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ITU-R

Radiocommunication Sector of ITU

Recommendation ITU-R BS.1771-1

(01/2012)

Requirements for loudness and true-peak indicating meters

BS Series

Broadcasting service (sound)

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Note: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

Electronic Publication
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RECOMMENDATION ITU-R BS.1771-1*

Requirements for loudness and true-peak indicating meters

(Question ITU-R 2/6)

(2006-2012)

Scope

This Recommendation specifies some requirements for audio metering devices that implement the loudness and true-peak algorithms specified in other ITU-R Recommendations.

The ITU Radiocommunication Assembly,

considering

a) that neither the VU meter nor a conventional peak programme meter gives an accurate indication of subjective loudness;

b) that neither the VU meter nor a conventional peak programme meter gives an accurate indication of the true-peak level of a digital signal;

c) that listeners may desire the subjective loudness of audio programmes to be similar for different sources and different programme types;

d) that the true-peak level of a digital signal may be larger than the maximum sample value;

e) that Recommendation ITU-R BS.1770 – Algorithms to measure audio programme loudness and true-peak audio level, specifies the measurement of programme loudness and of true-peak levels;

f) that the state of digital signal processing makes it practical to implement these algorithms in a cost-effective metering device;

g) that broadcasters have requirements that should be satisfied by meters used to indicate programme loudness and true-peak level,

recommends

1 that audio meters employed to measure programme loudness, and/or to indicate true-peak level to assist in the avoidance of overload of digital audio signals, should meet the requirements specified in Annex 1 and Annex 2;

2 that Note 1 be considered as part of the Recommendation

NOTE 1 – Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words shall in no way be construed to imply partial or total compliance with this Recommendation.

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* Radiocommunication Study Group 6 made editorial amendments to this Recommendation in October 2010 and in the year 2016 in accordance with Resolution ITU-R 1.

Annex 1

Requirements for loudness and true-peak indicating meters

Introduction

The purpose of this Annex is to specify requirements for programme loudness and peak indicating meters.

Scope

This Annex outlines requirements for a meter designed for three purposes:

a) For instrument-based prediction of subjective loudness of sound programme, measured over a short term.

b) For instrument-based prediction of subjective loudness of sound programme, measured over a longer period.

c) Optionally, for indication of programme signal peaks.

This meter may be used to assist a conventional meter or it may be used instead of a conventional meter.

There shall be two categories of electronic display, called Type I and Type II. These displays shall differ only in resolution. The Type I display is intended for studio use. The Type II display is intended for portable equipment where size, weight and power consumption must be minimized.

Definitions

Loudness unit (LU)	The loudness unit is the scale unit of the loudness meter. The value of the programme in loudness units represents the loss or gain (dB) that is required to bring the programme to 0 LU, e.g. a programme that reads –10 LU will require 10 dB of gain to bring that programme up to a reading of 0 LU.
Momentary loudness	Momentary loudness is defined as the ungated loudness in Recommendation ITU-R BS.1770 loudness algorithm when passed through a first-order IIR (infinite impulse response) low-pass filter with a 400 ms time-constant, as described in further detail in Annex 2 of this Recommendation.
Short-term loudness	Short-term loudness is defined as the ungated loudness in Recommendation ITU-R BS.1770 loudness algorithm when integrated over an interval of 3 seconds, as described in further detail in Annex 2 of this Recommendation
Type I electronic display	Electronic display with a resolution of one or more segments per loudness unit.
Type II electronic display.	Electronic display with a resolution of one segment for 3 loudness units.

TABLE 1

Requirements for loudness and peak indicating meters (General requirements)

Req No.	Requirement	Additional description	Req/Opt
PLG-1	The loudness meter may incorporate a display for peak level indication		Optional
PLG-2	The loudness meter may have one or more of the following operating modes: M mode (momentary), S mode (short), and I mode (integrated).		Optional
PLG-3	The loudness display reading must not vary by more than 0.5 loudness units when the signal polarity is reversed		Required
PLG-4	The integration mode may provide a time-averaged reading over a fixed time interval. The time interval should be manually selectable with a start/stop button or switch. A meter with an integration mode should have a numerical display accompanied optionally, by a bar graph or moving needle display		Optional

NOTE – The fast mode described in an earlier revision of this Recommendation is now deprecated.

