PMI-Gold Line Test DVD Tutorials
Title 6
12/08/00

Chapter 1: Calibrating System Sound Pressure Level

This section describes how to calibrate the individual channel levels of a multichannel sound system.

Use 500Hz to 2kHz filtered Narrowband Pink Noise from Chapters 1 to 6 of Title 1 for the Main Channels, and the 40Hz to 80Hz filtered Narrowband Pink Noise from Chapter 7 of Title 1 for the Subwoofer.

Use a basic sound level meter, such as the Gold Line SPL120 or Radio Shack Realistic 33-2050.

Select the C Weighting and Slow modes.
Hold the meter pointing straight up, at arms length and at seated ear height, directly over the main central seat (try sitting to the left or right of the main seat and holding out the meter). For best results place the meter on a camera tripod or a microphone stand. For setting the Subwoofer level it is best to slowly move the microphone one foot back and forth around the main seating area to get a level average.

Adjust your surround decoder individual channel level controls so that the test signals in Chapters 1 through 7 of Title 1 measure 75dB SPL (Sound Pressure Level). With the Gold Line SPL120 the level will be indicated in the 4 digit numeric display. If you are using the Realistic 33-2050, set the large dial to the 70 position and make the needle point to the +5 position of the dial; this will result in 70+5 = 75dB SPL.

Adjusting the level controls can be a complex process. On many surround decoders the adjustment mode can only be accessed while hearing a test signal internal to the decoder.

On THX®-certified products, this test signal is accurately calibrated for adjustments at 75dB SPL; so we recommend that you use this internal test signal and set levels with your sound level meter, as shown above. You can then double-check your results with the signals from Chapters 1 through 7 of Title 1.

With surround decoders that don't carry the THX logo, internal test signals are variable in overall level. Try setting the volume control so that the Left and Right channels reach 75dB SPL, then adjust the Center and Surround levels for 75dB SPL. Double-check your results by using Chapters 1 through 7 of Title 1 and apply any corrections to the master volume control so that these register at 75dB SPL.

Once levels match, you can further check your results by listening to Chapter 8 of Title 1. All levels should sound about the same as the test signal cycles around the speakers in the room. If you have a system equipped for THX Surround EX playback, you can also use Chapter 9 of Title 1.

If you don't have access to a sound level meter, you can listen to Chapter 8 of Title 1 (or Chapter 9 for THX Surround EX) and adjust levels so that all channel levels sound the same. You will not have any way to verify that the overall level is right, but at least the relative channel levels will be correctly set-up.

Once all channels are calibrated to 75dB SPL with the test signals from Chapters 1 to 7 of Title 1, you will hear your DVD movie soundtracks at the exact level intended by the Director and Sound Engineers. Of course you can turn it up or (more likely) down as you please. We advise that you mark the volume control position that yielded the correct level, for future reference. On THX-certified surround decoders this position should be called 0dB by default. On other products it could be anywhere on the dial.
Note that for multi-channel music programs there is no documented reference level, so you will need to set your volume control to taste as you have always done in 2 channel stereo.

Note: This disc is mastered at Dialnorm 27, which is the common standard for all Dolby Digital soundtracks. With tracks mastered at different Dialnorm levels you might need to set the volume control to match the film soundtrack level.

Good job. You have now completed the one task that will most enhance your system quality; this is something that 90% of Home Theater owners never knew how to do!

Chapter 2: Frequency Response Measurements and Equalization

One of the most important indicators of a system's quality is its frequency response (its evenness of restitution of all sounds across the bass-to-treble listening range). Acoustic Frequency response can be measured by many means and will often reveal how inaccurate most systems are when they are initially set up in a room. This disk provides test signals for use in measuring and listening to a system's frequency response. Once measurements are complete you have several options for correcting any errors, as discussed later in this chapter.

Use the Wideband Pink Noise signals from Chapters 10 to 15 of Title 1 for the Main Channels, and the 20Hz to 80Hz filtered Band-Limited Pink Noise from Chapter 16 of Title 1 for the Subwoofer.

You will need to use a Real Time Spectrum Analyzer (RTA), such as the Gold Line DSP30, coupled with a reference test microphone, such as the one included with the DSP30. An RTA measures the entire audible frequency band of Pink Noise and displays the levels of each section of the range. For proper measurements you will need to see the range with at least 30 points of information; this is known as 1/3 Octave resolution as there are three measurement points for every doubling of frequency. The human auditory system's spectral resolution is about the same as a 1/3 Octave analyzer, hence the appropriateness of this measurement method.

The Gold Line DSP30 is a high value portable 30 band ***digital*** 1/3 Octave Analyzer. It captures a full 85dB measurement window with scales from ¼ to 5dB. The DSP30 filters ***exceed*** ANSI specs, and it comes with an RS232 computer interface. It is easy to use and can memorize results for later recall and evaluation.

Setting up the DSP30 analyzer:
Plug the microphone into the Gold Line DSP30 unit. Turn on the DSP30 and hold it at arm's length over the main seat so that the microphone is more or less at seated-ear-height.

