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Tech Note

Setting the subwoofer levels.

Product: DFP-D3000, DFP-2000.
 S/N: All units.
 Document: **TN99051701**, CC
 Summary: An overview of the process of setting the digital and analog subwoofer levels and approximating a match between them, step by step.

The topic of setting subwoofer levels is the subject of numerous articles and even more numerous opinions, but of only a single proposed standard (SMPTE RP 200, and ITU 10-11R/Temp/11-E). There are many reasons for this. First, the use of the modern digital audio subwoofer is unique in comparison to the other channels and it is recorded with a different monitoring reference. The purpose of the subwoofer has changed with the evolution of cinema sound, from compensating for the poor low frequency response and bass power capability of older screen speakers, to adding power to low frequency effects even in theatres having full range screen speakers and capable amplifiers. Secondly, different post production facilities and even different engineers have followed their own alignment conventions. Finally, equipment and even meter standards are different when comparing the USA, Europe, and elsewhere. This wordy Tech Note is only an overview and is not meant to comprise a specific calibration process or set of instructions.

1. Setting the electrical reference level on the dub stage.

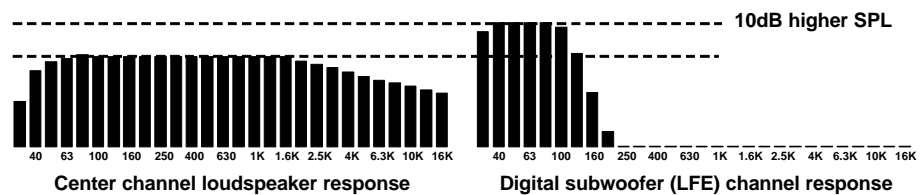
On the dubbing stage, a calibration tone is used in the console and recorders to establish the reference level through both, making sure they correspond. Generally, this *electrical reference* will be 0 VU = +4dBu, -20dBFS = +4dBu, 0 VU = -10dBV, or some other recognized reference convention. The digital subwoofer channel (often called LFE, for Low Frequency Effects) is aligned to the same recording reference level as the digital screen speaker channels.

2. Setting the acoustical reference level on the dub stage.

A signal, generally wide band pink noise, is sent through the dubbing console to each of the monitoring system's screen speakers at the *electrical reference* level. Using a real time multi-channel analyzer, the monitor system is adjusted for the preferred acoustical response at each loudspeaker, given the properties of the loudspeaker, the room, the screen, and the "X-curve" of SMPTE 202M. The electrical gain of each channel in the monitoring system is then adjusted to give an *acoustical reference* level in the room from each screen speaker. Almost always this is 85dB C-weighting, slow response, measured with a wide-band SPL meter; RP 200 calls for an rms responding meter with a frequency response of 22Hz to 22kHz. The actual electrical gain is not material to this setting, but this procedure ultimately ties the recording *electrical reference*, measured electrically, to a monitoring *acoustical reference*, measured acoustically.

3. Setting the subwoofer acoustical gain using a screen speaker as a reference.

The channel used for subwoofer or LFE (low frequency effects) in the dubbing theatre is then adjusted as above, except that the SPL is measured differently. To make this adjustment properly, a multi-channel real time analyzer must be used. Analyzer bands in the flat-response region of a screen speaker (generally, the center speaker) are taken as a reference. These bands will not individually measure 85dB SPL, but will be somewhat less, depending on the bandwidth of the analyzer's bands, typically about 70 dB SPL for a 1/3-octave analyzer as required by SMPTE 202M. This flat-response region, between the low frequency roll off caused by the loudspeaker cabinet and the high frequency roll off due to the screen and X-curve, is referred to as the in-band (*acoustical*) response of the monitor speaker. The subwoofer electrical gain is adjusted such that the analyzer channels in it's in-band region are 10dB greater than those in the screen speaker's in-band region. This is referred to as "10dB of in-band gain" (subwoofer level relative to each screen speaker level).



The measurement is made acoustically, not electrically. Typically, each band of the analyzer in the pass band of the subwoofer will then measure about 80 dB SPL. If a screen speaker and the LFE subwoofer loudspeaker are each measured with a *wide band* SPL meter, the subwoofer will typically measure *approximately* 5.5 dB higher.

Why we do it this way.

The reason for lowering the electrically recorded level of the subwoofer channel and making it up by turning up the playback gain dates back to 70mm film. The subwoofer recording level was lowered to prevent saturation of the magnetic track and the playback gain was increased to compensate. The loss of signal to noise performance was inconspicuous because the subwoofer signal was sent through a low pass filter and did not reproduce hiss. This level difference convention has been retained in the digital world, where it serves to give additional effective headroom for the playback of low frequency sound effects through the subwoofer loudspeaker.

