ITU-R BS.1770 Revisited

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ABSTRACT

International broadcast is moving towards loudness based normalization. The paper reports how loudness based guidelines are being adopted in the US, Japan and Europe; and it details new tools to improve on ITU-R BS.1770, specified in a remarkable and concerted effort between broadcasters and researchers around the world.

With the CALM act now passed by the Senate and by the Congress, transparent and predictable normalization of interstitials has become even more essential to production companies and to broadcasters.

The good news is how recent additions to BS.1770 enable improved leveling of commercials and promos without sacrificing the possibility for broadcasting wide loudness range content such as film, drama and music.

The paper describes how to root production, transmission and logging in a revised set of rules that may be used to create tighter delivery specifications than expressed in the first version of the ATSC A/85 recommended practices. Furthermore, the updated techniques work well not just with DTV, but also with personal, mobile platforms and IPTV.

Finally, the paper provides a glossary of new terms relating to loudness measurement in broadcast, to ITU-R BS.1770 and to EBU R128.

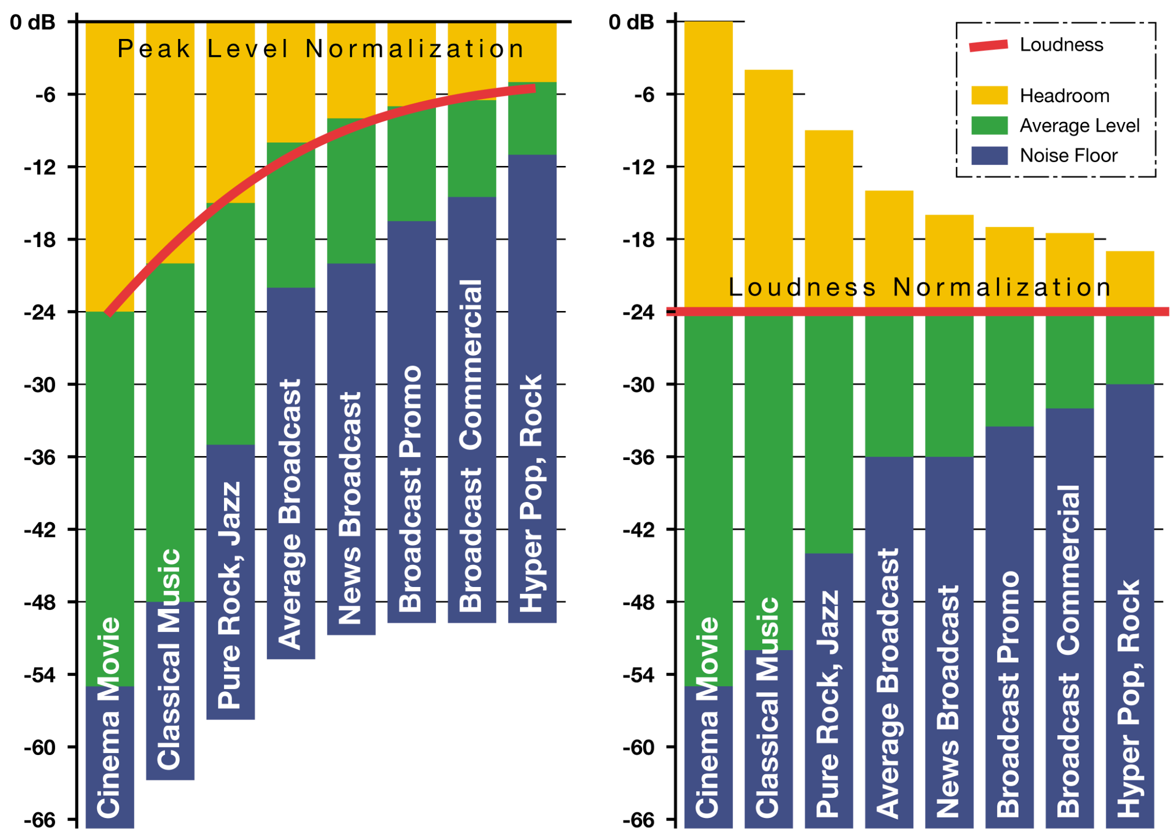

Fig 1. Pro audio is moving away from peak level normalization (left) towards standards based on loudness (right), thereby removing the main cause for systematic level differences between broadcast programs and commercials.

TERMINOLOGY

During the process of developing universal and adequate measurement techniques, new terms have been defined by ATSC [21], EBU [22] and ITU [6]. Important words are explained in the glossary addendum of this paper. When such terms appear for the first time, it is followed by [glossary].

Pro audio has traditionally used peak level normalization [glossary], based either on sample peak level (CD production) or quasi-peak level (broadcast), see *Fig 1.*

Consequently, digital broadcast has experienced a problem with level jumps; especially when wide loudness range programming is followed by narrow loudness range material; for instance, commercials, promos or sports. Normalization procedures that rely solely on peak level or dialogue intelligence simply have proven inadequate [8, 11], so there is a request from broadcasters, and now a requirement from the CALM act, to institute more efficient solutions [2, 3, 4, 5].

