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### Unit and Constant Definition

$$\text{cycle} := 2 \cdot \pi \cdot \text{rad}$$

$$\text{Air Density : } \rho := 1.205 \cdot \text{kg} \cdot \text{m}^{-3}$$

$$\text{Hz} := \text{cycle} \cdot \text{sec}^{-1}$$

$$\text{Speed of Sound : } c := 344 \cdot \text{m} \cdot \text{sec}^{-1}$$



### Part 1 : Thiele-Small Consistent Calculation

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

#### Series Resistance

$$R_{\text{add}} := 0.4 \cdot \Omega$$

#### Driver Thiele / Small Parameters :

$$f_d := 47 \cdot \text{Hz}$$

$$V_{\text{ad}} := 150 \cdot \text{liter}$$

#### Adjustments

$$R_e := 6.5 \cdot \Omega$$

$$Q_{\text{ed}} := 0.38$$

$$R_e := R_e + R_{\text{add}}$$

$$L_{\text{vc}} := 1.32 \cdot \text{mH}$$

$$Q_{\text{md}} := 7.7$$

$$Q_{\text{ed}} := Q_{\text{ed}} \cdot R_e \cdot (R_e - R_{\text{add}})^{-1}$$

$$B_l := 10.7 \cdot \frac{\text{newton}}{\text{amp}}$$

$$Q_{\text{td}} := \left( \frac{1}{Q_{\text{ed}}} + \frac{1}{Q_{\text{md}}} \right)^{-1}$$

$$S_d := 471 \cdot \text{cm}^2$$

$$Q_{\text{td}} = 0.383$$

#### Enclosure Geometry Definition :

$$L := 90 \cdot \text{cm}$$

(Internal Height)

$$z_{\text{driver}} := 20 \cdot \text{cm}$$

(Driver Internal Distance From Top < Height)

$$z_{\text{port}} := 75 \text{cm}$$

(Port Internal Distance From Top < Height)

$$S_0 := 32 \cdot \text{cm} \cdot 40 \cdot \text{cm}$$

(Internal Area of the Top End,  $z = 0$ )

$$S_L := 32 \cdot \text{cm} \cdot 40 \cdot \text{cm}$$

(Internal Area of the Bottom End,  $z = L$ )

$$\text{Density} := 0.35 \cdot \text{lb} \cdot \text{ft}^{-3}$$

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

$$r_{\text{port}} := 6 \cdot \text{cm}$$

(Inside Radius of the Port)

$$L_{\text{port}} := 5 \cdot \text{cm}$$

(Length of the Port)

$$\text{Power} := 1 \text{ watt}$$

(Input Power) Applied Voltage Reference ---->

$$R_{\text{ref}} := 8 \cdot \Omega$$

### End of Abbreviated User Input

## Pre Formated Geometry and Stuffing Location Input (Only Edit Details Below to Change Defaults)

### ML TL Definition

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

$n_{top} := 4$	( $n_{top} > 1$ )	$x_{top} := z_{driver}$
$n_{open} := 4$	( $n_{open} > 1$ )	$x_{open} := z_{port} - z_{driver}$
$n_{bottom} := 4$	( $n_{bottom} > 1$ )	$x_{bottom} := L - z_{port}$
$n_{port} := 4$	( $n_{port} > 1$ )	$x_{port} := L_{port} + 0.6 \cdot r_{port}$

### Geometry Definition

$TR := (S_L - S_0) \cdot L^{-1}$	$TR = 0 \text{ m}$
$S_D := S_0 + TR \cdot z_{driver}$	$S_D = 0.128 \text{ m}^2$
$S_P := S_0 + TR \cdot z_{port}$	$S_P = 0.128 \text{ m}^2$

### Top Section of Enclosure

(Driver ----> Top of Enclosure)

