SMPTE RP 200:2012
Revision of RP 200-2002

SMPTE RECOMMENDED PRACTICE

Relative and Absolute Sound Pressure Levels for Motion-Picture Multichannel Sound Systems — Applicable for Analog Photographic Film Audio, Digital Photographic Film Audio and D-Cinema

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Approved
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Foreword

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SMPTE RP 200 was prepared by Technology Committee 20F.

Intellectual Property

At the time of publication no notice had been received by SMPTE claiming patent rights essential to the implementation of this Recommended Practice. However, attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. SMPTE shall not be held responsible for identifying any or all such patent rights.

Introduction

This section is informative and does not form an integral part of this Engineering Document.

The motion picture industry is unique in having the target and capability of ensuring that the audio heard in the playback theatre matches that heard in the mixroom/dubbing theatre when the content was created. The two main criteria defining the audio environment are frequency response and level. B-chain electroacoustic frequency response is defined in SMPTE ST 202. This companion document covers a method for measuring and defining the absolute and relative audio level using steady state wideband pink noise. Note that the procedures defined in this document do not apply in the home, with or without picture, as the consumer normally has an uncalibrated and arbitrarily adjusted playback level.

1 Scope

This practice specifies a measurement method and wideband sound pressure levels for motion-picture dubbing theatres, review rooms, and indoor theatres using steady state wideband pink noise methodology. Together with SMPTE ST 202, it is intended to assist in standardization of reproduction of motion-picture sound in such rooms.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword “reserved” indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword “forbidden” indicates “reserved” and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows. Normative prose shall be the authoritative definition. Tables shall be next, followed by formal languages, then figures, and then any other language forms.

3 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this practice. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this practice are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

SMPTE ST 202:2010, Motion-Pictures — Dubbing Stages (Mixing Rooms), Screening Rooms and Indoor Theatres — B-Chain Electroacoustic Response

IEC 60268-17 (1990-10), Sound System Equipment — Part 17: Standard Volume Indicators

4 Definitions

4.1
absolute sound pressure level
the spatially averaged sound pressure level of a single channel of a theatrical sound system measured with broadband pink noise at the *reference electrical level* as a stimulus. The reference level for sound pressure is 20μN/m^2.

4.2
average responding meter
a meter which provides a voltage indication proportional to the average value of the rectified signal, with ballistics as described in IEC 60268-17.

4.3
bass extension
the technique of creating low-frequency information where there is no dedicated *LFE* channel, i.e. from an analog film photographic sound-track. The audio is taken from the sound-track, low-pass filtered, processed, and sent to the subwoofer (see Annex A.3).

4.4
B-chain (final chain)
that part of a motion-picture sound reproduction system, as shown in Figures 1 and 2, commencing at the audio input source selector and terminating in the listening area defined in Figure 3 (see Annex A.5 and Annex A.7).