Loudness descriptors are key numbers to summarize loudness properties of an audio segment, entire broadcast program or music track. The ITU-R BS.1770 standard specifies a baseline method for measuring integrated loudness level [6], but it does not address several of the challenges in the *application* of loudness-control. However, it is important for everyone in the production chain to agree on how to take advantage of the new tools. For this purpose, the author has contributed to specialist groups in ATSC (S6-3) and EBU (P/LOUD) in defining an adequate number of extra descriptors, and techniques of how to use them.

PROGRAM LOUDNESS

Program Loudness is essentially an integrating loudness measurement based on BS.1770, and the key metric for normalizing programs. However, rather than blindly integrating over all input-samples, it employs an adaptive gate specified in EBU Tech 3341. Depending on threshold, the adaptive gate enables the measure to be robust against 'silence' or background sounds in the program without making any rigid assumptions about the absolute levels of the material to be measured.

If one program should be aligned in loudness with another using only a gain offset, that offset would be the difference between the Program Loudness values of the two, see *Fig 2*. Both programs would simply be normalized to the same **Target Loudness** [glossary].

Wide loudness-range (WLR) material may contain regions of relatively high loudness as well as regions which have considerably lower loudness but are still part of the program (i.e. not background noise). We shall refer to these two components of WLR as foreground sound and background sound, respectively. It has been shown how WLR programs benefit from level-alignment based on the loudness of foreground sound, rather than on overall loudness [9, 11, 17].

In spring 2010, more than 50 experienced sound engineers from EBU P/LOUD conducted extensive listening tests using the integrated BS.1770 measure to determine if focus on foreground sound, by applying a relative gate at –6 LU or –10 LU, is an advantage when specifying normalization gain.

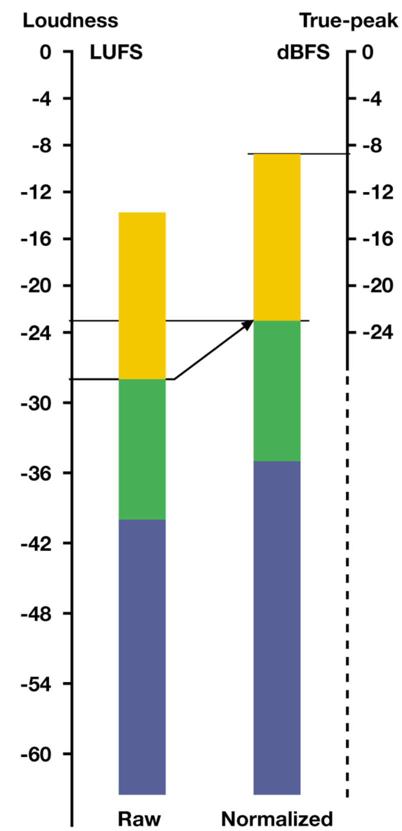

Fig 2. Normalization based on Program Loudness. The program before normalization is shown to the left. Its Program Loudness is measured to be –28 LUFS.

In this example, Target Loudness is –23 LUFS. Therefore, the program is normalized using a plain +5 dB gain shift. If Target Loudness had been –24 LUFS, the normalization gain would need to be +4 dB.

The results showed how a –8 LU relative gate gave a significantly better performance than other gating schemes. The findings have since been verified in several independent studies, for instance [9]. Note how the most relevant metric to consider here is Mean Subjective Deviation [19]. Despite the fact that independent studies all point to –8 LU as the optimum measurement gating level, ITU may settle for a political compromise with gating at –10 LU to be incorporated into the next revision of BS.1770. A comparison between different measurement gating strategies is shown in *table 1*.

Ungated Measure (GOff)	-20 LU Rel. Gate (G20)	-10 LU Rel. Gate (G10)	-8 LU Rel. Gate (G8)
Includes silence	Excludes silence	Focus on foreground	Focus on foreground
Application critical	Application friendly	Application friendly	Application friendly
Cross-genre critical	Cross-genre critical	Cross-genre friendly	Cross-genre friendly
In general, expect similar results with Narrow Loudness Range programs			
In general, expect different results with Wide Loudness Range programs			

Table 1. Comparison between different integrating loudness measures all based on Leq(K).

The ungated measure is specified in BS.1770-1. The –20 LU measure is known as Center of Gravity. Two versions of Program Loudness is shown: With –10 LU ("G10") and with –8 LU ("G8") relative gating.

An integrating measure of loudness without a gate, like in BS.1770 and BS.1770-1, is application hostile. Results even depend on how much pre-roll and post-roll is used during a measurement, making it virtually impossible to verify a result.

The new Program Loudness descriptors are analogous to TC's previously developed "Center of Gravity", but with a considerably higher threshold for the adaptive measurement-gate. Thus, Program Loudness measures the loudness level of the foreground sound of the segment, while gating out passages of background sound. If loudness-aligning a program having a high loudness range with another program having a low range, without gating, passages of foreground sound in the former program may appear unnaturally loud. Using Program Loudness (by including a G8 or G10 measurement gate) instead leads to a more pleasing result.

