ISCE

The Institute of Sound and Communications Engineers

Engineering Note 17.1

Measuring Thiele-Small parameters of a loudspeaker

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1. DC resistance R_{DC}.

Measure, using an ohmmeter or bridge.

2. Total Q-factor, Q_t

Requires: Audio oscillator and amplifier, frequency counter, audio voltmeter, 1 kΩ 10 W resistor, calculator!

Connect the oscillator, to the amplifier, thence to the resistor and loudspeaker in series. Set the amplifier output voltage to 10 V (thus passing 10 mA through the loudspeaker.)

Adjust the oscillator frequency for maximum voltage across the loudspeaker and check for zero phase condition with Lissajou's Figure. Call this frequency f_0.

Note the voltage across the loudspeaker. Divide by 10 mA to get the resistance R_0. Divide R_0 by R_{DC}, call the result r_0. Calculate the square root of r_0.

Adjust the oscillator frequency so that the loudspeaker voltage corresponds to a resistance (DC resistance) × $\sqrt{r_0}$. Note the two frequencies f_1 and f_2 . Check that $\sqrt{(f_1 \times f_2)}$ is nearly equal to f_0.

Calculate $Q_T = \{\sqrt{(f_1 \times f_2)}\}/\{\sqrt{r_0} \times (f_2 - f_1)\}$

3. Equivalent volume V_{as}

The 'official' method (IEC/EN 60268-5) requires a vented box of suitable dimensions with bung for vent.

Alternative method using added mass (not very accurate!)

Determine the new resonance frequency f_3 with a known mass M added to the cone (Blu-Tac, or a wire ring fitted round the voice-coil former: NOT making a shorted turn!).

(M should be approximately equal to the cone mass, so that the resonance frequency is reduced to about 0.7 of its normal value.)

Calculate $C_{ms} = (f_0^2 - f_3^2)/Mf_1^4$ and then $C_{as} = C_{ms}S_d^2$, where S_d is the effective diaphragm area.

Then $V_{as} = \rho_0 c^2 C_{as}$ = 139636.48 × C_{as}. BUT 139636.48 is SILLY! Use 140 000!

Example: Hokutone 5 inch 120F30, 8 ohms

Determining Q_T

DC resistance 7.73 ohms Resonance at 175 Hz, with voltage 0.186 V from 10 mA current, i.e. resistance 18.6 ohms. r_0 = 2.406, $\sqrt{r_0}$ = 1.551, 7.73 × 1.551 = 12. Voltage corresponding to 12 ohms is 0.12 V. Frequencies where voltage is 0.12 V are 156 Hz and 198 Hz. Check: $\sqrt{(156 \times 198)}$ = 175.75 -OK.

Q_T = 175.75/{1.551 × (198 - 156)} = 2.7

For reflex box use, the Q_T should ideally be down in the 0.3 range.

Determining V_{as}

Added mass 5 grams = 0.005 kg. New resonance frequency f_3 = 90 Hz (So 5 g is really too much: the resonance should have not gone below 0.7 × 175 = 123 Hz.)

Calculate $C_{ms} = (175^2 - 90^2)/(0.005 \times 175^4) = 3.8 \times 10^{-5}$

Effective radius of cone = 50 mm, so $S_d^2 = 6.17 \times 10^{-5}$

$C_{as} = 3.8 \times 10^{-5} \times 6.17 \times 10^{-5} = 2.34 \times 10^{-9}$

Then $V_{as} = 2.34 \times 10^{-9} \times 140\ 000 = 3.27 \times 10^{-4}\ m^3 = 0.33$ L

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Data collection form

DC resistance R_{DC}:

Free air resonance frequency f_0:

Resonance voltage V_0:

Resonance current I_0:

Resonance resistance R_0:

Resistance ratio r_0:

Root of r_0:

Off-resonance impedance:

Corresponding voltage or current:

Lower off-resonance frequency f_1:

Upper off-resonance frequency f_2:

Check: $f_1 f_2 =$ $f_0^2 =$

Calculate: $Q_T = \{\sqrt{(f_1 \times f_2)}\}/\{\sqrt{r_0} \times (f_2 - f_1)\}$:

Added mass M:

New resonance frequency f_3:

Calculate $C_{ms} = (f_0^2 - f_3^2)/Mf_1^4$:

Cone diameter d_D:

Cone area S_D:

Calculate $C_{as} = C_{ms}S_d^2$:

Calculate $V_{as} = 140\ 000 C_{as}$: