

Audio levels

— in the new world of digital systems

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In this short article, the author outlines some of the difficulties encountered with the setting of audio levels and loudness in the “old” analogue world – and describes some new possibilities for the digital environment.

Programme alignment in the analogue world

In the “old” analogue world, a live programme exchange involved a whole series of analogue levels on different media. This might have involved radio or RF-modulated cable links, flux levels on magnetic tape, or even groove excursions on disk recordings. Because of the analogue weaknesses of some of these elements, three different (but related) levels of line-up signal were recognized internationally. These are still important as the anchors of programme production, and they are described in the ITU-R document, BS 645-2 [1]. They are known as **Alignment Level (AL)**, **Permitted Maximum Level (PML)**, and the almost forgotten **Measurement Level (ML)**.

- Alignment Level is the most enduring of these three signals, and it is the signal level that is still to be found on the headers of recordings, or left connected on sound lines in the absence of programme. Normally, 1 kHz continuous or interrupted tone is used, but 400 Hz tone is also known.
- Permitted Maximum Level, on the other hand, equates to the peak modulation on a radio link. It is set at a level 9 dB higher than Alignment Level, except in some countries where it is 8 dB higher than AL, mainly to fit the PPM meter scales in use.
- Measurement Level was set 12 dB lower than Alignment Level. ML is fairly low because it was used for measuring the technical parameters of the signal chain, such as the frequency response. If the level was set any higher, the narrow-band test signals might have caused crosstalk problems to adjacent circuits, or simply would have reproduced too loud on monitoring loudspeakers. In the case of analogue tape recording, this low level was also less prone to frequency-dependent level compression effects.

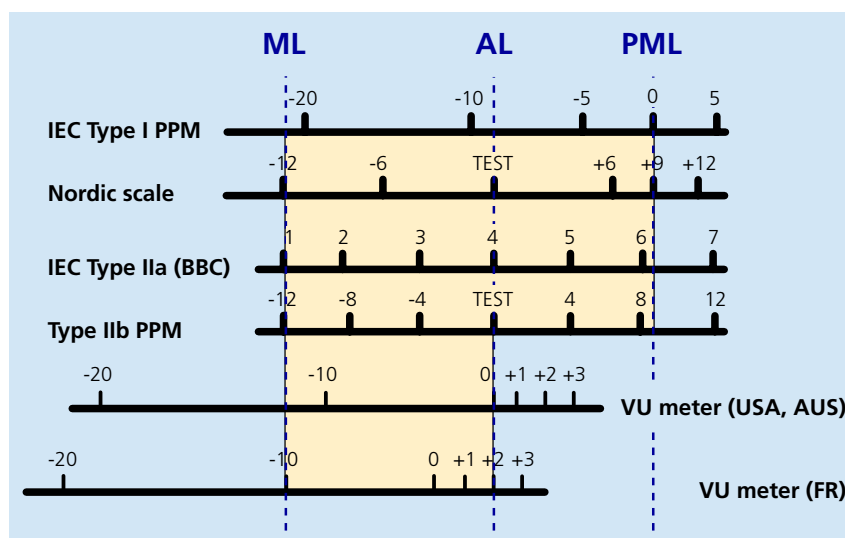


Figure 1
Rule-based loudness control

The relationships between these three important signal levels, and the common programme meters in use throughout the world, can probably be illustrated most simply by the diagram shown in *Fig. 1*.

Rule-based loudness control

Despite *engineering-based* modulation level control, different programme genres require different levels in order to fit together without loudness variations. These variations have never affected the recording industry, as the consumer can adjust the volume to suit each disk as they play it, even with DVDs. In broadcasting practice, fitting together short programme segments in a smooth manner requires extra work. Remember that some of these broadcast extracts will be live or of unknown type, so they will not be amenable to any pre-recorded metadata control.

Table 1 represents one set of rules which were established in the 1950s for broadcast loudness control, using the (IEC) Type IIa PPM, as is used at the BBC.