Program Loudness used in EBU R128 and specified in EBU Tech 3341 is based on a relative measurement gate threshold at –8 LU.

TARGET LEVEL AND HEADROOM

Programs call for various amounts of true-peak headroom above their integrated loudness. Commercials and pop/rock music typically require very little headroom to reproduce while film, drama and some genres of music need much more, see *Fig 1.*

The question is what Target level to aim for in order to satisfy listener requirements and platforms without going for a common denominator where audio quality gets sacrificed because of frequent clipping or limiting.

Table 2 shows the maximum Target Level that can be used with a certain program without any need to run it through a limiter or other time-variant processing. Note how WLR programs are given extra headroom for a given Target Level where gating is applied in the measurement, while gating or no gating makes little difference with NLR programs.

All programs fit the ATSC Target Level of –24 LKFS ungated, and the EBU Target Level of –23 LUFS gated at –8 LU. Notice how a –23 LUFS target with G8 gating provides *more* headroom than a –24 LKFS target without gating. It's not impossible to find film or music where a bit of limiting would still be needed, but the –23 LUFS target actually offers 12-15 dB of extra headroom compared to analog broadcast.

Mobile platform hardware may be engineered in a way where an average loudness of –23 LUFS is too low. Apple devices, for instance, target –16,3 LUFS when the Sound Check function is enabled. Some platforms therefore need re-alignment before transmission, see the section "Multi-platform Management".

Program	G Off LUFS	G8 LUFS	LRA LU
Matrix, full movie	-21,5	-17,5	25,0
NBC Interstitials, Jan. 2008, all together (3:30)	-17,1	-16,6	9,4
Friends Episode 16	-19,8	-18,8	6,6
Speak Ref., Male, German, SQUAM Trk 54	-18,7	-17,1	6,2
Speak Ref., Female, French, SQUAM Trk 51	-15,9	-15,1	4,8
Speak Ref., Male, English, Sound Check	-17,8	-17,2	3,3
Wish You Were Here, Pink Floyd	-19,5	-17,6	22,1
Gilgamesh, Battle of Titans, Osaka Symph.	-16,6	-14,6	19,7
Don't Cry For Me Arg., Sinead O'Conner	-20,7	-19,8	13,7
Beethoven Son in F, Op 17, Kliegel & Tichman	-19,7	-19,1	12,0
Rock'n Roll Train, AC/DC	-9,0	-8,9	6,0
I.G.Y., Donald Fagen	-19,3	-19,2	3,6

Table 2. Loudness Range and Integrated Loudness of entire programs with and without gating. All programs have max true-peak level at –1.0 dBFS.

LKFS, LUFS & LU

The unit used on loudness meters currently varies. LKFS and LUFS are interchangeable and both denote an **absolute** measure of loudness. Illustrations in this paper and during my presentation may have "LUFS" substituted for "LKFS" and vice versa.

LU is a **relative** measure of loudness. When used to display loudness level on a meter, a certain Target Loudness is explicit.

For instance, if the Target loudness level of a station is –24 LKFS (which is the same as –24 LUFS) a meter may show that number as "0 LU". A level of –27 LUFS would thus be shown as –3 LU, while one of –20 LUFS would show as +4 LU.

It's merely a question of preference if a user likes an absolute or a relative display of loudness level better. More information may be found in the glossary section of this paper.

LOUDNESS RANGE

Loudness Range [glossary] quantifies the variation in a time-varying loudness measurement. It measures the variation of the loudness on a macroscopic timescale, in units of LU (i.e. on a dB scale). Loudness Range is therefore intended for use on programs of a certain duration.

In order to achieve a good compromise between precision and robustness, the measurement of Loudness Range is based on the statistical distribution of measured loudness. Thus, a short but very loud event would not affect the Loudness Range of a long program, and similarly the fade-out at the end of a music track would not increase the measured Loudness Range noticeably. Specifically, the range of the distribution of loudness levels is determined by estimating the difference between a low and a high percentile of the distribution. This method is similar to the Interquartile Range (IQR), used in the field of descriptive statistics to obtain a robust estimate of the spread of a data sample. Percentiles belong to non- parametric statistics and are employed in the computation of Loudness Range because the loudness levels can in general not be assumed to belong to a particular statistical distribution.

This definition of Loudness Range turns out to work well for many different genres of material and is specified in EBU Tech 3342.

From an application's point of view, Loudness Range is compelling 1) as a production guideline, 2) for prediction of platform compliance during ingest or on a server, 3) for verifying a transparent signal-path all the way from the studio to the home-listener.

METER REQUIREMENTS

A useful measurement standard must be based on unambiguous criteria, and different manufacturers must be able to comply without violating patents or intellectual property. For instance, we wouldn't like to go to Paris just to find out how long a meter is, or to have to pay for finding out.

