



Software : by Martin J. King  
e-mail MJKing57@aol.com

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**Unit and Constant Definition**

cycle := 2·π·rad

Hz := cycle·sec<sup>-1</sup>

**Air Density :** ρ := 1.21·kg·m<sup>-3</sup>

**Speed of Sound :** c := 342·m·sec<sup>-1</sup>



**User Input (Edit This Section and Input all of the Parameters for the System to be Analyzed)**

R<sub>add</sub> := 1·Ω

**Driver Thiele / Small Parameters : Lowther DX2 Average Driver Properties**

f<sub>d</sub> := 55.6·Hz

V<sub>d</sub> := 45.1·liter

R<sub>e</sub> := 7.1·Ω + R<sub>add</sub>

Q<sub>ed</sub> := 0.33·(R<sub>e</sub>)·(R<sub>e</sub> - R<sub>add</sub>)<sup>-1</sup>

L<sub>vc</sub> := 0·mH

Q<sub>md</sub> := 4.02

Bl := 9.08· $\frac{\text{newton}}{\text{amp}}$

Q<sub>td</sub> :=  $\left(\frac{1}{Q_{ed}} + \frac{1}{Q_{md}}\right)^{-1}$

S<sub>d</sub> := 206·cm<sup>2</sup>

Q<sub>td</sub> = 0.344

**Enclosure Geometry Definition**

L := 42·in

(Height)

z<sub>driver</sub> := 6·in

(Driver Distance From Top < Height)

z<sub>port</sub> := 38·in

(Port Distance From Top < Height)

S<sub>0</sub> := 9.5·11·in<sup>2</sup>

(Area of the Top End)

S<sub>L</sub> := 9.5·11·in<sup>2</sup>

(Area of the Bottom End)

Density := 0.25·lb·ft<sup>-3</sup>

(Stuffing density : 0 lb/ft<sup>3</sup> < D < 1 lb/ft<sup>3</sup>)

r<sub>port</sub> := 2.0·in

(Radius of the port)

L<sub>port</sub> := 2.0·in

(Length of the port)

## Ported Box Definition

$$(0 \text{ lb/ft}^3 < D < 1 \text{ lb/ft}^3)$$

$$n_{\text{top}} := 4$$

$$(n_{\text{top}} > 1)$$

$$x_{\text{top}} := z_{\text{driver}}$$

$$n_{\text{open}} := 4$$

$$(n_{\text{open}} > 1)$$

$$x_{\text{open}} := z_{\text{port}} - z_{\text{driver}}$$

$$n_{\text{bottom}} := 4$$

$$(n_{\text{bottom}} > 1)$$

$$x_{\text{bottom}} := L - z_{\text{port}}$$

$$n_{\text{port}} := 4$$

$$(n_{\text{port}} > 1)$$

$$x_{\text{port}} := L_{\text{port}} + 0.6 \cdot l_{\text{port}}$$

## Geometry Definition

$$TR := (S_L - S_0) \cdot L^{-1}$$

$$TR = 0 \text{ m}$$

$$S_D := S_0 + TR \cdot z_{\text{driver}}$$

$$S_D = 0.067 \text{ m}^2$$

$$S_P := S_0 + TR \cdot z_{\text{port}}$$

$$S_P = 0.067 \text{ m}^2$$

## Top Section of Enclosure

(Driver ----> Top of Enclosure)

### Section Length

### Initial Area

### Final Area

### Stuffing Density

$$L_{c_0} := x_{\text{top}} \cdot (n_{\text{top}} + 1)^{-1}$$

$$S_{c_{0,0}} := S_D$$

$$S_{c_{0,1}} := S_{c_{0,0}} - TR \cdot L_{c_0}$$

$$D_{c_0} := \text{Density}$$

$$L_{c_1} := x_{\text{top}} \cdot (n_{\text{top}} + 1)^{-1}$$

$$S_{c_{1,0}} := S_{c_{0,1}}$$

$$S_{c_{1,1}} := S_{c_{1,0}} - TR \cdot L_{c_1}$$

$$D_{c_1} := \text{Density}$$

$$L_{c_2} := x_{\text{top}} \cdot (n_{\text{top}} + 1)^{-1}$$

$$S_{c_{2,0}} := S_{c_{1,1}}$$

$$S_{c_{2,1}} := S_{c_{2,0}} - TR \cdot L_{c_2}$$

$$D_{c_2} := \text{Density}$$

$$L_{c_3} := x_{\text{top}} \cdot (n_{\text{top}} + 1)^{-1}$$

$$S_{c_{3,0}} := S_{c_{2,1}}$$

$$S_{c_{3,1}} := S_{c_{3,0}} - TR \cdot L_{c_3}$$

$$D_{c_3} := \text{Density}$$

$$L_{c_4} := x_{\text{top}} \cdot (n_{\text{top}} + 1)^{-1}$$

$$S_{c_{4,0}} := S_{c_{3,1}}$$

$$S_{c_{4,1}} := S_0$$

$$D_{c_4} := \text{Density}$$

## Open Section of Enclosure

(Driver ----> Port Position)

