

Loudness

— don't forget the distribution chain!

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EBU Recommendation 128 is a milestone in the history of audio broadcasting. It started a loudness revolution by specifying normalized loudness levels in production, in play-out systems and, potentially, in many other applications. But not all broadcasters may follow the book, an act which threatens the position of the ones who do.

This article explains how distributors could support the good broadcasters while improving consumer satisfaction at the same time. But even if all broadcast stations were to transmit with the right loudness levels, there is no guarantee that the equipment at home would reproduce the signals correctly. A lot can go wrong before the broadcast signal reaches its final destination. Issues can be found not only in distribution head-ends but also in consumer equipment. The resulting level jumps cause annoyance and spoil the quality of experience after all. So what can be done about that?

To complete the loudness revolution, the EBU group *PLLOUD* included the distribution and reproduction stage in the scope of its work. As a result, a document has been created which engineers and designers could never have found before: [the EBU Tech 3344 distribution guidelines](#). That report includes all processing stages and works around all known problems in the link between the broadcast centre and the consumer. This article offers an introduction to what can be found in detail in that almost 90-page document.

The second line of defence

At first sight, one would say that broadcasters 'just' need to switch to [EBU R128](#) and that's it. Distribution parties can subsequently transfer the signals transparently and loudness consistency is guaranteed. However, it is not that simple. In many countries there is no legislation about loudness levels, which means that broadcast stations that do not follow R128 can keep transmitting at whatever level they want. But even regulation is not ideal, as somebody needs to keep an eye on what is going on out there, acting like a loudness police – strictly and firmly if parties don't obey the rules. Forcing equal loudness by law can also lead to heavy audio processing, making the sound as dull as ditch water and the dynamic range as flat as a pancake because the objective is just focused on avoiding charges by the authorities.

Unfortunately, the loudness war has become part of the competition amongst stations. Viewing figures and ratings, along with the ever-repeated message to 'stay tuned', rule the roost in broadcast land. Normalizing the loudness to the EBU recommended target level typically means that stations

go down in average loudness in comparison to their previous level. Although they can gain a lot in audio quality, their decision to lower the loudness level actually puts them in a weak position against competitors that remain at their old – sometimes extremely loud – level. Instead of seeking refuge in legislation, PLOUD came up with a much more efficient approach in offering protection and comfort: loudness normalization in distribution.

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By making the distribution stage part of the R128 paradigm, several goals can be achieved at the same time. The challenge is to pass through signals untouched from those broadcasters that are transmitting by the R128 book, while correcting those that deviate and which thereby intimidate the good broadcasters. Just as loudness normalization of all content cannot be achieved without the negative side-effects of using an end-stage processor in the studio of the broadcast station, similar fast-operating processing devices in distribution head-ends would cause the same drawbacks and would even spoil the quality of stations that transmit in a proper way. That's why a completely different approach has been designed.

The only acceptable solution – not least for the EBU Members themselves – is to align loudness levels integrated over a long term. This starts by performing measurements. Rather than assessing the loudness of individual programmes which would require individual start, stop and pause data being available, the trick is to monitor a service over a full day by looking at the loudest measurements during 24 blocks of one hour each. The outcome of that analysis is called ‘Service Loudness’ and represents the averaged maximum loudness of the broadcast station. The process used, in which the loudest blocks are selected, is meant to discard the blocks that are not representative, for example when playing just background music during the night while the video is displaying text pages.

The target loudness level according to EBU R128, which all broadcast stations should comply with, is specified as -23 LUFS, where a LUFS stands for Loudness Unit relative to the Full Scale reference. Instead of this absolute measurement, the loudness level can also be expressed on a relative scale compared to that reference level, in LU (Loudness Unit). As R128 itself specifies a strict and narrow maximum range of ± 1 LU for the loudness of individual (live) programmes, it is quite representative to take the loudest one-hour blocks from a full day as a reference.

To improve stability and to avoid negative side effects of this estimation, the outcome of a full day's measurement is integrated yet again, over several days. After all, it is not the performance of a particular day that is of interest but the long-term trend that the station applies. The outcome of the measurement is subsequently used to feed an adaptation device that applies the loudness correction. This is done by means of an offset value that remains static until it gets updated, if necessary, at three o'clock in the morning. The reason for using this particular time is to have minimal influence on daily programming.

The gain change is done very efficiently in the digital domain, avoiding any quality loss, and it is described in Tech 3344 for MPEG-1 Layer II, Dolby Digital and HE-AAC codecs. Dynamically-switching metadata remains fully supported. The task can be implemented easily in a DVB multi-

Abbreviations

AAC	Advanced Audio Coding	HDMI	High-Definition Multimedia Interface
AV	Audio-Visual	HE-AAC	High Efficiency AAC
AVR	Audio-Video Receiver	iDTV	Integrated Digital (or Decoder) TeleVision
DAB	Digital Audio Broadcasting (Eureka-147)	LU	Loudness Unit
DRC	Dynamic Range Control	LUFS	K-weighted Loudness Unit with reference to digital Full Scale
DVB	Digital Video Broadcasting	PCM	Pulse Code Modulation
FM	Frequency Modulation	S/PDIF	Sony/Philips Digital InterFace

plexer or a similar processing device. By separating the measurement and adaptation, the latter is reduced to a simple process without introducing risks for reliability. The measurement system could, for example, be switched off for maintenance without affecting the continuity of the distribution.

Broadcasters remain responsible for the consistency of the loudness of their own output over the day, as it should be. Inconsistency on an hourly basis – in other words, loudness levels in some blocks that are significantly louder than those in other blocks on a daily basis – will result in a less loud average transmission level overall, not the other way around. This encourages broadcasters to get their loudness level more consistent, without giving them the chance to deliberately peak loud during the competitive prime time. However, broadcasters which conform to the loudness requirements but which support a relatively wide loudness range will not be penalised and will be aligned to other stations that have reasons to compress heavily.

