DTS Neural Loudness Control Presets:

Compliance with ITU-R BS.1864 and EBU R-128

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Executive Summary

Broadcasters who need to comply with industry standards for loudness should be aware that the ITU is currently revising BS.1770 (the foundation for many loudness measurement practices worldwide) to include a gating method. Tests show that, with real-world content, the DTS Neural Loudness Control™ algorithm can achieve compliance with the strictest (±1 LU) ungated and gated loudness measures. Broadcasters can use DTS Neural Loudness Control in real-time applications to conveniently conform to current and potential future loudness compliance standards, while maintaining desirable short-term dynamics.

Introduction

Over the past few years, a variety of loudness measurement standards have emerged. Three standards of particular importance include: 1) The International Telecommunications Union ITU-R BS.1864,[1] 2) the European Broadcasting Union EBU R-128,[2] and 3) the Advanced Television Systems Committee ATSC A/85.[3]

At this time, each standard uses the ITU-R BS.1770[4] algorithm as the core measure specifying long-term loudness and peak-level detection. However, each standard may add a variety of custom enhancements and requirements to calculate the final loudness level.

The most divergent enhancement is the EBU's gating method. Gating improves the loudness matching of programs which contain longer periods of silence or isolated utterances. The EBU gating method ignores loudness levels below a dynamic threshold relative to the content. It has also been shown to improve the measure by removing low-level audio events that appear to have no impact on human assessment of loudness.

The ITU is currently revising its BS.1770 standard to include a gating method. Although it is too early to say what type of gating method will be adopted, early indications show support for a version that is nearly identical to EBU gating.

To satisfy BS.1770 in its current form, an ungated measurement is used to evaluate compliance of content processed with DTS Neural Loudness Control. To satisfy the upcoming revision of BS.1770 (and in turn, future versions of the standards dependent on BS.1770), the EBU gated algorithm can be used as a benchmark for future compliance.

The EBU gated algorithm is an integrated measure that results in a single loudness value for an entire program. This number is very useful in an offline loudness control system where the entire program can be analyzed and then gain-scaled up or down once to match a target. In many cases, the entire program cannot be analyzed offline, and must be processed in real time. Real-time algorithms are constrained by latency and computational resources. Any "look ahead" the algorithm uses to make intelligent decisions will result in latency, which must be kept to a minimum. While an offline process can theoretically spend as much time as needed to analyze and process a program, a real-time algorithm must process a block of audio and output it before the next block of audio is input. Failing to process the audio quickly enough causes unacceptable dropouts and artifacts in the audio.

Systems like DTS Neural Loudness Control make decisions in real time, relying on limited knowledge of future content and intelligent consideration of past content. Real-time loudness control requires a short-term loudness measurement. Each standard describes a short-term loudness measure in the same way (i.e., a short-term average of the ungated BS.1770 output). Even the EBU does not suggest gating a short-term measure.

While the current version of DTS Neural Loudness Control does not utilize the EBU gated loudness measure, DTS has conducted extensive tests showing compliance with both the ungated BS.1770 and the gated EBU loudness measurements. For simplicity, the two measures will be referred to as ungated (current BS.1770) and gated (EBU measure and potential future BS.1770). The goal of these tests was to arrive at a set of presets for DTS Neural Loudness Control that has the least effect on original audio dynamics, while maintaining compliance. The rest of this document will discuss our test setup, results, and presets recommended to comply with the standards of today as well as the standards of tomorrow.

Recommended Presets

Table 1 describes a set of recommended presets determined through our compliance testing. These presets represent a good balance between the preservation of dynamics and conformance to standards. While the results below demonstrate that DTS Neural Loudness Control conforms to a wide range of content that falls within the outlined standards, no real-time loudness correction device can guarantee 100 percent compliance. Further analysis of these presets can be found in the Results section.

Table 1: Recommended presets for ungated and gated measurement compliance

API Parameter Name	ITU / EBU Ultra Light	ITU / EBU Light	ITU / EBU Medium	ITU / EBU Aggressive
lmsType	DTS_LC_LEQ_1770	DTS_LC_LEQ_1770	DTS_LC_LEQ_1770	DTS_LC_LEQ_1770
targetLoudness_dBEq	--	--	--	--
target_Ratio	0.80	0.95	0.98	1.0
upperLoudnessThresh_dB	0.0	0.0	0.0	0.0
lowerLoudnessThresh_dB	0.0	0.0	0.0	0.0
freezeWindow_dB	5.0	4.0	2.0	1.0
quietThreshold_dBEq	-55.0	-55.0	-55.0	-55.0
attack_msec	80.0	50.0	50.0	50.0
release_msec	300.0	220.0	150.0	100.0
compressorThresh_dB	5.0	5.0	5.0	5.0
Compressor_Ratio	0.5	0.5	0.5	0.5
loudnessShaping	0.0	0.0	0.0	0.0
finalLimiterCeiling_dBFS	0.0	0.0	0.0	0.0
Bypass	0	0	0	0
runFinalLimiters	1	1	1	1
meterAlg	1	1	1	1

Test Setup

The following is a brief discussion of the test system used to determine the recommended presets. Twenty audio files were used of varying lengths (3 min – 30 min) and channel formats (stereo and 5.1).