### Section Length

### Initial Area

### Final Area

### Stuffing Density

$$L_{o_0} := x_{\text{open}} \cdot (n_{\text{open}} + 1)^{-1}$$

$$S_{o_{0,0}} := S_D$$

$$S_{o_{0,1}} := S_{o_{0,0}} + TR \cdot L_{o_0}$$

$$D_{o_0} := \text{Density}$$

$$L_{o_1} := x_{\text{open}} \cdot (n_{\text{open}} + 1)^{-1}$$

$$S_{o_{1,0}} := S_{o_{0,1}}$$

$$S_{o_{1,1}} := S_{o_{1,0}} + TR \cdot L_{o_1}$$

$$D_{o_1} := \text{Density}$$

$$L_{o_2} := x_{\text{open}} \cdot (n_{\text{open}} + 1)^{-1}$$

$$S_{o_{2,0}} := S_{o_{1,1}}$$

$$S_{o_{2,1}} := S_{o_{2,0}} + TR \cdot L_{o_2}$$

$$D_{o_2} := \text{Density}$$

$$L_{o_3} := x_{\text{open}} \cdot (n_{\text{open}} + 1)^{-1}$$

$$S_{o_{3,0}} := S_{o_{2,1}}$$

$$S_{o_{3,1}} := S_{o_{3,0}} + TR \cdot L_{o_3}$$

$$D_{o_3} := \text{Density}$$

$$L_{o_4} := x_{\text{open}} \cdot (n_{\text{open}} + 1)^{-1}$$

$$S_{o_{4,0}} := S_{o_{3,1}}$$

$$S_{o_{4,1}} := S_P$$

$$D_{o_4} := 0.0 \cdot \text{lb} \cdot \text{ft}^{-3}$$

**Bottom Section of Enclosure****(Port Position ---> Bottom of Enclosure)****Section Length****Initial Area****Final Area****Stuffing Density**

$$L_{b_0} := x_{\text{bottom}} \cdot (n_{\text{bottom}} + 1)^{-1}$$

$$S_{b_{0,0}} := S_P$$

$$S_{b_{0,1}} := S_{b_{0,0}} + TR \cdot L_{b_0}$$

$$D_{b_0} := 0.0 \cdot \text{lb} \cdot \text{ft}^{-3}$$

$$L_{b_1} := x_{\text{bottom}} \cdot (n_{\text{bottom}} + 1)^{-1}$$

$$S_{b_{1,0}} := S_{b_{0,1}}$$

$$S_{b_{1,1}} := S_{b_{1,0}} + TR \cdot L_{b_1}$$

$$D_{b_1} := 0.0 \cdot \text{lb} \cdot \text{ft}^{-3}$$

$$L_{b_2} := x_{\text{bottom}} \cdot (n_{\text{bottom}} + 1)^{-1}$$

$$S_{b_{2,0}} := S_{b_{1,1}}$$

$$S_{b_{2,1}} := S_{b_{2,0}} + TR \cdot L_{b_2}$$

$$D_{b_2} := 0.0 \cdot \text{lb} \cdot \text{ft}^{-3}$$

$$L_{b_3} := x_{\text{bottom}} \cdot (n_{\text{bottom}} + 1)^{-1}$$

$$S_{b_{3,0}} := S_{b_{2,1}}$$

$$S_{b_{3,1}} := S_{b_{3,0}} + TR \cdot L_{b_3}$$

$$D_{b_3} := 0.0 \cdot \text{lb} \cdot \text{ft}^{-3}$$

$$L_{b_4} := x_{\text{bottom}} \cdot (n_{\text{bottom}} + 1)^{-1}$$

$$S_{b_{4,0}} := S_{b_{3,1}}$$

$$S_{b_{4,1}} := S_L$$

$$D_{b_4} := 0.0 \cdot \text{lb} \cdot \text{ft}^{-3}$$

**Port Section of Enclosure****(Port Inside ---> Port Outside)****Section Length****Initial Area****Final Area****Stuffing Density**