Dynamic Range Control (DRC) implemented in Dolby Digital and HE-AAC can influence the perceived loudness. It is expected that the next update of Tech 3344 will include information on how to handle situations where the loudness differs substantially if several DRC settings are used. This includes TV stations that use loudness normalization based on voice level.

Loudness normalization in distribution is not only an answer to differences in television services, but can be used for digital radio transmission and for FM radio as well. Being applied to all services, it creates 'the second line of defence' in the cooperative fight against the loudness war.

Other sources

Nowadays, the separation between creation and delivery is not as clear as it used to be. Many distributors are generating and broadcasting their own content by means of video-on-demand, locally-inserted advertisements, show channels and interactive set-top box applications. It is the aim to have all these sources at the same target level. For all file-based material, the approach can be exactly the same as for a broadcast station. An application such as ad-insertion is by tradition susceptible to the creation of loudness jumps. However, as long as the average loudness of the station itself is consistent over time, switching over from that service to a local source becomes a simple task if loudness normalization in distribution is being applied. As the content to be inserted is also file-based, it can be normalized in advance to -23 LUFS so that it can be inserted into any desired channel, including those that support Dolby Digital or HE-AAC. By combining service and file-based normalization, all content leaves the head-end with equal long-term loudness, which forms the ideal take-off point for further processing at home.

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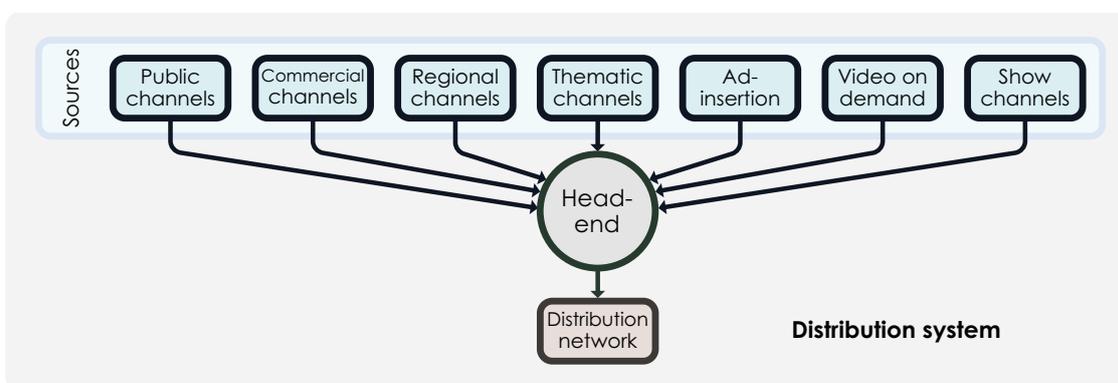


Figure 1

Several sources are combined in a distribution head-end. The aim is to bring them all together at the same loudness level. According to Tech 3344, what comes out is one long-term average reproduction level for all.

Consumer equipment

Perhaps one would suppose that loudness issues are solved once the levels of all services have been equalized in the head-end, as we just discussed. Regrettably, this isn't the case. Another link in the chain is involved. To reproduce the television and radio signals, consumer equipment – such as a set-top box, a television set and home theatre equipment – is used. These devices have a number of connections and are able to process several kinds of signals. That's exactly where the problems arise.

Whenever signals, codecs and interfaces come together in an audio device, there is a risk that differences appear regarding loudness levels. If, for example, the set-top box is used as the source, playback by a connected home theatre receiver can currently be spoiled by loudness jumps of 11 LU or more, when switching from one television service to another. This sounds about twice as loud to our ears and it usually forces people to

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grab the remote control urgently. The outcome can differ between set-top box and iDTV ¹ brands and models. Most set-top boxes also have a volume control that often affects signal levels on one codec, while there is no effect at all on others, if the sound is reproduced by a home theatre device. This behaviour shows itself as yet another level uncertainty when switching between TV channels.

The combination of faults makes it very difficult to achieve consistency and it may look as if it is just a fact of life that loudness levels simply never appear correct. However, that was not acceptable for the PLOUD group. They therefore included these concerns into the scope of the project in an ultimate attempt to resolve them. Not just some, but all of them, and also in the shortest possible term. To counteract the consumer-equipment issues, Tech 3344 contains extensive guidelines while integrating maximum backward compatibility with the installed base of devices.

Cause of the trouble

There are roughly two reasons for the level chaos. First, there is often a lack of clarity about the alignment of codecs, systems and interfaces. This includes analogue as well as digital systems. Although some of these alignments have been written down in technical standards and recommendations, something essential was missing: a common loudness level. The change to –23 LUFS as a reference level offered the PLOUD group the opportunity to create a completely new overview from

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the physical output of the broadcast studio up to the physical output connections on a consumer playback device. A number of these overviews are included in Tech 3344 in the form of tables and graphs for each European television and radio transmission system. It includes set-top boxes, television sets, radios (FM and DAB) and professional equipment. To improve understanding, the correct

level relationship can just be read out graphically, giving the engineers the answers at a glance as to ‘what comes out if a certain level goes in’ (see *Fig. E-1* in Appendix E for details).

The second cause is a lack of interoperability that stretches out beyond the territory of one codec, one system or one interface. Connections like HDMI were added to set-top boxes at some point, but

1. iDTV = a television set with integrated digital decoder

apparently without awareness that the designs of the different systems that can connect to this interface – a television set or a home theatre device – require other levels because they are intended to treat audio in a different way.

Television sets need to be designed to operate with loudness levels that are compatible with the built-in analogue tuner and analogue interfaces like the SCART connector. Home theatre devices on the other hand, are built to function in an environment of decoders that are designed to operate with the highest dynamic audio range ever to be found on digital media. Hence, their internal loudness reference is considerably lower than that of a television set, something that needs to be taken into account when making connections.

