and center to surround on a second stereo buss can also be an effective way to place sounds, although this technique is not as easy to use, especially for moving effects.

On small, function limited consoles, the front channel panning can be accomplished using the stereo buss and the Surround channel can be fed by an auxiliary buss. This is extremely limiting in use, but will work if necessary. For complicated panning moves, bringing up the signal on more than one fader, with each fader feeding a different output, will allow you to use the faders as panners.

For example, assigning one fader to the left/right pan, with the pan pot set halfway between left and center, and another fader assigned to the surround buss will allow you to pan from left center to surround by bringing up the fader feeding the Surround channel as the fader feeding the left/right busses is brought down. If the console is automated, these moves can be perfected one at a time and then repeated by the automation system. This method will also work on larger consoles where automated pans are required.

By taking the signal and assigning it to four faders, with each fader assigned to a different input of the encoder, a circle pan can also be created.
5.5 Stacking Encoded Tracks

A common practice in the film industry is to premix elements for the final mix. This could be done for the opening sequence for a series of shows or a sound effect panning through the room.

The individual elements may be mixed as Dolby Surround encoded 2-channel elements (Lt/Rt) and all of those elements may be mixed together in the final mix. When doing this, each element should be assigned to the left and right inputs of the encoder.

5.6 Magic Surround

In certain cases, stereo microphone placement techniques and stereo electronic instruments will cause a phenomenon known as magic surround. In these cases, some of the signal will be decoded by the decoder and placed in the Surround channel. The cause of this is out of phase or inverted information in the stereo pair. XY stereo microphone techniques will almost always produce this effect. While this may sound pleasing by itself and you may feel that no encoding is necessary, this process is unpredictable and should not be relied on. A simple addition of another element in the mix such as a voiceover could easily change the phase characteristics of the mix and the decoder would no longer decode the same way. The best thing to do is put at least a little information from this signal source through the surround input of the encoder. This will ensure that the decoder will decode the real surround signals and not some random out of phase information.

In some cases, too much surround information may be present. This is especially true with electronic keyboards which use electronic processing to achieve a stereo signal from a mono source. If you have too much information in the Surround channel with your favorite sound, simply pan the left a little towards center and the right an equal amount towards center. This will cancel out some of the out of phase information and make the decoder work normally again. The amount of panning required will vary with the sound, but it usually does not take much to produce a good result.

5.7 Decoder Mistracking and Steering Artifacts

When mixing, you will quickly realize that the decoder can only steer in one direction at a time. This requires careful planning of the sound field. Before you begin to think that this sounds impossible, movie mixers have been successfully doing just that for more than 20 years. It can be done quite easily.

Troubles usually occur when two very different and unrelated sounds are sent to two different channels at once. For example, crickets in the Surround channel and chickens in the front. The result is that the sounds bleed into the other channels and produce a dynamic image shift as they do. This effect is very distracting and undesirable.
Another common occurrence is when a music track contains a lead instrument that is prominent in the mix in the Left or Right channel while an announcer comes and goes from the Center channel. In this case, the instrument will appear to move from its intended speaker towards the center when the announcer speaks and then return to the correct speaker when the announcer stops talking. The solution here is to either pan the music element towards center or reduce its level until the problem goes away.

Often, when producing sound effects for motion pictures, the sound effects designer will remove all ambient sounds briefly to allow for another sound to be more prominently heard. For example, there may be night time sounds and a little traffic in the background. The next big sound might be a door slam. While the door is slamming, the traffic and night sounds will either be very low in level or will disappear entirely. When the door slam sound is gone, the other sounds are already back in the mix. They will never be missed by the audience as the door slam would have covered over them anyway.

5.8 Surround Pumping

Pumping of the Surround channel is frequently caused by bad transmission paths and is rarely heard in the mixing environment. A common problem is that a limiter is active in one channel of the transmission path but not the other, or a stereo limiter is not set up the same for both channels. The solution is to either remove the limiters or set them up identically and verify that they are linked together. This problem can be heard during the mix if a stereo limiter is being used excessively or if part of the element is limited, but not all of it. It is impossible to cover every possibility here, but look for inconsistency between the two stereo channels as the likely cause of the problem. The problem is usually noticed by the viewer as Surround channel ambience pumping in response to the dialog. This can be particularly noticeable during live sporting broadcasts when there is crowd noise in the Surround channel.