TABLE 2

Common requirements for programme loudness displays

Req No.	Requirement	Additional description	Req/Opt
PLD-1	The loudness display may be a moving indicator mechanical type, an array or multi-segment electronic type		Optional
PLD-2	The loudness display shall show units at all times, that is, either LU or LKFS[1] as appropriate		Required
PLD-3	The loudness display scale may change colour or intensity at 0 LU		Optional
PLD-4	The loudness display scale should have one of two ranges: from −18LU to +9LU or from −36LU to +18LU (or the equivalent on an absolute LKFS scale). The scale shall be linear in these ranges	further study	Optional
PLD-5	Loudness of a stereo or multi-channel sound programme shall be shown by a single display. (This does not prevent meters from also displaying individual channel loudnesses.)		Required

[1] LKFS: Loudness K-weighed relative to nominal Full Scale.

TABLE 3

Requirements for programme loudness display – mechanical type

Req No.	Requirement	Additional description	Req/Opt
MCD-1	A mechanical loudness meter display shall have a non-linearity of not more than 1% of full-scale deflection over its operating range		Required

TABLE 4

Display requirements – Optional peak level indicator on loudness meter

Req No.	Requirement	Additional description	Req/Opt
PLI-1	The digital overload indication should consist of one red indicator		Optional
PLI-2	The threshold for overload indication shall be –2 dB re full scale digital input		Required
PLI-3	The overload indicator shall activate if the true-peak digital audio level exceeds the threshold		Required
PLI-4	Once the indicator light is activated it shall remain activated for at least 150 ms after the signal has fallen below the threshold		Required

Appendix 1
to Annex 1 (informative)