What it means.

The consequence of having 10dB more *acoustical* gain in the subwoofer monitoring channel is that the dubbing engineer will tend to turn down the *electrical* recording level of the subwoofer by about 10dB compared to what she would have done without the increased monitor gain. However, unlike the screen speaker channels, the engineer does not use a console meter to check the electrical recording level of the subwoofer (except perhaps to guard against overload conditions). There is no specific electrical reference for the subwoofer signal, which instead reflects the artistic purpose of this channel and the wide range of factors that affect any subwoofer cabinet's electroacoustical response.

4. Setting the digital screen speakers in the cinema.

In the cinema, the screen speakers are adjusted in the almost same manner as they were on the dubbing stage. This calibration, which encompasses the cinema processor's main fader, equalizers, power amplifiers, crossovers, loudspeakers, screen, and room response, is referred to as the B-chain alignment. Consider the digitally driven loudspeaker alignment first, as it is the most important. An *electrical reference* signal, generally wide band pink noise generated within the cinema processor at a specific level, is used to align each of the screen speakers to give the desired response (the X-curve or other reference response) and *acoustical reference* level for each individual speaker (again, 85 dBC, slow response, measured with a wide-band SPL meter). This procedure ties the cinema processor's *electrical reference* to an *acoustical reference* in the cinema, similar to what was done on the dubbing stage.

5. Setting the digital subwoofer in the cinema.

In a similar way as on the dubbing stage in Step 3, the level of the digital subwoofer is set by using a multi-channel real time analyzer and adjusting the *electrical gain* of the monitor system to achieve 10dB of in-band *acoustical gain*, relative to a screen speaker. The consequence of this adjustment is that signals which were recorded approximately 10dB lower for the subwoofer will now play back in the cinema at the same acoustical level as they did when the dubbing engineer recorded them on the dubbing stage, because the playback conditions have been acoustically matched between the dubbing stage and the cinema (as closely as variations in rooms and loudspeakers will allow).

6. Setting the optical screen speakers.

The equalizers, amps, and loudspeakers for optical playback are the same as for digital playback, of course. No additional B-chain adjustments are needed. In order to match the electrical level of the optical A-chain (the circuits and components in the signal flow preceding the cinema processor's main fader) with the previously established B-chain settings, a test film is played which has a reference sinewave modulation of 60% (according to SMPTE RP 200). After slit illumination, solar cell preamplifier gain, slit loss correction, and any other adjustments are applied, the resulting A-chain electrical level is matched to an internal reference in the cinema processor using a gain adjustment. If a 50% modulation alignment film is used, the acoustical level of the screen speakers should be set to 1.6dB less than 85dBC, or 83.4dBC SPL. In the Sony DFP-3000, this electrical calibration process is done automatically by a software subroutine. Having completed the optical input calibration, analog and digital playback should result in identical screen speaker acoustical levels with a properly recorded film.

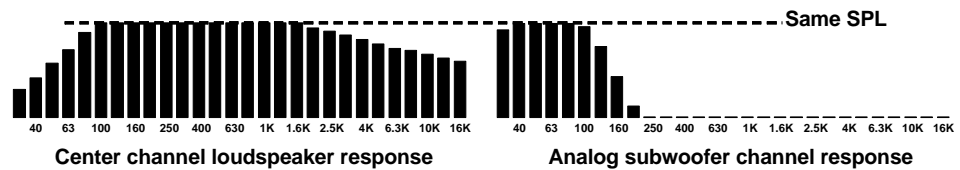
Optical subwoofer defined.

The optical subwoofer has a different function than the digital subwoofer. It serves to enhance the bass response of the optical playback. It is totally artificial, synthesized in the cinema processor by combining the L, C (-3dB), and R signals from the decoded optical Lt,Rt and sending the sum through a low pass filter. The cut off frequency of this filter may be 50Hz, 80Hz, 100Hz, 120Hz or some other frequency, depending on the cinema processor and the installer's judgement. A high pass filter may also be applied, if it is not already a component of the optical preamplifier, to reduce low frequency artifacts caused by ground noise timing (GNR) errors and streaking noise on the print. The end result is a signal containing frequency components which overlap those being sent to, though not necessarily reproduced by, the screen speakers. In

Hollywood, the dubbing engineer may not have listened to this signal on the dubbing stage (in part because the DS4 without a cat. 160 card does not create it) and so made no artistic decisions based on it. It is merely an enhancement created in the cinema to give the effect of more bass extension in the screen speakers and has no correspondence to any discrete signal on the dub stage. Note that it also has a much lower dynamic range than the digital subwoofer signal. The digital subwoofer signal, in contrast, was creatively recorded on its own discrete channel (Sub or LFE) of the print master and is used for specific low frequency sound effects.

