SMPTE RECOMMENDED PRACTICE

Method of Measurement of Perceived Loudness of Short Duration Motion Picture Audio Material

Table of Contents

Approved April 23, 2010

Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Recommended Practices, and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

SMPTE Engineering Documents are drafted in accordance with the rules given in Part XIII of its Administrative Practices.

SMPTE RP 2054 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 Standard. 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 entirely informative and does not form an integral part of this Engineering Document.

This Recommended Practice should be used in conjunction with the Standards and Recommended Practices that cover the reproduction of motion picture sound, in particular SMPTE RP 200.

A recommended replay architecture exists for most current cinema sound formats. This matches a specific recorded modulation level with a specific sound-pressure level in the auditorium. The noise and over-modulation points of each sound format are positioned to allow for a wide range of signal components to be recorded and faithfully reproduced at a valid absolute level as part of a motion picture presentation.

Perhaps due to their competitive nature, some motion picture commercials and trailers have trended towards making sustained use of the highest recording level possible for the format. Consequently, many exhibitors have found it necessary to reduce the replay level to a point much lower than the calibrated recommended playback level. This has caused uncertainty as to the validity of the recommended replay level, which in turn leads to a further escalation in record levels to match ever lowering anticipated replay levels.

1 Scope

This Recommended Practice assists in assessing the subjective loudness of short duration motion picture material, typically commercials and trailers that do not exceed three minutes in length. It does not specify a maximum recommended level for such material, and is solely aimed at describing a measurement method.

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 Reference

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

SMPTE 202M-1998, Dubbing Theaters, Review Rooms and Indoor Theaters — B-Chain Electacoustic Response

SMPTE RP 200-2002, 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

4 Definitions

Reference level: Modulation level equivalent to 50% modulation of optical variable-area soundtracks, -20 dB (level relative to digital full-scale) in the digital domain, and 185 nW/m in the magnetic domain, measured using an average responding meter and a steady-state tone.

Reference pink noise: Pink noise, band-limited to 20 Hz to 20 kHz, set at the *reference level*, using an average responding meter.

Frequency weighting equalizer: A device having a frequency response that makes the system correspond with perceived loudness, roughly accounting for the frequency response of human hearing, and the typical tonal content of the type of material of interest.

Frequency response: The amplitude response of a system as a function of input frequency, usually rated in decibels over a frequency range.

Pink noise: A random, stochastic signal having a continuous spectrum with equal energy per equal logarithmic intervals of frequency, and with Gaussian probability distribution of instantaneous amplitude.