Realtime loudness metering has been studied for years [1, 10], but EBU recently specified a set of precise meter requirements in Tech 3341 and 3342. Program Loudness and Loudness Range are two elements of the requirements, but Tech 3341 also specifies important links to live production and to the taming of commercials through Momentary Loudness, Short-term Loudness and Max Loudness [glossary].

PRODUCTION AND LIVE METERING

While Program Loudness and Loudness Range are efficient parameters for handling entire programs, compliant loudness tools are required for production and live mixing purposes.

Production and mixing engineers should be encouraged to use their ears plus loudness meters, and forget all about peak level, as long as no overloads are generated.

The two most important metrics for this purpose are the new sliding window based metrics, Momentary Loudness and Short-term Loudness. Both provide a running, un-gated status of loudness and need no resetting. In radar type loudness meters, Momentary loudness is shown in the outer ring, while Short-term loudness is displayed as the radar itself.

INTER-PROGRAM LOUDNESS-JUMPS

In previous papers [11, 13] we have shown how subjects would want to turn down the level in more than 95% of the cases where an inter-program loudness jump created an increase of 5 LU or more *(Table 3)*. Subjects would turn up the level in more than 95% of the cases where an inter-program loudness decrease of 8 LU or more occurred.

	50% of subjects would adjust	95% of subjects would adjust
Loudness **increase** between programs	3 LU	5 LU
Loudness **decrease** between programs	6 LU	8 LU

Table 3. Inclination for the consumer to reach for the remote because of inter-program loudness-jumps.

In other words, subjects are more sensitive to a loudness increase than to a loudness decrease at program transitions. It was noted how any sound or genre could trigger the desire for adjustment. The Zap test [glossary] also showed how it requires only one of the programs at a junction to be WLR before an annoying loudness-jump is to be expected from time to time.

This asymmetrical loudness-jump tolerance appears to be a fact [11, 20] which needs to be taken into consideration when applying loudness measurement and loudness descriptors in production and distribution.

COMMERCIALS AND THE CALM ACT

For producers of commercials as well as for broadcasters, transparency in the way interstitials are managed at the station is vital. Program Loudness in itself is not enough to prevent extraneous loud incidents from occurring, and Loudness Range can't gather enough data points from a very short program to be of real use. EBU Tech 3341 therefore provides a second line of defense against annoyingly loud promos and commercials.

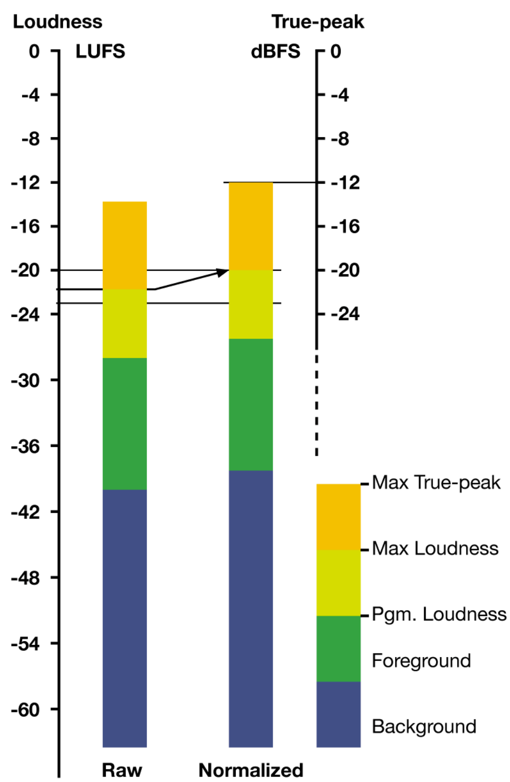

Fig 3. Normalization of promos and commercials should use Max Loudness as a second line of defense.

The technique has been used with good results by commercial broadcasters in the UK since 2008. It is now being adopted by conscious stations around the world, and would provide an instant upgrade of ATSC A/85 to make it CALM act responsive.

The procedure is this: All programs are normalized as described in *Fig 2*. However, a second normalization rule takes effect with programs of a duration of less than 5 minutes. Such programs are also judged by a sliding window to identify "hot" incidents. The standardized Max Loudness parameter returns a number signifying how loud the commercial gets during its loudest moments.

Using a 3 sec sliding window for the computation of Max Loudness, a 3 LU increase over Program Loudness is a suitable specification. This principle is shown in *Fig 3*, where Max Loudness prevents the full +5 dB normalization gain of *Fig 2* from being applied. Instead, only +2 dB of gain is used, thereby bringing Max Loudness up to –20 LUFS, even though Program Loudness ends up being 3 LU below target.

MULTI-PLATFORM MANAGEMENT

To minimize workload at the station, and the number of things to go wrong, it's highly advisable to specify a generic Target Level based on Program Loudness to be observed in production, in delivery specs and for normalizing programs [8, 13].