5.9 Proper Surround Level and Content

When is there enough surround content? This question is usually left up to the taste of the producer and engineer mixing the project. As a guideline, the image should direct your attention to the front of the sound field and the listener should notice something missing when the Surround channel is removed from the mix, but should not have their attention drawn directly to the Surround channel when it is returned to the mix. Surround channel effects should complement on-screen action and should not be distracting. There is no right or wrong mix within reason.

5.10 Limiters, Delays, Reverb Units, Other Effects Processors

As with any mixing situation, signal processing devices are common in Dolby Surround mixes. Limiters and compressors are easily used with little side effects as long as they
are used before the encoder. Digital delays and sound field generators, reverbs, etc., may also be used. However, the tricks used to generate the sound fields from these effects may not work as expected when Dolby Surround decoding is used. Since you are monitoring through a decoder, you can instantly hear what the sound field will actually sound like. If you find that your favorite reverb program has excessive surround content without sending anything to the Surround channel, try taking the stereo output of the device and panning it a little towards the center instead of hard left and right. Experimentation will be required to get the exact sound you desire. This effect is caused by the phase shifting of the effects unit competing with the phase encoding found in Dolby Surround; stereo keyboards also have this problem.

5.11 Mono to Stereo Synthesizers

Mono to stereo synthesizers can create all sorts of havoc in a Dolby Surround mix. First, the Dolby Surround program is a stereo signal so there is no need for a synthesizer in the transmission path. Second, if you have ever listened to a mono show run through an aggressively adjusted stereo synthesizer, and then through a surround decoder, you have experienced the dialog coming from all the speakers all the time. All localization of the voices to the screen is lost. For this reason, with complete mixes, this is not a desired tool in the transmission path. This is not to say that a stereo synthesizer can't be used to an advantage for individual mono sources within a Dolby Surround mix during production and before encoding. When used properly, they can be effective on certain elements. They should not, however, be used excessively when dialog or vocals are part of the mono element.

5.12 Dolby Surround Compatible Processors

There are several Dolby Surround compatible processors available now. As is the case with reverb processors, these units can offer mixed results. If the unit is supposed to substitute for a real Dolby Surround encoder, ask yourself “why not use the real thing?” Units that are designed for use with two speakers, 3D audio processors, can be used with pleasing results. The secret is to listen to the mix through a Dolby Surround decoder so you know what it will actually sound like to the end user. Encoders that are designed to be used with their own decoders are another issue. The real issue is how many consumers are going to be able to hear the mix with the proper decoder. Dolby Surround is the de facto standard matrix surround system worldwide. If a listener has a surround decoder, it most likely is a Dolby Surround decoder.

5.13 Mono, Stereo and Dolby Surround Compatibility

Mixing techniques used in Dolby Surround productions are similar to those used in normal stereo productions. Just as you should check mono compatibility of a stereo mix, you should also check mono and stereo compatibility of a Dolby Surround mix.
In most cases, stereo compatibility is not an issue. The surround element of the mix will appear to be outside of the speakers as an out of phase signal would. Notice that the entire mix should not sound out of phase, and there should still be a hard center image.

Mono compatibility is a little trickier. Anything that is in the Surround channel will disappear in mono. This can be considered an asset in some cases and a detriment in others.

In situations like live sporting events, the lack of some crowd information in the mono mix will help those at home listening in mono on a 3-inch television speaker to hear the announcers a little easier. In other applications, the mix may have a critical element in it that is predominately in the Surround channel. For this reason, surround elements should also be present in a front channel, interior panned, so they will be heard in mono, as is commonly practiced in the film industry.

