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DB(ELC) - A PROPOSAL TO MODIFY THE DB(A)

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1. INTRODUCTION

The dB(A) is a widely used measure for loudness. In contrast to the dB(A), the proposed dB(ELC) (Equal Loudness Contours) uses four different weighting filters. This kind of dynamic loudness-contour adaption corresponds with the unequal weighting of different frequency components at variable sound pressure levels. The idea originates from the 1930s. At that time, it would have been too much technical effort to implement a real-time dynamic loudness-contour adaption. As a compromise, three different weighting contours, A, B and C were introduced and one of these three filters was intended to be used, depending on the range of sound pressure levels. At the end of the 1960s, the dB(A) was chosen as the preferred measurement quantity. Regarding this fact, the dB(ELC) is based upon the dB(A).

2. CALCULATING THE dB(ELC)

Fig. 1 shows the flow diagram of the proposed dB(ELC)-device.

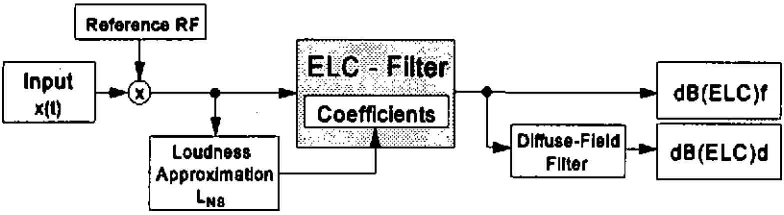

Fig. 1: Determination of the dB(ELC)

The input x(t) can be assigned to various loudness levels by adjusting the reference factor RF. An approximation of the loudness level (L_{NS}) is used to select the appropriate ELC-filter (inverse 40, 60, 80 or 100 phon contour) which is implemented as a recursive filter. To distinguish between free-field and diffuse-field levels, the output of the ELC-filter is additionally filtered with a diffuse-field filter. This results in two different measurement quantities, the dB(ELC)f for free-field conditions and the dB(ELC)d for diffuse-field conditions. The approximation of the loudness level L_{NS} is shown in Fig. 2:

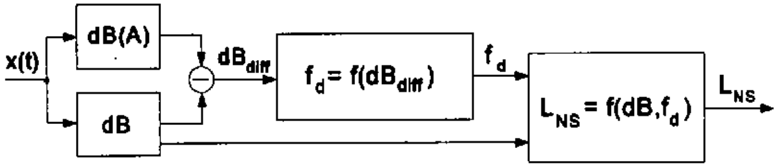

Fig. 2: Approximation of the loudness level L_{NS}

A 'dominant frequency' f_d is obtained by using the difference between unweighted and A-weighted sound level dB_{diff} and the dB(A)-transfer function. This process presumes input signals with one dominant frequency component. The actual signal bandwidth is not taken into account. For an approximation of the loudness, this simplification is tolerable. Making use of the dominant frequency f_d and the unweighted sound level, the loudness approximation is determined with a table look-up containing the equal loudness level contours.

Several authors have found considerable deviations from the equal-loudness level contours fixed in ISO 226 [1-5]. These results led us to develop modified phon-contours (Fig. 3). The modifications are mean values of recent re-eximinations and will be replaced as soon as a new standard is published. The additional distinction between ISO and modified equal-loudness contours results in four different measuring quantities: dB(ELC)fl (free-field, ISO 226), dB(ELC)dl (diffuse-field, ISO 226), dB(ELC)fm (free-field, modified), dB(ELC)dm (diffuse-field, modified).

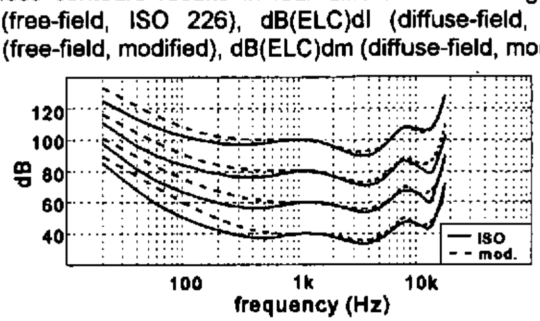

Fig. 3: ISO 226 and modified equal-loudness level contours

3. ANALYSIS AND RESULTS

The difference between dB(ELC) and dB(A) is more than 10 dB for 3% of the analysed sounds [6]. These pronounced deviations led us to investigate the differences between dB(ELC) and two more sophisticated methods for calculating loudness levels. Fifteen thousand signal frames of industry and traffic noise, each 125 ms long, were randomly selected. Most of the selected sounds were broadband with strong noise components. A distinction between free-field and diffuse-field dB(ELC)-values can be ignored because the differences between dB(A) and dB(ELC) are much more prominent than the free-field - diffuse-field differences. Therefore, dB(ELC)d-quantities were not further investigated.

