

Example 1 - Woofer

Speaker Specifications

DC resistance	R_e	6.4 Ohms
BL product	$B\ell$	9.35 Newtons/Ampere
Suspension compliance	C_{ms}	0.81 mm/Newton
Moving mass	M_{ms}	32.8 grams
Electrical Damping	Q_{es}	0.47
Mechanical Damping	Q_{ms}	2.96
Piston Area	SD	211 cm ²
Voice Coil Impedance	L_e	2.36 mH

Lumped Parameter Model

See [Appendix A](#) for conversions.

R_e	6.8 Ω
R_m	4.03 k Ω
C_m	375 μ Fd
L_m	70.8 mH

Infinite Baffle

Transfer function (not including air loading)

$$T_1(S) = \frac{417S}{S^2 + 417S + 37612}$$

Poles are at $S = -132$ and $S = -285$ (over damped). Input impedance

$$Z_1(S) = 6.4 \frac{S^2 + 417S + 37612}{S^2 + 0.611S + 37612}$$

Poles are at $S = -3055 \pm 193j$.

Simple Enclosure

The Butterworth solution with no acoustic damping materials added occurs when

f_0	47 Hz	
L_a	53.9 mH	or 2.75×10^{-7} m ⁵ /Newton
V	39.1 liters	using $\rho c^2 = 1.42 \times 10^5$ Newtons/m ²

Transfer function (not including air loading)

$$T_1(S) = \frac{417S}{S^2 + 417S + 87086}$$

Input impedance

$$Z_1(S) = 6.4 \frac{S^2 + 417S + 87086}{S^2 + 0.662S + 87086}$$

Adding acoustic damping reduces the volume required, but also increases f_0 as shown in the following table.

R_a	L_a	V	F_0
100	43.8	31.8	50
50	36.5	26.5	53
25	26.8	19.4	59
10	13.6	9.87	77
Ω	mH	liters	Hz

Bass Reflex

A Butterworth solution with no acoustic damping materials added occurs when

$$\begin{aligned} f_0 & 26 \text{ Hz} \\ C_a & 487 \mu\text{Fd} \quad \text{or } 79.1 \text{ m}^{-1} \\ L_a & 79.9 \text{ mH} \quad \text{or } 4.06 \times 10^{-7} \text{ m}^5/\text{Newton} \\ V & 58 \text{ liters} \end{aligned}$$

For example, one could use a port 5.63 cm long and 3 cm in diameter.

Transfer function (not including air loading)

$$T_1(S) = \frac{417S^2}{S^4 + 417S^3 + 9.67 \times 10^4 S^2 + 1.07 \times 10^7 S + 9.67 \times 10^8}$$

Input impedance

$$Z_1(S) = 6.4 \frac{S^4 + 417S^3 + 9.67 \times 10^4 S^2 + 1.07 \times 10^7 S + 9.67 \times 10^8}{S^4 + 0.661S^3 + 9.67 \times 10^4 S^2 + 1.7 \times 10^4 S + 9.67 \times 10^8}$$

For example, one could use a port 5.63 cm long and 3 cm in diameter.

Frequency Responses

In the following graph, the normalized response for infinite baffle is shown in red, the simple enclosure is shown in black and the bass reflex is shown in blue.