$$L_{p_0} := x_{\text{port}} \cdot (n_{\text{port}} + 1)^{-1}$$

$$S_{p_{0,0}} := \pi \cdot r_{\text{port}}^2$$

$$S_{p_{0,1}} := \pi \cdot r_{\text{port}}^2$$

$$D_{p_0} := 0.0 \cdot \text{lb} \cdot \text{ft}^{-3}$$

$$L_{p_1} := x_{\text{port}} \cdot (n_{\text{port}} + 1)^{-1}$$

$$S_{p_{1,0}} := S_{p_{0,1}}$$

$$S_{p_{1,1}} := \pi \cdot r_{\text{port}}^2$$

$$D_{p_1} := 0.0 \cdot \text{lb} \cdot \text{ft}^{-3}$$

$$L_{p_2} := x_{\text{port}} \cdot (n_{\text{port}} + 1)^{-1}$$

$$S_{p_{2,0}} := S_{p_{1,1}}$$

$$S_{p_{2,1}} := \pi \cdot r_{\text{port}}^2$$

$$D_{p_2} := 0.0 \cdot \text{lb} \cdot \text{ft}^{-3}$$

$$L_{p_3} := x_{\text{port}} \cdot (n_{\text{port}} + 1)^{-1}$$

$$S_{p_{3,0}} := S_{p_{2,1}}$$

$$S_{p_{3,1}} := \pi \cdot r_{\text{port}}^2$$

$$D_{p_3} := 0.0 \cdot \text{lb} \cdot \text{ft}^{-3}$$

$$L_{p_4} := x_{\text{port}} \cdot (n_{\text{port}} + 1)^{-1}$$

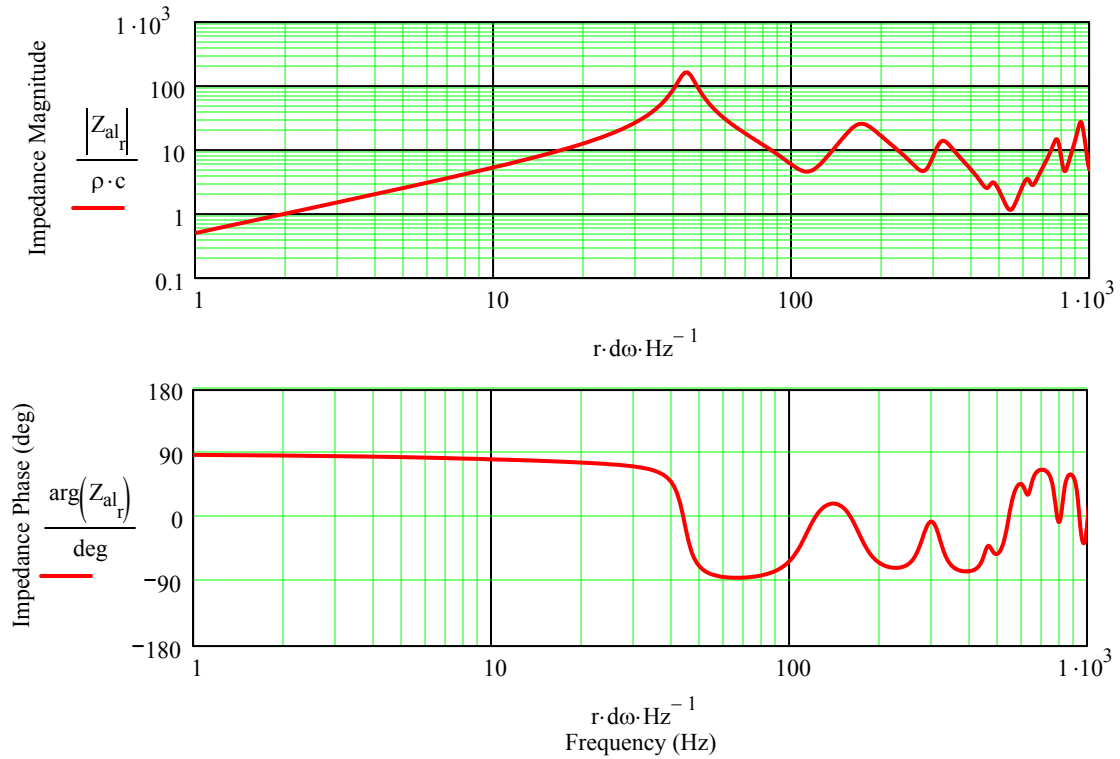
$$S_{p_{4,0}} := S_{p_{3,1}}$$

$$S_{p_{4,1}} := \pi \cdot r_{\text{port}}^2$$

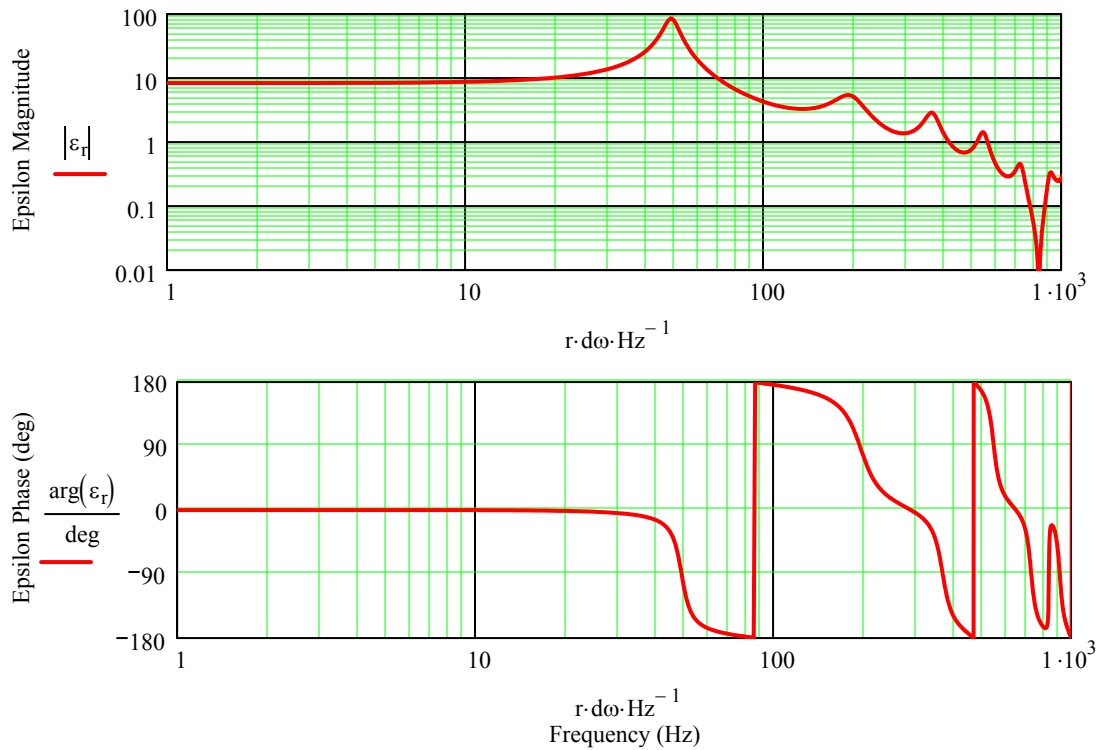
$$D_{p_4} := 0.0 \cdot \text{lb} \cdot \text{ft}^{-3}$$