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To make matters even worse, AV receivers are manufactured in one of two different ways, depending on model and brand, which causes a mismatch of 4 dB that adds to or subtracts from the level variation of set-top boxes. This 4 dB originates from THX guidelines and causes a loudness level difference between MPEG and Dolby Digital encoded television services that have been aligned to –31 LUFS.

Certified home theatre systems can be recognized by the attached THX logo. However, some manufacturers also decided to design their non-certified AV receivers like that, which makes it hard to see from the outside to which of the two families a particular unit belongs. However again, many of these receivers expose their true nature by displaying ‘Dialnorm –4 dB’ or ‘D-norm –4 dB’ if a source that supplies a –23 LUFS referenced Dolby stream is connected, where the number indicates the opposite offset to a level of –27 LUFS. It is again a hidden piece of the puzzle of the reproduced loudness level.

Television sets themselves also seem to appear in two design families, one accepting Dolby-encoded streams on their HDMI input, while others explicitly do not. Where loudness is concerned, the variations that can be found in the design of consumer equipment make the expected behaviour of a set of devices in the home appear like a lottery. Only thorough awareness about what is happening makes it possible to understand why the levels appear different depending on codecs, systems, settings, connections, dynamic range control and volume control behaviour.

One fix for all

As the current HDMI specification seems to miss a mechanism to faultlessly distinguish all the use cases that lead to different loudness levels depending on the connected device, the approach to resolve that matter is reduced to just one basic principle. Tech 3344 works around the problems in

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consumer equipment in a modest way: just make the user able to tell the set-top box or the iDTV what device is connected. Subsequently, the device applies the correct levels. This is the quickest and simplest way to fix the issues for television broadcasting and includes a golden rule for implementing a change: backward compatibility. After all, we cannot just tell the consumers to replace all their televi-

sion sets and home theatre equipment now that EBU R128 is being applied.

The approach for the S/PDIF output is exactly the same. By implementing the adaptation in the set-top box, all currently installed television sets and home theatre equipment can be used in a consistent and best possible way. Set-top boxes and iDTVs are the most ‘reachable’ devices from

outside and if the design allows implementation of adaptations by use of a firmware update, the opportunity is offered to solve or at least reduce the problems remotely. Set-top boxes also have the relatively shortest ‘replacement time’ which makes it possible to get rid of faulty designs as soon as possible.

What’s on the menu?

Instead of sometimes rather cryptic settings to be found in the user menu of present set-top boxes and iDTVs, the way to describe which device is connected can be done in several user-friendly and intuitive ways. Although the manufacturer is fully free to design his own menu lay-out and content, some hints can be given. *Fig. 2* shows a possible way how this could look. The menu could also offer a ‘wizard’ or graphics to guide the user through the settings during installation, but as has been said, this is up to the manufacturer to choose. *Fig. 3* shows a simple example of a graphical layout.

If the user connects a home theatre device to the HDMI output, we run into the complication that this device belongs to one of the two families which produce an undesired loudness difference of 4 dB when switching between codecs and services. Although settings like ‘LOW and HIGH’, ‘LESS and MORE’ or ‘STANDARD and THX-STYLE’ could help, a more intuitive way to assist the user in making the correct menu choice can be created if the set-top box or iDTV is able to play out a signal with an audible pink noise, sequentially and repeatedly coded as PCM and Dolby Digital. If the user does not hear a difference in loudness when the menu item appears, the setting is correct for the connected device. If the set-top box or iDTV contains an internal media player, all the required components are already available to perform this job. An example is shown in *Fig. 4*.

Another way to identify a THX-style receiver is to periodically interrupt a Dolby test stream that carries -23 LUFS referenced metadata. When the set-top box or iDTV asks the user to make the right choice, most THX-style AV receivers (certified or not) will show ‘Dialnorm -4 dB’ or ‘D-norm -4 dB’ on its display according to the THX requirements.

The scenarios above are backwards compatible with currently installed television sets and home theatre equipment. As pointed out, there are also two design families of television sets, but the possible complications arising from that state of affairs are taken care of by a specific setting included in the Tech 3344 approach: if the user

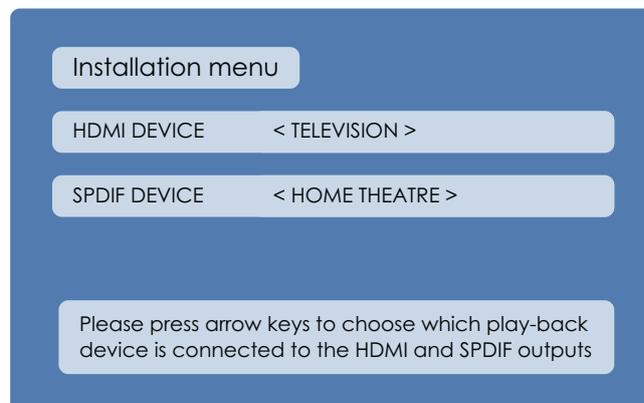


Figure 2
Logical and simple user settings in the installation menu that can be used to enable the set-top box to apply the right loudness levels

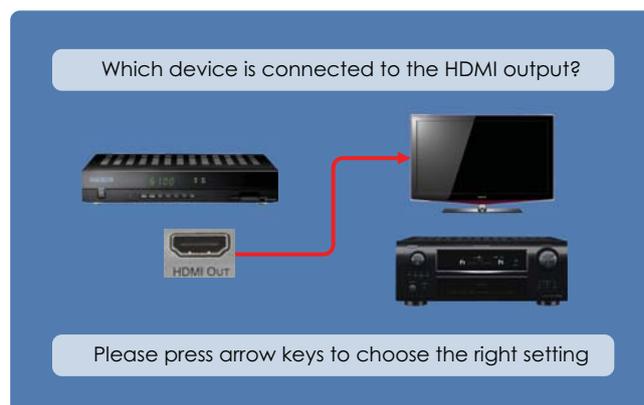


Figure 3
The same user setting as in the picture before, but now graphically displayed