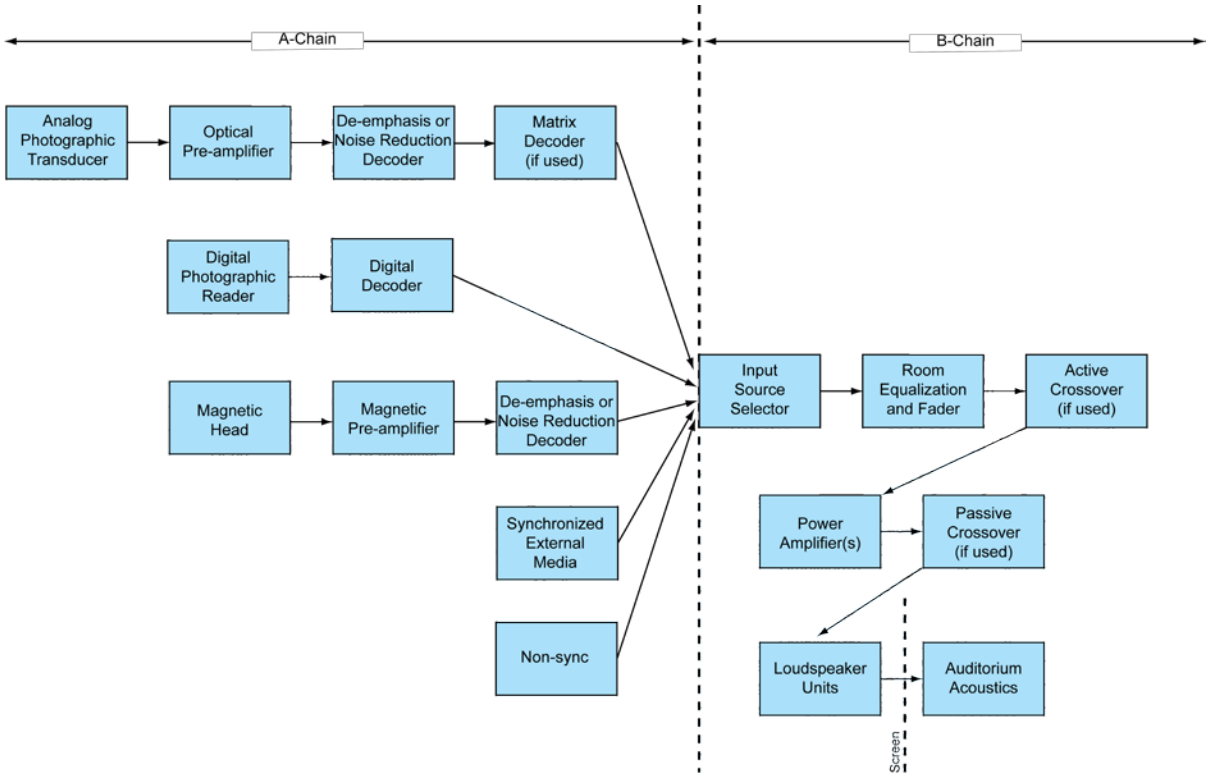

Figure 1 – Complete theatrical sound reproduction chain
(Traditional Film Formats – see Annex A.7)

