Dolby® Digital is a standard multichannel audio format for cinema and DVD all over the world. It uses Dolby AC-3 (Adaptive Transform Coder 3), a flexible audio data compression technology capable of encoding a range of audio channels into a low rate bit stream.

By 1990, the 4-2-4 Dolby Surround system had been in place in the 35 mm cinema for some 14 years, and interest was growing to offer the cinema industry new digital sound technology. In 1989, a SMPTE subgroup studied the issue of how many sound channels a new digital film sound system should offer. The conclusion was that 5.1 channels should be provided (left, center, right, left surround, right surround, subwoofer). In order to place digital sound data on film reliably, and yet not interfere with either the picture or analog sound area of the film, the available data rate is limited. It was determined that 320 kb/s of error corrected audio data could be reliably placed and extracted from the film area between the sprocket hole perforations on one side of the 35 mm film. All that was required was to realize the concept of AC-3 as a 5.1 channel audio coder operating at 320 kb/s.

AC-3 has been designed to take maximum advantage of human auditory masking. It divides the audio spectrum of each channel into narrow frequency bands of different sizes optimized with respect to the frequency selectivity of human hearing. By reducing or eliminating noise wherever there are no audio signals to mask it, the sound quality of the original signal can be subjectively preserved. In this key respect, a perceptual coding system like AC-3 is essentially a form of very selective and powerful noise reduction.

In professional surround mastering studios dedicated Dolby Digital hardware suites are commonplace. These include:

**DP569 Dolby Digital Multichannel Encoder.** This is a 1-U rack-mount device that encodes 5.1 audio channels and metadata into a Dolby Digital stream

**DP564 Multichannel Audio Decoder:** A 2-U rack-mount device that decodes Dolby Digital and Pro Logic® streams

**DolbyRemote:** Software that controls the DP569 Dolby Digital Encoder

**Dolby Digital Recorder:** Software that takes an encoded Dolby Digital data stream from the DP569 and records it to disk as an .ac3 file
For our purposes we can use ‘Sonic Foundry Softencode’ to encode Dolby Digital!!

**Important Dolby Digital Parameters:**

**Mastering of Dolby Digital**

Dolby Labs has been doing high-quality audio with cutting-edge techniques for a long time, using their past experience as a guide. As such, there is often confusion about their methods and philosophy to those of us who are not privy to that information. Of prime example is the problem: *Why is Dolby Digital so much quieter compared to my original sound?*

Most audio destined for DVDs is audio originally recorded for use in the movie theater. The movie industry has a huge advantage when producing audio for the theater -- the theater has large speakers and amplifiers, and a quiet, near-ideal listening environment. Huge dynamic ranges are possible, where the slightest whisper of dialogue is audible, yet gunshots and explosions can be earth-shattering. Dolby's dilemma was: "How do we bring this audio, with its huge dynamic range, into the home?" This is a major problem -- most homes don't have the speakers and amplifiers necessary to shake the living room. Further, background noise in the home can easily drown out those subtleties in the soundtrack.

Dolby's answer is to allow the decoder to modify the sound to compensate for these problems. Low-volume sounds are boosted automatically so they can be heard, whereas high-volume sounds are quieted down so that speakers aren't blown and other persons in the home are not disturbed. Further, Dolby Digital allows for different program material to be equalized, so that volume does not have to be adjusted when switching between
inherently quiet programs and inherently loud programs. (Note, by program material, we mean both music and film).

**Decoder Specifics**

The methods I'm about to present here for encoding Dolby Digital are generic and do not apply specifically to any one encoder. All Dolby-certified encoders (and some non-certified ones) will have the appropriate parameters available to follow this procedure. For our purposes, we will use the Sonic Foundry Softencode program.

**Basic Parameters**

Every Dolby Digital encoder has some basic parameters that need to be set. The first is the channel combination, presented as (Number of front channels)/(Number of rear channels), with an optional ".1" added to represent a low-frequency-effects (LFE) channel if present, i.e. 2/0 represents normal left and right stereo sound. 3/2.1 represents a standard "5.1" setup, of Front Left, Front Right, Front Center, Rear Left, Rear Right, and LFE. This parameter should obviously be set to the number of channels of program material you will be encoding.

The other major basic parameter is the bitrate. Higher bitrates allow for less compression. Typical bitrates used are 192 kbps for 2/0 program material, and 448 kbps for 5.1 program material.

**Referencing Volume to a Known Level - Dialogue Normalization**

To meet the Dolby Digital requirement that different programs should have approximately the same listening level (thus the consumer does not have to adjust volume level between programs), Dolby Digital incorporates a parameter called dialogue Normalization. This metadata parameter tells the decoder how far away from the reference level the average sound pressure level of the material's dialogue is.

The movie industry typically masters the "normal" listening level of dialogue (where people are speaking in a normal voice) at -31 dBFS. Since movie content is the largest class of programs to go on DVD, Dolby chose -31 dBFS as the reference level for audio on DVD.