During ingest or on the server, all programs are normalized to Target Level, typically in the –22 to –24 LUFS range. Platform specific Loudness Range restriction and peak limiting should happen *after* normalization in order to avoid washing out the difference between foreground and background sounds of a program. A convenient and easy way of achieving the goal is:

1) Normalize programs to Target Level.
2) Apply LRA adaptation and limit true-peak level.
3) Apply gain to arrive at a desired Platform Level.

For *AC3 based platforms*, use dialnorm [glossary] to indicate the Target Level used for normalization. Prior to the AC3 encoder, true-peak limiting at –3 dBFS should be applied in order to preserve sound quality. For *HD platforms* based on linear audio or newer codecs, a true-peak level restriction of –1 dBFS is adequate and provides extra headroom.

For *legacy platforms*, for instance to support analog cable, general limiting at –10 dBFS is desirable in combination with emphasis limiting.

Mobile platforms need special attention as the gain structure typically is designed for hyper-compressed content. Platform Level should therefore sit around –15 LUFS, which implies limiting and an 8 dB gain shift as shown in *Fig 5*.

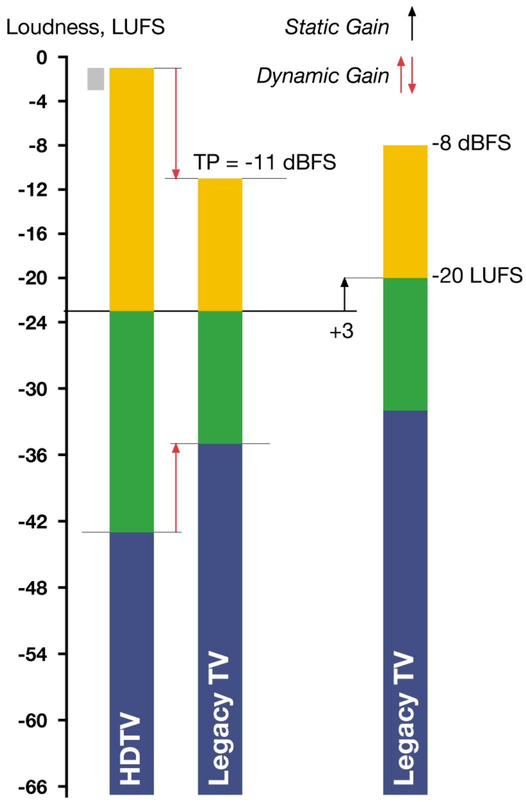

Fig 4. Automatic LRA and peak level adjustment for trickle-down to legacy platforms. Note +3 dB final gain make-up to satisfy platform requirements.

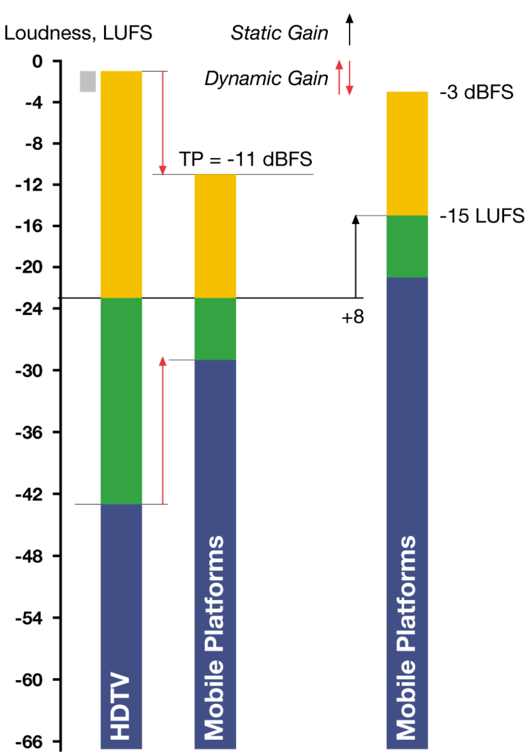

Fig 5. Automatic LRA and peak level adjustment for trickle-down to mobile platforms. Note +8 dB final gain make-up to satisfy platform requirements. Production and delivery specs are always aimed at HDTV.

DELIVERY SPECIFICATIONS

It is advisable to take advantage of new loudness standards and to make delivery specs more precise and transparent. These specs are compliant with ATSC A/85 as well as with EBU R128:

Production Guidelines:
Regular speech: -26 to –23 LUFS
Regular music: -24 to –21 LUFS
True-peak level: Max –1 dBFS

Delivery Specs:
Program Loudness: -23 LUFS +- 1 LU
Max Loudness (short programs): < -20 LUFS
Loudness Range: < 20 LU for HDTV, < 12 LU for legacy platforms, < 8 LU for mobile platforms.

All programs are to expect loudness-based normalization and true-peak based limiting.

CONCLUSION

A complete suite of new, coherent loudness tools, based entirely on ITU-R BS.1770 and open standards, has been presented.

Several brands of loudness meters adhering to this improved concept are in daily use in the UK, Germany, Japan, Austria, United States and Scandinavia; and the updated tools have proven indispensable in production as well as for the handling of finished programs.