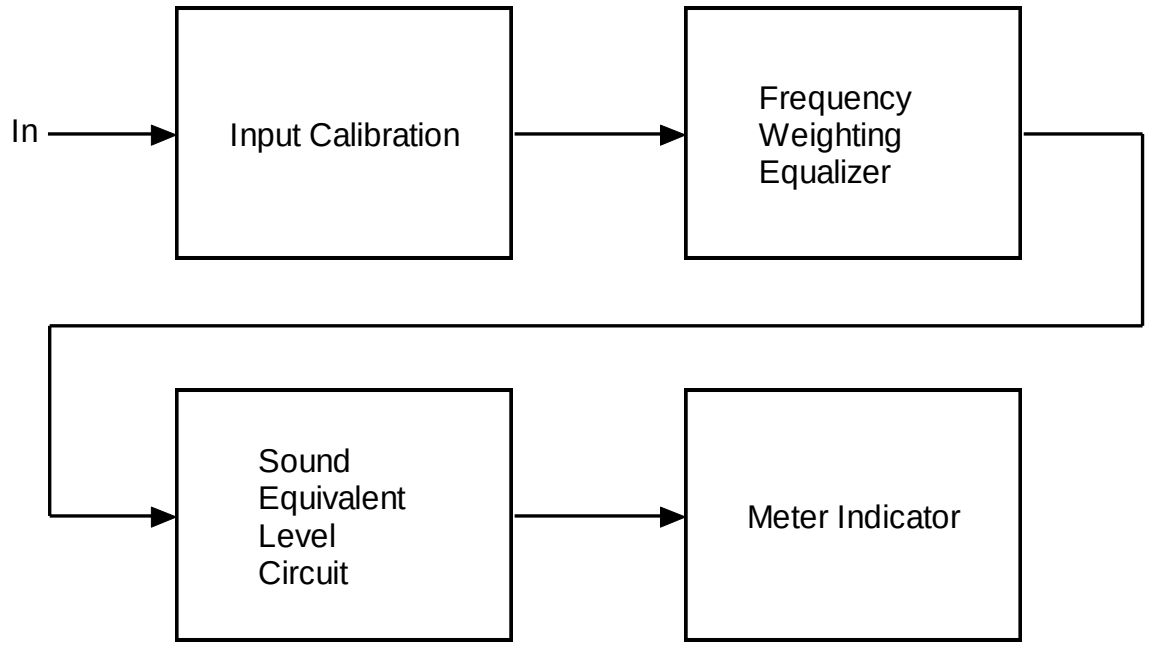
Sound Equivalent Level: The average amplitude of sound measured over an interval of time, calculated according to the equation in Section 5.3. Commonly shown as Leq_x, where x describes the type of *Frequency weighting equalizer* in use.

Recommended replay level: Sound-pressure level (C-weighted with slow response) that the sound system should produce in the main seating area of the room with reference pink noise

5 Method of Measurement

The method of measurement shall be as described by the block diagram given below, with an Input Calibration section, a Frequency Weighting Equalizer to better correspond to human hearing response than un-weighted measurements, a Sound Equivalent Level section for assessing the cumulative effect of the energy of the sound level over the time interval of the program, and a Meter Indicator. The elements of the block diagram are further defined in Sections 5.1 – 5.4. The measurement interval, and the accuracy and precision of measurements are discussed in Informative Annex A and Annex B.

Other methods of measurement are permissible so long as the results are equivalent to those specified herein within the recommended accuracy of Annex B.



Block Diagram of Method of Measurement

5.1 Input Calibration

The input calibration section shall scale an input voltage, defined for each distribution format (analog soundtrack on film, digital soundtrack on film or D-Cinema file soundtrack) to a voltage that corresponds to the Reference Sound Pressure Level.

For example, using SMPTE Standards, −20 dBFS on a digital medium represents the reference level. A distribution format may produce +4 dBu at −20 dBFS, and may be designed so that such an electrical reference level produces 85 dBC Sound Pressure Level re: 20 μPa for each channel.

For multi-channel sound, each of the source channels shall be electrically summed in the correct proportion to the Sound Pressure Level calibration of the individual channels. For example, if the surround level is calibrated at 82 dBC for each channel rather than 85 dB given in the example above, the contribution of each surround channel to the sum shall be 3 dB less than a screen channel.

To prevent differences between electrical addition (vector) and acoustical addition in the reverberant field of a room (scalar), each of the channels shall employ a separate detector circuit, and the output of each of the detector circuits shall be added.

5.2 Frequency Response and Tolerance of Frequency Weighting Equalizer

The frequency weighting equalizer is based on an International Telecommunications Union recommended filter for the assessment of background noise in audio programs. This filter (more accurately, equalizer) has also been found to be useful for the purpose of assessing the human response to the loudness of typical soundtracks. In this application, the characteristic described in the table below has been termed “M-weighting”. The frequency response of the equalizer, and the tolerance on the response, is given in Table 1.