Make sure that the DSP30 is in the following modes:
Weight: Flat. You do this by pressing the 2 (*weight*) button and observing that the red light over the word ***FLAT*** is **ON**. Each time you press the 2 (*weight*) button, you will see the light changing.
Set the ***Decay*** for ***Slow***, which you can change by pressing the 3 button (labeled *DECAY*) and observing that the red light above the word *SLOW* is illuminated.
Then make sure the DSP30 is in ***Averaging* mode**, which you change by pressing the 5 button and observing that the red light above the word AVG is illuminated.
Next make sure you have ***peak hold*** turned **OFF**. Press the 6 button to turn off the peak hold by observing that the PK HOLD light is off.

The last selection is ***RTA* mode** (Real Time Analysis). Do this by pressing the "**RTA"* button to the left of the 0 button.

Measuring Frequency Response:
Select the Pink Noise Chapter that matches the speaker you want to measure.
Start with the Left Channel (Chapter 10 of Title 1), then proceed to the Center, Right, Surround Right, Surround Back (for THX Surround EX Systems), Surround Left, and Subwoofer (using the LFE signal).

Use the DSP30 at seated-ear-height over the main seat and verify that all the little red lights in the main display come up to the same level. You might need to adjust the overall level of those red lights by pushing either the 8 or 0 button. The 8 button will lower all the red lights, while the 0 button will raise them all. Choose a setting that will bring all the red lights within the main window of the display. Once you have all the lights within the main window, you can change the value of the difference between the height of all the red lights; that is called the "Scale." The scale is visible in the row of lights below the window and ranges from 0.25dB up to 5dB. You can change this by pressing the 1 button to cycle around the different steps. Start at the 5dB position, then cycle around until you reach the 2dB-per-division selection.

Your sound system has ideal frequency response when all the lights are within one or two divisions from each other (+/-2dB deviation). The lights should form a horizontal flat line, give or take one division. You should find that above approximately 8kHz the line will have a downward turn; this is normal in most listening rooms, and should not be corrected. You might also find that your sound system does not produce a flat line below 8kHz and that it is rather bumpy, especially in the low frequency region, in the left half of the display. This is often a problem and is due to low frequency resonance in the listening room. These errors may be corrected by a combination of four changes:

Correcting Frequency Response Errors:
Several methods should be used in conjunction with each other to improve the response.

1. Changing the position of the loudspeakers.
2. Changing the position of the listener.
3. Adjusting the acoustics of the room. Acoustical adjustments are best done during design and construction of the room because they involve changing the size of the room or adding special acoustic treatments. However, some can be done as a retrofit, such as adding bass absorbers specially designed to dampen problem frequencies, or adding resistive absorbers to remove mid-frequency echoes and reflections.

4. Adjusting the frequency response of each channel in the system using equalizers. An equalizer is a device that allows you to control the frequency response of a system by boosting or cutting energy in any desired frequency region.
Several manufacturers make equalizers for this particular application, and some are good while others are not. Combined with the three above modifications (*the loudspeaker position, the listener position, and the room acoustics*) equalization can

result in completely smooth frequency response, which is well known to yield high quality sound.
A recommended equalizer is the Gold Line EQ2. It is a 2-channel high quality digital equalizer that works very well in conjunction with the Gold Line DSP30.

For a 5.1 channel system you would need two Gold Line EQ2 Equalizers to adjust the frequency response of at least the Left, Center, Right, and Subwoofer channels. To equalize the Surround channels you will need one more EQ2 (or two more if you have a THX Surround EX system). Other good equalizers are the Rane 44 and the Audio Control Bijou, both of which are Multichannel analog equalizers.

Setting the Equalizer:
To use an equalizer, simply examine the measured frequency response on the Analyzer display. Where there is a measured peak, at say 250Hz, compensate it by adjusting the 250Hz band of the equalizer by the corresponding amount of attenuation. It is generally best to start by cutting off peaks, rather than boosting dips. In fact some dips can't be compensated at all, if they are the result of a sound wave cancellation. After applying corrections in all the needed frequency bands, measure the results and examine the improvement. It will normally take three or four passes of measuring/adjusting until the response is sufficiently smoothed out.

For equalization of the subwoofer use Chapter 16 of Title 1. It is best to measure low frequency response with 1/12th Octave resolution (twelve measurements points between any doubling of frequencies). The Gold Line DSP30 with Option 112 can perform 1/12th Octave measurements. Conduct the same measurements and adjustments as for the main channels, but average out the listening zone measurements by slowly moving the microphone back and forth over a 2 x 2 foot area centered in the main seat. Make sure to use the averaging mode (Ctrl 7 on the DSP30) to get the right results.
After the subwoofer is equalized, its level needs to be matched to that of the main channels. The best method is to re-measure the Center + Subwoofer combination, using Wideband Noise from Chapter 11 of Title 1. Adjust the level of the Subwoofer channel so that it "splices" in correctly to the Center channel at the Crossover frequency, usually 80 to 100Hz. If there is a visible response dip at the crossover frequency try switching the subwoofer polarity and observe if there is an improvement by repeating the measurement.

Once you have measured each channel and corrected whatever errors you found, you can do a quick verification of your results by listening to Chapters 17, 18, or 19 of Title 1. Chapter 17 will allow you to compare the three front channels (the most important ones!) Listen to Pink Noise and verify that it generally sounds identical in each of the three front speakers. Pink Noise is a very sensitive test signal, and you will easily be able to identify differences; it can be difficult to get the three front channels to sound exactly the same. Experience will tell you what is close enough to be acceptable by even the most

discerning listener. As a general rule +/-4dB errors are easy to hear, while +/2dB errors are harder to notice on regular program material. If the three front channels sound very different from each other, go back to your measurement results and compare them. With the DSP30 you can draw up a difference curve between any two measurements by using the subtraction mode (see the DSP30 manual for more details). Verify that the overall differences are less than +/3dB, and apply correction if necessary.

Chapter 18 will allow you to audibly compare all the main channels of a 5.1 channel system, and Chapter 19 will compare all the main channels of a system equipped with THX Surround EX. For a more precise audible verification of frequency response, see the section below, called “Using Audiometric Earphones.”
Once your have completed your equalization, verify and readjust the system channel levels, as described at the end of this Chapter.

Using The DSP30 with a Computer:
You can connect the DSP30 to a computer to make it easier to use. The DSP30 comes with a software diskette that you load into your computer, and it also comes with a cable that connects to a serial port of your computer. With this computer interface you can store graphs, print them, display them, and generally have better visual interaction with the data than just by looking at the front panel of the DSP30. All you need is a basic PC computer or laptop, 486 type or better, with Windows 95, and you will save time and get improved results.

Using The DSP30 with an MX4 Multiplexer:

For best results we recommend expanding your measurement system to include a multiplexer and four test microphones. The MX4 multiplexer is a device that allows a single channel Real Time Analyzer to average information from up to four microphone positions in a single test. When this information is processed by the DSP30 analyzer which has "time averaging," the resulting curve is called "spatially averaged." Spatial averaging is recommended by all of the major film cinema/home theater organizations, including Lucasfilm THX, and Dolby Laboratories.

The advantage of multiplexing is that the resulting curve on the real time analyzer reflects the overall response of the room across the entire seating area, rather than only the acoustics of a single point in the room.

The MX4 can be used with all Gold Line 1/3 Octave Real Time Analyzers and with most other popular models. The MX4 is provided with three DSP30 model MK8A reference microphones. If you have a DSP30, use your RTA microphone as the fourth microphone. Additional microphones are available from Gold Line.

Setting up the Multiplexer:
Plug as many microphones as you plan to use into the unit.

Select each input from the front panel On/Off switches.
Each of the four channels has a gain control to allow the user to match the input level from different locations. Set each level so that they are equal to each other when measuring the Narrowband Pink Noise signal from Chapter 2 of Title 6. Observe the SPL value displayed in the Level window of the DSP30 or of the computer display. Start by setting the Mic 1 level at the 12 o'clock position, and then match the values of the other mics to that of Mic 1. To measure each individual microphone level turn all the other ones off.
Once the MX4 is set up, enable all the relevant microphone inputs and start measuring frequency response on the DSP30 as shown above. Make sure you use the averaging mode by pressing Ctrl 7. Take an average value for about 30 seconds, then store the results in a memory location or in a separate file if you are using the computer interface.

Checking Frequency Response through Listening Comparison:

If you don't have access to a Spectrum Analyzer, or if you want to double check your analysis work, you can get to a reasonable approximation by comparing a reference of Pink Noise sound to the sound of each loudspeaker. A good way to hear reference Pink Noise is to get a set of high-quality audiometric free-field compensated ear-canal earphones, and listen to Pink Noise through them. One good source for such a device is the Etymôtic brand ER4S earphone. The ER4S fits into your ear like a set of earplugs, blocks outside sounds, and sends precise soundwaves directly to your eardrums. Listen to Pink Noise from this DVD, or from any other good Pink Noise source, through the earphones, then pull them out and compare what you just heard to the sound of the speaker playing Pink Noise. You will need to match the overall sound level of the speaker and earphones. One simple solution for this test is to use a portable CD player with the line output connected to the amplifier driving the speaker to compare, and the headphone output connected to the ER4S. You will need to get a CD with Pink Noise, and play it on the CD player (contact PMI, Ltd. if you need a low cost Pink Noise CD). Set the headphone output level to match the speaker level, and compare the two sounds. If the speakers sound heavier on the bass than the earphones, try pulling them away from walls and floors. Ultimately, for best results you will need to equalize your system, as discussed above in the section "Setting the Equalizer." With the listening comparison try moving bands of the equalizer up and down, until you notice which ones seem to affect the areas where you notice differences between the ER4S and your speaker. This method will of course take you a fairly long time, so make sure to take regular breaks to let your ears rest! We highly recommend you invest in an analyzer if you are serious about your sound quality or if you often perform sound system alignments; it will save you time over the earphone method and will yield better results. By the way, it is always good to check you work with the ER4S earphone comparison. Also, the ER4S earphones are of great use if you travel and like to listen to music or movies in airplanes; they cut out the ambient noise and any annoying neighbors!

Rechecking System Sound Pressure Level Calibration:

Once you have adjusted or corrected your system frequency response you should verify and re-adjust all your individual channel level controls, as they might have changed. Go back to the Tutorial in Chapter 1 of Title 6 and repeat all the steps.

Chapter 3: Polarity Verifications – Main Channels

Use the 500Hz to 2kHz filtered Gated Narrowband Pink Noise from Chapters 20 to 27 of Title 1 for the Main Channels.