5.14 Monitoring

For applications where tracks are being generated for use with other elements like a music mix for film or video, it is often desirable to monitor through a Dolby Surround decoder. These tracks are seldom mixed and encoded before delivery, but are commonly sent as elements on separate tracks (L, C, R, and S). It is important that you know that the elements are acceptable when run through the Dolby Surround encoding system during the final mix or undesirable results could be present. The two most common problems are soundtracks that are very mono in nature or that contain phase information that make them sound surround heavy. The measures required to correct these problems at the final mix session will compromise the mix of the elements, and so these problems should be corrected before the four channel elements are recorded.

5.15 Common Pitfalls

Although you may like a surround effect that spins your head around, and it may be just what your production needs, repeating that move dozens of times will usually be tiring to the listener. The key to good surround mixes is being subtle with the effect. Don’t draw attention to the techniques you are using. The listener should never stop paying attention to what is happening up front while they try to figure out what they just heard coming from the back. Loud, obnoxious or out of place effects are distractions, not additions. Keep it fun, but keep it tasteful too.

Another pitfall is too much information in the Surround channel. It is better to be a little shy on surround information. Mixes that are surround heavy will distract the viewer from the on screen action. If you find yourself thinking about what you just heard in the Surround channel instead of paying attention to the action on the screen, you have too much surround information. Too much surround information may also make dialog intelligibility suffer to the point where it can be difficult to understand the actors lines.
Chapter 6
Live Broadcast Applications

6.1 Transmission Path Considerations

With fiber optic and satellite transmission lines being standard fare at sports arenas and stadiums, this part of the signal chain is usually repeatable and predictable. Frequency response and headroom often remain very consistent from event to event. Most of the early problems encountered in Dolby Surround broadcasts were related to additional signal processing introduced by the station. The two most common offenders were phase chasers and stereo synthesizers.

6.2 Phase Chasers

Because Dolby Surround uses phase encoding of the Surround channel, it is entirely possible to have situations where significant out of phase information in the program cannot and should not be corrected, even by well-meaning devices. There are two basic functions performed by phase chasing devices. One is to correct the small phase errors between two audio channels, such as from azimuth misalignment or drift in analog video tape recorders and cart machines; the other is to correct polarity inversions in one channel relative to the other. When either function occurs in response to Dolby Surround signals, the results can be both unnecessary and unfortunate.

With live feeds or audio sourced from a digital recorder becoming the norm, phase correction is essentially unnecessary, as there is no azimuth error introduced. Relative polarity can be easily checked before air time, and this is especially easy when monitoring at the station through an SDU4. If the announcer or dialog comes out the Surround channel, or becomes virtually inaudible in mono, the polarity is inverted! As many people still listen in mono, loss of the announcer either during the game or during a commercial is bound to raise complaints from one party or another.

6.3 Station Limiters

No matter how good your mix, stations will always try to extract that last quarter dB from the transmitter. The usual way of doing this is with a program limiter. In general, use of these should be avoided. Since we live in a real world, stations need to set these up for minimal effect. Mixers need to mix such that these devices are not required to limit the program material in order to keep the mix in the useful range of the transmitter.
6.4 Station Processing
Along with station program limiters, other signal processors may be used, including the Dolby Model 740 Spectral Processor. While there is little that a mixer can do while on location to defeat the use of these units, if they have been properly set up, without too much radical signal processing, they should not pose a problem.

6.5 Headroom
The amount of available headroom will depend on what the final distribution medium is. In broadcast transmission applications 6 dB of headroom above reference level is the usual limit. For transmission paths between venues and satellite uplinks, 10 dB may be available. VHS tape hi-fi tracks have about 12 dB of headroom. CDs, laser discs and digital video recorders have 20 dB of headroom. It is important that you know what headroom is available and stay within the boundaries. Failure to do so will create unwanted side effects. The headroom of the encoder and decoder are sufficient for any of the requirements above.