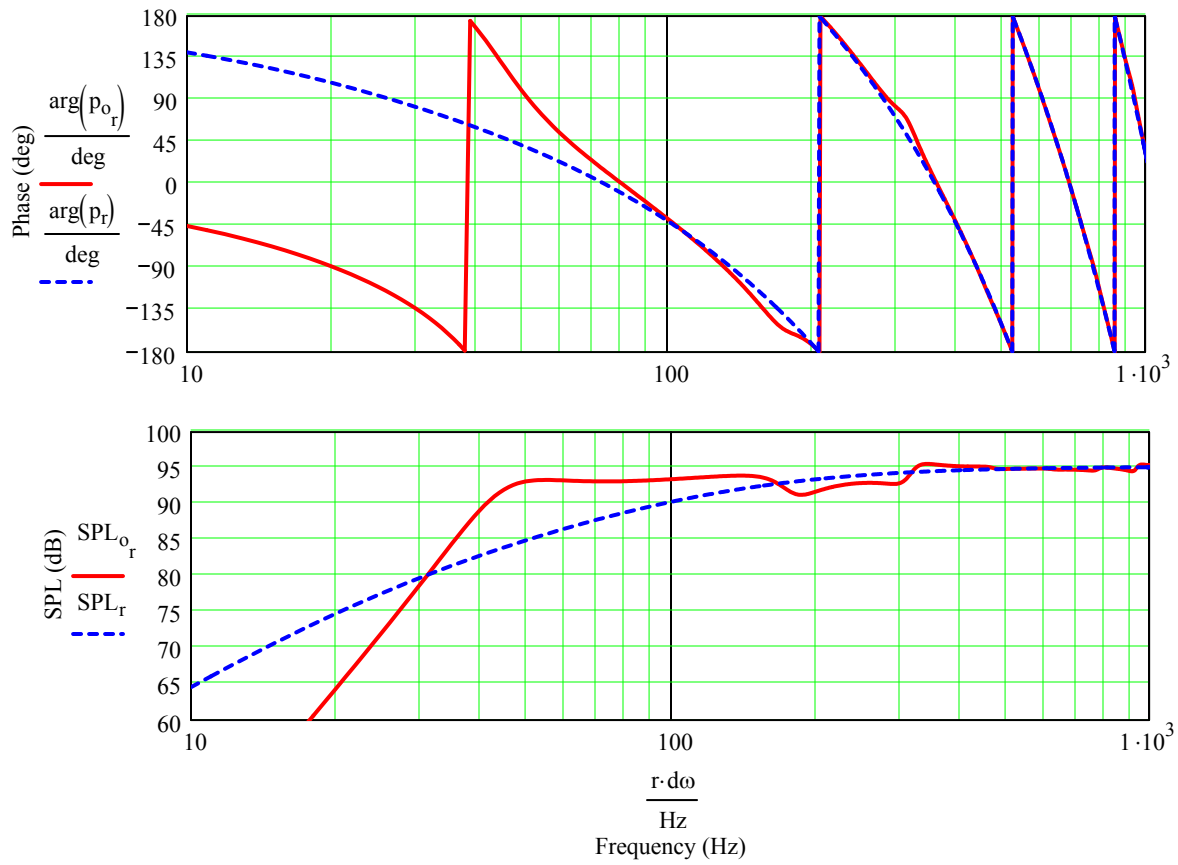
## Resulting Acoustic Impedance for the Enclosure



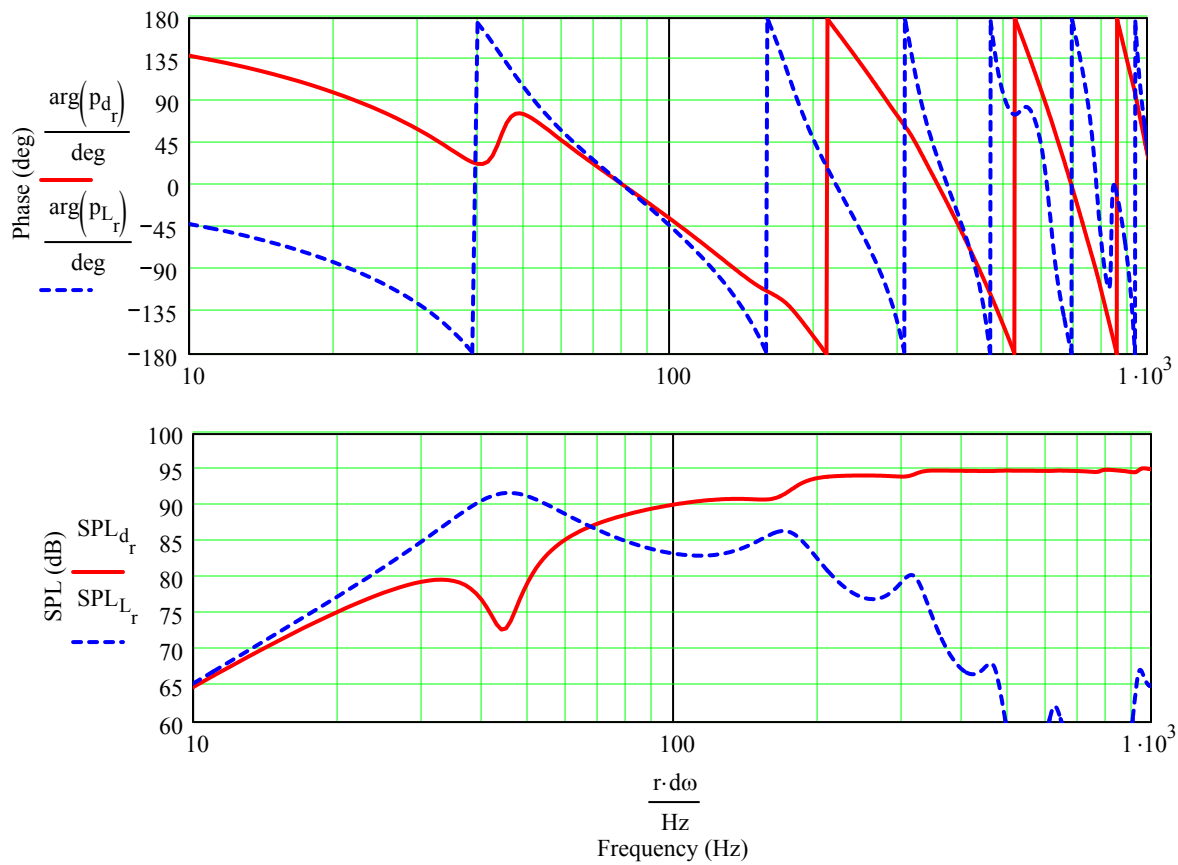
## Velocity at the Terminus of the Ported Box for a 1 m/sec Driver Excitation