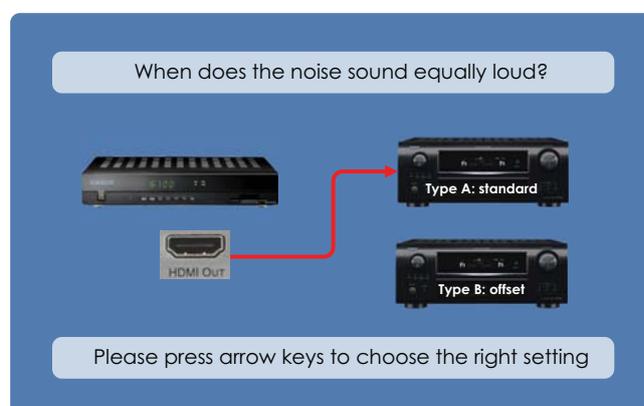


Figure 4
Support for the user to identify the kind of AV receiver by playing out a noise signal

selects the default setting for a connected TV set by choosing 'HDMI DEVICE = TELEVISION' in the text-based menu variant, the output of the set-top box is restricted to PCM audio only. This option guarantees that the loudness level of the television broadcasters appears correct on ALL television sets with HDMI input, regardless of brand and model, new or old.

An alternative scenario is created if a home theatre device is connected to the television set, as shown in *Fig. 5*. This scenario is also included as an option in the menu settings described in Tech 3344, but in this specific case the television set must also comply with that document to properly process the levels. For older television sets it is recommended to choose the default setting 'HDMI DEVICE = TELEVISION'.



Figure 5
Correct loudness processing on a television set which is compliant to Tech 3344 and that enables pass-through via the television set using the HDMI Audio Return Channel (ARC)

Future solution

Although Tech 3344 offers solutions to work around the loudness-level issues in consumer equipment, it would be very attractive if this matter could be handled automatically without bothering the user. This is an open opportunity and could be arranged as part of an update of the HDMI specification. Next-generation set-top boxes, iDTVs and home theatre equipment would then be able to recognize each other and apply the correct loudness levels once the connection is made, without intervention and independently of brand and model. Following the golden rule, this should be done while being backwards compatible: a next-generation model should still offer the Tech 3344 solutions to be able to connect equipment which is based on older designs. Eventually, the issues will die out completely.

Analogue systems

In spite of the continuing trend to transmit broadcast signals digitally, analogue TV systems and FM radio will still be present in many countries for several years to come. In cable head-ends, the digital signals need to be converted by means of digital decoders and analogue modulators. A few matters complicate this step. If loudness levels differ on digital platforms, the line-up for analogue modulation may also vary per channel, despite the attempt of the cable operator to decrease these variations manually. This also makes it very difficult to standardize the adjustments. The lack of calibration results in the situation where the loudness of, for example, BBC1 can be higher than ZDF in one place, but reversed in another cable network. It is also hard to avoid changes in loudness level after the equipment has been exchanged due to a defect. If you perceive a sudden change in average level from one day to another, it may well be that your cable operator has replaced some equipment.

In the light of R128, it would help if engineers knew how to adjust their systems consistently. EBU Tech 3344 therefore includes level overviews and tables for all European television and radio systems. Yet, this way to standardization is still dependent on the number of broadcast stations that comply with R128 without too much deviation.

“ Time-consuming maintenance on determining the adjustments can be avoided. Attention, Directors and Managers of Cable TV Networks! This is an investment that earns itself back! ”

At this point, loudness normalization at the distribution's head-end offers the solution. As all content is normalized to the EBU target level, there is also only one line-up setting left for decoders and

analogue modulators. This means that if normalization is being applied to the digital network and the systems for analogue modulation are fed by that same platform, all radio and TV equipment – including analogue ad-insertion – can be left on default settings. Time-consuming maintenance on determining the adjustments can be avoided. *Attention, Directors and Managers of Cable TV Networks! Normalizing the loudness at the head-end is an investment that earns itself back.*

What about radio?

Radio on FM and DAB is fully included in Tech 3344. Cable networks can use the same normalization process as for television and benefit from the same advantages: equal loudness and the use of default settings on equipment. The alignment scheme can be used to achieve standardization for combined DAB and FM (car) receivers. For FM radio, Tech 3344 introduces an unambiguous loudness reference, independent from stereo or mono modulation and irrespective of the amount of bandwidth used for additional signals in the FM multiplex. It offers an alternative for terrestrial planning standard ITU-R BS.412 – with or without an offset – for optimum use of the terrestrial FM band. MPX limiters can be kept out of the circuit for a more stable and consistent loudness level.

Other consumer equipment and more

Instead of just working around the complications by improving set-top boxes and iDTVs, Tech 3344 also addresses the weaknesses in other consumer equipment directly. Manufacturers can find recommendations for home theatre equipment, television sets, media players including DVD and Blu-ray, DAB and FM radio receivers.

Conclusions

A lot of complications, uncertainties and problems have been found along the route from the broadcast studios to the viewers and listeners at home. Annoyances – because of level jumps and quality losses – are the result. By extending the scope of the EBU loudness-normalization project up to and including distribution and consumer equipment, these issues have been investigated and identified. Subsequently, solutions for these troubles have been designed. Together with ready-to-use instructions, overviews, hints and suggestions for improvements, this has led to a document that engineers and designers could never have found before: the EBU Tech 3344 guidelines for broadcast distribution and consumer equipment.