The meaning of novel words such as Program Loudness, Loudness Range, Short-term Loudness and Momentary Loudness are described in the paper and in the glossary addendum.

While adopting new and improved leveling techniques, it's natural that broadcast organizations around the world stand on each other's shoulders. For example, the section about calibrated monitoring in ATSC A/85 is monumental, as is its manual on Dolby-based solutions and metadata in AC3.

However, in order to make ATSC A/85 CALM act responsive, a revision is indicated. The document could readily be updated with efficient leveling of promos and commercials described in this paper and detailed in EBU Tech 3341. The revision might also include a description of automatic cross-platform audio handling. It becomes more and more important not to burden broadcasters with extra work, or with proprietary (and therefore expensive) technology. To this end, inspiration may be found in EBU Tech 3343.

ACKNOWLEDGEMENTS

The author would like to thank colleagues Esben Skovenborg and Søren H. Nielsen plus the entire Pro Team at TC for inspiring discussions and cooperation in finding new solutions to loudness measurement and correction.

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ADDENDUM: LOUDNESS GLOSSARY

ATSC A/85 Recommended practices for Digital Television in the US. A/85 is rooted in BS.1770 Loudness and True-peak level. It specifies an anchor based or a universal approach to audio normalization without a clear distinction of when to use what. A/85 includes extensive information about calibrated monitoring environments and may function somewhat like a Dolby manual. Unlike EBU R128, A/85 is only focused on the digital television platform and on the AC3 codec.

Calibrated Monitoring Studio speakers may be calibrated to produce a specific SPL at a specific location in a specific room. Calibrated monitoring is of benefit to the production of quality audio, and makes moving of a project between studios less complicated. Calibrated monitoring is an advantage to keep loudness under control by ear (as well as by loudness meter), but also to achieve a consistent spectral balance from program to program. When monitoring level is undefined, the level-dependent sensitivity of our ears is allowed to play a role in mixing. With broadcast loudness now standardized, the time is perfect to encourage calibrated monitoring widely. ATSC A/85 includes a discerning chapter about this issue.

Center of Gravity Universal program loudness measurement, available in TC loudness meters. Center of Gravity (“CoG”) is based on BS.1770 and pioneered the relative-threshold measurement gate. CoG only disregards silence, whereas EBU Loudness focuses on foreground sound. The BS.1770 measure originally didn’t have a measurement gate at all, making it susceptible to operator mistakes. CoG may be regarded as a application friendly update of BS.1770. When a raw BS.1770 measurement is performed by an alert operator to start and stop the measurement, the numbers produced would basically be the same as with CoG. For more information, see Skovenborg & Lund, “Loudness Descriptors to Characterize Programs and Music Tracks”, AES 125 convention paper.

CRC Communications Research Centre. Federal R&D facility in Canada and driving force behind the studies and listening experiments underlying ITU-R BS.1770.

dBFS An absolute unit used to describe the sample level in the digital domain. 0 dBFS, where “FS” stands for Full Scale, denotes the maximum encoding value for a sample. Measurements of level specified in dBFS typically indicate sample peak level or true-peak level.

dBTP Refers to dBFS true-peak level.

dialnorm The name of a metadata field in AC3, indicating the average or anchor level of a program. In the AC3 decoder, dialnorm may be used to normalize programs by applying a gain offset and also acts as reference point for the DRC system. Despite its name, dialnorm has no speech-specific use in the decoder. The Target level of a broadcast station is normally used as its dialnorm setting for AC3 based platforms.

Dialog Intelligence A proprietary technology patented by Dolby Labs to discriminate between speech and other sounds, and thereby gate out non-speech portions when measuring loudness. The technique may not be effective at controlling commercials, nor of use across genres where the distinction between speech and non-speech is blurred. Dialog Intelligence (“DI”) is ambiguous and not defined in a standard. Dolby audio meters may run different revisions of software where a certain version of DI is combined with various weighting methods. Also see “Universal Measurement”.

DRC Dynamic Range Control. May refer to a feature of AC3, capable of restricting dynamic range during reproduction. AC3 DRC does not employ BS.1770 compliant correction capability and is in some products impossible to disable for the end-listener.

EBU Program Loudness Integrated, universal loudness measure applicable to an entire program, film or music track. EBU Program Loudness is based on ITU-R BS.1770, but adds a relative-threshold measurement-gate allowing it to focus on foreground sound. See also Target Level.

EBU Mode Loudness meter specification defined by EBU. Loudness meters compliant with EBU Mode can be relied on to perform measurements accordingly. Operational details such as scales and units are also covered. EBU Mode is defined in EBU Tech 3341.

EBU R128 Audio guidelines for broadcast in Europe, rooted in ITU-R BS.1770 Loudness and True-peak level. Compared to ATSC A/85, R128 includes significant new BS.1770 compliant tools that work across genres and across broadcast platforms, and is based entirely on open standards.