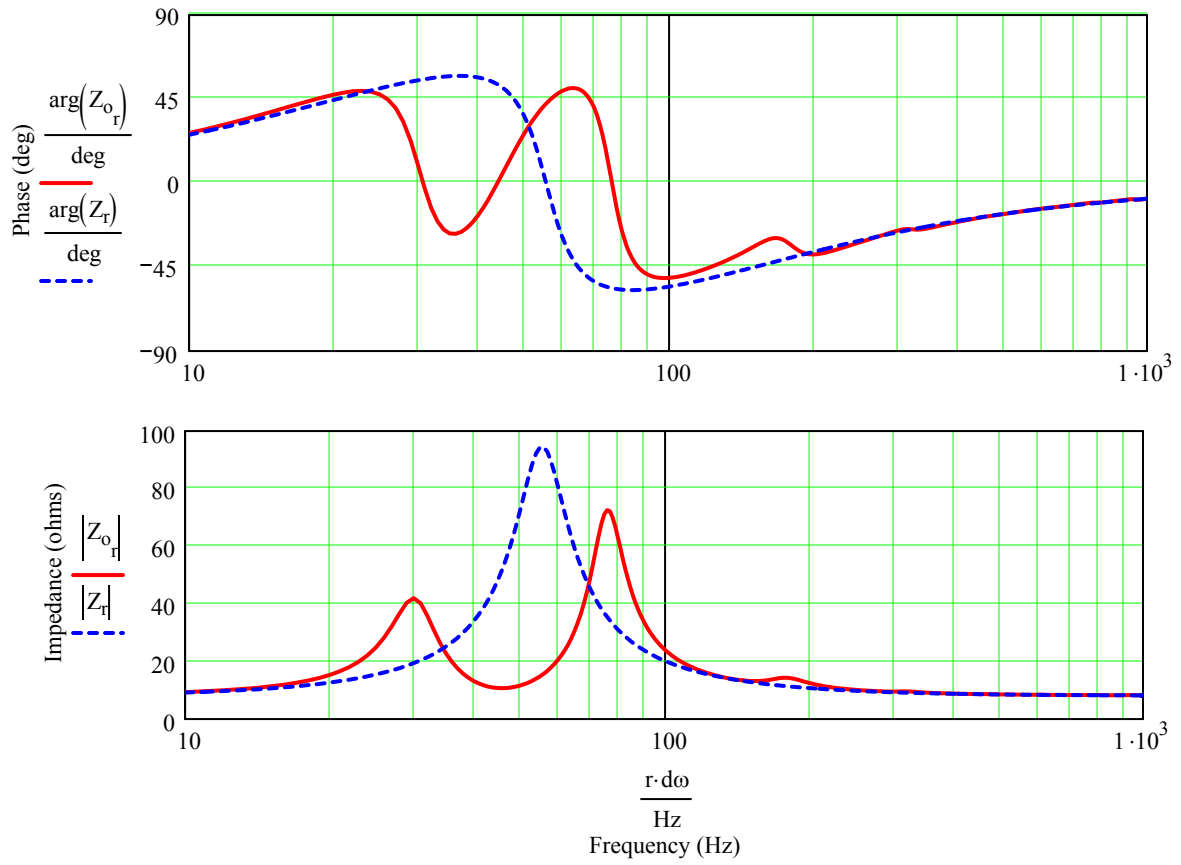
### Far Field Ported Box System and Infinite Baffle Sound Pressure Level Responses



