

$$p(A, B) := \frac{A \cdot B}{A + B} \quad j := \sqrt{-1} \quad \rho_0 := 1.17 \quad c := 345$$

## Mark Audio Alpair-6M 3.5"

$$R_E := 3.6 \quad f_S := 63 \quad L_E := 128.7 \cdot 10^{-6}$$

$$S_D := 36.3 \frac{1}{100^2} = 3.63 \times 10^{-3} \quad (\text{m}^2)$$

$$a := \sqrt{\frac{S_D}{\pi}} = 0.034 \quad (\text{m})$$

$$V_{AS} := 4.8 \cdot \frac{1}{1000} = 4.8 \times 10^{-3} \quad (\text{m}^3)$$

$$Q_{MS} := 2.76 \quad Q_{ES} := 0.45 \quad Q_{TS} := p(Q_{MS}, Q_{ES}) = 0.387$$

### Mechanical Components

$$C_{MS} := \frac{V_{AS}}{S_D^2 \cdot \rho_0 \cdot c^2} = 2.616 \times 10^{-3}$$

$$M_{MS} := \frac{1}{(2 \cdot \pi \cdot f_S)^2 \cdot C_{MS}} = 2.44 \times 10^{-3} \quad M_{MD} := M_{MS} - 2 \cdot \frac{8 \cdot \rho_0}{3 \cdot \pi^2 \cdot a} \cdot S_D^2 = 2.195 \times 10^{-3}$$

$$R_{MS} := \frac{1}{Q_{MS}} \cdot \sqrt{\frac{M_{MS}}{C_{MS}}} = 0.35 \quad BI := \sqrt{\frac{R_E}{Q_{ES}}} \cdot \sqrt{\frac{M_{MS}}{C_{MS}}} = 2.78$$

$$Z_M(f) := j \cdot 2 \cdot \pi \cdot f \cdot M_{MD} + R_{MS} + \frac{1}{j \cdot 2 \cdot \pi \cdot f \cdot C_{MS}}$$

Define mechanical impedance

### Acoustic Components, using infinite baffle analysis

$$R_{A1} := \frac{0.4410 \cdot \rho_0 \cdot c}{\pi \cdot a^2} = 4.904 \times 10^4 \quad R_{A2} := \frac{\rho_0 \cdot c}{\pi \cdot a^2} = 1.112 \times 10^5$$

Front components

$$C_{A1} := \frac{5.94 \cdot a^3}{\rho_0 \cdot c^2} = 1.675 \times 10^{-9} \quad M_{A1} := \frac{8 \cdot \rho_0}{3 \cdot \pi^2 \cdot a} = 9.3$$

$$Z_{AF}(f) := p \left[ j \cdot 2 \cdot \pi \cdot f \cdot M_{A1}, R_{A2} + p \left[ R_{A1}, \frac{1}{j \cdot (2 \cdot \pi \cdot f) \cdot C_{A1}} \right] \right]$$

$$Z_{AB} := Z_{AF}$$

Define acoustic impedances

### Voice Coil Impedance

$$Z_{\text{mot}}(f) := \frac{\frac{(Bl)^2}{S_D^2}}{\frac{Z_M(f)}{S_D^2} + Z_{AF}(f) + Z_{AB}(f)}$$

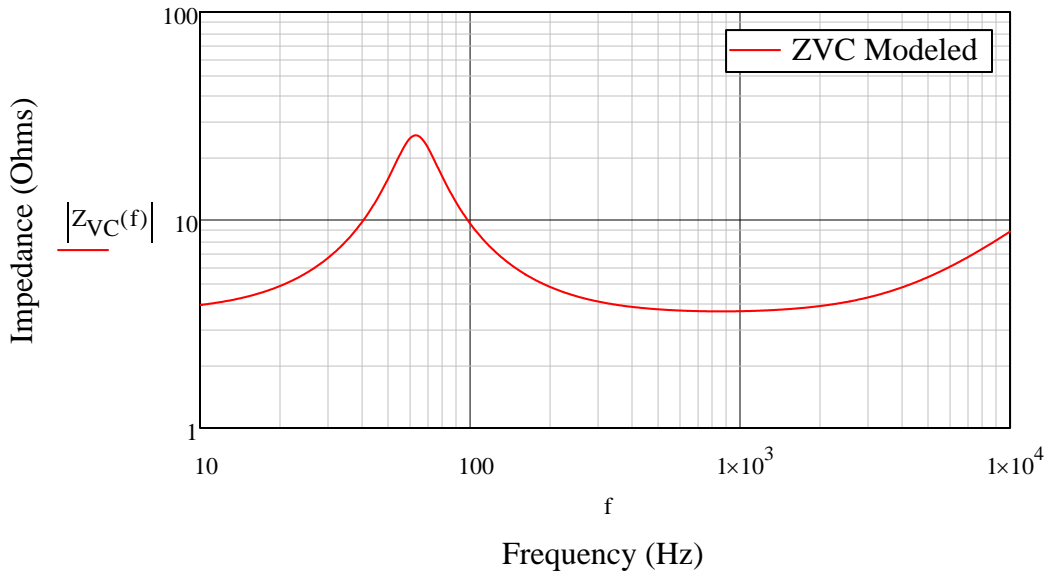
Define motional impedance of voice coil

$$Z_L(f) := j \cdot 2 \cdot \pi \cdot f \cdot L_E$$

$$Z_{VC}(f) := R_E + Z_L(f) + Z_{\text{mot}}(f)$$

Add to RE, making ZVC with no electrical inductance

### Modeled ZVC vs. Frequency



### Closed Box Design

$$Q_{TC} := \frac{1}{\sqrt{2}} \quad Q_{MC} := 3.5 \quad Q_{EC} := \frac{Q_{MC} \cdot Q_{TC}}{Q_{MC} - Q_{TC}} = 0.886 \quad \alpha := \left( \frac{Q_{EC}}{Q_{ES}} \right)^2 - 1 = 2.878$$