For each frame the dB(A), dB(ELC)fl, dB(ELC)fm, phonGF (Zwicker´s method for calculating loudness levels [7]) and phonStR (Stevens´ method for calculating loudness levels with third band levels and Robinson's modification [8]) were calculated. The distributions of the measuring quantities versus phonGF are shown in Figures 4-7.

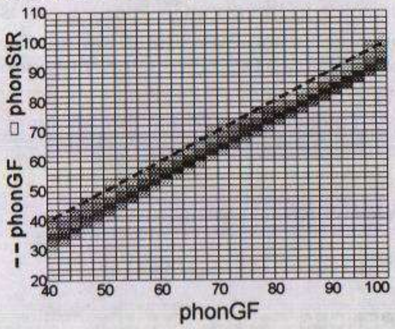

Fig. 4: phonStR compared to phonGF

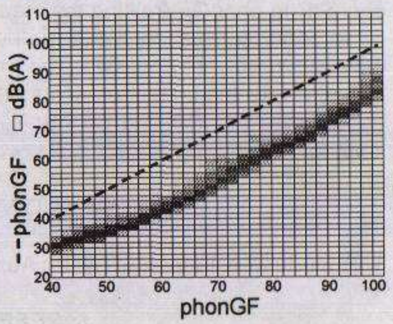

Fig. 5: dB(A) compared to phonGF

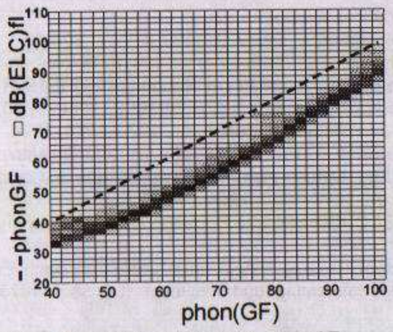

Fig. 6: dB(ELC)fl compared to phonGF

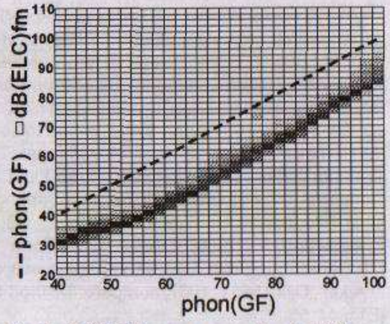

Fig. 7: dB(ELC)fm compared to phonGF

For example, column 1 in Fig. 4 shows the phonStR distribution for frames whose phonGF-values are between 40 and 42 phonGF. The dashed lines indicate the phonGF comparison.
The mean value of the phonStR is roughly 5 phon below the phonGF (Fig. 4) as reported in [8]. There is no linear relation between the dB-values (dB(A), dB(ELC)fl, dB(ELC)fm) and phonGF (Fig. 5-7). The mean differences are larger because the increasing loudness due to larger signal bandwidths are not considered in the dB-values. The deviations are approximately the same for both the phonStR and the dB quantities.

4. DISCUSSION AND CONCLUSIONS

- In contradiction to the dB(A), the proposed dB(ELC) takes into account the entire hearing area. Depending on the absolute level and the specific frequency content of a sound, the differences between dB(A) and dB(ELC) can be significant (about 10 dB [6]).
- After converting the four quantities dB(A), dB(ELC)fl, dB(ELC)fm and phonStR to phonGF (raising the mean value to the phonGF level), there is no stronger correlation between phonStR and phonGF than between the dB-quantities and phonGF. The expected tighter correlation between quantities, which take into account the dependancy of loudness on signal bandwidth (phonGF and phonStR), can not be proved for the analysed sounds.

5. ACKNOWLEDGEMENT

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6. REFERENCES

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