Table 1
Rules for using the (IEC) Type IIa PPM (as used in the BBC)

Material	Normal peaks	Dynamic range
Speech, Talks, News, Drama, Documentaries, Panel Games, Quiz Shows, Announcements	5	1 - 6
Music, Variety, Dance Music	4.5	2 - 6
Brass Bands, Military Bands	4	2 - 5
Orchestral Concerts	6	1 - 6
Light Music	5.5	1 - 6
Pop Music	5	2 - 5
Programmes containing a high degree of compression	4	2 - 4
Comercials containing a high degree of compression	4	2 - 4

By reference to the PPM scale in *Fig. 1*, it can be deduced that this rule-based loudness control range amounted to some 8 dB. This is to say that, within the programme types listed, the perceived loudness-to-signal-level ratio was expected to vary by around 8 dB.

Even if it were possible to employ all the skilled personnel needed to maintain this system today, the rule-based technique cannot be sensibly extended any further to satisfy the metering needs of a multi-channel, multi-supplier, multi-delivery and multi-listening environment.

Free at last

With the widespread adoption of digital file-based programme distribution (encouraged by the AES/EBU “BWF” format), the opportunity arises to use a “level-chunk” to represent the signal-level history of the programme audio [2]. This is equivalent to manually metering the entire programme, and soon this type of technique could free the operator from any concerns over signal excursions within the entire digital signal chain, provided of course that the original entry into the system was performed correctly. This digital entry process requires a “true-peak” meter [3], which is quite different to the “programme” meters under study here.

This automation of the engineering-based signal-level control leaves a degree of freedom to choose alternative and more perceptually-based *programme* metering parameters that will bring the greatest listening or creative benefits.

Multichannel broadcasting

During the introduction of two-channel stereo NICAM to television some ten years ago, lessons were learnt from the music recording industry and the cinema, both of whom had trodden that particular path some years earlier. In general these lessons can be summed up as follows:-

- many programme stereo “styles” had to be developed from scratch, especially those involving live action;
- dialogue intelligibility could suffer on the matrix-derived mono signal.

But overall, the message was one that might find some resonance today:

- **Quality sound actually sold television sets.**

The groundwork for European television multichannel audio production commenced some 10 years ago under HDTV initiatives such as Eureka-97, and it continued under collaborative projects such as MEDUSA. Meanwhile, the global movie industry forged ahead with the art of audio production in the 5.1 format, and this experience has now entered the home in the form of DVD recordings.

A choice of audio programmes, languages, delivery forms, dynamic range and dialogue-to-effects ratios are routinely provided on DVD, and it cannot be long before our listeners and viewers expect these same facilities.

Measuring combinations of audio channels

Note that in most future broadcast reproduction scenarios, some of the audio mix process may be at the command of the viewer (or listener) who can receive all the audio elements, just as is possible from DVD sources today. Other mixes, such as those for legacy monophonic services, may have to be automatically created for the listener or viewer, either at the studio or at a remote emission site.

A major issue in Europe is that the audio programme “bundle” is often disassembled and reassembled many times along the broadcast distribution path, before it actually gets to the transmitter. In view of all this, how can we simplify (and as far as possible, automate) any metering and control process?

The first requirement must surely be to break away from the metering of individual channels, and concentrate on matching and balancing the separable audio *strands*.

Dialogue as the foundation element

No matter how many audio channels are involved, any linked programme assembly can be divided into three strands comprising the *dialogue*, *effects* and *musical score*. In broadcasting, as in the cinema, the key strand is going to be the dialogue, particularly for intelligibility, and that involves control of the loudness. The thing to remember here is that once the audio programmes have been mixed for final delivery in many forms, the dialogue is rarely separable. Where dialogue tracks can be isolated, loudness metering is a fairly easy process and, in standard movie theatre usage where the signal levels can be related directly to the reproduced sound pressure levels, metering with algorithms such as Leq(m) (which uses the fixed “A” weighting) are successfully used [4]. For broadcast applications, a more accurate level adaptive algorithm will probably be needed [5]. Not only is the dialogue in broadcasting of a much wider character, but there may be other audio elements that are inseparable from the dialogue.