Although some of the issues are related to shortcomings in the design of billions of consumer devices already in use at home, Tech 3344 offers the possibility of working around them by adapting the most accessible devices: the set-top box and the iDTV. Engineers and the technical management of distribution companies, broadcasters, legislators and manufacturers of head-end equipment and consumer devices are strongly recommended and very much invited to dive into this work and to follow up the recommendations and instructions at the first opportunity. The industry is also advised to extend the HDMI specification with identification that can be used to automatically solve the loudness issues at a later stage. After all, that is what we demand in this decennium: connect and play, without having to deal with loudness-level issues.



Richard van Everdingen started his career as a computer engineer at Getronics. He then moved to cable operator Casema, where he specialized in head-end systems. He led the development of a patented measurement system for FM modulated broadcasting, a loudness-based levelling system for dedicated rebroadcasting use and he introduced the idea for a levelling system for DVB distribution, operating directly in the MPEG domain.

Mr van Everdingen currently works as a consultant for broadcast companies at Delta Sigma Consultancy in the Netherlands. He is a member of the Dutch Broadcast Loudness Committee and leads the Distribution Subgroup within the EBU group, PLOUD.

Appendix A: Loudness levels from the distribution head-end to the home

A hypothetical example of the loudness levels of seventy different TV channels at the output of the distribution head-end after applying normalization is shown in *Fig. A-1*; all broadcast signals have around the same long-term loudness level.

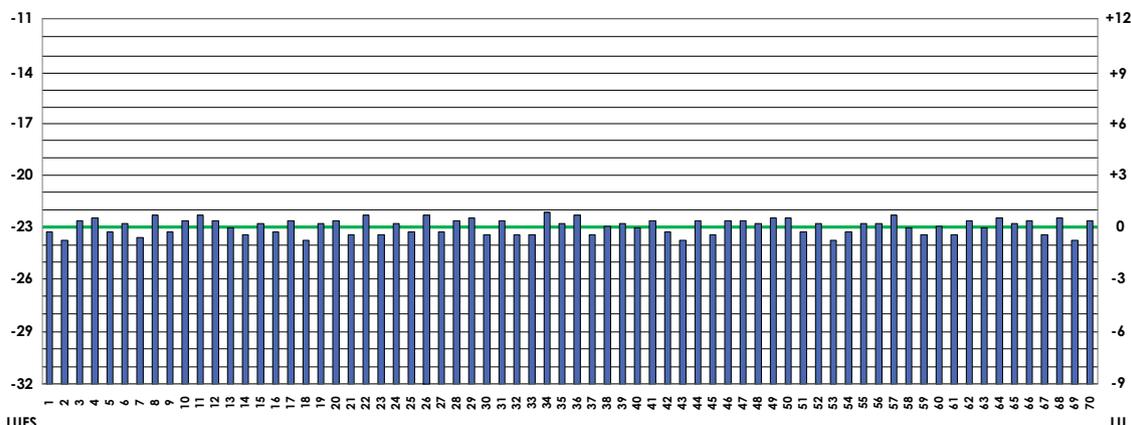


Figure A-1
Loudness levels at the output of a head-end. The services are listed on the x-axis. The left y-axis shows the absolute loudness level (in LUFS), and the right y-axis displays the loudness on the relative scale (in LU).

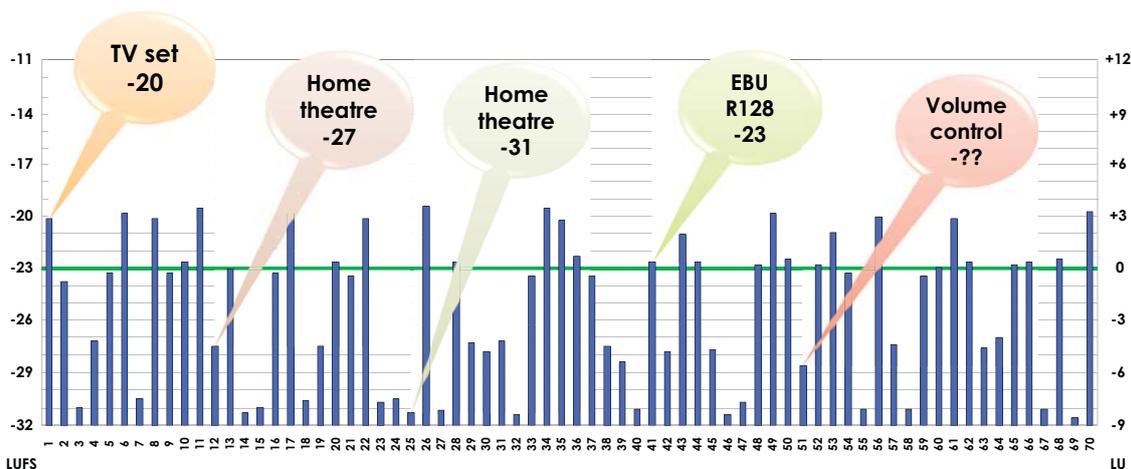


Figure A-2
The reproduced loudness level differs, depending on the equipment and the position of the volume control on the set-top box

Based on the current situation, the reproduced loudness at home can be very different, in spite of the fact that the head-end levels are indeed equal. The reproduced loudness level depends on both the consumer equipment and the listening situation. For example, in *Fig. A-2*:

-20 LUFS	=>	A set-top box or iDTV that uses its internal Dolby Digital RF Mode decoder.
-23 LUFS	=>	A set-top box or iDTV that decodes a TV channel with MPEG-1 Layer II audio.
-27 LUFS	=>	A set-top box or iDTV delivering a Dolby Digital bitstream to a THX style home theatre system.
-31 LUFS	=>	A set-top box or iDTV delivering a Dolby Digital bitstream to a regular home theatre system.
?? LUFS	=>	A set-top box or iDTV that decodes a TV channel with MPEG-1 Layer II audio or that uses its internal Dolby Digital RF Mode decoder, while the volume control is affecting the output level.