Start by verifying that the Left and Right channels are “In-Phase” with each other by playing Chapter 20. The polarities are identical if the noise test signal sounds like it is clearly coming from between the Left and Right speakers, forming a “phantom image”. Make sure you are listening at a location equidistant from the two speakers. Also, verify that the + (red) and – (black or white) wires are hooked up to your amplifier and speakers in the identical way. You can try inverting the + and - wires of the Right speaker and observe if the phantom image sounds clearer. Make sure you turn off the power amp or receiver before you change connections to avoid any short-circuits.

Next step is to verify that the Center channel is “In-Phase” with the Left channel. Play Chapter 21 and listen for a solid phantom image appearing to come from between the Left and Center speakers. Listen at a location equidistant between the two speakers. Again, you can try inverting the + and - wires at the back of the speaker and listen for an improvement or worsening of the image. Make sure you turn off the power amp or receiver before you change connections to avoid any short-circuits. If the speakers are clearly in opposing polarity, you should get a sense that there is a sonic hole between the two speakers. Also note that if your Center speaker is different from your Left speaker, it can be difficult to hear a clear phantom image no matter how you hook up the wires. For this reason it is best to have identical Left, Center, and Right speakers.
Another note: 5.1 channel surround decoders usually have delay time settings for the outputs. If the settings are incorrect it will be difficult to get a clear image. Start off by setting the Center delay identically to the Left/Right. Once you have completed the polarity test you can adjust the delay setting to correct for differences in distance between your listening position and each of the speakers. A hint for setting delays is that sound propagates at about 1 foot for every millisecond of time; if the Center speaker is closer to you by 2 feet compared to the Left/Right speakers, a center delay of 2 milliseconds will correct the imaging error. If you are using a THX certified decoder adjust the delay times by setting speaker distances.

Next, verify that the Center and Right speakers are correctly polarized by using Chapter 22. If the two above tests were successful, the Center and Right should be OK. However, for several acoustical reasons the Center/Right phantom image could be more or less focused than the Left/Center image, and it is good to verify that you have a good match throughout. Ensure that furnishings, wall boundaries, etc., around the Left and Right speakers are similar, in order to get a good match of phantom images.

Verify polarity match of the Right and Surround Right with Chapter 23. You will need to face the right side of your listening room and place yourself so that the Right and Surround Right speakers form an equilateral triangle with your head position. You should hear a phantom image halfway between the two speakers. Note that it can be difficult to get a clear image if you have different speakers in these two locations. Aim for the wiring

polarity that yields the best results. Make sure you turn off the power amp or receiver before you change connections to avoid any short-circuits. Also, note the delay time setting issues covered in the Left/Center polarity section above.

Verify polarity match of Left and Surround Left speakers with Chapter 24. Observe all the guidelines in the Right/Surround Right section above.

If you have a THX Surround EX system, verify the polarity match of Surround Right and Surround Back speakers with Chapter 25. If you are using two speakers for the Surround Back, disconnect the Surround Back Left speaker for easiest verification. Make sure you turn off the power amp or receiver before you change connections to avoid any short-circuits. Also, note the delay time setting issues covered in the Left/Center polarity section above.

If you have a THX Surround EX system, verify the polarity match of Surround Left and Surround Back speakers with Chapter 26. If you are using two speakers for the Surround Back, disconnect the Surround Back Right speaker for easiest listening. Make sure you turn off the power amp or receiver before you change connections to avoid any short-circuits. Also, note the delay time setting issues covered in the Left/Center polarity section above.

You can verify the polarity match of any two speakers in the room by using Chapter 27 of Title 1. Chapter 27 sends test noise to all the main channels simultaneously. Simply disconnect all the unwanted speakers. Make sure you turn off the power amp or receiver before you change connections to avoid any short-circuits. Again, note the delay time setting issues covered in the Left/Center polarity section above.

For a final and more difficult test you can switch to listening to Gated Wideband Pink Noise, using Chapter 28 of Title 1. This is more challenging because there are many opportunities for mismatch with wideband signals. Chapter 28 sends wideband test noise to all the main channels simultaneously. Simply disconnect all the unwanted speakers. Make sure you turn off the power amp or receiver before you change connections to avoid any short-circuits. Again, note the delay time setting issues covered in the Left/Center polarity section above.

Chapter 4: Crossover Polarity Verifications

This test is only necessary of you are using a subwoofer in your system.
First you need to determine your system's specified crossover subwoofer frequency. Most good quality 5.1 channel surround decoders have a preset crossover frequency at 80Hz. Some use 100Hz, and some even have selectable crossovers frequencies. Look at the information in the marketing materials, owner's manual, Websites, or even magazine reviews for your decoder. Once you know the crossover frequency, select the Chapter between 29 and 39 of Title 1 that corresponds to that frequency. These chapters each have a very narrow bandwidth noise test signal centered on the crossover frequency. For example, if your system uses an 80Hz crossover, select Chapter 34.

Next play the selected test signal. It should come out of the Center speaker and the Subwoofer. Listen to and measure the sound level at the main seating position. Try inverting the subwoofer polarity and comparing the results. Whichever of the two choices is loudest is the better setting. Changing the polarity can be as simple as finding the switch labeled "Polarity +/-" on the rear panel of a powered subwoofer. If you have a passive subwoofer with a separate power amplifier, try inverting the + and – wires that lead to the subwoofer, and compare the results. Make sure you turn off the power amp before you change connections to avoid any short-circuits.