6.6 Stereo Synthesizers In Transmission Paths
Although stereo synthesizers, used to make mono programs stereo, are less common now than they were when stereo TV first became a reality, they are still in use. They must not be used in the transmission path of a Dolby Surround encoded soundtrack after the encoding process. Use of these devices will destroy all surround encoding. Also, although the effect may sound all right to some people in stereo for a mono program, the result of any stereo synthesized program when decoded through a Dolby Surround decoder is nothing short of obnoxious.
7.1 Introduction

Dolby Surround has become a popular tool for video game and multimedia developers. There are several ways to include Dolby Surround within a video game, and each is dependent on the platform used by the game.

It is often desired to be able to control the spatial position of a sound in response to the game player’s input. There are several techniques that can be used to achieve this in the game itself. The degree of complexity and resulting quality varies, and so the technique should be chosen based on what is appropriate for the intended effect.

7.2 Normal Dolby Surround Encoding

The easiest way is to simply encode all of the audio files for the game in Dolby Surround. This will give you a pleasing, but non-interactive soundtrack. To accomplish this, mix the project as you would any other type of project and save the sounds as stereo files with the game.

7.3 Polarity Inversion

The second method is to emulate Dolby Surround. This is common in cartridge games. This method allows you to place sounds at each of the four cardinal points, Left, Center, Right and Surround. This is an approximation of Dolby Surround and is limited in its capability. For simple cartridge games where sound file space is at a premium, this technique will produce an adequate Dolby Surround effect.

Effects such as door creaks or gun shots need to follow the action on the screen. These sounds occur less frequently, and are usually mono elements that are cached and looped. Sound placement can be handled within the game itself, using only basic controls. The front cardinal points, Left, Center, and Right, can be encoded by panning like any conventional stereo signal. Simple channel switching during game play allows the sound to be output from the Left, Right or Center (both channels). If the game provides a variable balance control function, the sound may be smoothly panned across the front or positioned between channels.

The simple frontal positioning may be adequate for many sounds that need run-time control. For more realism, placing sounds in the Surround channel may be desired as well.
Sounds appear in the Surround channel when the Lt/Rt signals into the decoder are equal in level (much like a center signal), except one of the signals is inverted, commonly called 180° out-of-phase, relative to the other.

By adding an inverter, multiplication by -1, to the game audio tool kit, it is possible for a sound to be placed at any of the four cardinal points. If the level of one of the two output signals can be attenuated, it is possible to move the sound across the front or down either side toward the Surround channel. This degree of sound positioning is often adequate for many situations in game play. However, it does not allow for either interior sounds or center-to-surround pans. To achieve these effects, phase encoding is needed.

If the game audio playback software allows for the creation of small time delays or certain filter or pitch-shift functions, these may be suitable for creating signals that appear to spread wider or otherwise occupy the interior space.

### 7.4 Phase Encoding

To give increased capability of positioning sounds in more advanced games, Dolby has prepared a simple C-code program to provide surround encoding during game play. This simplified encoding utility comprises two sections: a phase shifter and a surround positioner. The shifter takes any mono signal and creates two new audio signal components, F (Front) and S (Surround), which are phase shifted relative to each other.

The positioner moves the F input signal along the front axis in response to the L/R input control. It moves the S input signal along the surround axis in response to the F/S input control. This x/y coordinate system allows the game to position the sound anywhere in the Dolby Surround sound field.

![Figure 7-1 Phase Shifter and Positioner](image)

The phase shifter is deliberately simple to minimize the impact on game speed. Since the shifter is needed only when a sound is placed or panned through the interior space, it need not run at other times. If the phase shifter is too much of a processing burden to run during game play, or if the sound quality is not deemed good enough for some reason, the positioner can also work with signals preprocessed in what is called game mode.
7.5 Dolby Surround Game Mode Encoding

This method involves encoding the main tracks with Dolby Surround and then encoding certain effects tracks with game mode encoding. This option gives you basic audio with Dolby Surround encoding as well as the ability to position additional sounds as the game is played. In this mode, the final encoding of these sound effects is done by the game itself.

Dolby Surround Game Mode was designed to assist computer game developers with creating sound effects and elements that can be used within the game and spatially placed within the sound field by the game while being played.