7. Setting the optical subwoofer.

The optical (analog) subwoofer is adjusted to match the optical screen speakers and effectively extend their low frequency response, again using a multi-channel real time analyzer to compare bands in the pass band of a screen speaker and the pass band of the subwoofer, and setting in-band *acoustical* levels accordingly. In this case, there is no in-band acoustical gain difference, as the subwoofer signal is just the low frequency components of the screen speaker signals.



Full range screen speakers need less help from the synthesized optical subwoofer signal than do older speakers with poor bass extension. Experienced cinema engineers may chose to reduce the nominal level of the optical subwoofer, lower the frequency of its low pass filter, or even eliminate the synthesized signal altogether, depending on the capabilities of the screen loudspeakers and the auditorium's acoustical response.

8. Balance analog and digital by listening tests.

Finally, the installer must make an aesthetic judgement regarding the optical subwoofer level adjustment. The goal is to have optical playback sound as close as possible to digital playback when playing actual films. Adjustments of the optical subwoofer level may be needed to achieve this while at the same time avoiding excess bass in dialog. A final listening test with high quality film or non-sync must be done to ensure that the low frequency region is smooth and natural, in addition to being extended. Keep in mind that the digital and optical subwoofer signals are very different. Also, the test signal reaching the subwoofer for the optical subwoofer calibration will be different from the test signal used to set the digital subwoofer, as they are of completely different origin. Even though the digital LFE and optical subwoofer signals may be played back through the same loudspeaker cabinet, they will likely have different bandwidths and frequency spectra, and so will have different acoustical outputs and different measured wide-band SPL, apart from any nominal 10dB in-band gain difference.

When evaluating the digital subwoofer (LFE) level, no listening test is entirely definitive, because the amount of energy in the LFE channel is a creative decision made when the soundtrack of each film was mixed. A dialog-only film, for example, may have almost no LFE digital subwoofer signal. For the same

reason, the digital subwoofer (LFE) low pass filter setting has no relationship to the screen loudspeakers' performance. It merely serves to exclude undesirable sound from the subwoofer (LFE) cabinet. The actual sounds reproduced through the digital subwoofer (LFE) channel are determined by what has been placed there by the film's sound mixer, so long as the low pass filter's frequency is not set so low as to remove sounds that the mixer intended to be included.

9. Subwoofer polarity.

As a side note, it is often difficult to determine the correct polarity of the subwoofer, digital or analog. Even if pink noise is sent to the subwoofer and center channels simultaneously, in many cases there will be no apparent difference in combined wide band SPL measurement when switching subwoofer polarity. In the end the best polarity may come down to an aesthetic judgement on the part of the cinema technician, based on listening to actual films.

10. Rule-of-thumb methods.

Measuring the level of a subwoofer with a wide-band SPL meter is of questionable value except as a rule-of-thumb method to re-check a theatre that has already been properly calibrated. The reasons for this include the fact that the measured acoustical output of a subwoofer (or any loudspeaker system) depends on the bandwidth of the signal ultimately being measured. That will be affected by the bandwidth of the input test signal, any equalizer or low pass filter settings, the auditorium's response, the loudspeaker cabinet response, and the accuracy of the C weighting response at low frequencies of the SPL meter used for the measurement. A subwoofer signal with a wider bandwidth may measure the same as another with a narrower bandwidth but higher level (as indicated by analyzer bands within the pass band of the subwoofer), using the same speaker cabinet. Considering the DFP-D3000, the bandwidth of the pink noise sent to the subwoofer is affected by a low pass filter that can be adjusted from 80Hz to 330Hz—a difference of three octaves or eight times in acoustical energy. No standards exist for such wide band SPL measurements of subwoofers.

Although the measured SPL of wide band pink noise through the subwoofer will change if the subwoofer's low pass filter is adjusted, this will not change the actual playback level of the digital LFE channel from film. So long as the filter frequency is not set too low, the signals recorded on the dubbing stage will determine what is heard in the cinema when the proper in-band gain difference is established acoustically, as previously described. This is why an engineer who uses a wide-band SPL meter to set the digital subwoofer level is engaging in self deception. In general, a low pass filter setting for the digital subwoofer (LFE) of 125 Hz, 160 Hz, or even 200 Hz should serve in most installations, and all settings should sound the same when playing digital multichannel material. A low pass filter setting of 125 Hz will give a wide band subwoofer SPL pink noise measurement of *approximately* 91 dBC. This rule-of-thumb result is only approximate and should not be used for the primary alignment of a theatre.