Example of programme loudness display

FIGURE 1

Example of programme loudness display, mechanical type

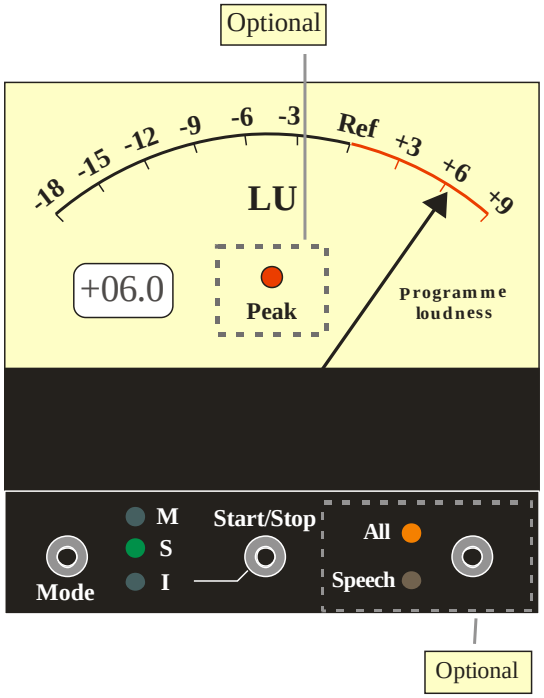

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FIGURE 2

Example of programme loudness level display, opto-electronic Type I

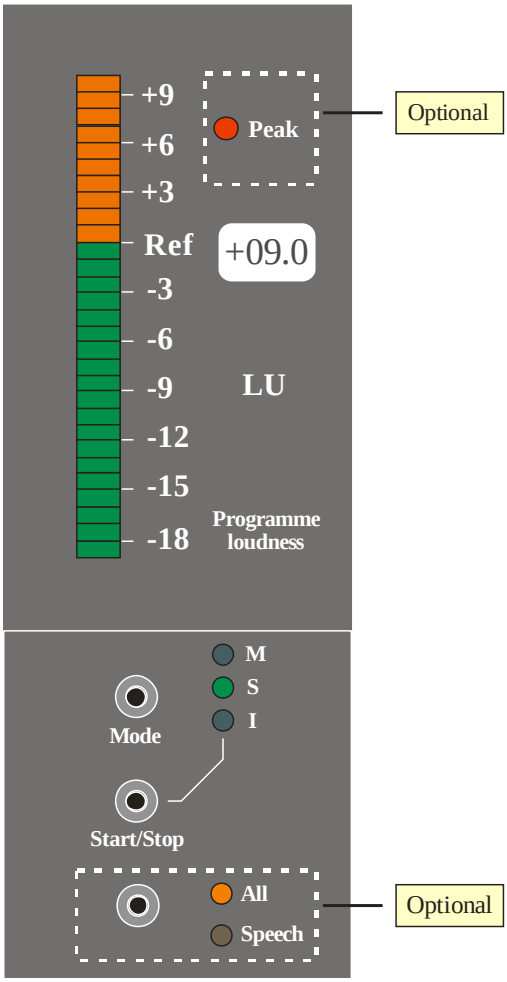

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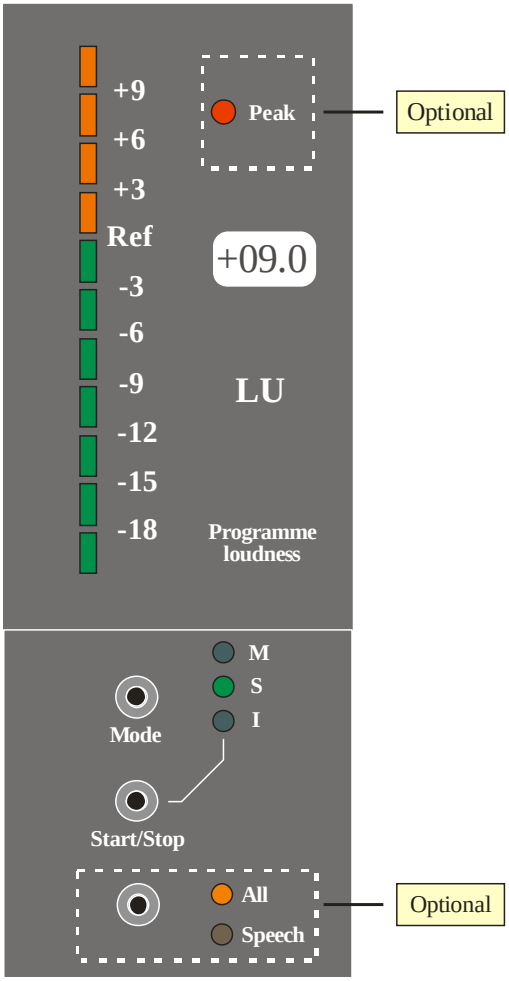
FIGURE 3

Example of programme loudness level display, opto-electronic Type II



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Appendix 2
to Annex 1
(Informative)

Explanatory notes

1 Background and terminology

Loudness is a perceptual property of an audio signal when it is reproduced acoustically. It is a complex, non-linear function of amplitude, frequency and bandwidth.

Level is the amplitude of a signal – either the r.m.s. voltage of an electrical signal or the sound pressure of an acoustical signal. It is an objective property which is independent of frequency and bandwidth and can be measured linearly in volts if electrical, or Pascals if acoustical, or logarithmically in decibels (dB) with respect to a stated reference level.

For the purposes of broadcasting, loudness can also be measured as an electrical property, assuming a fixed electro-acoustic gain for reproduction. This assumption is the basis for the broadcast loudness meter specified in Recommendation ITU-R BS.1770. The reproduction level that has been assumed in the home is 60 dBA, a level found by Benjamin to be a typical listening level for television viewing in actual homes [Benjamin, 2004].

Recommendation ITU-R BS.1864 specifies a target operating loudness level of −24 LKFS. Some organizations may specify operation at different levels. The chosen operating loudness level corresponds to 0 LU on a loudness meter that indicates relative loudness.