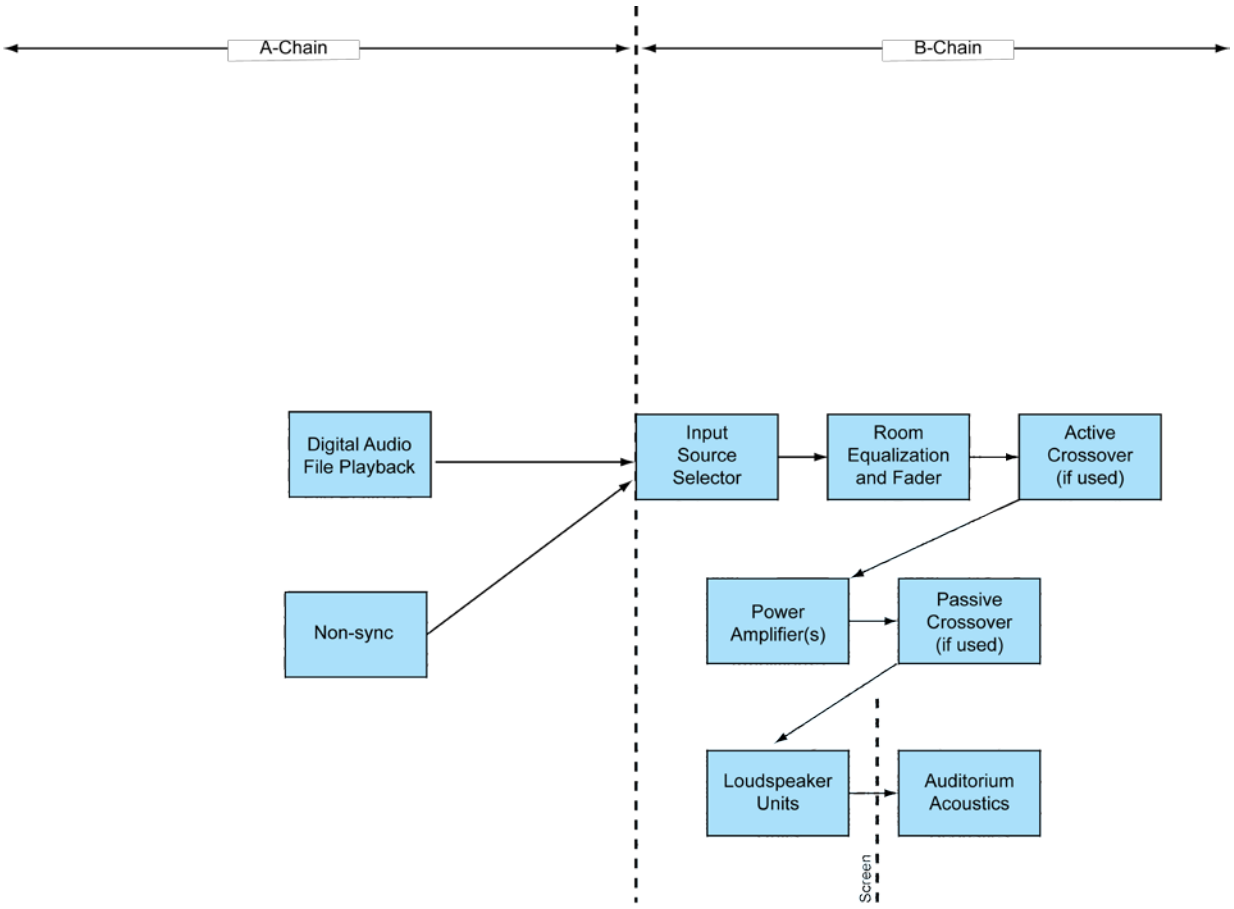

Figure 2 – Complete theatrical sound reproducing chain (Digital Cinema – see Annex A.7)

