Momentary Loudness Metering: RMS Filter Options

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Introduction

Measurement and metering of loudness in broadcast has been specified in several international standards issued in recent years. Employing such loudness meters provides an efficient way of balancing the levels of broadcast programs and channels in order to prevent the viewer/listener from experiencing annoying level jumps.

In the *EBU Mode* specification for loudness meters, two different types of dynamic loudness measures are specified: **Momentary loudness**, which reflects sudden changes in levels, or "the loudness of what you hear now", and **Short-term loudness**, which is responsive to more general changes in loudness levels [EBU 2010]. In general, it is agreed that displaying such complementary measures in loudness meters is beneficial to the operator [Skovenborg 2007; EBU 2010; Norcross 2011].

However, two options are being considered for the ballistics of the faster of the 2 measures, Momentary loudness:

1. A square sliding-window RMS with an integration time (i.e. window length) of 400 ms; abbreviated **SQR**.
   As in EBU Mode loudness meters [EBU 2010].
2. A first-order IIR filter with a time-constant of 400 ms; abbreviated **IIR**.
   As proposed for revision of ITU-R BS.1771 [ITU-R 2011].

A subjective evaluation of these two options (and others) is described in *Evaluation of Live Meter Ballistics for Loudness Control* [Norcross 2011], based on multiple criteria of usefulness for production and post-production. These results indicate that the IIR-option is preferable. However, a meter scale similar to the *EBU +9* scale was apparently used for these tests. Therefore, it is relevant to also compare the performance of the SQR- and IIR-options on a meter with a longer scale, such as the *EBU +18* scale which spans the interval -36 LU to +18 LU. The extra headroom that loudness normalization provides (in contrast to peak-normalization) makes production and broadcast of wide loudness range programs possible. The EBU +18 scale is required to support metering in such productions.

Below, we compare the SQR and IIR-options for a Momentary loudness filter on both the EBU +9 and the EBU +18 meter scales, considering both the technical and the visual consequences of the ballistics options.

Technical Differences

The table below shows some characteristic differences between the 2 filter options for the Momentary loudness.

	Square window, 400 ms integration	**IIR filter, 400 ms time-constant**
max. level for 400 ms tone burst at 0 LU	0.00 LU	-1.99 LU
max. level for 200 ms tone burst at 0 LU	-3.01 LU	-4.05 LU
max. level for 100 ms tone burst at 0 LU	-6.02 LU	-6.55 LU
time for level indicator to drop 'out of scale' from 0 LU, with EBU +9 scale	0.39 s	1.66 s
time for level indicator to drop 'out of scale' from 0 LU, with EBU +18 scale	0.40 s	3.32 s
time for level indicator to drop 'out of scale' from +18 LU (scale top), with EBU +18 scale	0.40 s	4.97 s

Evaluation by Video

In a prototype of the LM6 Loudness Meter, we have implemented both SQR and IIR options. Using the prototype, the effect of the two Momentary filters can be subjectively evaluated measuring real signals, as a supplement to the analytic differences described above.

The test signal is composed of 3 segments, with a total duration of 90 s:

1. 10 s of 1kHz tone at 0 LU (i.e. target level)
2. 10 s of 1kHz tone at -24 LU (i.e. below range of the EBU +9 meter scale, but within the EBU +18 scale)
3. The first 70 s from the EBU Tech. 3341 test signal #8 (the authentic, 'wide loudness-range' signal).

Two videos show the LM6 prototype meter in each Momentary filter mode while measuring the same signal, both using the EBU +9 and the +18 scale; so 4 videos in total.

The videos can be found here on YouTube via the following links:

- **LM6, EBU +9, SQR:** http://youtu.be/n4Q64IK7_rg
- **LM6, EBU +9, IIR:** http://youtu.be/QgnMtf3nzkc
- **LM6, EBU +18, SQR:** http://youtu.be/NkBdx8jCmRk
- **LM6, EBU +18, IIR:** http://youtu.be/ym7bQdk2DhM

Note how the EBU +18 scale fits the wide loudness range material, starting at 50 s in the videos, better than the EBU +9 scale. The combination of the EBU +18 and the SQR filter provides a good sense of the foreground vs. background loudness levels, whereas the IIR filter seems to work better with the EBU +9 scale.

A Third Alternative

We hereby propose, as a third alternative, a *loudness peak hold* indicator for the Momentary loudness. The meter would thus have both the advantage of the symmetric and fast attack/decay of the SQR filter (EBU Mode), *and* at the same time the ability to retain peak loudness levels for several seconds, like the IIR filter. The decay of the loudness peak hold indicator follows a constant dB/s rate, similar to an IIR filter.

A video demonstrating this idea can be found here on YouTube via the following link:

- **LM6, EBU +9, SQR, Peak hold:** http://youtu.be/2oeKZ1Bxq3Q

Summary

We have investigated the differences between two ballistics options for the Momentary loudness metering: A square sliding-window RMS with an integration time of 400 ms (abbrev. SQR), and alternatively, a first-order IIR filter with a time-constant of 400 ms (abbrev. IIR).

The most noticeable difference is that the SQR has symmetric attack/decay rates, whereas the IIR has fast attack, slow decay. For example, on the EBU +18 scale the SQR takes 0.4 s for the indicator to fall from 0 LU (target level) to -36 LU (bottom of scale), whereas the IIR takes 3.3 s. The slow decay of the IIR would help the operator assess the loudest parts of a dynamic signal. However, in situations where soft sound follows loud sound, the SQR meter has a higher degree of '*what you hear is what you see*', because the softer sound is heard *before* the IIR meter has fallen back to its level – several seconds later. The videos illustrate this difference, which is most pronounced with the EBU +18 scale.

We propose combining the SQR-type meter with a loudness peak hold indicator with a decay rate similar to that of the IIR filter, thereby getting 'the best of both worlds'.

Both SQR and IIR options described in this paper measure the RMS level. In contrast, an IIR filter with *asymmetric* time-constants, which has also been suggested, would NOT perform an RMS measurement as required for loudness meters (but rather a pseudo-peak measurement).

The EBU Mode requires two meter scales: the EBU +9 and the EBU +18 scale. The standardized Momentary filter should work well with BOTH of the scales. Having two different ballistics (i.e. different filters) for the two scales would be counter-intuitive for the operator of the meter.

Finally, please do not be fooled into thinking that '400 ms RMS integration time' and '400 ms IIR time-constant' mean the same thing because both say '400'. There has been some confusion in discussions of the issues at hand. This confusion also involves (incorrectly) comparison of the 'time-constants' of (Q-)PPM and VU meters even though they are specified differently.

A closer agreement between the EBU Mode of the EBU R128 and the ITU-R BS.1771 specifications for loudness meters seems within reach for an upcoming revision of the standards. This would benefit broadcasters and meter manufacturers alike. With this report, we aim at providing information to complement existing studies and proposals, and thus contribute to a balanced, well-informed decision.

References

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