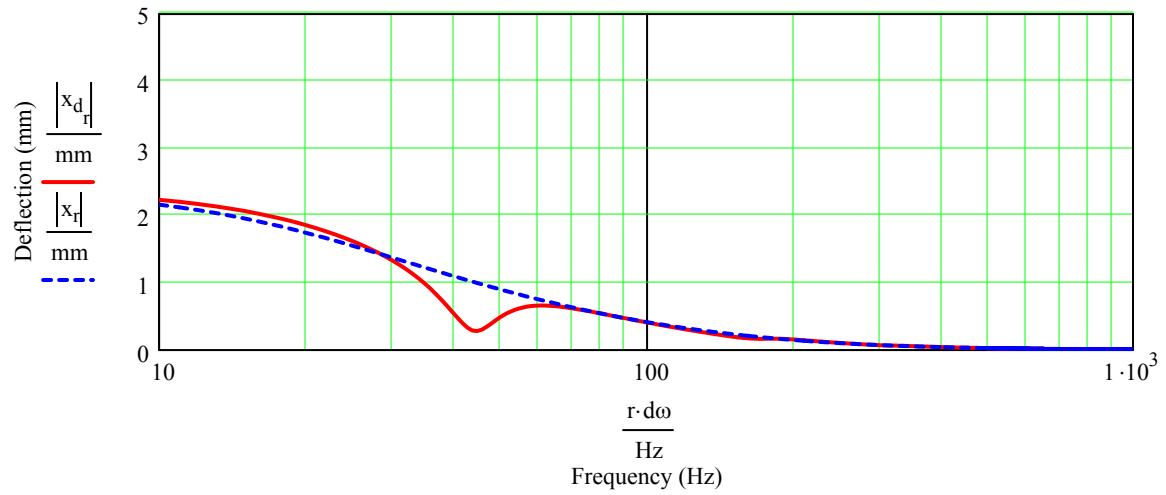
### Woofer and Terminus Far Field Sound Pressure Level Responses



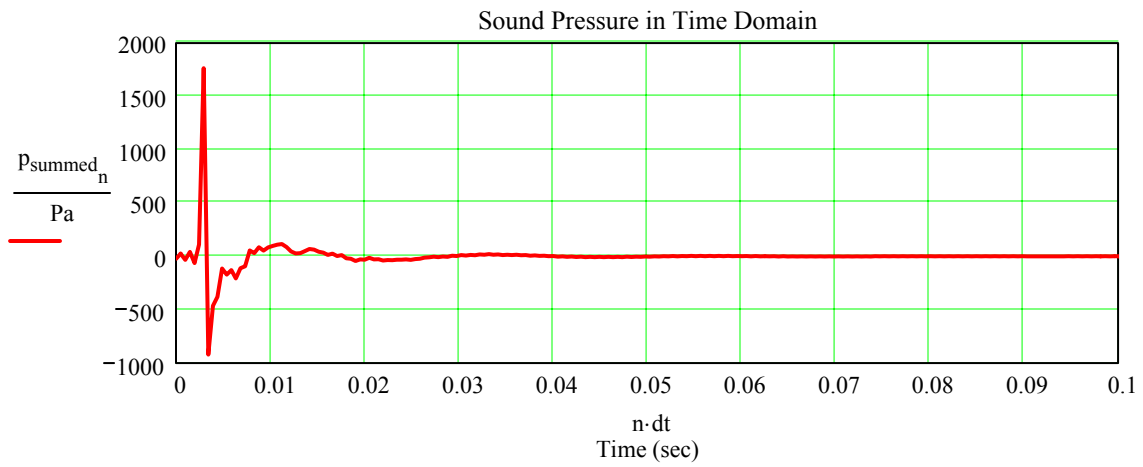
## Ported Box System and Infinite Baffle Impedance