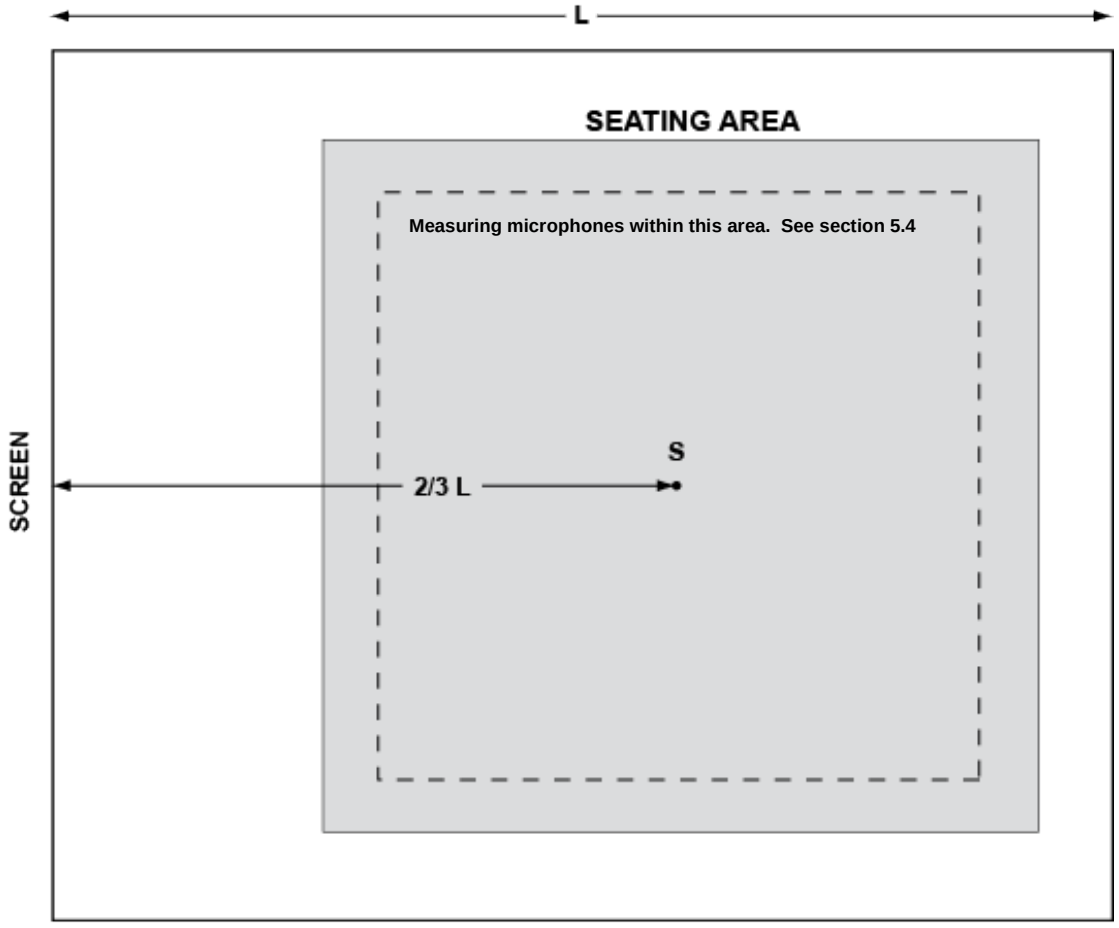

Figure 3 – Placement of Sound-Level Meter
(See Section 5.4)

4.5
electroacoustic response
the electroacoustic response of the B-chain is the spatially averaged frequency response measured in 1/3-octave bands expressed in decibels, as described in SMPTE ST 202.

4.6
LFE channel
a discrete low-frequency effects channel, having a recommended upper -3 dB band limit of 125 Hz.

4.7
pink noise
a stochastic signal having a continuous spectrum with equal energy per equal logarithmic interval of frequency, and with a gaussian probability distribution of instantaneous amplitude.

4.8
reference electrical level
the voltage measured by an average-responding voltmeter of *wideband pink noise* using a measurement bandpass filter of 22 Hz to 22 kHz bandwidth when the test signal is at *reference recorded level*, and when the main fader is at its normal/calibration setting (see Annex A.5 and Annex A.7). In practice today the reference electrical level is 20 dB below 100% modulation.

4.9
reference recorded level
originally defined as the level of pink noise equivalent to 50% modulation on an analog photographic sound-track. Today, the equivalent level on a digital photographic sound-track or a digital cinema (D-Cinema) sound-track (typically in each digital case 20 dB below 100% modulation).

4.10
relative sound pressure level
in this context, the sound pressure level of one channel when compared with another during reproduction of the wideband test signal of 4.1, as opposed to the sound pressure level in one frequency range when compared with another.

4.11
wideband pink noise
pink noise having a bandwidth exceeding the normal acoustic frequency range. A suitable wideband pink noise test signal should have a frequency response flat to within $\pm$ 0.5 dB when measured in 1/3-octave bands with center frequencies from 25 Hz to 20 kHz with an integrating averaging technique.

5 Method of Measurement

5.1 Electroacoustic response confirmation

The electroacoustic response of each channel should be measured and confirmed to conform to SMPTE ST 202 before measurement of relative and absolute sound pressure levels.

5.2 Measuring equipment

5.2.1 Screen and Surround channels. The sound pressure level of screen and surround channels is most commonly measured using a wideband sound-level meter set to C-weighting and slow response.

In some circumstances, for example an auditorium with aberrant electroacoustic responses at frequency extremes, it can be beneficial to use a calibrated 1/3 octave analyzer to set the primary channels. Using a limited section of the analyzer display and averaging the level within that section can avoid any aberrations at frequency extremes. A wideband pink noise signal has a level 15 dB above that in a single 1/3 octave band. For example, an 85 dBC wideband pink noise signal equates to 70 dB in each individual 1/3 octave band. A typical window will be 500 Hz to 2 kHz.