This is a mode of the Dolby Surround encoder itself: A mono input signal, the audio that will be positioned by the game, is processed by the game mode encoder to produce a two channel output signal having the same F and S components as with the phase shifter just described. During game play, this two channel signal may be moved using the positioner as described above.

![Figure 7-2 Signal Flow for Game Encoding](image)

The result is that this signal has the same audio processing as other true Dolby Surround encoded signals, and needs no extra phase shift processing during game play. The main disadvantage is that this mono element now occupies twice the audio storage space a mono element would in the delivered program.

7.6 Modification Principle

Game mode encoding is accomplished by modifying a Dolby Surround encoder to remove the surround signal from the phase shift combine for the Left channel output of the encoder. The input signal to be encoded is delivered to both the Left and Surround channel inputs of the encoder.
The left output (labeled Lt) of the encoder becomes the front information (F) and the right output (labeled Rt) of the encoder becomes the rear (S) information.

Once the F and S signals are prepared, they are recorded in two channels of the game soundtrack. To create the final surround encoded outputs, the F and S components are blended together during game play using the simple mixer shown in Figure 7-4.

**Figure 7-4 Game Mixer**

### 7.7 Application Information

Game mode encoding is only useful for the generation of sound files for use in video games and the like. The output of the encoder cannot be monitored without additional circuitry or signal processing which is normally part of the video game. The output of the encoder should look like a near circle, an ellipse, on a phase scope as in Figure 7-5.
When measured for level, the Left channel output (front information) should be the same level as the input to the Left channel. The Right channel output (surround information) should be 3 dB lower in level than the Surround channel input.

### 7.8 SEU4 Game Mode Alignment

If the encoder has been aligned for normal operation, no changes to alignment will be necessary for game mode. If the encoder has not been aligned, you can either set it up following the normal operation, with the unit in the normal mode, or follow the procedure below which is valid only for game mode.

1. Make sure the unit is in the game mode. To determine this, look at the Surround Active LED on the front of the encoder, see Figure 3-10. If the unit is modified for game mode and the LED is on, the unit is in the normal mode. If the LED is off, the unit is in the game mode.

2. Apply 1 kHz at 0 dB reference level to the left input.

3. Adjust the left input level to light both green LED's.

4. Adjust the Lt output for unity gain or as appropriate for your situation.

5. Remove the 1 kHz tone from the Left channel and apply it to the surround input.

6. Adjust the surround input to light both green LED's.

7. Adjust the Rt output for -3 dB relative to unity gain or as appropriate for your situation.
ALTERNATE METHOD:

PUT THE 1 KHz TONE INTO THE RIGHT INPUT, ADJUST THE INPUT TO LIGHT BOTH LED’S AND ADJUST THE RT OUTPUT FOR UNITY GAIN OR AS APPROPRIATE FOR YOUR SITUATION.

7.9 Testing Game Mode Encoding with an Audio Console

Because the output of the encoder in game mode cannot be directly monitored with the decoder, additional circuitry or processing is required to properly assemble the signals. In most circumstances, this is accomplished within the game. However, it is possible to take the two encoded signal outputs from the encoder, run them through the console and mix them together to check for compatibility through the decoder.

To do so, connect the left (F information) output to a console fader, the right (S information) output to a second fader, and a polarity inverted version of the Rt output to a third fader. The polarity inversion may be accomplished by using the phase invert switch for the applicable input module on the console, or by wiring the input connection with a reverse wired connector or patch cable.

![Figure 7-6 Positioner Function Via Audio Console](image)

The left (F) signal is panned from left to right for the front channel information. The right (S) information that is in phase should be assigned to the Left channel, the Rt information that is inverted polarity should be assigned to the right channel. The Left and right channels from the console then feed the SDU4 decoder. By bringing up both the inverted and non-inverted polarity S signals together, surround information will appear. Bringing up the front fader will affect the front level. By bringing up the front fader while bringing down the 2 back faders, pans from back to front will occur. Reversing this action will pan from front to back.
The following table summarizes the basic encoding methods discussed above. No one method is necessarily perfect for all cases. The best judge is the final result. Please contact Dolby Laboratories in case questions arise.