## Woofer Displacement



## System Time Response for an Impulse Input



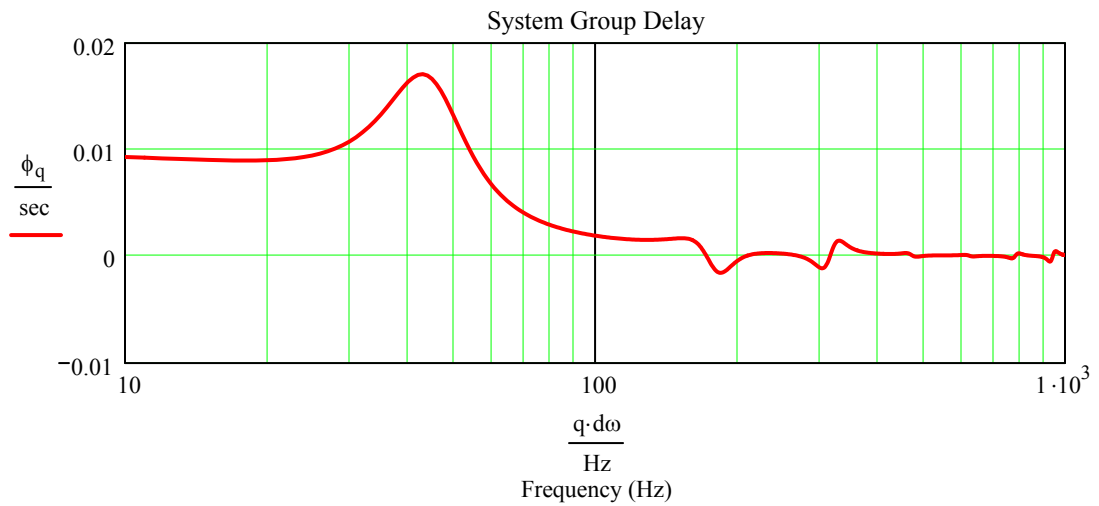
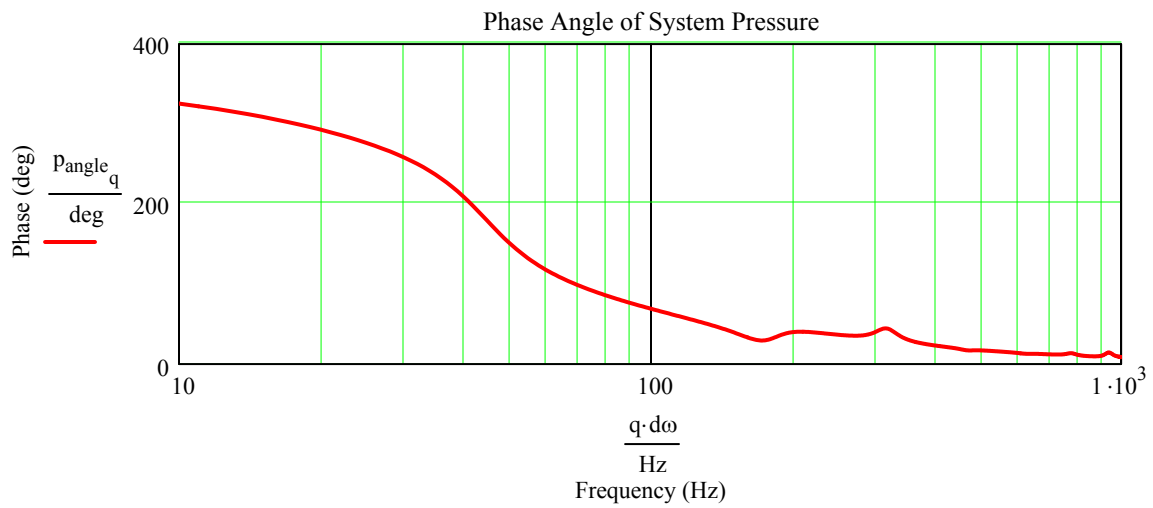
## TL System Group Delay Calculation

$q := 2, 3 \dots 1000$

Removing the Phase Change Associated with the 1 meter Measurement Distance.

$$pangle_r := \text{if} \left( \arg \left( p_{O_r} \cdot \exp \left( j \cdot \frac{r \cdot d\omega}{c} \cdot 1 \cdot \text{m} \right) \right) < 0, \arg \left( p_{O_r} \cdot \exp \left( j \cdot \frac{r \cdot d\omega}{c} \cdot 1 \cdot \text{m} \right) \right) + 2 \cdot \pi, \arg \left( p_{O_r} \cdot \exp \left( j \cdot \frac{r \cdot d\omega}{c} \cdot 1 \cdot \text{m} \right) \right) \right)$$

$$\phi_q := - \frac{pangle_{q+1} - pangle_{q-1}}{2 \cdot d\omega}$$





Port Air Velocity (< 10 m/sec / 342 m/sec = 0.03)

$$v_{\text{port}_r} := \frac{U_{L_r}}{\pi \cdot r_{\text{port}}^2}$$

$$|v_{\text{port}_{42}}| = 1.8 \frac{\text{m}}{\text{sec}}$$