The content can be broken down into the following categories:

Speech/News
Movie/Theatrical
Sports
Music
Commercials

The test procedure is summarized as follow:

1. A fixed level offset was first applied to each audio file to ensure the measured loudness level was not within ±2 LU of the loudness target (in this case, -23 LKFS).
2. The DTS Neural Loudness Control algorithm processed each file using the Ultra Light, Light, Medium and Aggressive presets.
3. The gated and ungated loudness levels were then measured for each of the processed outputs.
4. In addition to the loudness level, a measure of short-term dynamics was found using the Loudness Range (LRA) as described in EBU R-128.

Results

The ITU and EBU have different thresholds of acceptable error. ITU allows ±2 LU deviations from the target, while EBU allows ±1 LU deviation from the target (Note: In this context, LU is similar to dB). For this document, we will use the stricter EBU requirements for determining compliance. For example, if the loudness level measures -24.5 LKFS for a -23 LKFS target, the file would be ITU compliant, but not EBU compliant.

Table 2 summarizes our findings. The top two rows show the average error and the compliance for each preset. The error equals the difference between the measured output loudness and the target -23 LKFS. As expected, the more aggressive the preset, the lower the average error and the greater the compliance.

The LRA row quantifies the amount of original dynamics maintained in the output. This is calculated using a ratio of the processed output LRA to the original unprocessed LRA. A measure of 100 percent would mean the output has the same dynamic range as the input. The smaller the measure, the less dynamics the output has with respect to the input.

Table 2: Results for each preset

Measure	Ultra Light	Light	Medium	Aggressive
Ungated Average Error Compliance	1.11 LU 50 %	0.57 LU 85%	0.41 LU 100%	0.31 LU 100%
Gated Average Error Compliance	1.11 LU 55%	0.54 LU 95%	0.40 LU 100%	0.34 LU 100%
LRA: % of original	67%	53%	42%	34%

As seen above, the Ultra Light preset preserves the most dynamics. It can risk moments of non-compliance, however, depending on the loudness standard, acceptable tolerances of deviation, and the window of averaging for the loudness values. The Light, Medium and Aggressive presets reduce dynamics further, but increase the chance that content (no matter the loudness measurement technique) will be in compliance.

As expected, there is a tradeoff when applying real-time loudness correction, in terms of loudness standards compliance and dynamics preservation. The more aggressively the loudness is controlled, the higher the chance of compliance with any type of loudness standard (at the expense of reduced dynamics).

Conclusions

Recent steps taken by the ITU to revise its BS.1770 loudness measurement standard indicate a leaning toward a revised standard that could be nearly identical to EBU gating. Therefore, broadcasters who need to satisfy the potential upcoming revision of BS.1770 (and in turn, future versions of the standards dependent on BS.1770) can use the EBU gated algorithm as a benchmark.

The above DTS tests indicate that, with real-world content, the DTS Neural Loudness Control algorithm can achieve compliance with the strictest, ±1 LU ungated and gated loudness measures. Loudness presets are recommended (Ultra Light, Light, Medium and Aggressive) that represent a balance between the preservation of dynamics and conformance to standards.

While no real-time loudness correction device can guarantee 100 percent compliance, test results indicate that DTS Neural Loudness Control conforms to a wide range of content that falls within the outlined standards. Selecting more aggressive presets lowers the average error and increases compliance.

The Ultra Light preset preserves the most dynamics. However, it has a 50 percent risk of non-compliance. The Light preset offers 85 percent compliance, and both the Medium and Aggressive presets offer 100 percent compliance.

As loudness standards are finalized, DTS Neural Loudness Control continues to serve broadcasters as a versatile tool that can be easily adjusted to conform to any loudness goal, while maintaining desirable short-term dynamics.

References

[1] Recommendation ITU-R BS.1864, Operational practices for loudness in the international exchange of digital television programmes, International Telecommunications Union, Geneva, 2010.

[2] EBU Recommendation R-128, Loudness normalisation and permitted maximum level of audio signals, European Broadcasting Union, Geneva, 2010.

[3] ATSC A/85 Recommended Practice: Techniques for establishing and maintaining audio loudness for digital television, Advanced Television Systems Committee, Washington D.C., 2009.

[4] Recommendation ITU-R BS.1770-1, Algorithms to measure audio programme loudness and true-peak audio level, International Telecommunications Union, Geneva, 2007.