You can also use the test signals in Chapters 29 through 39 to measure the frequency response of the subwoofer channel when you don't have a spectrum analyzer. See the tutorial in Chapter 5 for more information.

Chapter 5: Frequency Response Measurement and Equalization with 1/3rd Octave Pink Noise

You can use this measurement method if you don't have a Spectrum Analyzer but have a good Sound Level Meter.
Use the 1/3 Octave-filtered Narrowband Pink Noise signals from Chapters 40 to 69 of Title 1 for the Main Channels only and above the Crossover frequency, for Subwoofer-Satellite systems. These Chapters send test noise to all the Main Channels simultaneously. Simply disconnect all the unwanted speakers. Make sure you turn off the power amp or receiver before you change connections to avoid any short-circuits.

Use the 1/3 Octave-filtered Narrowband Pink Noise signals from Chapters 29 to 39 of Title 1 for the Subwoofer Channel. These Chapters send test noise to the Center channel only, and if the Bass Management settings of your 5.1 channel surround decoder are set correctly, the signal will end up in the subwoofer up to the crossover frequency

Use a good sound level meter, such as the Gold Line SPL120.
If you use the Radio Shack Realistic 33-2050 note that it is not reliable below 50Hz and above 8kHz.
Select the Flat Weighting and Slow modes.
Hold the meter pointing straight up, at arms length and at seated ear height, directly over the main central seat (try sitting to the left or right of the main seat and holding out the meter). For best results place the meter on a camera tripod or a microphone stand. When measuring the bands from 20Hz to 100Hz it is good to slowly move the microphone one foot back and forth around the main seating area to get a level average.

The test signals in Chapters 40 through 69 of Title 1 are designed to be reproduced at 75dB SPL (Sound Pressure Level) when played from one Main channel at a time. They are not to be used in Subwoofer-Satellite systems for frequencies below the crossover point, as all the channels will add together into the subwoofer and cause an excess of level.
With the Gold Line SPL120 the level will be indicated in the 4 digit numeric display. If you are using the Realistic 33-2050 set the large dial to the 70 position and adjust your surround decoder individual channel level controls so that on average the needle points to the +5 position of the dial; this will result in 70+5 = 75dB SPL.

The low frequency test signals in Chapters 29 through 39 of Title 1 are designed to be reproduced at 75dB SPL (Sound Pressure Level) when played through a Subwoofer-Satellite System.

Measure each band individually and write down the level displayed on the meter. If you have graph paper you could plot the response from the numbers you just noted.

Your sound system has good frequency response when all the measurement points are within four decibels from each other (+/-2dB deviation). The dots of your plot should

form a horizontal flat line give or take some minor deviations. You should find that above approximately 8kHz the line will have a downward turn; this is normal in most listening rooms, and should not be corrected. You might also find that your sound system does not produce a flat line below 8kHz and that it is rather bumpy, especially in the low frequency region. This is common and is due to low frequency resonances in the listening room. These errors may be corrected by a combination of four changes.

Correcting Frequency Response Errors:
Several methods should be used in conjunction with each other to improve the response.
1. Changing the position of the loudspeakers.
2. Changing the position of the listener.
3. Adjusting the acoustics of the room. Acoustical adjustments are best done during design and construction of the room because they involve changing the size of the room or adding special acoustic treatments. However, some can be done as a retrofit, such as adding bass absorbers specially designed to dampen problem frequencies, or adding resistive absorbers to remove mid-frequency echoes and reflections.

4. Adjusting the frequency response of each channel in the system using equalizers. An equalizer is a device that allows you to control the frequency response of a system by boosting or cutting energy in any desired frequency region. An equalizer with 1/3rd Octave resolution should be used, at least for the range from 20Hz to 1000Hz. The 1/3 Octave tones in Chapters 29 to 69 of Title 1 are a good match for adjustment of such equalizers. For equalizers with less resolution (1 Octave) consider using the tones in Chapters 70 to 77 of Title 1 (see Chapter 6 tutorial).

See the information on Equalization in the Chapter 2 tutorial of this Title for more information.

Chapter 6: Frequency Response Measurement and Equalization with Octave Pink Noise

You can use this measurement method if you don't have a Spectrum Analyzer but have a good Sound Level Meter, and if you want to use a basic Octave resolution equalizer (10 band) for room corrections.
Use the Octave-filtered Narrowband Pink Noise signals from Chapters 70 to 77 of Title 1 for the Main Channels only and above the Crossover frequency, for Subwoofer-Satellite systems. These Chapters send test noise to all the main channels simultaneously. Simply disconnect all the unwanted speakers. Make sure you turn off the power amp or receiver before you change connections to avoid any short-circuits.

