Loudspeaker

Power Apportionment

For: Internal Use Only

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1.00 Object

1.01 The object of this document is to provide a brief outline of the theory used to deduce the power apportionment of a loudspeaker, and to present a method of using the power apportionment and sensitivity data to calculate the octave band power tappings needed for EASE 2.1.

2.00 Scope

2.01 The scope of this document is limited to the theory and use of loudspeaker power apportionment, and does not consider system losses which may prevent the full power of an amplifier being presented to the loudspeaker driver.

3.00 Introduction

3.01 EASE 2.1 accepts power to its model loudspeakers in octave bands only and therefore a translation must be made from the available wide band loudspeaker tappings and the octave band data required for EASE. The reverse is also true.

3.02 The exercise has been carried out because there exists an uncertainty in the wide band loudspeaker tappings required for a given installation.

4.00 Theory

4.01 When a wide band signal (e.g. pink noise) is presented to a loudspeaker, the power of that signal is distributed not only in relation to the signal itself but also in relation to the impedance (electrical and mechanical) of the loudspeaker.

4.02 The equation used to calculate the percentage of power apportioned to each octave band for a given wide band signal is:

$$\%P_{oct} = 100\left(\frac{P_{oct}}{\sum_{125Hz}^{8kHz} P_{oct}}\right)$$

(1)

Where:

P_{oct} = average power in the octave band = $\frac{V_{oct}^2}{Z_{oct}}$

V_{oct} = octave band rms voltage measured across the loudspeaker
Z_{oct} = mean octave band impedance of the loudspeaker

4.03 Equation 1 assumes that 100% of the power presented to the loudspeaker is confined within the octave band range 125Hz to 8kHz. Since the pink noise used to test loudspeakers is band limited to the range 100Hz to 10kHz, the approximation is likely to be reasonable.

4.04 It is important to reiterate that the power apportionment depends on the test signal being presented to the loudspeaker. Table 1 gives a comparison of calculated apportioned power of band limited (125Hz - 8kHz) weighted pink noise.

Apportioned Power (%) vs. Frequency (Hz)
for Pink Noise (125Hz - 8kHz

Pink noise	125	250	500	1k	2k	4k	8k
Flat	14.3	14.3	14.3	14.3	14.3	14.3	14.3
SPS	17.0	19.0	19.5	18.6	15.1	8.3	2.5
A-Weighted	0.6	2.9	9.8	19.9	26.3	25.1	15.5
Speech Shaped	11.6	38.5	33.5	11.9	3.0	1.0	0.5

Table 1

5.00 Tapping Calculations

5.01 Currently, the output sheet of a loudspeaker report shows the octave band sensitivity and apportioned power data for flat pink noise, band limited to the range 125Hz to 8kHz.

5.02 Using this information along with the available wide band transformer tappings of a loudspeaker, all allowed octave band EASE 2.1 loudspeaker tappings can easily be calculated as follows:

$$ET_{oct}(W) = L/S.Tapp_{wide}(W)\left(\frac{\text{Apportioned Power}_{oct}(\%)}{100}\right)$$

Where:

$ET_{oct}(W)$ = octave band EASE 2.1 tapping
$L/S\ Tapp_{wide}(W)$ = available wide band transformer tapping

5.03 Table 2 shows an example tapping spreadsheet for the JLE3 loudspeaker.

	125	250	500	1k	2k	4k	8k
Apportioned Power (%)	12	13	18	18	16	12	11
L/S Tapps (W)	EASE Tapping (W)						
1	0.12	0.13	0.18	0.18	0.16	0.12	0.11
2	0.24	0.26	0.36	0.36	0.32	0.24	0.22
3	0.36	0.39	0.54	0.54	0.48	0.36	0.33
4	0.48	0.52	0.72	0.72	0.64	0.48	0.44
6	0.72	0.78	1.08	1.08	0.96	0.72	0.66

Table 2

5.04 Given the loudspeaker octave band apportioned power, on axis sensitivity and available transformer tappings, the following useful parameters can easily be determined:

(i) Maximum $L_{p,d}$ (lin), $L_{p,d}$ (A) and $L_{P,d}$ (oct) at a given distance and loudspeaker tapp.

(ii) Required loudspeaker tapp to produce a given $L_{p,d}$ (A) and $L_{p,d}$ (oct) at a given distance.

(iii) Required loudspeaker tapp to produce a given power in a given octave band.

(iv) Maximum on axis distance from a loudspeaker tapped at W watts to achieve a given minimum $L_{p,d}$.

6.00 Discussion

6.01 The approximation of equation 1 falls down if the test signal is not pink noise (125Hz -8kHz).

6.02 Table 3 shows the calculated apportioned power of a Simulated Program Signal over the octave band range 31.5Hz to 16kHz.

Apportioned Power (%) vs. Frequency (Hz)
for Simulated Program Signal

31.5	63	125	250	500	1k	2k	4k	8k	16k
3.2	9.9	14.7	16.5	16.9	16.1	13.1	7.2	2.1	0.3

Table 3

6.03 Comparing this data with the data of table 1 demonstrates that the power apportionment, and hence $L_{p,d}$ (oct), of a loudspeaker on a site installation, will only be the same if, and only if, the site test signal is the same as that used to determine the loudspeakers sensitivity.

6.04 The accuracy of equation 1 may be improved if the total power presented to the loudspeaker were measured as part of the sensitivity test.

6.05 Loudspeaker power apportionment then becomes:

$$\%P_{oct} = 100\left(\frac{P_{oct}}{P_{tot}}\right)$$

7.00 Recommended Further Works

7.01 Investigate by experimentation the results presented in this document.

7.02 Determine a method of deducing the total power transferred to the loudspeaker during a sensitivity test.

7.03 Investigate maximum transformer power transfer.