The dialogue normalization parameter needs to be set to the LAeq level of your program material's dialogue. LAeq stands for the long-term A-weighted sound pressure level. Loosely, this is the average volume level of your source material's dialogue. Us lowly consumers really don't have a tool that can measure this parameter, but we can get close. Sonic Foundry's Sound Forge has a "Normalization" feature that can measure the RMS level of a .wav file (or the portion thereof containing dialogue). To use it in Sound Forge, open your .wav file containing the movie audio. Select a section containing dialogue (no sound effects or music). Go to "Process"/"Normalize". Select the "Average RMS Power
(Loudness)" radio button. Then click the "Scan Levels" button. The displayed "RMS" level is very close (within 1-2 dB) to the LAeq level.

That RMS level is the number that the dialogue normalization parameter should be set to. In other words, if the RMS level in Sound Forge shows as -17.6 dB, set the dialogue normalization parameter in your Dolby Digital encoder to -18 dBFS.

The decoder will perform an attenuation of (31 + dialnorm) dB to the program material when played back. So, in this case, the decoder will attenuate by (31 + -18) = 13 dB. This will bring the average sound level of the material to (-17.6 - 13) = -30.6 dBFS. The program is now played back at approximately -31 dBFS, the reference level. -31 dBFS is a lower average volume level than what is typical from other sources. It will be noticeable that you will have to turn the volume up on your system when playing a DVD versus playing broadcast, tape, or other non-Dolby Digital program material.

**Allowing Comfortable Listening - Dynamic Range Compression**

Meeting the other end of the requirement, that the consumer should be able to listen to quiet and loud sections of the program without having to adjust volume levels, requires a decrease in the dynamic range of the program. A movie, with whispers at -50 dbFS and explosions at -5 dBFS can't be comfortably listened to in the average home. The whisper is drowned out by extraneous background noise, and if the explosion is played at a tolerable level that doesn't wake up the neighbors, regular dialogue at -31 dBFS requires straining to adequately hear.

Dolby solves this problem by compressing the dynamic range of the program material. Quiet sounds are automatically boosted in volume so that they're audible, and loud sounds are automatically cut down in volume to tolerable levels.

There are several dynamic range compression profiles available that are custom tailored to the particular flavor of program material. However, all of them share the same basic features. All of the compression profiles can be thought of as an input-output "black box", where certain input volume levels are mapped to certain output volume levels. Observe this graph, which is a graph of one of the Dolby Digital compression profiles (Film Light).
The blue line is the "unity gain" line, also referred to as the "no compression" line. This line represents that the dynamic range compressor feature of the decoder is essentially turned off, and no boost or cut of the program material is done.

The purple line is the compression profile for "Film Light". It is divided into 5 different sections, as are the other Dolby Digital compression profiles:

Unity Gain = Volume neither boosted nor cut
Variable Boost = Beginning of increasing volume of soft sounds
Constant Boost = Increase volume by a fixed amount for very soft sounds
Early Cut = Beginning of attenuating volume for loud sounds
Cut = Very loud sounds almost limited to a maximum volume level

The application of a compression profile like this allows the soft sounds to be heard while preventing speaker overdrive and disturbances by the loud sounds.

The Dolby Digital encoder offers 5 different compression profiles that can be specified depending on the nature of the program material being encoded. The profiles range from no compression ("None"), to fairly light compression ("Music Light") all the way to extremely aggressive compression ("Speech").

For the exact dB numbers where each range of dynamic range compression is located on the graph, see the Dolby technical documents available from the Dolby website.

Many authors, when compressing audio to Dolby Digital, are turned off by the idea of
dynamic range compression. You have this well-mixed audio with nice dynamic range and are then going to kill it by compressing that dynamic range. This is a valid concern, but should be answered by looking at what the listening environment is going to be. If you are authoring a DVD only for yourself, and you have a home theater room that can deliver theater-like sound, perhaps a compression profile of "None" is suitable for you. However, this profile may not sound good in a more mundane living room. Some experimentation may be in order to determine what compression profile will sound best for you. Most Hollywood DVDs use "Film Light" or "Film Standard".

The following point, however, cannot be stressed enough: **In order for the Dynamic Range Compression to work as designed, the Dialogue Normalization parameter MUST be properly set first!**

All of the dynamic range compression profiles assume that the average volume level of the program material's dialogue being fed to the dynamic range compressor is -31 dBFS. If that is not the case, boost or cut will be applied to the material when it shouldn't be!

**Line Mode and RF Mode**

The Dolby Digital compressors have the ability to further alter the compression profile to compensate for different transport mediums. Most of the time, audio is transported between devices in "Line Mode", where a line-level is used. There is also "RF Mode", meant for broadcasting of Dolby Digital and devices that send audio via RF cables to a TV set. RF mode sound from the decoder uses a higher average volume level (-20 dBFS vice -31 dBFS) in order to correlate volume level well with other, non-Dolby broadcast audio, and also can use a more aggressive Dynamic Range Compression to prevent overmodulating the signal. There is an option in most Dolby Digital encoders to turn on that overmodulation limiter (in Soft Encode, it is labeled as "RF Overmodulation Protection"). Since we are primarily interested in authoring for DVD which will operate in Line Mode, we do NOT want to insert the additional Dynamic Range Compression that RF Overmodulation Protection will add. Therefore, for DVD authoring, the RF Overmodulation Protection option should be turned off.