EBU Tech 3341	Definition of EBU Mode, a set of requirements for loudness meters, by EBU PLOUD.
EBU Tech 3342	Definition of Loudness Range, standardized by EBU.
EBU Tech 3343	Broadcast distribution guidelines to multiple platforms in accordance with EBU R128.
EBU Tech 3344	Practical production guidelines in accordance with EBU R128.
ITU-R BS.1770	Global standard on Broadcast Loudness and True-peak level measurement. The loudness part is based on an leq measurement employing K weighting. This baseline method is relatively simple but has been verified independently. The True-peak part of the standard was specified by AES SC-02-01. BS.1770-1 may be used for measuring mono, stereo and 5.1. Up for revision in 2011.
Integrated Loudness	The principle of indicating loudness as one number to specify the overall loudness of an entire program or music track from beginning to end. Examples of Integrated Loudness: Center of Gravity, EBU Program Loudness, "raw" BS.1770 Loudness Level.
K weighting	A frequency weighting developed by the CRC also known as "R2LB".
Leq	Equivalent sound level. An energy-integrated measure of sound often combined with a frequency weighting to approximate hearing at a certain sound pressure level. Integration may be over seconds, minutes or hours. The loudness part of BS.1770-1 makes use of a certain frequency weighting, Leq(K), as well as different gain factors for front and rear channels in 5.1.
LKFS	The unit of loudness on an *absolute* scale. The same as LUFS. EBU has submitted a proposal to ITU-R, documenting how the inclusion of the "K", denoting K-weighting, is out of line with a standardized use of units, and also is inconsistent with LU. EBU therefore recommends the use of "LUFS" instead of "LKFS".
Loudness	A perceptually property of sound. Humans rate loudness between quiet and loud. Several physical and psychological factors contribute to the sensation of loudness. An example of a listening experiment to investigate this property is described in Skovenborg, Quesnell & Nielsen, "Loudness Assessment of Music and Speech", AES 116 convention paper. Note: Loudness does not refer to the switch on a hi-fi which changes the frequency response as the gain ("volume" control) of the system is varied.
Loudness Range	A standardized measure of a the loudness range of a program or a music track. Loudness Range, abbreviated LRA, is based on BS.1770 and part of EBU R128. Loudness Range is measured in units of LU and basically measures the distance between soft and loud parts of the program. The measure is used as a production guideline, for QC manually or on a server, and for checking the integrity of an entire signal-path. The number stays the same downstream of production, even if a program is normalized. Note: Loudness Range replaces a TC Electronic descriptor, "Consistency", used in first generation of its LM5 meters.
LRA	Abbreviation of Loudness Range.
LU	The unit of loudness on a *relative* scale. 1 LU is equivalent to 1 dB. It may also be used to measure Program Loudness, if a Target Level has been defined a zero point on the LUFS scale, for instance 0 LU = -23 LUFS.
LUFS	The unit of loudness level of a digital signal on an *absolute* scale. 1 LUFS is equivalent to 1 dB. Most levels in broadcast are in the –36 to –18 LUFS range, while level closer to 0 LUFS would signify very loud.
Max Loudness	The maximum loudness level measured when a sliding window is applied from the beginning to the end of a program. In EBU R128, the width of the sliding window is defined at 400 ms or 3 sec. Max Loudness may be used as a second line of defense against annoyingly loud commercials, should producers start dodging the average approach to loudness that comes with EBU Program Loudness normalization.
Metadata	Extra data about core data. Core data could be the actual audio, video or text content while metadata may hold the tools necessary to access or understand core data. Metadata is widely used to lock out other vendors from dealing with core data, for instance in word processing, and should therefore only be embraced when based on open standards. The AES/EBU audio interface includes open standard metadata, while AC3 contains certain Dolby specific metadata. In such cases, one goal is to minimize dependency of these elusive extra data.

Momentary Loudness — The measurement of loudness using a 400 ms sliding window, defined in EBU R128. Momentary loudness should be available for real-time display of loudness on EBU Mode meters. Momentary Loudness yields the fastest and most dynamic display of loudness level.

Normalization — Applying a static gain offset to a source, a program or a music track to fulfill certain criteria. Normalization may be based on a variety of criteria, for instance a specific definition of loudness or peak level. Loudness normalization at the station is an advantage to all broadcast platforms.

OP-59 — Operational practice by FreeTV, Australia. OP-59 is rooted in BS.1770 Loudness and True-peak level and recommends a speech based as well as a universal approach to audio normalization. All short form programs should be measured using the universal (full mix) method.

phon — A unit of perceived loudness level. The phon scale is similar to the SPL dB scale. The two coincide, for 1 kHz tones, at SPL levels above 40 dB. Consequently, a 1 kHz pure tone with an SPL of 50 dB measures 50 phons, and is typically perceived as having double the loudness of 40 phons.