5.2.2 Subwoofer. The sound pressure level of the subwoofer channel should be measured using a 1/3-octave real-time analyzer, or a sound-level meter with a built-in 1/3-octave filter set.

5.3 Test signal

The test signal should be wideband pink noise, fed into the sound system one channel at a time. The pink noise should be inserted into the system prior to the main fader, typically at a position at or equivalent to the input source selector. The fader should be set to its normal setting (see Annex A.7)

5.4 Sound pressure level measurement locations

The sound pressure level should be measured in at least one position for each screen and surround channel and the measurements for each channel then spatially averaged. If a single location only is selected, it should be position S as shown in Figure 3. All sound pressure level measurement locations should be within the seating area as shown in Figure 3. The subwoofer sound pressure level should be measured in at least four positions and averaged over time intervals of not less than 30 seconds.

5.5 Screen channels

The relative sound pressure level of each screen channel should be within ± 0.5dB of the absolute sound pressure level.

5.6 Surround channel(s)

If there is one single surround channel, then the sound pressure level when playing the test signal should equal that of the absolute sound pressure level. If there are two independent surround channels, left and right, then each should display a sound pressure level such that when they are simultaneously fed the same in-phase test signal the sum should equal the absolute sound pressure level. This means that typically the sound pressure level for each surround channel array will be 3 dB below the absolute sound pressure level (see Annex A.8). This procedure will ensure compatibility for theatres with fewer surround playback channels where the surround information is combined. With three or more surround channels, the individual channel reproduction levels should be set up to be equal to one channel of a two channel surround system.

5.7 Subwoofer LFE channel, playback of discrete digital photographic sound-track or D-Cinema sound-track

The subwoofer LFE channel, when compared with a wideband screen channel, should show +10 dB of in-band gain when viewed on a real-time analyzer. Therefore, the subwoofer will have the same level in its passband as the level in the passband of a screen channel (see Figure 4 and Annex A.1).

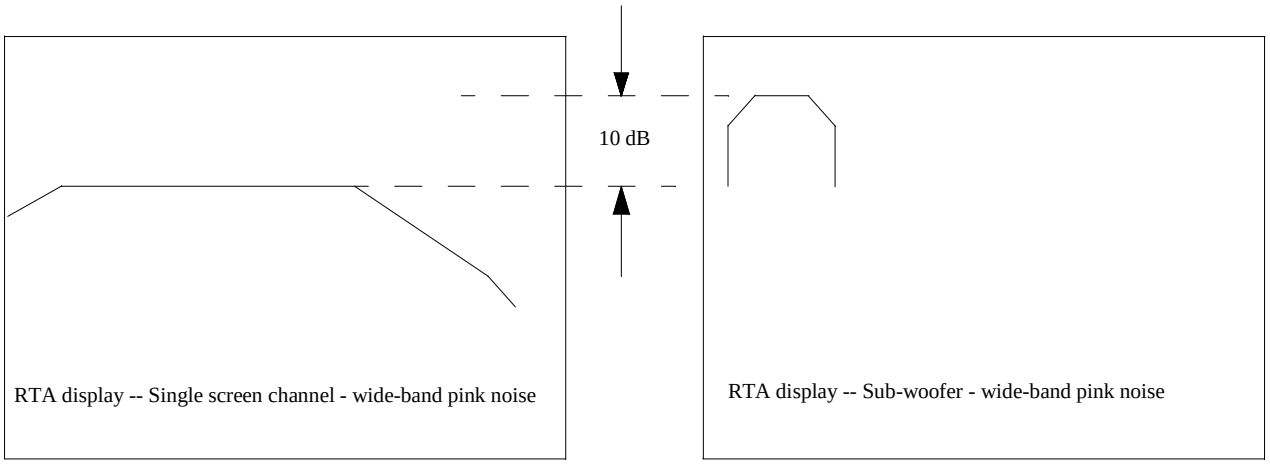

Figure 4 – Measurement of subwoofer sound-pressure level, digital LFE sound-track, using real-time analyzer

5.8 Subwoofer bass extension channel, for playback of analog photographic sound-track with bass extension playback processing

The bass extension subwoofer channel, when compared with a wideband screen channel, should show the same in-band level; i.e. should show no in-band gain when viewed on a real-time analyzer (see Figure 5, Annex A.2 and Annex A.3). If the test signal is applied to both the center screen channel and the subwoofer channel simultaneously, the analyzer should show 3 dB of in-band gain in the frequency area common to both loudspeakers.