Table 7-1  Dolby Surround Game Encoding Options

<table>
<thead>
<tr>
<th>Game Characteristic</th>
<th>Studio encoder</th>
<th>Game Mode</th>
<th>Phase Shifter/Positioner</th>
<th>Polarity Inversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIPs impact</td>
<td>none</td>
<td>medium</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>positioning range</td>
<td>n/a</td>
<td>very good</td>
<td>very good</td>
<td>mainly surround</td>
</tr>
<tr>
<td>sound quality</td>
<td>very good</td>
<td>very good</td>
<td>good</td>
<td>very good</td>
</tr>
<tr>
<td>delivery impact</td>
<td>none</td>
<td>2x sound file</td>
<td>none</td>
<td>none</td>
</tr>
</tbody>
</table>

7.10  Game Playback

A game may use any one or all of the surround encoding options described and still be a valid Dolby Surround game as long as the end result is consistent with the general quality found in other such games.

Figure 7-7 shows how the various sound elements may join together in the final game. The final audio output is a complete surround mix in the Lt/Rt encoded form, which is output from the sound card. It is then the task of the Dolby Pro Logic decoder to extract the multichannel sound field for reproduction over several speakers, or to be further virtualized for playback over a conventional pair of speakers.

Figure 7-7  Game Audio Creation and Reproduction
Chapter 8
Theory of Operation

8.1 Encoder

Figure 8-1 is the block diagram of a Dolby Surround encoder.

![Figure 8-1 Dolby Surround Encoder](image)

The encoder takes the left and right inputs and passes them through untouched except for an all pass phase shift network in each channel which delays the signal from input to output by two cycles (720 degrees) at all frequencies. The Center channel input is first reduced in level by 3 dB and then sent to both the Left and Right channels before the all pass networks. The Surround channel is reduced in level by 3 dB, band pass filtered with a 100 Hz high pass and 7 kHz low pass filter, encoded with a Dolby B-type processor which is modified to have only 5 dB of noise reduction instead of the normal 10 dB, and then phase shifted 630 degrees. The result is a signal that is +90 degrees with respect to the Left, Center and Right channels. An inverted signal of the 630 degree surround signal is also created. It has a total phase shift of 810 degrees. The result of this is two surround signals, one +90 degrees and one -90 degrees with respect to the front channels. The -90 degree signal is fed to the Left channel output and the +90 degree signal is fed to the Right channel output. The net phase shift from left to right for a surround signal is 180 degrees, out of phase.

8.2 Decoder

The Dolby Surround decoder detects the equal amplitude in phase (center) and equal amplitude inverted (surround) signals. These signals, combined with the left and right signals during encoding, are decoded by the steering matrix based on which signal is dominant at any time. The Center channel information can either be fed from the Center channel input of the encoder or sent to both the left and right inputs equally. The decoder does not differentiate between the two methods. For this reason, signals panned to the center of the left/right buss will appear in the Center channel output after decoding, not the Left and Right channels.
Figure 8-2 is a block diagram of the Dolby Surround Pro Logic decoder.

In the SDU4 decoder the input signals are first fed to the input level control section for setting the decoder reference level to match the encoder reference level. The noise sequencer, which generates the calibration noise used during setup of the speaker system, is added with the output of the input level controls and is fed to the input of the matrix steering decoder. The matrix steering decoder handles the routing of the Center channel signal and controls the level of each of the four matrix outputs to increase the separation between channels whenever possible. The left, center and right signals are then sent to the master volume control. The Surround channel is first sent to an anti-aliasing filter, an adjustable length digital delay, a 7 kHz low pass filter, and a Dolby B-type noise reduction decoder which has complimentary modifications to match the B-type noise reduction encoder used during the surround encoding process. The output of this signal chain is then sent to the master volume control. The output of the master volume control is the output of the decoder.
Chapter 9
Miscellaneous Information

9.1 Contacting Dolby Laboratories

In addition to headquarters in San Francisco, Dolby has several other offices around the world. All offices are equipped to provide information on soundtrack production and encoding.