$$V_{AB} := \frac{V_{AS}}{\alpha} = 1.668 \times 10^{-3} \quad V_B := \frac{V_{AB}}{1.2} = 1.39 \times 10^{-3} \quad f_C := f_S \cdot \sqrt{1 + \alpha} = 124.059$$

$$C_{AB} := \frac{V_{AB}}{\rho_0 \cdot c^2} = 1.198 \times 10^{-9} \quad M_{AD} := \frac{M_{MD}}{S_D^2} = 166.558 \quad R_{AB} := \left( \frac{\sqrt{1 + \alpha} \cdot Q_{MS}}{Q_{MC}} - 1 \right) \cdot \frac{R_{MS}}{S_D^2} = 1.468 \times 10^4$$

$$C_{AT} := \frac{\alpha \cdot C_{AB}}{1 + \alpha} = 8.889 \times 10^{-9} \quad M_{AC} := \frac{1}{(2 \cdot \pi \cdot f_C)^2 \cdot C_{AT}} = 185.158$$

$$M_{AB} := M_{AC} - M_{AD} - M_{A1} = 9.3$$

## Vented Box

$$Q_{TS} = 0.387 \quad Q_L := 20$$

$$h := 1 \quad \alpha := 1.286 \quad q := 1$$

BL4 Alignment!

$$V_{AB} := \frac{V_{AS}}{\alpha} = 3.733 \times 10^{-3}$$

$$f_B := h \cdot f_S = 63$$

Helmholtz resonance frequency

$$f_L := q \cdot f_S = 63$$

Lower cutoff frequency

$$C_{AB} := \frac{V_{AB}}{\rho_0 \cdot c^2} = 2.68 \times 10^{-8} \quad R_{AL} := \frac{Q_L}{2 \cdot \pi \cdot f_B \cdot C_{AB}} = 1.885 \times 10^6$$

$$a_p := 0.0125$$

Choose a 2.5cm port diameter

$$R_{A1P} := \frac{0.4410 \cdot \rho_0 \cdot c}{\pi \cdot a_p^2} = 3.626 \times 10^5 \quad R_{A2P} := \frac{\rho_0 \cdot c}{\pi \cdot a_p^2} = 8.223 \times 10^5$$

$$C_{A1P} := \frac{5.94 \cdot a_p^3}{\rho_0 \cdot c^2} = 8.331 \times 10^{-11} \quad M_{A1P} := \frac{8 \cdot \rho_0}{3 \cdot \pi^2 \cdot a_p} = 25.29$$

$$M_{AP} := \frac{1}{(2 \cdot \pi \cdot f_B)^2 \cdot C_{AB}} - M_{A1P} = 212.823$$

$$S_P := \pi \cdot (a_p)^2 = 4.909 \times 10^{-4}$$

$$L_P := M_{AP} \cdot \frac{S_P}{\rho_0} - 1.462 \cdot \sqrt{\frac{S_P}{\pi}} = 0.071 \quad 100 \cdot L_P = 7.102 \quad (\text{cm})$$

Calculate port length

$$f_C := f_S \cdot \sqrt{1 + \alpha} = 95.253$$

$$C_{AT} := \frac{\alpha \cdot C_{AB}}{1 + \alpha} = 1.508 \times 10^{-8} \quad M_{AC} := \frac{1}{(2 \cdot \pi \cdot f_C)^2 \cdot C_{AT}} = 185.158$$

$$M_{AB} := M_{AC} - M_{AD} - M_{A1} = 9.3$$

### Internal Box Dimensions

$$L_W := 0.012$$

Wall thickness 12mm (1/2")

$$V_{PORT} := S_P \cdot (L_P - L_W) = 2.897 \times 10^{-5}$$

Calculate in-box port volume

$$V_D := 6 \cdot 10^{-6} \cdot (2 \cdot 3)^4 \cdot \left(\frac{12^3}{1}\right) \cdot \left(\frac{0.0254^3}{1}\right) = 2.202 \times 10^{-4}$$

Approximate in-box driver volume

$$V_{TOT} := V_{AB} + V_{PORT} + V_D = 3.982 \times 10^{-3}$$

Given  $w := 0.1$   $h := 0.1$

Use 0.6x1x1.6 ratio

$$d \cdot w \cdot h = V_{TOT} \quad \frac{w}{h} = \frac{0.6}{1.6} \quad \frac{d}{w} = \frac{1}{0.6} \quad \frac{h}{d} = 1.6$$

$$\begin{pmatrix} d \\ w \\ h \end{pmatrix} := 100 \text{ Find}(d, w, h) = \begin{pmatrix} 16.067 \\ 9.64 \\ 25.707 \end{pmatrix} \quad (\text{cm})$$