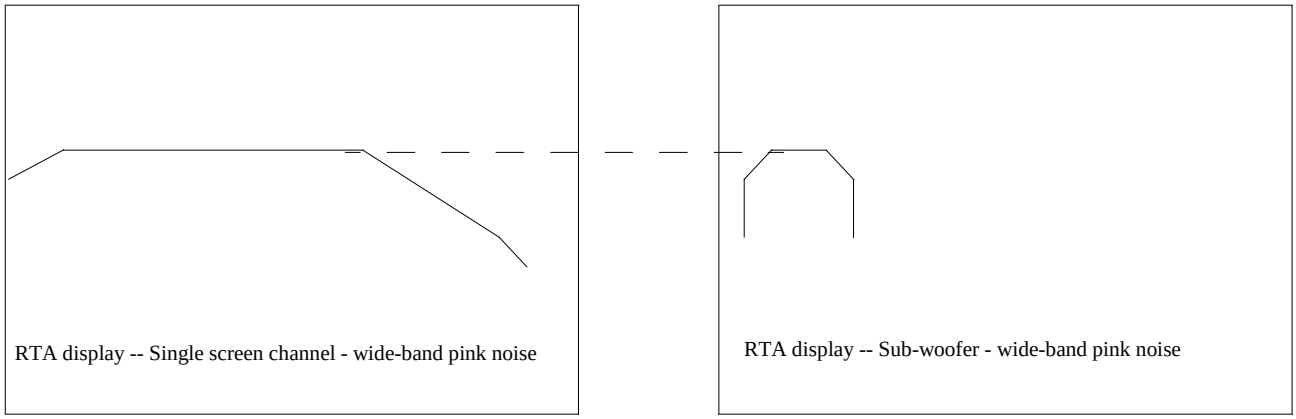

Figure 5 – Measurement of subwoofer sound-pressure level, analog photographic Sound-track with bass extension playback processing, using real-time analyzer

6 Reference Level

The recommended reference level, as defined in Section 4.1 and measured as specified in this practice, should be 85 dBC for normal theatrical operation.

Annex A General Information (Informative)

A.1 Subwoofers and sound-level meters

While a wideband sound-level meter is suitable for measuring sound pressure levels of screen and surround channels, it is not suitable for measurement of subwoofer levels. The first reason for this is the differing low-pass cut-off of different subwoofers. For example, if pink noise and a sound-level meter were used to set equal levels between one loudspeaker extending to 80 Hz and another extending to 125 Hz, the sound pressure levels in the passband of each loudspeaker would be significantly different, as shown in Figure A.1.

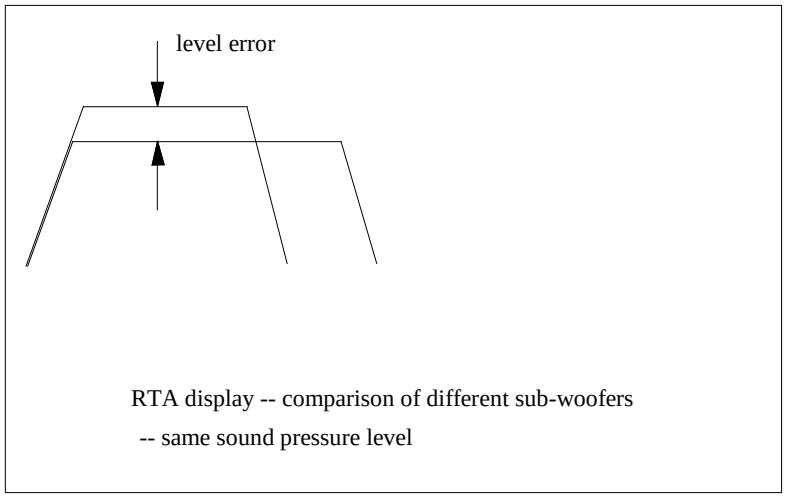

Figure A.1 – Setting sound-pressure levels of subwoofers with sound-level meters can create level ambiguity