On the other hand, the cinema has to face the complexity of incorporating material where variable levels of dialogue have to be catered for. In broadcast use, it would be possible to simplify this and establish from the start a *fixed* dialogue loudness level with respect to the digital full-scale deflection (FSD) signal level. Levels

for AM mono (maybe covering webcasts also) could well be automatically generated from the higher dynamic range service. Along with an agreed (and measurable) level, there may also have to be dynamic range measurement and control, again probably using loudness-based perceptual criteria [3].

Having established dialogue loudness as the foundation element, we have probably reached a long way into the first two of these three desirable features for a future metering and control system:

- 1) The viewers/listeners want even “loudness” between channels, and across programme changes / commercial breaks [6].
- 2) The viewers/listeners want good dialogue intelligibility, especially on derived mono / 2-channel stereo where the dialogue cannot be separated out at the point of delivery.
- 3) Broadcasting would benefit from a single international metering standard.

The third desirable feature may appear obvious, but notice that there is no mention of completely removing the human operator from the control loop. There is little danger of this occurring until a compressor can tell a harpsichord from bagpipes! Nevertheless, reduced operator effort in interpreting meter readings is likely to guarantee the success of any new format. This, therefore, introduces the third element of the metering process.

Visual presentation of meter measurements

A single operator can watch several hundred video screens, but is limited to listening to a single sound field. Therefore we must accept that visual metering must often replace audible metering where the number of available human operators is limited. The visual metering interface is therefore a vital element, as the meter display may be required to totally replace the audible stimuli.

Conventional moving-coil meters display a needle, the angle of which varies over a range of 90 degrees or so. Fortunately, our eyes are very sensitive to angular measurement, probably as a result of our need to remain upright on our two legs. Sensitivity to such stimuli can be measured by Weber’s Law, which basically states that the absolute magnitude of a stimulus is proportional to the smallest discernible differences. Thus, high angular-measurement sensitivity infers that the angular stimulus is a very powerful one. This particularly applies in comparison with judging the length of an audio “light bar”, for instance.

Powerful visual stimuli are desirable for metering, as it is often only possible to glance at meters in the course of doing other tasks. For the same reason, a reasonably long persistence of a meter reading is desirable. To emphasize these factors, *Fig. 2* illustrates the visual field for a television sound operator in an often frenetic “live” studio environment.

On the other hand, overpowering the operators’ visual stimulus (e.g. by flashing lights) is not desirable unless indications of severe problems are intended. In this respect, the unintended flashing stimulus created by incrementing and decrementing discrete light bar elements can be visually fatiguing, and is recognized as such in [7].

All these reasons still seem to point to some kind of simple angular display as being desirable: experience with motor vehicles and aircraft instruments, where linear-bar and other alternatives have largely been rejected in favour of the older types of display, only adds to this view. However, in modern control rooms (as well as



Figure 2
The visual field typically encountered by a TV sound operator



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during the manufacturing process), the mechanical moving-coil meter has some disadvantages, and must surely be considered as approaching obsolescence.

The way forward

The organization that did much to put order into the days of analogue chaos was the CCIR (now ITU-R). Study Group 6 has been assigned a question [8] to cover just the kind of issues outlined in this article.

The aspects that stand out as urgently needing study – away from this initiative – are those to do with metering audio strands rather than individual physical audio channels. The human factors that are involved in the display interface should also not be ignored, or there is a danger that good technical work will go unused because of poor presentation.

New aspects of metering lead to new control possibilities, and here the importance of *assisting* rather than restricting the artistic decisions seems worth emphasizing at this stage. The move to digital audio should be shown as a clear effort to automate the engineering aspects of audio programme production, rather than automate the programme production staff.

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