SMPTE RP 155:2014
Revision of RP 155-2004

SMPTE RECOMMENDED PRACTICE

Reference Levels for Analog and Digital Audio Systems

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Approved
November 13, 2014

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 its Standards Operations Manual.

SMPTE RP 155 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 (Informative)

SMPTE RP 155-2004 recommended a reference level for digital audio systems; SMPTE EG 9-2005 gave guidance on reference levels for both sprocketed and non-sprocketed analog and digital magnetic and photographic materials. This revision of SMPTE RP 155-2004 incorporates the information from both documents.

1 Scope

This document provides Recommendations for the level of reference signals that facilitate the interchange of audio content on analog, digital or photographic media, and for the calibration of audio level indicators and other devices. The reference levels described by this Recommended Practice are not related to the subjective loudness of any audio content that they may be associated with.

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.

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 that, 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 ST 40:2002, Release Prints — Photographic Audio Records

SMPTE ST 41:2004, Motion-Picture Film (16-mm) — Prints — Photographic Audio Records

SMPTE ST 203:2011, Motion-Picture Film (35-mm) — Prints — Two-Track Photographic Analog Audio Records

4 Definitions

4.1
dBFS
Decibels with respect to full scale.

4.2
Full Scale

- A full scale sine wave has positive peaks with a value of 7FFF (hex) and negative peaks with a value of 8000 (hex) in a 16-bit digital audio system.
- A full scale sine wave has positive peaks with a value of 7FFFF (hex) and negative peaks with a value of 80000 (hex) in a 20-bit digital audio system.
- A full scale sine wave has positive peaks with a value of 7FFFFF (hex) and negative peaks with a value of 800000 (hex) in a 24-bit digital audio system.

5 Specification

5.1 The reference signal shall be the digital representation, in twos complement format, of a 1000-Hz sine wave, at a level of -20 dBFS, as described in Section 5.2. Where present in a system in analog form, the reference signal shall be a 1000-Hz sine wave whose amplitude is such that the system analog-to-digital converter generates the reference digital representation from the appropriate analog representation in Section 5.3 or Section 5.4.

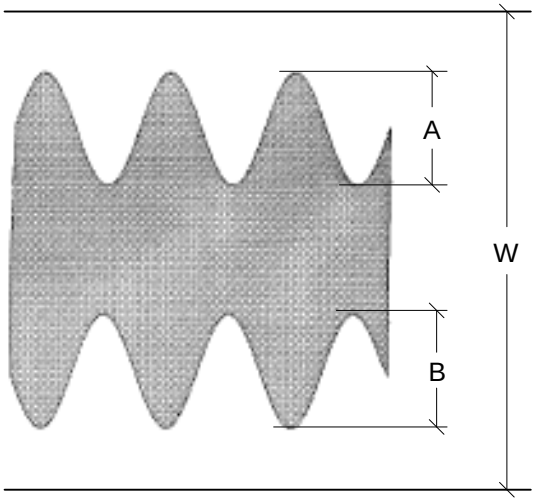
5.2 A -20 dBFS reference signal shall be a sine wave that has positive peaks with a value of 0CCD (hex) and negative peaks with a value of F333 (hex) in a 16-bit digital audio system. In a 20-bit audio system, the positive peaks should have a value of 0CCCD (hex) and the negative peaks should have a value of F3333 (hex). In a 24-bit audio system, the positive peaks should have a value of 0CCCCD (hex) and the negative peaks should have a value of F33333 (hex).

5.3 For analog recording on magnetic materials, the fluxivity of the reference level signal should be either 185 nWb/m or 320 nWb/m, depending on local practice.

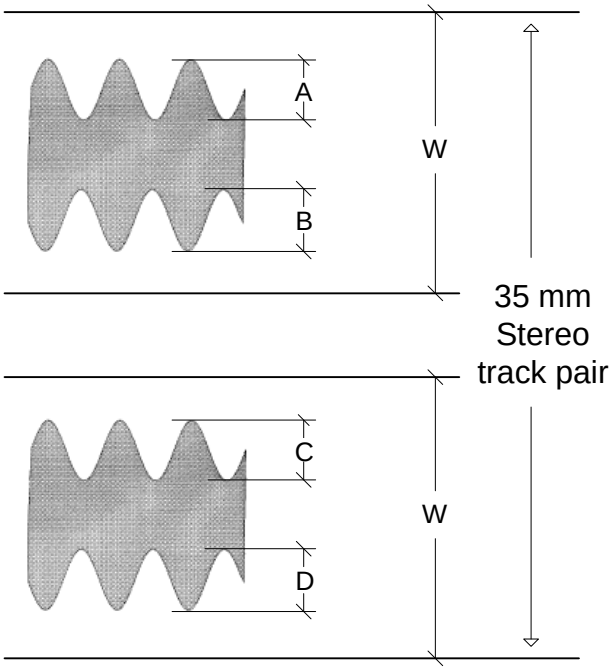
5.4 For analog recording on photographic audio tracks, the reference level should correspond to 50% maximum modulation. The maximum modulation width is 0.076 in (1.93 mm) for 35-mm monophonic sound tracks, 0.033 in (0.84 mm) for each track of 35-mm stereo sound tracks, and 0.060 in (1.52 mm) for 16-mm monophonic sound tracks. The condition of 100% modulation is commonly referred to as optical clash, and thus 50% modulation represents a level of nominally 6 dB below optical clash (see Figure 1).

5.5 Pre-emphasis should not be used when recording the digital reference signals.

5.6 The reference level used when recording a program should be clearly associated with, marked on or embedded in the media itself so that the next user may re-establish the correct playback level. This is particularly important as reference fluxivities or reference levels may vary with local practices.



$$PercentModulation = \frac{A+B}{W} * 100$$



$$PercentModualtion = \frac{A+B}{W} * 100 = \frac{C+D}{W} * 100$$

Where:
W = 0.076 inch (1.93 mm) for 35 mm Mono (SMPTE ST 40)
W = 0.033 inch (0.84 mm) for each track of a 35 mm Stereo pair (SMPTE ST 203)
W = 0.060 inch (1.52 mm) for 16 mm Mono (SMPTE ST 41)

Figure 1 – Measurement of Percent Modulation

Annex A Level Setting (Informative)

In the past, European broadcasters have used a reference level of -18.06 dBFS for the line-up tone in accordance with EBU R 68. In 2011, that reference was deprecated in favor of a loudness measurement as specified in EBU R 128, which derives from ITU-R BS.1770. Program levels are not set by line-up tones, but rather by “Programme Loudness Level”, which is measured in LUFS (Loudness Units). The target level is -23 LUFS. For further information on this level setting method, please see the loudness documents listed in Annex B.

Annex B Bibliography (Informative)

Note: All references in this document to other SMPTE documents use the current numbering style (e.g. SMPTE ST 183:1996) although, during a transitional phase, the document as published (printed or PDF) may bear an older designation (such as ANSI/SMPTE 183M-1996). Documents with the same root number (e.g. 183) and publication year (e.g. 1996) are functionally identical.

SMPTE ST 183:1996, Motion-Picture Film — Photographic Audio Level Test Films — Measurement of Photoelectric Output Factor

EBU Recommendation R68–2000, Alignment Level in Digital Audio Production Equipment and in Digital Audio Recorders

EBU Recommendation R128–2011, Loudness Normalisation and Permitted Maximum Level of Audio Signals

ITU-R BS.1726–2005, Signal Level of Digital Audio Accompanying Television in International Programme Exchange

ITU-R BS.1770–2012, Algorithms to Measure Audio Programme Loudness and True-Peak Audio Level