A broadcast loudness meter has a combination of the following three operating modes: M mode (momentary), S mode (short), and I mode (integrated). These are used for different purposes.

– Momentary and short-term modes are used in production, post-production and presentation. The programme level should be set so that for the full programme mix, or anchor element of the programme content (typically dialogue), the meter should display 0 LU on average.

– Integrating mode is used for quality control, mainly at programme ingestion, programme emission and in post-mortem analysis. The single-number output from this mode allows clear and unambiguous information for loudness-matching and gain setting.

2 Meter display format

A fundamental decision is whether the display should use a mechanical meter, an electronic display or whether it should be specified to allow implementation in either format.

Although many operators prefer electronic displays, and these are increasingly common on digital sound and video equipment, some operators, especially visually impaired operators, prefer a mechanical meter. The requirement has therefore been written to cover both types of implementation.

3 Signal type discrimination

Another fundamental decision is whether the meter includes a selectable mode whereby it can recognize speech and only actively measure during those time-periods when the signal is primarily speech/dialogue.

While it can be useful to know the loudness of isolated elements of the audio signal such as speech, it is difficult to specify the performance of such a facility, and it is often desirable to know the overall loudness. Therefore, the primary mode of the meter has no speech discrimination. An optional secondary mode may allow speech discrimination; this mode can be useful to help measure dialogue level.

4 Multi-channel metering

As our perception of loudness is independent of the number of sound sources involved, a single level display is sufficient to indicate the loudness for multi channel sound systems. If level displays are included for the individual input channels, the true peak level indicator must be driven by the maximum value that was measured across all input channels.

This does not interfere with the usual practice of separate level metering for each channel, as separate level/peak meters may be provided for the individual channels.

5 Peak level indicator (optional)

a) Ergonomics

There can be ergonomic difficulties with presenting two sets of information (relative loudness and peak level) on a single meter display.

More information is not always better. Consideration should be given to the meter design to ensure that peak levels are not confused with loudness levels. If a meter is to present two sets of information it is preferable to have a primary display giving detailed information and a secondary display giving less information as a warning rather than as a measurement. For this reason, on a meter primarily intended to show programme loudness, the information presented by the peak level display is less than the information displayed by a conventional peak programme meter

b) Hold time of peak indicator lights

A minimum hold time of 150 ms was chosen as a long enough time for the light to register with the eye, as very brief indications will look quite dim otherwise.

c) Option for separate level metering

While the form of the peak indication on the loudness meter is mandatory, the peak indication feature itself is not mandatory. This Recommendation is not intended to alter existing level metering practices – it is intended as an adjunct to them. It is expected that in most situations, separate level metering on each channel will be retained, removing the need for peak indication on the loudness meter.

d) Metering in recording

In the application of setting levels of analogue signals being converted to digital signals, i.e. microphone levels into a digital recorder, the primary goal is to record at a sufficiently high level to avoid quantization noise, without risking overload. In this application, it would be appropriate to employ a meter that primarily indicates true-peak level rather than loudness or general signal level.

6 Loudness units

The goal of the loudness meter utilized in broadcasting is to predict subjective loudness under anticipated reproduction conditions in the consumer environment, where the typical loudness level is 60 dBA SPL. The perceptual model for loudness is a non-linear function of amplitude, frequency, and bandwidth. In general, changing the audio level by x dB does not change the perception of loudness by the same amount due to the non-linear response of the human auditory system.

For practical reasons, many broadcasters have expressed a desire for dB units to be used. This is understandable as it is a long-standing tradition in audio measurement. The dB is not a perceptual unit however and should not be used for measuring loudness. However, one can choose a unit that is linked to dB, so that the meter can indicate the gain/loss in decibels that need to be applied to the programme to adjust it to become reference loudness.

Loudness units have been proposed as the measurement unit. These are defined as representing the gain/loss in decibels that would have to be applied to a signal to bring that signal to reference loudness, i.e. a programme that measures –10 LU would require 10 dB of gain to bring it to the reference loudness of 0 LU.