The problem is that a switch from one TV channel to another can cause a level jump between any two of the levels shown in this list, i.e. up to 11 dB when the user is unlucky. If Tech 3344 is being applied in the set-top box or iDTV, the levels are adjusted for all codec systems to the reference level of all currently-installed TV sets and home theatre systems.

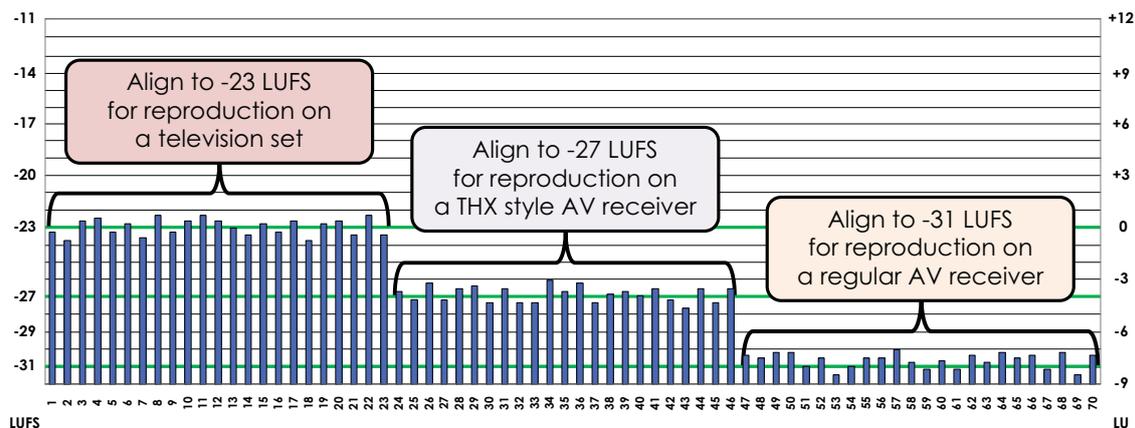


Figure A-3

The set-top box or iDTV aligns the loudness level correctly for the particular playback device to which the consumer is listening. Consequently, all codec systems of all services appear at the same loudness level within that box. By the way: the loudness levels in the graph are relative and indicate the jump caused by incorrect processing. Ultimately, the loudness playback level is defined by the consumer, who makes use of the volume control of the equipment chosen to reproduce the sound.

Appendix B: Different use cases for consumer equipment

This section shows an overview of the levels of a set-top box, a television set and a home theatre device. The level attenuation stated refers to PCM signals only. Native bitstreams like Dolby Digital (Plus) or HE-AAC are transferred over the interface without any change.

Fig. B-1 shows the level overview where the HDMI connector is used to feed the TV, while an AV receiver is connected to the S/PDIF output. It means that the set-top box sends PCM audio to the TV set at a level of -23 LUFS, while it attenuates the signal to -27 or -31 LUFS on the S/PDIF if a home theatre device is connected, depending on the type of AV receiver. The level adaptation inside a set-



Figure B-1

TV connected to the HDMI, and the AVR connected to the S/PDIF, of a set-top box

top box is not meant to act like an automatic gain control; it only sets the level for the relevant device by using the proper and fixed attenuation.

Fig. B-2 displays the situation where the AV receiver is fed from the set-top box directly via its HDMI input while the TV set is connected to the HDMI output of that home theatre device. It means that the set-top box attenuates PCM audio to -27 or -31 LUFS depending on the type of AV receiver. In case the viewer wishes to listen to the loudspeakers of the TV itself, the AV receiver forwards the audio at a level of -23 LUFS.

ideal because of influences of phase shifts and codecs in the supply line, the broadcaster can still decide to maintain this arrangement if the cable operators do not apply pre-emphasis processing. But if this is the only audio signal being supplied, it negatively affects transmission of digital sound systems, which do not have these limitations. Pre-emphasis processing also leads to some deviation of the loudness level, dependent on the content and the kind of processor used. In Tech 3344 it is therefore recommended to separate the audio supply for digital and analogue transmission. In DVB systems, this can be done by generating an additional audio stream.