Table 1 – M-type frequency weighting

Frequency in Hz	*Response in dB*	*Tolerance in dB*
31	– 35.5	± 2.0
63	– 29.5	± 1.4
100	– 25.4	± 1.0
200	– 19.4	± 0.85
400	– 13.4	± 0.7
800	– 7.5	± 0.55
1000	– 5.6	± 0.5
2000	0.0	± 0.5
3150	3.4	± 0.5
4000	4.9	± 0.5
5000	6.1	± 0.5
6300	6.6	± 0.0
7100	6.4	± 0.2
8000	5.8	± 0.4
9000	4.5	± 0.6
10000	2.5	± 0.8
12500	– 5.6	± 1.2
14000	– 10.9	± 1.4
16000	– 17.3	± 1.65
20000	– 27.8	± 2.0
31500	– 48.3	+ 2.8, - ∞

Note that for the purposes of insertion gain, the frequency 2.0 kHz is used for the 0 dB reference level. For the purposes of tolerance, the insertion gain is to be adjusted at the reference frequency of 6.3 kHz to 6.6 dB, since this is the center frequency of the boost in the equalizer. If a 1-kHz reference frequency is used, levels shall be offset by 5.6 dB, as shown in Table 1.

5.3 Sound Equivalent Level

The Sound Equivalent Level shall be calculated according to the following:

$$Leq_m = 10\log_{10}\left(\frac{1}{n}\sum_{i=1}^{n}10^{\frac{L_i}{10}}\right)$$

Where Leq_m is the Sound Equivalent Level in decibels, with m indicating the use of the frequency weighting given above, n is the number of seconds in the total time interval, and L_i is given by:

$$L_i = 10\log_{10}\left(\frac{1}{n}\sum_{i=1}^{n}\frac{p_i^{\,2},\mathrm{meas}}{p_i^{\,2},\mathrm{ref}}\right)$$

where n is the number of instantaneous pressures measured over 1 second, p_i^2 is the instantaneous sound pressure, measured (*meas*) or reference (*ref*) as given, and the period over which p_i is averaged is 1 second. The reference Sound Pressure Level is $20\,\mu\mathrm{Pa}$.

Note that the Sound Equivalent Level is measured in the electrical domain using the calibration supplied by the Input Calibration section.

5.4 Meter Indication

The meter indication shall be the result of the frequency weighting equalizer and the sound equivalent level circuit, with scaling to represent the acoustical Sound Pressure Level which the program material would produce when playing the test material specified in the next paragraph at the Standard Fader Setting over a sound system calibrated to the standard of the distribution format in use.

The frequency response of theatrical sound systems, the B-chain response, specified in SMPTE 202, is deliberately not to be accounted for in this method of measurement. The X curve response is not to be a part of the frequency weighting equalizer.

Note: Acoustical rather than electrical summation of the channels, and the fact that the X curve is not accounted for in the electrical measurement described herein, will probably make the electrical based measurement described in this method of measurement different from the reading of a Sound Level Meter — even if one were to be equipped with the frequency equalizer specified herein and made to measure Leq_m. In addition, variations from room to room, including seat location selection, would make Sound Level Meter measurements unreliable.

Annex A Measurement Interval (Informative)

When the duration of the program material is greater than 30 seconds, it is recommended that the duration of the measurement in time correspond to within ± 3 seconds of the length of the audio program. When the material has a duration of 30 seconds or less, it is recommended that the duration of the measurement be to within ± 1 seconds of the length of the audio program.

Annex B Accuracy and Precision of Measurement (Informative)

It is recommended that the accuracy of the measurement be maintained to within ± 0.3 dB. This tolerance on accuracy includes a summation of all sources of error, including, but not limited to: input calibration error, insertion gain, error in the frequency weighting filter or elsewhere, calculation of the sound equivalent level, and meter indication.

Annex C Bibliography (Informative)

"Are Movies too Loud?" — Ioan Allen, SMPTE Journal (March 22nd 1997)

ISO 21727:2004, Cinematography — Method of Measurement of Perceived Loudness of Motion-Picture Audio Material

TASA — Trailer Audio Standards Association — http://www.tasatrailers.org/