Section Length	Initial Area	Final Area	Stuffing Density
$L_{c_0} := x_{top} \cdot (n_{top} + 1)^{-1}$	$S_{c_{0,0}} := S_D$	$S_{c_{0,1}} := S_{c_{0,0}} - TR \cdot L_{c_0}$	$D_{c_0} := \text{Density}$
$L_{c_1} := x_{top} \cdot (n_{top} + 1)^{-1}$	$S_{c_{1,0}} := S_{c_{0,1}}$	$S_{c_{1,1}} := S_{c_{1,0}} - TR \cdot L_{c_1}$	$D_{c_1} := \text{Density}$
$L_{c_2} := x_{top} \cdot (n_{top} + 1)^{-1}$	$S_{c_{2,0}} := S_{c_{1,1}}$	$S_{c_{2,1}} := S_{c_{2,0}} - TR \cdot L_{c_2}$	$D_{c_2} := \text{Density}$
$L_{c_3} := x_{top} \cdot (n_{top} + 1)^{-1}$	$S_{c_{3,0}} := S_{c_{2,1}}$	$S_{c_{3,1}} := S_{c_{3,0}} - TR \cdot L_{c_3}$	$D_{c_3} := \text{Density}$
$L_{c_4} := x_{top} \cdot (n_{top} + 1)^{-1}$	$S_{c_{4,0}} := S_{c_{3,1}}$	$S_{c_{4,1}} := S_0$	$D_{c_4} := \text{Density}$

### Open Section of Enclosure

(Driver ----> Port Position)

Section Length	Initial Area	Final Area	Stuffing Density
$L_{o_0} := x_{open} \cdot (n_{open} + 1)^{-1}$	$S_{o_{0,0}} := S_D$	$S_{o_{0,1}} := S_{o_{0,0}} + TR \cdot L_{o_0}$	$D_{o_0} := \text{Density}$
$L_{o_1} := x_{open} \cdot (n_{open} + 1)^{-1}$	$S_{o_{1,0}} := S_{o_{0,1}}$	$S_{o_{1,1}} := S_{o_{1,0}} + TR \cdot L_{o_1}$	$D_{o_1} := \text{Density}$
$L_{o_2} := x_{open} \cdot (n_{open} + 1)^{-1}$	$S_{o_{2,0}} := S_{o_{1,1}}$	$S_{o_{2,1}} := S_{o_{2,0}} + TR \cdot L_{o_2}$	$D_{o_2} := \text{Density}$
$L_{o_3} := x_{open} \cdot (n_{open} + 1)^{-1}$	$S_{o_{3,0}} := S_{o_{2,1}}$	$S_{o_{3,1}} := S_{o_{3,0}} + TR \cdot L_{o_3}$	$D_{o_3} := 0.0 \cdot \text{lb} \cdot \text{ft}^{-3}$
$L_{o_4} := x_{open} \cdot (n_{open} + 1)^{-1}$	$S_{o_{4,0}} := S_{o_{3,1}}$	$S_{o_{4,1}} := S_P$	$D_{o_4} := 0.0 \cdot \text{lb} \cdot \text{ft}^{-3}$

### 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
$L_{p_0} := x_{\text{port}} \cdot (n_{\text{port}} + 1)^{-1}$	$S_{p_{0,0}} := \pi \cdot r_{\text{port}}^2$	$S_{p_{0,1}} := \pi \cdot r_{\text{port}}^2$	$D_{p_0} := 0.0 \cdot \text{lb} \cdot \text{ft}^{-3}$
$L_{p_1} := x_{\text{port}} \cdot (n_{\text{port}} + 1)^{-1}$	$S_{p_{1,0}} := S_{p_{0,1}}$	$S_{p_{1,1}} := \pi \cdot r_{\text{port}}^2$	$D_{p_1} := 0.0 \cdot \text{lb} \cdot \text{ft}^{-3}$
$L_{p_2} := x_{\text{port}} \cdot (n_{\text{port}} + 1)^{-1}$	$S_{p_{2,0}} := S_{p_{1,1}}$	$S_{p_{2,1}} := \pi \cdot r_{\text{port}}^2$	$D_{p_2} := 0.0 \cdot \text{lb} \cdot \text{ft}^{-3}$
$L_{p_3} := x_{\text{port}} \cdot (n_{\text{port}} + 1)^{-1}$	$S_{p_{3,0}} := S_{p_{2,1}}$	$S_{p_{3,1}} := \pi \cdot r_{\text{port}}^2$	$D_{p_3} := 0.0 \cdot \text{lb} \cdot \text{ft}^{-3}$
$L_{p_4} := x_{\text{port}} \cdot (n_{\text{port}} + 1)^{-1}$	$S_{p_{4,0}} := S_{p_{3,1}}$	$S_{p_{4,1}} := \pi \cdot r_{\text{port}}^2$	$D_{p_4} := 0.0 \cdot \text{lb} \cdot \text{ft}^{-3}$