Use the 1/3 Octave-filtered Narrowband Pink Noise signals from Chapters 29 to 39 of Title 1 for the Subwoofer Channel. These chapters send test noise to the Center channel only, and if the Bass Management of your 5.1 channel surround decoder is set correctly, the signal will end up in the subwoofer up to the crossover frequency

Use a good sound level meter, such as the Gold Line SPL120.
If you use the Radio Shack Realistic 33-2050 note that it is not reliable below 50Hz and above 8kHz.
Select the Flat Weighting and Slow modes.
Hold the meter pointing straight up, at arms length and at seated ear height, directly over the main central seat (try sitting to the left or right of the main seat and holding out the meter). For best results place the meter on a camera tripod or a microphone stand. When measuring the bands from 20Hz to 100Hz it is good to slowly move the microphone one foot back and forth around the main seating area to get a level average.

The test signals in Chapters 70 through 77 of Title 1 are designed to be reproduced at 85dB SPL (Sound Pressure Level) when played from one Main channel at a time. They are not to be used in Subwoofer-Satellite systems for frequencies below the crossover point, as all the channels will add together into the subwoofer and cause an excess of level.
With the Gold Line SPL120 the level will be indicated in the 4 digit numeric display. If you are using the Realistic 33-2050 set the large dial to the 80 position and adjust your surround decoder individual channel level controls so that on average the needle points to the +5 position of the dial; this will result in 80+5 = 85dB SPL.

The low frequency test signals in Chapters 29 through 39 of Title 1 are designed to be reproduced at 75dB SPL (Sound Pressure Level) when played through a Subwoofer-Satellite System.

Measure each band individually and write down the level displayed on the meter. If you have graph paper you could plot the response from the numbers you just noted.

Your sound system has ideal frequency response when all the measurement points are within four decibels from each other (+/-2dB deviation). The dots of your plot should form a horizontal flat line give or take some minor deviations. You might find that the 8kHz point has a downward turn; this is normal in most listening rooms, and should not be corrected. You might also find that your sound system does not produce a flat line below 8kHz and that it is rather bumpy, especially in the low frequency region. This is common and is due to low frequency resonance in the listening room. These errors may be corrected by a combination of four changes:

Correcting Frequency Response Errors:
Several methods should be used in conjunction with each other to improve the response.
1. Changing the position of the loudspeakers.
2. Changing the position of the listener.
3. Adjusting the acoustics of the room. Acoustical adjustments are best done during design and construction of the room because they involve changing the size of the room or adding special acoustic treatments. However, some can be done as a retrofit, such as adding bass absorbers specially designed to dampen problem frequencies, or adding resistive absorbers to remove mid-frequency echoes and reflections.

4. Adjusting the frequency response of each channel in the system using equalizers. An equalizer is a device that allows you to control the frequency response of a system by boosting or cutting energy in any desired frequency region. The Octave tones in Chapters 70 to 77 of Title 1 are a good match for adjustment of Octave (10 band) equalizers. Note that 1/3rd Octave (30 band) resolution is preferable for accuracy and should be used in any high-quality system.

See the information on Equalization in the Chapter 2 tutorial of this Title for more information.

Chapter 7: Calibrating Subwoofer Sound Pressure Level (non- 5.1 systems)

This section describes how to calibrate the level of a subwoofer in a system where the subwoofer is fed from the Left, Center, or Right output of your decoder. Note that THX certified controller/decoders not equipped for 5.1 channel digital soundtrack decoding don't need this special section as they all have dedicated subwoofer outputs and built-in level calibration means.

This section also assumes that you have gone through the level calibrations in Chapter 1 of this tutorial for the Main channels.

Use 40Hz to 80Hz filtered Narrowband Pink Noise from Chapter 78 of Title 1.

Use a basic sound level meter, such as the Gold Line SPL120 or Radio Shack Realistic 33-2050.

Select the C Weighting and Slow modes.
Hold the meter pointing straight up, at arms length and at seated ear height, directly over the main central seat (try sitting to the left or right of the main seat and holding out the meter). It is good to slowly move the microphone one foot back and forth around the main seating area to get a level average.

The test signal in Chapter 78 of Title 1 is designed to be reproduced at 75dB SPL (Sound Pressure Level). With the Gold Line SPL120 the level will be indicated in the 4 digit numeric display. If you are using the Realistic 33-2050 set the large dial to the 70 position and adjust your subwoofer level control so that the needle points to the +5 position of the dial; this will result in 70+5 = 75dB SPL.

Remember to note down the final adjustment position on some masking tape near the control knob. If the setting gets changed for some reason (teenagers in the house?) you can easily bring it back.

Chapter 8: Subwoofer Peak Output Sound Pressure Level

This section describes how to determine the peak output level of a subwoofer in a 5.1 channel system. A 5.1 channel soundtrack can be recorded with enough level to require 115dB SPL capability in the bass region and any high quality system should be able to reproduce that level (neighbors beware!!)

Use 20Hz to 80Hz filtered Pink Noise from Chapter 79 of Title 1.

Use a basic sound level meter, such as the Gold Line SPL120 or Radio Shack Realistic 33-2050.

Select the C Weighting and Slow modes.
Hold the meter pointing straight up, at arms length and a seated ear height, directly over the main central seat (try sitting to the left or right of the main seat and holding out the meter). It is good to slowly move the microphone one foot back and forth around the main seating area to get a level average.

The test signal in Chapter 79 of Title 1 is designed to be reproduced at 115dB SPL (Sound Pressure Level) if your system is properly level calibrated and if it has vast low frequency output capabilities. With the Gold Line SPL120 the level will be indicated in the 4 digit numeric display. If you are using the Realistic 33-2050 set the large dial to the 110 position and observe the needle position. A 0 indication means 110dB; a +5 indication means 115dB SPL.