You may contact Dolby from anywhere in the world by e-mail using the following addresses:

<table>
<thead>
<tr>
<th>Address</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="mailto:info@dolby.com">info@dolby.com</a></td>
<td>General information and inquiries</td>
</tr>
<tr>
<td><a href="mailto:tsa@dolby.com">tsa@dolby.com</a></td>
<td>To apply for a Dolby trademark agreement (TSA)</td>
</tr>
<tr>
<td><a href="mailto:dvd@dolby.com">dvd@dolby.com</a></td>
<td>Questions on audio encoding for DVD</td>
</tr>
<tr>
<td><a href="mailto:multimedia@dolby.com">multimedia@dolby.com</a></td>
<td>Questions on multimedia applications</td>
</tr>
</tbody>
</table>

In addition, a wide variety of technical and trademark information can be found on Dolby’s web site at www.dolby.com.

Information on local Dolby offices is given below. Please contact the nearest office for direct assistance.

San Francisco Headquarters
Dolby Laboratories
100 Potrero Avenue
San Francisco, CA 94103-4813
415-558-0200
Facsimile 415-863-1373

Los Angeles
Dolby Laboratories
3375 Barham Boulevard
Los Angeles, CA 90068-1446
Phone 213-845-1880
Facsimile 213-845-1890

New York
Dolby Laboratories
1350 Avenue of the Americas
New York, NY 10019-4703
Phone 212-767-1700
Facsimile 212-767-1705

England
Dolby Laboratories
Wootton Bassett
Wiltshire SN4 8QJ England
Phone (44) 1793-842100
Facsimile (44) 1793-842101
9.2 Software Identification and Trademark Usage

Dolby Laboratories encourages use of the Dolby Surround trademark to identify soundtracks that are encoded in Dolby Surround. This is an effective way to inform listeners of the soundtrack format, and the use of a standard logo promotes easy recognition in the marketplace. However, like any trademark, the Dolby Surround logo may not be used without permission. Dolby Laboratories therefore provides a royalty-free Trademark and Standardization Agreement (TSA) for companies who wish to use Dolby trademarks. This agreement must be signed by the company that owns the program material being produced. Recording studios or production facilities that provide audio production, encoding, or manufacturing services for outside clients generally do not require a trademark license. However, we do ask that these facilities refer their clients to us for trademark licensing information.

If you would like to use the Dolby Surround logo you can apply for a Dolby Trademark and Standardization Agreement (TSA) by sending e-mail to tsa@dolby.com or by contacting Dolby Laboratories at any of the locations given in Section 9.1 Contacting Dolby Laboratories. When sending written requests please indicate that you would like a Dolby Surround trademark license and include your name, your company name, mailing address, and the type of media on which your soundtracks will be distributed, such as CD, laser disc or VHS.

For detailed information on Dolby trademark licensing, please refer to the document Use of Dolby Trademarks on Audio and Video Media, available on the Dolby web site at www.dolby.com. We are also planning to make our license application form available on-line, so check the Dolby web site in the coming months for the on-line version of the Media Licensing Questionnaire.
If you are already a Dolby licensee and would like more information on trademark use, please contact Dolby Laboratories. We are always happy to review artwork and assist with the proper use of our trademarks. Information on trademark licensing plus instructions for using the Dolby Surround trademark and marking audio features on DVD can also be found on the Dolby web site.

9.3 Dolby Surround Consultants

Dolby Laboratories has consultants available to assist with setting up rooms, checking calibrations, and mixing. Consultants are available for a fee for either half or full days. Charges for engineering services do not include travel to and from the studio. If the facility is outside of the local area for one of our offices, travel, hotel and meals will be added at actual cost.

9.4 Dolby Surround Software Lists

To let consumers know what programs, CDs, games and videos are available with Dolby Surround encoding, Dolby Laboratories maintains listings on the Dolby Web Page (www.dolby.com) and in print. In order to keep these lists current, studios and engineers producing Dolby Surround encoded programs are encouraged to give us information on their titles for inclusion on these lists. Program information can be sent to info@dolby.com.