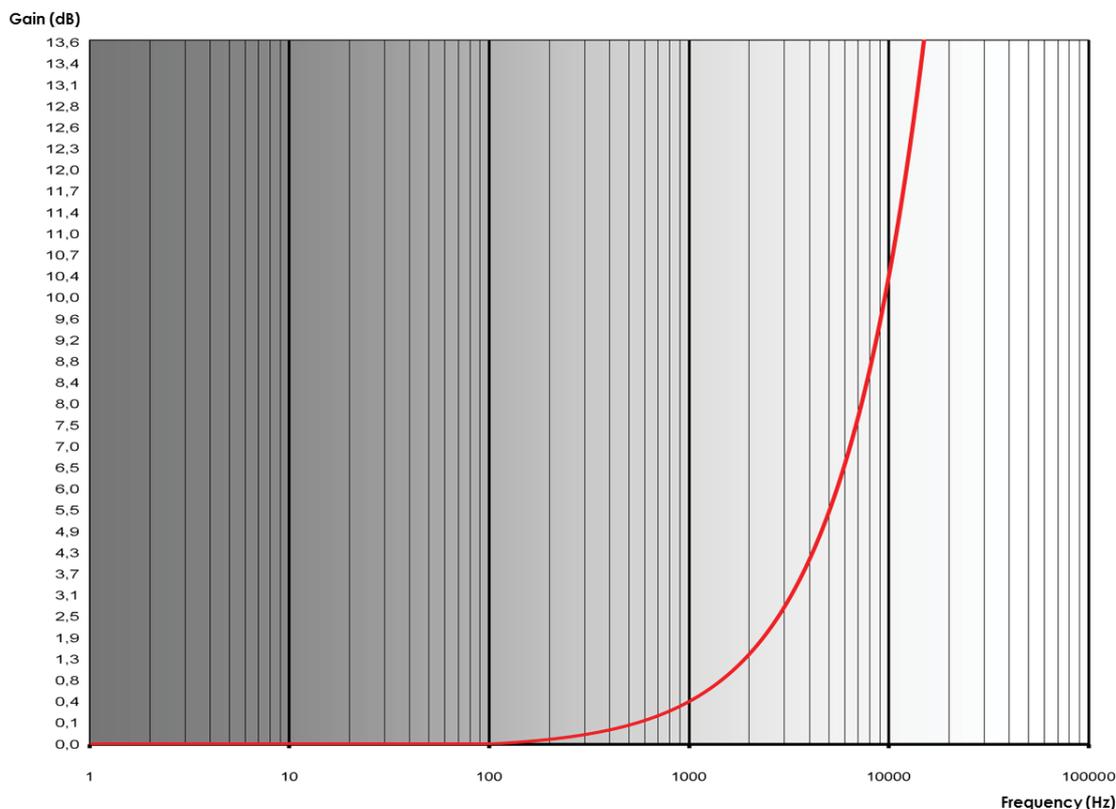


Figure C-1
An example of pre-emphasis gain in an analogue television or FM radio system

As the number of services processed by cable operators that have not been pre-processed by broadcast stations is increasing, it is strongly recommended in Tech 3344 to broadcasters, distributors and manufacturers of head-end equipment to apply pre-emphasis limiting at the best place where it can be done: just in front of, or inside, the modulator. Modern modulation equipment based on digital generation of the analogue signal offers opportunities to integrate digital pre-emphasis limiting and 15 kHz low-pass filtering in a very cost-effective manner. In that way, analogue processing does not need to be applied any longer in the broadcast studio and the quality of both the analogue and digital audio will improve.

Appendix D: Diagrams from EBU Tech 3344

To clarify what is written down in detailed text, Tech 3344 contains a lot of colourful block diagrams. Displayed below (*Fig. D-1*) is the audio signal processing inside a set-top box of one of the two major codec combinations: MPEG-1 Layer II and Dolby Digital (Plus). By following the arrows and blocks, the engineers working for distributors and manufacturers can specify and implement what needs to be done to achieve the correct audio levels. For HDMI and S/PDIF, the output level depends on the connected equipment, simply based on what was set in the menu during installation.

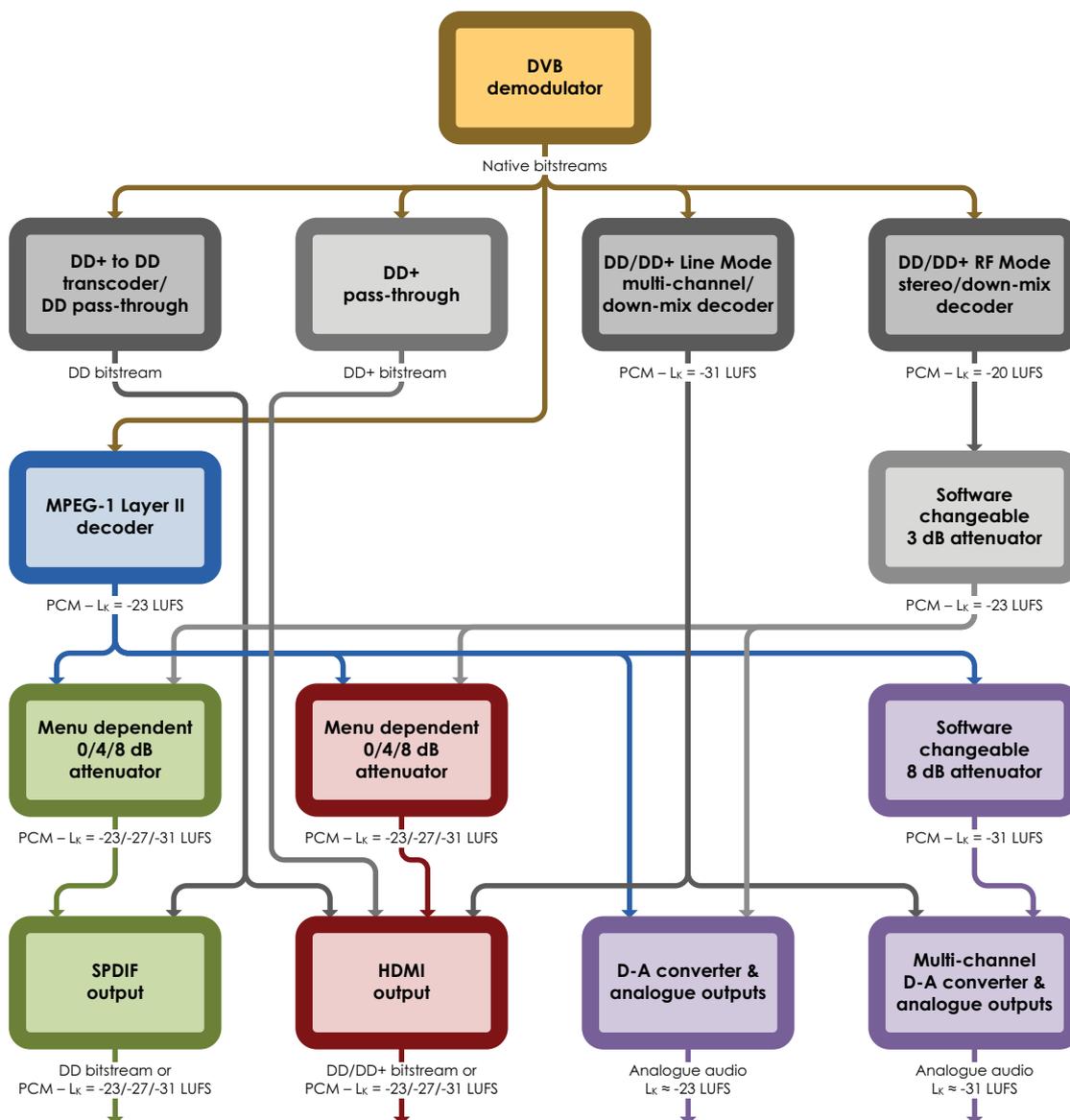


Figure D-1
Loudness adaptation inside a set-top box; one of the many diagrams included in Tech 3344 to explain the methodology

