Proceedings of the Institute of Acoustics

A PROGRAMME LOUDNESS METER

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Introduction

Programme Loudness variation has been a serious concern of Broadcasters since Radio Broadcasting began in the 1920's. By the end of that decade, the VU meter had been standardised in the USA, its first use being to control electrical levels on the long amplified landlines between American cities. In most of Europe, however, the peak programme meter was to become the preferred level monitoring instrument. This was first developed in the 1930's, but it only came into its present form in the 1950's. (1)

The primary requirement of both these meters was an engineering one, to prevent over modulation of the transmitter or over driving of electronic items such as amplifiers or mixers. However, at an early stage in the practical use of these meters, it was recognised that the apparent loudness of the programme depended upon the type of sound material, as well as the meter reading. The best that could be done at that time was to formulate guidelines as to the peak meter readings to be used for various types of programme. This difference of recommended readings on a PPM could amount to some 6dB between say pop music and speech, and in skilled hands, such recommendations are quite adequate today, provided that the programme content is well defined. In Europe this situation was normal until tape cartridges came into use in the 1960's. Since then it has become common to have a closely spaced group of inserts or commercials, with completely different programme content which have to be balanced together in the space of seconds rather than hours. The close time spacing between these different items also means that listeners became more awaré of loudness comparisons, and indeed in the annals of commercial television, viewers first complaints date from around 1959, the period when VTR was first used.

Although partial attempts were made in the 1970's to produce loudness meters (2), the different nature of their display to the standard PPM or Vu, meant that despite their possible value in displaying sensory loudness, you really needed two operators to balance the programme, one to watch over-modulation and the other to balance for loudness variations. The rapid changes of programme material that are now commonplace as well as the reduced manpower and rehearsal time available, clearly count against this arrangement.

A glimmer of hope came whilst Thames Television were installing the first all digital audio broadcast chain in 1988.

A Digital Recording System, with interconnections and eventual transmission also in a digital form, guarantees stability of audio signal levels throughout the programme chain. Therefore, audio metering of this system can be done at any point in the chain, including at the receiver! This also means that the metering can be done off-line, and so the metering system which we are now developing closely indicates the sensory loudness under average home listening conditions, it can be used during playout assembly operations in a fully automatic manner, and above all its readings can be standardised and easily calibrated.

DESIGNING A SENSORY LOUDNESS METER

The metering system adheres closely to the psychoacoustical model of the ear that has been built up since the 1950's by acousticians such as Zwicker (3).

Figure 1 is an electrical block diagram of the system. The incoming signal is filtered using equal loudness contours for the 70 phon level, this level being typical for home listening. Next, the signal is divided into the "critical bands", which are typically a quarter to one third of an octave wide in the most acute hearing range, and somewhat wider at the extremes.

In our prototype, the three lower critical bands (as defined by Zwicker) and also the three highest, have been combined into Low and High pass sections. This simplification was introduced because it was expected that programme material would have very little loudness energy contributing in these bands. Although this proved to be true for the High pass filter, the low pass section below 450 Hertz can be quite busy in practice, despite the equal loudness contouring which attenuates this range by at least 14dB compared to the peak value at 4kHz. In future, therefore, it may be advantageous to reintroduce one more band pass filter centred on 375 Hertz and reduce the Low pass filter frequency to 300 Hertz.

An important hearing phenomena to be simulated us the masking effect of closely spaced sound frequencies. Masking takes place when a loud sound at one frequency effectively blocks out sounds close to it in frequency. This action is assymetric, higher frequencies being blocked more completely and over a wider frequency range than lower frequencies. The effect is also non-linear to some extent, high level sound having a wide range of blocking, proportionally, than lower levels of sound.

To simulate masking, therefore, a network of cross coupled gates adjusts the detector thresholds for each of the bands according to the level in adjacent bands. Finally the corrected masked levels are summed together and processed for a display format resembling a conventional Peak Programme meter.

TESTING THE METER

Two test programme taps were assembled, each consisted of 25 commercials interspersed with different types of programme material. A sample of 40 viewers, consisting of both experts and non-experts, were asked to evaluate the loudness of the numbered programme items. Unknown to the viewers was the fact that the two tapes were assembled in a different order, and both contained a hidden check on attentiveness. The idea of the different order was to see if there was a perceptual element in the loudness judgement. For instance, would the first commercial after a quiet programme always seem too loud? Another manifestation of perceptual loudness is illustrated by the "cocktail party" effect whereby a viewer may latch on to an interesting facet of conversation, despite other louder interfering content. Clearly no sensory meter could decide what any particular viewer finds most interesting, and anyway any pursuit of perceptual loudness factors could easily lead to interference with artistic content. Test results would show any kind of dominant perceptual factor by showing differences between the averaged grades from the two tapes.

In reality, both tape tests identified the same four "loud" items, and the same three "quiet" items, defined as those items more than the standard deviation of grading away from the average. There was one "rogue" loud item on one tape which was just not identified on the other tape. On the prototype loudness meter, no item identified as "loud" had a reading of less than 2dB above the PPM reading and no item identified as "quiet" in the tests had a peak reading of more than 2dB below PPM. In other words, the meter clearly indicated the viewers average preferences with no false positive identification. The rogue item indicated 1dB above PPM, consolidating its marginal rating.