Loudness units have the advantage that they are clearly distinguished from dB so the meter will not be easily confused with a PPM or VU meter.

References

BENJAMIN, E. [October, 2004] Preferred listening levels and acceptance windows for dialog reproduction in the domestic environment. 117th Convention of the Audio Engineering Society, San Francisco, Preprint 6233.

Annex 2
(normative)

Momentary and short-term loudness meter characteristics

The momentary loudness is generated by calculating the ungated loudness signal, with a one sample integration period, as measured by Recommendation ITU-R BS.1770 according to equation (2), but passing it through the 1st order filter shown in Fig. 4 using appropriate filter coefficients to achieve a 400 ms time-constant before the $10 \log_{10}$ calculation is performed. The block diagram of this process is illustrated in Fig. 5.

FIGURE 4

Signal flow diagram for a 1st order filter

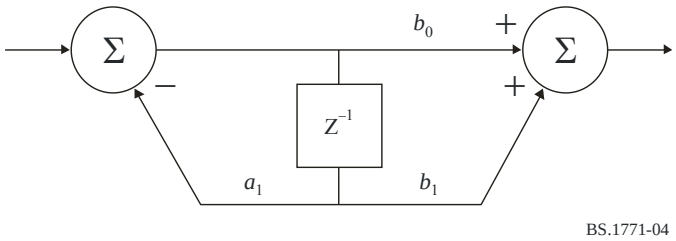
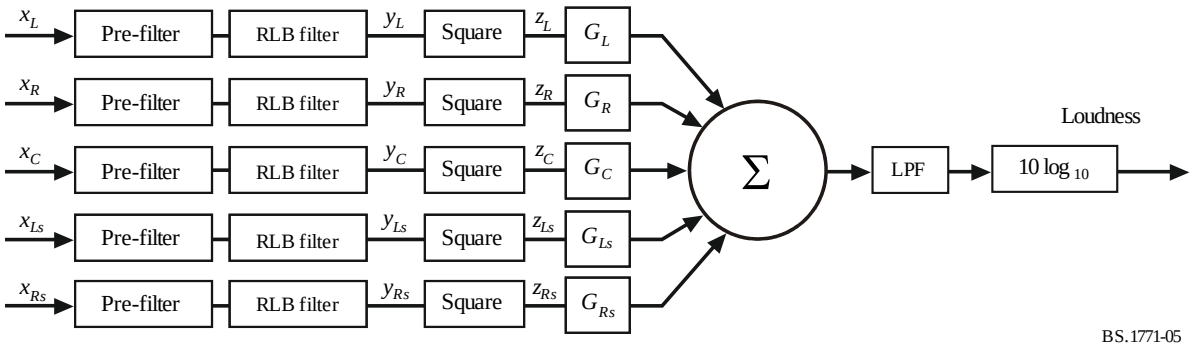


FIGURE 5

Modified loudness algorithm block diagram



Decimation by averaging blocks of samples may be used to reduce the computation load of the filter. The decimated sample rate is arbitrary but should be significantly higher than 10 sample/s. Table 5 give examples of filter coefficients for a decimated sample rate of 320 sample/s.

NOTE 2 – If another decimated sample rate is used, filter coefficients and gain should be adjusted depend on the sample rate to achieve a 400 ms time-constant.

TABLE 5

Filter coefficients for first order low-pass filter, T = 400 ms

Sample rate	**320/s**	**Gain**	**2.556465999e + 02**
–	–	b_0	1
a_1	−0.9921767002	b_1	1

A more detailed description is presented in Report ITU-R BS.2103-1.

The short-term loudness is generated by using the measurement algorithm described in Recommendation ITU-R BS.1770, but without the use of a gate, and setting the integration period to be 3 seconds.

For both momentary and short-term loudness, the display rate of each measurement is arbitrary but it is suggested that a minimum rate of 10 Hz is used.