Appendix E: Level overviews from EBU Tech 3344

Fig. E-1 shows one of the overviews included in Tech 3344 that displays the level alignment between codecs, systems and physical interfaces. The red line shows at what levels limiting is required, in this example starting with -1 dBTP (True Peak) for production, -3 dBTP for the codecs that we use today in television broadcasting and -6.7 dBTP for analogue FM modulation. To check the level alignment, several well-known test signals can be used: a 1 kHz sine tone at -12 dBTP, -18 dBTP or -23 dBTP.

If a True Peak meter is not available, a sine wave at 997 Hz, encoded at the specified level in dBFS (Full Scale), may be used for reference. The -23 dBTP tone – where identically present on Left and Right channels – is equivalent to a loudness level of -23 LUFS. The output levels can simply be read out from the graph or be looked up in tables. It also shows the levels where the adaptations in set-top boxes have been applied correctly. The graph indicates, for example, that the output level on

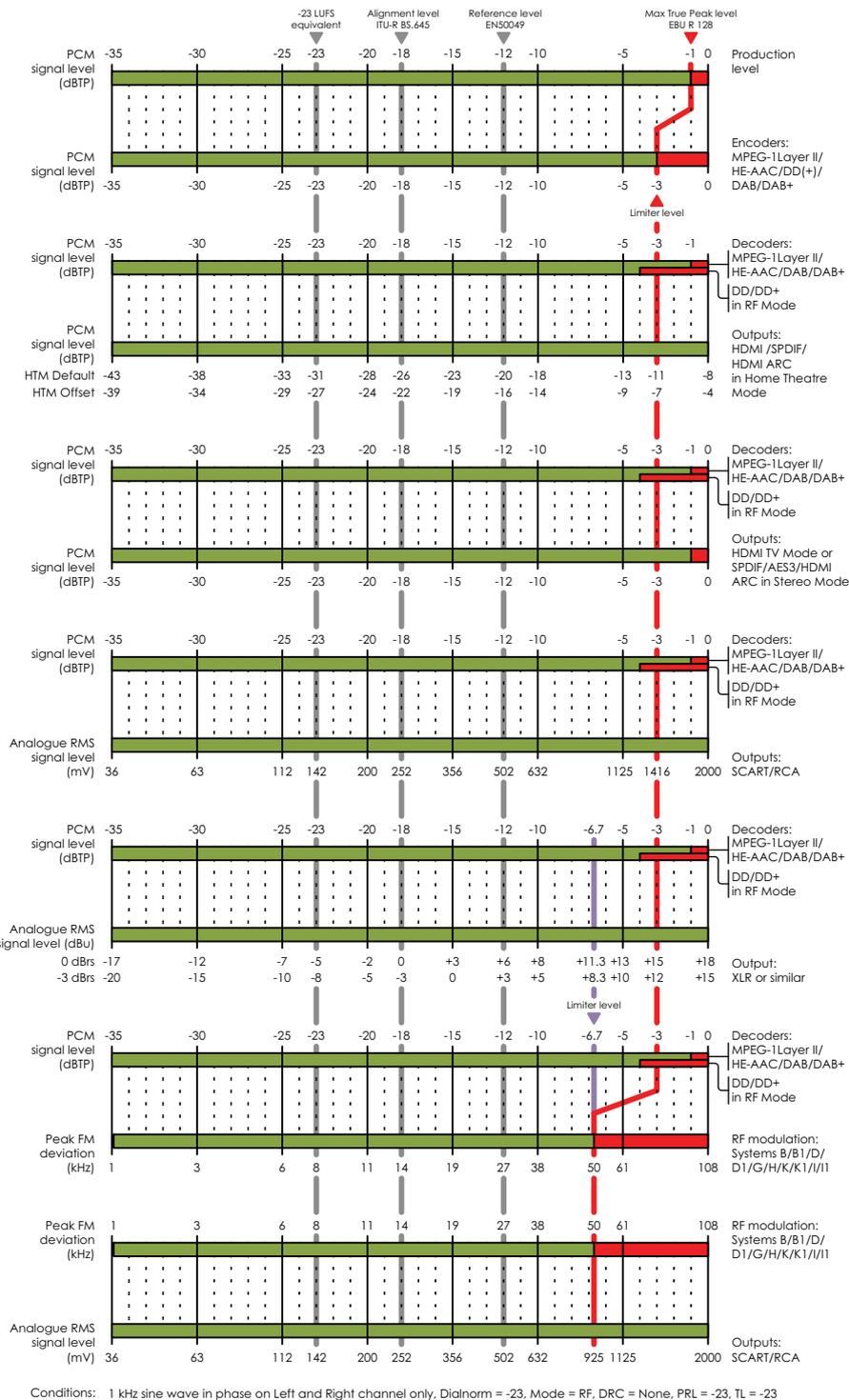


Figure E-1
One of the Tech 3344 signal alignment level overviews between codecs, systems and interfaces

the SCART connector of a set-top box is exactly the same as the output level on the SCART interface of a television set after analogue transmission and demodulation, which in fact means that equal loudness can be achieved on all TV and radio platforms: the ultimate goal of EBU R128.

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