A second reason to avoid use of wideband sound-level meters for subwoofer measurement is the loose tolerance at low-frequencies associated with the inexpensive meters typically used.

A sound-level meter incorporating a 1/3-octave filter set may provide acceptable results.

A.2 In-band gain

Using a real-time analyzer is the only accurate method of measuring band-limited signal levels. In-band gain is the relative level within the bandpass of interest, as seen on a real-time analyzer display.

A.3 Bass extension

With analog photographic sound-tracks, unwanted noises can occur at very low frequencies, below approximately 50 Hz. Two main causes of these noises are ground noise reduction timing errors causing thumping, and low-frequency streaking noise caused by bad print washing. For this reason, some analog processors process the stripped-out low-frequency information to remove low-level unwanted components. This processed output is then sent to a dedicated subwoofer.

A.4 Subwoofer polarity

It is frequently very difficult to determine the best polarity of a subwoofer by conventional methods of checking the speaker cone polarity. The effective phase may change with frequency, especially with a discrete digital subwoofer channel where filter slopes may cause changing phase with frequency. For this reason, it is recommended that subwoofer polarity is evaluated with pink noise sent to center and subwoofer channels simultaneously. The best result should be selected of the two polarities by looking at the resultant combination signal measured with a real-time analyzer.

A.5 Main Fader setting

The vast majority of theatre B-chains have a calibrated main fader, which allows the operator to return to a known mark. In many cases, there is a scale ranging from 0 to 10, and fader point 7 is the calibrated setting. This 70% of full-scale allows for a fade to silence, and has some gain in hand for the playback of unusual modulation level program. In some theatre equipment fader setting “0” is the calibrated setting, with permissible variations to both plus and minus. For all normal film program, the playback level should be at the calibration point, which in turn should result in the reference level as described in Section 6.

A.6 Historical note

Early versions of this recommended practice were technically correct in describing the test signal level as being equivalent to 60% modulation on an analog photographic sound-track, and at that time 18 dB below 100% modulation on a digital sound-track, when measured with a true rms meter. However, field experience shows that practically all users employ average responding meters for measuring level of noise in day-to-day work, including VU meters to IEC 60268-17. This recommended practice recognizes this widely used conventional practice rather than the more technically accurate use of rms derived metering, due to the ready availability of VU and other average responding meters. These changes represent an effective level difference of approximately 0.6 dB — motion picture theatres set up according to older versions of this recommended practice will play 0.6 dB quieter than theatres set-up according to procedures described in this practice.

A.7 Noise insertion point

While Figures 1 and 2 show typical system playback layouts, in some cases the fader will follow the B-chain equalizer. Regardless, the pink noise should be inserted at an equivalent position prior to the B-chain equalizer, and any non-linear signal processing or decryption after the noise insertion point should be disabled. The fader should always be set at its normal setting (see Annex A.5).

A.8 Sum of multiple surround arrays

Theoretically two surround channels carrying the same in-phase signal each at -3 dB below reference level, will generate a sum equal to reference level. In rare cases, however, the required individual levels from each array may be only 2 dB or even 1 dB below reference, or occasionally 4 dB below reference, depending on the number of speakers in each array, the geometry and spacing of the array, the dimensions of the theatre and the reverberation time.

A.9 Surround level during playback of matrix encoded sound-tracks

Crosstalk in the optical pick-up assembly may reduce the subjective amplitude of surround signals with matrix encoded material. For this reason, a test film is sometimes used to make slight subjective adjustments to the analog surround output, after initial alignment according to the procedures described in this practice.