You might want to start playing this test with the master volume level reduced, then gradually increase it until you notice some form of distress from the subwoofer, or until the level stops increasing.

Subwoofers without proper overload protection will show signs of distortion, driver overload, port wind-noise, cabinet rattles, and the like. They should not be used at levels exceeding the “distress point” as they will distract the listener, and possibly result in equipment failure. Subwoofers with built-in limiting can be pushed into the limit point but the result will sound like one-note bass without proper definition, and definitely no dynamics.

Also, note that the Bass Management in THX decoders also incorporates a “Bass Peak Manager” system, and this needs to be set during system configuration. Such decoders have a built-in test signal, which you should use for peak limiter ceiling setting. You can confirm your results by using the Chapter 79 test signal. The low frequency bandwidth of this disc’s test signal is slightly extended compared to THX controllers, so you might measure a lower maximum level on some subwoofers. You could start off by setting the Bass Peak Manager control to off, or maximum output level, then measure your subwoofer’s capabilities. Following that, you should go back and re-set the Bass Peak Manager to match you subwoofer’s limitations.

Chapter 9: Sound Leak Detection

This section describes how to find sound leaks in walls, windows, doors, ventilation systems, outlet plates, etc. A 5.1 channel soundtrack can be recorded with enough level to produce 105dB SPL per channel in the midrange, and 115dB SPL in the bass region so neighbors beware!

Use Gated Wideband Pink Noise (1/2 sec ON – 1/2 sec OFF) from Chapter 80 of Title 1.

The test signal in Chapter 80 of Title 1 is designed to be reproduced at 105dB SPL (Sound Pressure Level) per channel if your system is properly level calibrated and if it has vast output capabilities. All together the multiple channels could add up to sound pressures in excess of 110dB SPL so it will be real easy to hear sound leaks!

You might want to start playing this test with the master volume level reduced, then gradually increase it until well before you notice any form of distress from the sound system.

Once you have set the desired level, go to the rooms adjoining the Listening room and listen for sound leaks. Because of the gated nature of the test signal you will easily notice the leak locations at the start of each sound burst. Leaks could be in outlet plates, at the tops of walls, at the bottoms, under or around doors, and of course, directly through the walls.

If you want to quantify the noise transmission, you can measure the level in the listening room, then measure the level in the adjoining spaces. The difference in levels can simply be expressed in dB of attenuation. It is best to use continuous noise for such measurements. Use the signals in Chapter 28 of Title 1, and turn the volume control up to a desired level. Use all the measurement guidelines from Chapter 1 of this tutorial. Take measurements at several locations within the adjoining rooms, and compute averages of these levels. If repairs or construction modifications are needed you will be able to measure the improvements through these sets of measurements.

Chapter 10: Reverberation Measurements

This section describes how to measure Reverberation time (RT60) using a device designed expressly for that purpose.

Use Gated Wideband Pink Noise (10 sec ON - 10 sec OFF) from Chapter 81 of Title 1.

You can use a Real Time Spectrum Analyzer (RTA) with RT60 capability, such as the Gold Line DSP30 with OptRT60, coupled with a reference test microphone, such as one of those included with the DSP30. An RTA measures the entire audible frequency band and displays the levels of each section of the range. An RT60 function measures the time it takes for a signal to decay 60dB from its original level. Typical RT60 systems display the resulting value in octave bands and also as a total averaged value of all the octave bands.

The test signal in Chapter 81 of Title 1 is designed to be reproduced at 105dB SPL (Sound Pressure Level) per channel if your system is properly level calibrated and if it has vast output capabilities. All together the multiple channels could add up to sound pressures in excess of 110dB SPL so you might want to start playing this test with the master volume level reduced, then gradually increase it it is well above the room's background noise, but until well before you notice any form of distress from the sound system.

Once you have set the desired level, you are ready to pause for a little while and set up your measurement system. Because of the gating time nature of the Chapter 81 test signal, it will be automatically recognized by the Gold Line DSP 30 as valid for RT60 measurements.

Setting up the DSP30 analyzer:
Plug the microphone into the Gold Line DSP30 unit. Turn on the DSP30 and hold it at arm's length over the main seat so that the microphone is more or less at seated-ear-height.

Make sure that the DSP30 is in the following modes:
Weight: Flat. You do this by pressing the 2 (*weight*) button and observing that the red light over the word ***FLAT*** is **on**.
For small rooms set the ***Decay*** for ***Fast***, which you can change by pressing the 3 button (labeled *DECAY*) and observing that the red light above the word *FAST* is illuminated.
For mid-sized rooms select the *MEDIUM* mode.

Next, follow instruction on page 14 of the DSP30 Owner's manual section on RT60 measurements. For easier data visualization it is recommended to run the DSP30 from a PC computer for RT60 measurements.

Using The DSP30 with a Computer:

You can connect the DSP30 to a computer to make it easier to use. The DSP30 comes with a diskette (*taped to the front cover of the manual*) which you load into your computer, and it also comes with a cable that connects to a serial port of your computer. With this computer interface you can store graphs, print them, display them, and generally have better visual interaction with the data than just by looking at the front panel of the DSP30. All you need is a basic PC computer or laptop, 486 type or better, with Windows 95, and you will save time and get improved results.