### Total Amount of Stuffing

$$\sum_{r=0}^{n_{\text{top}}} \left[ \frac{(S_{c_{r,0}} + S_{c_{r,1}})}{2} \cdot L_{c_r} \cdot D_{c_r} \right] + \sum_{r=0}^{n_{\text{open}}} \left[ \frac{(S_{o_{r,0}} + S_{o_{r,1}})}{2} \cdot L_{o_r} \cdot D_{o_r} \right] \dots = 0.839 \text{ lb}$$

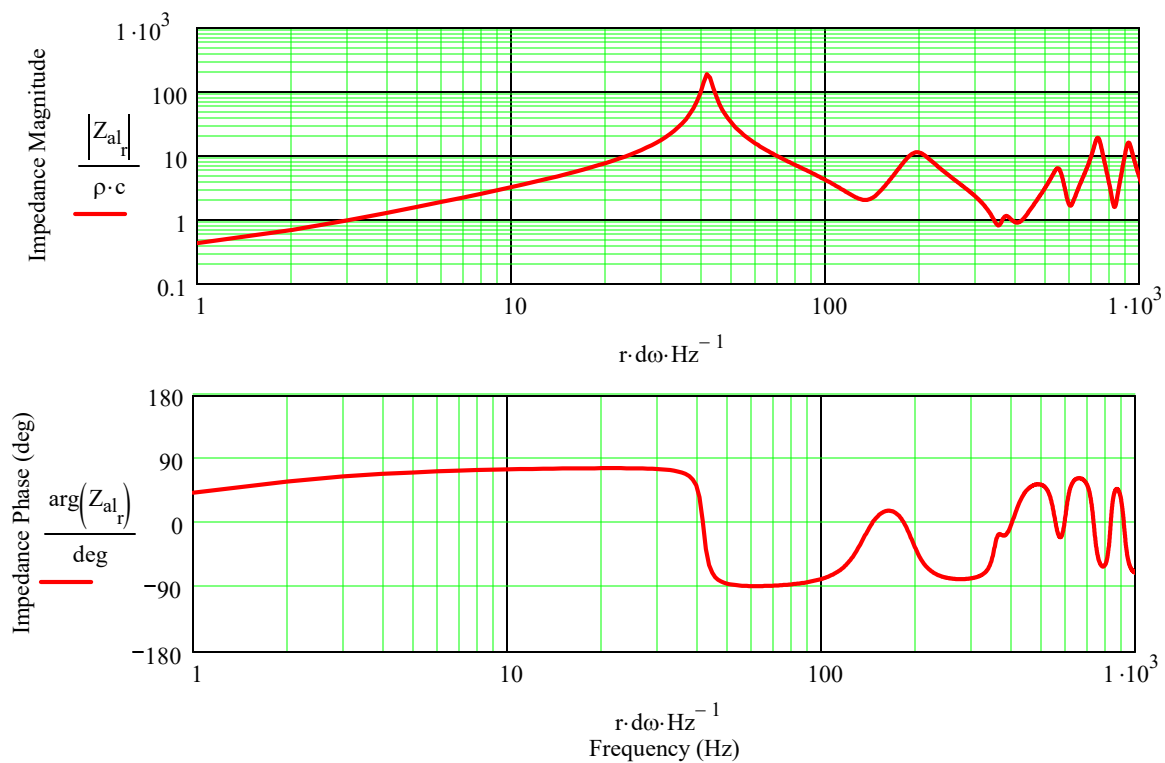
$$+ \sum_{r=0}^{n_{\text{bottom}}} \left[ \frac{(S_{b_{r,0}} + S_{b_{r,1}})}{2} \cdot L_{b_r} \cdot D_{b_r} \right] + \sum_{r=0}^{n_{\text{port}}} \left[ \frac{(S_{p_{r,0}} + S_{p_{r,1}})}{2} \cdot L_{p_r} \cdot D_{p_r} \right]$$