The total span of peak loudness readings compared to PPM was some 7dB between the quietest and loudest test items. In an ideal operation, some of this 7dB would be removed by skilled sound balancers during assembly of the programme material. In our tests, skilled operators removed 3-4dB of the difference in one pass, but this control was, of course, subjective in nature and therefore cannot be considered consistent, nor can it be automated in any way. The future advantage of the loudness meter is that it is objective in operation and therefore could be adapted equally easily to automated or manual balancing of programme material.

References

1. IEC Standard 268 part 10. Covers both the "Vu" and "PPM" types of meter.

2. Bauer B.B, Torick E.L. and Allen R.G. "The Measurement of Loudness Level". J Acoust. Soc. Am. 50 pp 405-414 (1971).

3. Zwicker E. "Subdivision of the Audible Frequency Range into Critical Bands". J Acoust. Soc. Am. 33 pp 248 (1961).

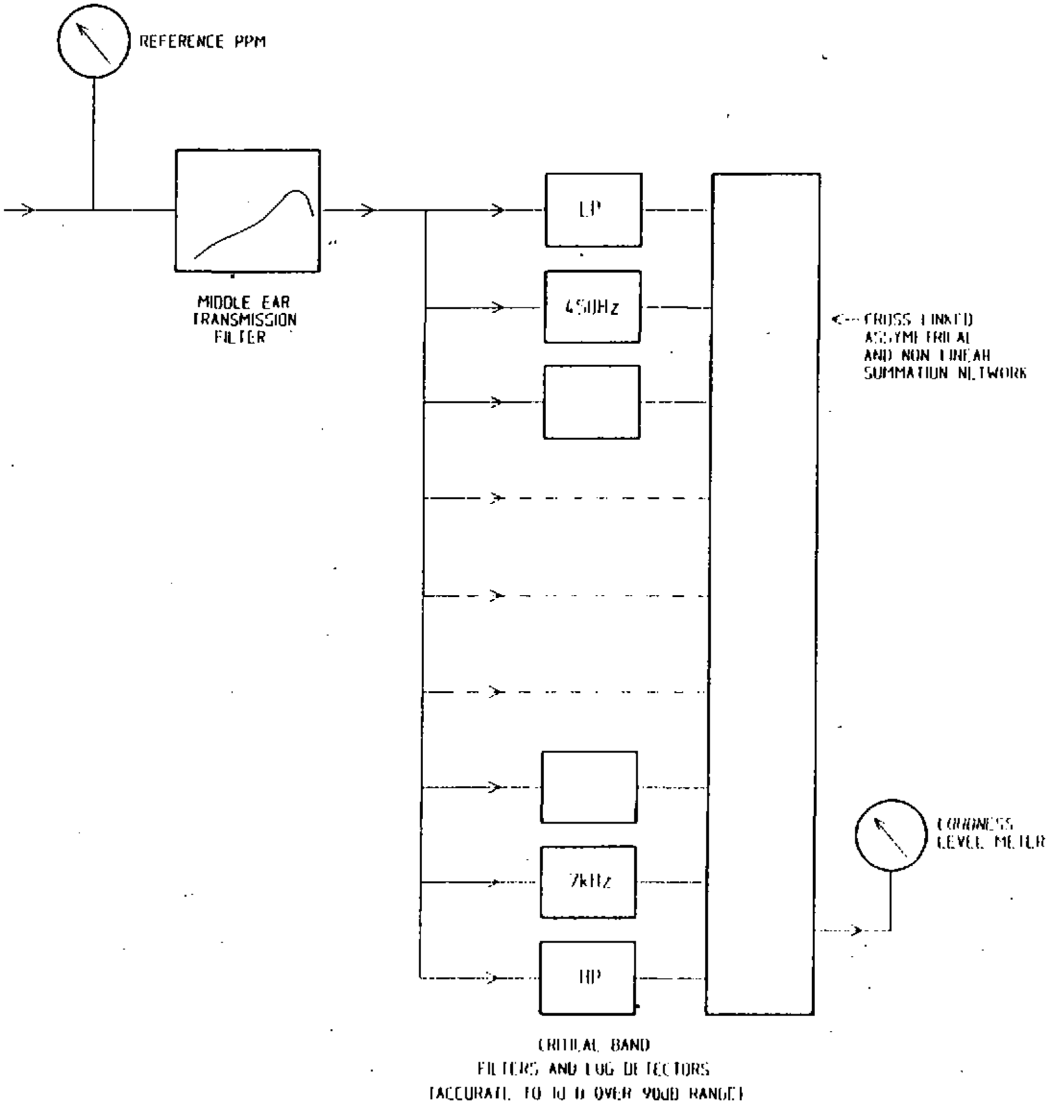

FIG 1
LOUDNESS LEVEL METER BLOCK DIAGRAM