Follow instruction on page 16 of the DSP30 Owner's manual for operation under PC control.

Chapter 11: Electrical Frequency Response Measurements

This section describes how to measure the electrical frequency response of the various products and channels in a 5.1 channel sound system.

Use the 20Hz to 20kHz single tone stepped sweep from Chapter 3 of Title 2.
The 31 steps in the sweep are at 1/3rd octave steps with each one lasting 1 second. You can determine what frequency you have reached by using a stopwatch and counting the number of seconds since the sweep started. The sweep starts with a 1kHz level reference tone so start your stopwatch at the end of that tone.
The steps are:

1kHz (For reference – 2 sec duration)
20Hz
25Hz
31.5Hz
40Hz
50Hz
63Hz
80Hz
100Hz
125Hz
160Hz
200Hz
250Hz
315Hz
400Hz
500Hz
630Hz
800Hz
1,000Hz
1,250Hz
1,600Hz
2,000Hz
2,500Hz
3,150Hz
4,000Hz
5,000Hz
6,300Hz
8,000Hz
10,000Hz
12,500Hz
16,000Hz
20,000Hz

Use a good quality rms AC voltmeter, with measurement bandwidth up to above 20kHz. Radio Shack models 22-168A and 22-174 are acceptable devices, and Fluke, Hewlett-Packard, and many others also make fine precision devices. The 22-168A can also be hooked up to a PC interface and will get you a display in second increments that works well if correctly synchronized.

Measure the voltage at each second-long step, and note them all down. You can graph the measurement on graph paper and notice the +/- deviation in response over the measured range.

You can use this response test to verify several items:

1. Overall response from source to speaker outputs: Play the sweep signal from your DVD player and measure the voltage at the speaker terminals, with the speakers connected. Select system mode for basic Dolby Digital, with no other post-processing enhancements. Be careful when connecting your voltmeter that you don't cause a short-circuit or don't connect grounds to the wrong pin. If your system is using the Crossover in the Bass Management function (you selected "Small" speakers), you should see a roll-off below 100Hz, then you should find identical voltages all the way up to 20kHz. If there are any peaks or dips between 100Hz and 20kHz you need to troubleshoot your system. The maximum deviation should be 1dB. Try replacing speaker wires (maybe try a larger gauge if you have a long run) or interconnects. Consider if your amplifier has a failure mode.
Note that the sweep starts with 2 seconds of 1kHz so that you can get a level reference at the start of the sweep.

2. Subwoofer Crossover High-Pass and Low-Pass filter functions: After you have selected the right modes in your Bass Management set-up it is good to verify that the results are as expected. Connect a voltmeter to the line output of your Surround Decoder and play the Sweep from your DVD. The Main channels that have High-Pass filtering applied to them should show a downward slope in measured levels below 100Hz. The Subwoofer output should show equal levels from 20Hz up to 60Hz, then gradually attenuating above that. Note that the subwoofer output level will typically be higher than the main outputs for systems where the main speakers are selected as "Small". If all speakers are selected as "Large" none of the signals from Chapter 3 of Title 2 will appear at the subwoofer output, as there is no bass re-direction. Use Chapter 4 of Title 2 for this case

Chapter 12: Low Frequency Electrical Frequency Response Measurements

This section describes how to measure the electrical frequency response of the LFE channel and subwoofer output in a 5.1 channel sound system.

Use the 20Hz to 80Hz single tone stepped sweep from Chapter 4 of Title 2.
The 25 steps in the sweep are at 1/12th octave steps with each one lasting 1 second. You can determine what frequency you have reached by using a stopwatch and counting the number of seconds since the sweep started. The steps are:

20Hz
21Hz
22Hz
23Hz
25Hz
27Hz
28Hz
30Hz
32Hz
34Hz
36Hz
38Hz
40Hz
42Hz
45Hz
47Hz
50Hz
53Hz
56Hz
60Hz
63Hz
67Hz
70Hz
75Hz
80Hz

Use a good quality rms AC voltmeter, with measurement bandwidth up to above 20kHz. Radio Shack models 22-168A and 22-174 are acceptable devices, and Fluke, Hewlett-Packard, and many others also make fine precision devices. The 22-168A can also be hooked up to a PC interface and will get you a display in second increments that works well if correctly synchronized.

Measure the voltage at each second-long step, and note them all down. You can graph the measurement on graph paper and notice the +/- deviation in response over the measured range.

You can use this response test to verify several items:

1. Subwoofer Crossover Low-Pass filter functions: After you have selected the right modes in your Bass Management set-up it is good to verify that the results are as expected. Connect a voltmeter to the Subwoofer line output of your Surround Decoder and play the Sweep from your DVD. The Subwoofer output should show equal levels from 20Hz up to 60Hz, then gradually attenuated above that. Note that the Subwoofer output from Chapter 4 of Title 2 is independent of Main Speaker size selections, since the sweep signal is in the Low Frequency Effects (LFE) channel only.

2. Subwoofer Rattles: You can verify audible rattles in your subwoofer cabinet, or in the listening room, from this sweep. It is best to use a continuously variable single tone sweep generator, but this signal is a good start.