P/LOUD — A group of audio professionals within EBU and from everywhere in the world investigating loudness measurement and loudness control in broadcast. P/LOUD is chaired by Florian Camerer of ORF and is a sub-group of EBU's Expert Community on Audio, ECA. One of the outputs of P/LOUD, recommendation EBU R128, was published September 2010, pioneering various new BS.1770 compliant tools and production techniques.

PPM — Peak Program(me) Meter. Often used about a Quasi-peak Meter.

Program Loudness — The notion of having one integrated loudness number represent an entire program or music track. EBU Program Loudness and Center of Gravity are such examples. Program loudness may be used to normalize broadcast programs, commercials, music tracks etc. individually.

QPPM — The same as Quasi-peak Meter.

Quasi-peak Meter — Display of audio level. The quasi peak meter, PPM or QPPM, has been widely used in broadcast and film. Standardized as IEC 60268-10, the meter is intentionally slowed down in its "attack" response time, and even more in its decay. Arguably, it's neither a peak level nor an average level meter, and also not suitable for measuring loudness level. Higher peaks than what is shown on a QPPM can readily be found in a signal when also measured by a true-peak meter.

Sample-peak Meter — The sample-peak meter is one of the dregs of digital audio. Easy to implement and easy to cheat, it carries the main responsibility for the loudness wars in CD and commercial productions. The sample-peak meter is typically found in workstations and in editing systems, but don't rely on it. Use a true-peak meter to display peak level and a loudness meter to determine normalization.

Short-term Loudness — The measurement of loudness using a 3 sec sliding window without gating, defined in EBU Tech 3341. Short-term loudness is available for a running display of loudness on EBU Mode meters.

Sliding Window — A sliding window provides a method to process only a number of data points at a time. Sliding RMS window measurements are useful in audio, for instance where a property is examined for time variability. Considering loudness, sliding window methodology is particularly useful for live and production applications where there is not yet access to the full data. The sliding window length is therefore specified in Tech 3341, and defined as either 400 ms (Momentary Loudness) or 3 sec (Short-term Loudness).

sone — A unit of perceived loudness. 1 sone is defined as the loudness of a 1 kHz pure tone with an SPL of 40 dB. Doubling the perceived loudness regardless of its absolute level, doubles the loudness in sones. Sone is a psychoacoustic unit as opposed to dB.

SPL — Sound Pressure Level. An acoustic, logarithmic measure relative to a sound pressure of 20 µPa (1 kHz pure tone), which is considered to be the threshold of human hearing. Note: Unlike how dB is otherwise used, this reference point is implied when we speak about, for instance, "an SPL of 60 dB". Because the ear's spectral sensitivity depends on SPL, a filter to approximate the ear's sensitivity in a specific SPL range is used when measuring, for instance A or C weighting.

Static Metadata — The principle of keeping metadata the same as much as possible in broadcast transmission, thereby limiting the number of things that can go wrong. Stations employing static metadata continuously insert Target Loudness as the program loudness number ("dialnorm" in AC3), and only switch metadata if the format changes, for instance from stereo to 5.1. EBU R128 and ATSC A/85 include descriptions of static metadata broadcast station designs.

Target Loudness	Target Loudness is by definition the normalization level of a broadcast station. In EBU R128, Target Loudness is – 23 LUFS for all genres and program types. In ATSC A/85, Target Loudness is –24 LUFS, however measured without the gating of EBU Mode. With calibrated monitoring in place, target loudness is translated to a predictable SPL in production studios. Once a Target Loudness has been defined, users may choose to show loudness measurement on a relative scale (LU) rather than on an absolute scale (LUFS). In a metadata-based delivery system, Target Loudness is the default number to indicate program level. In AC3, the name of this metadata parameter is "dialnorm".
True-peak Level	An absolute measure used to describe the true-peak level of a digital signal. Can be measured as specified in ITU-R BS.1770. The intrinsic or true-peak level of a digital signal may be 3 or more dB higher than the sample peak level of the same signal. Contrary to sample-peak level, true-peak is a valuable estimate of the headroom required to handle a signal without clipping. 0 dBFS+ level is routinely printed to CDs, leading to distortion in reproduction equipment, sample rate converters and data reduction systems. For more information see Lund, "Stop Counting Samples", AES 121 convention paper.
True-peak Meter	An improved type of peak level meter for use in digital audio. While the sample-peak meter was sufficient in the early days of digital, it is easy to deceive and not a trustworthy tool anymore.
Universal Measurement	The principle of basing a loudness measure on all sources of a program as opposed to measuring only one, i.e. speech or music. A universal measure based on an open standard is transparent and does not depend on ambiguous discrimination between sources. Examples of universal measurements: EBU Program Loudness, Center of Gravity, Max Loudness and Sliding Window Loudness of EBU R128. Also see "Dialog Intelligence".
Zap Test	The highest jumps in loudness typically occur when "zapping" between different TV channels. The Zap Test is a statistically founded method to examine how the extent of these loudness jumps are affected by applying different normalization schemes. For more information, see Skovenborg & Lund, "Loudness Descriptors to Characterize Wide Loudness Range Material", AES 127 convention paper.