End of Pre Formatted Default Input

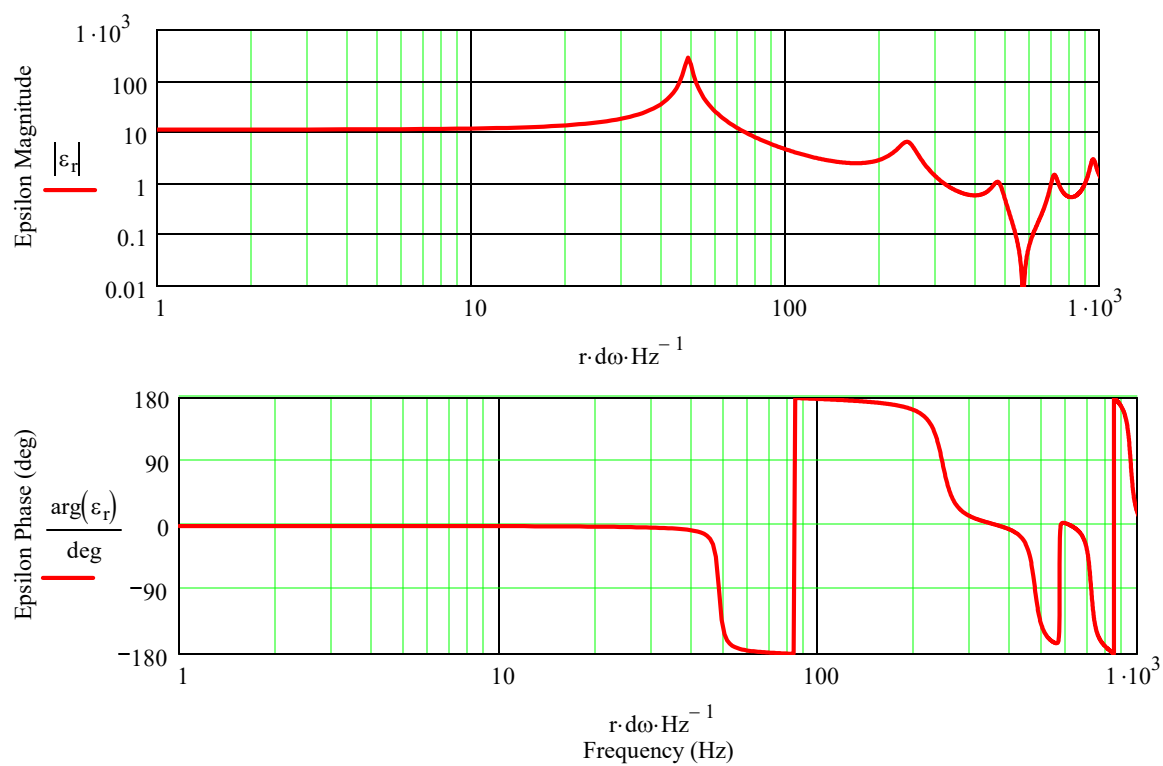
End of Part 1 Input



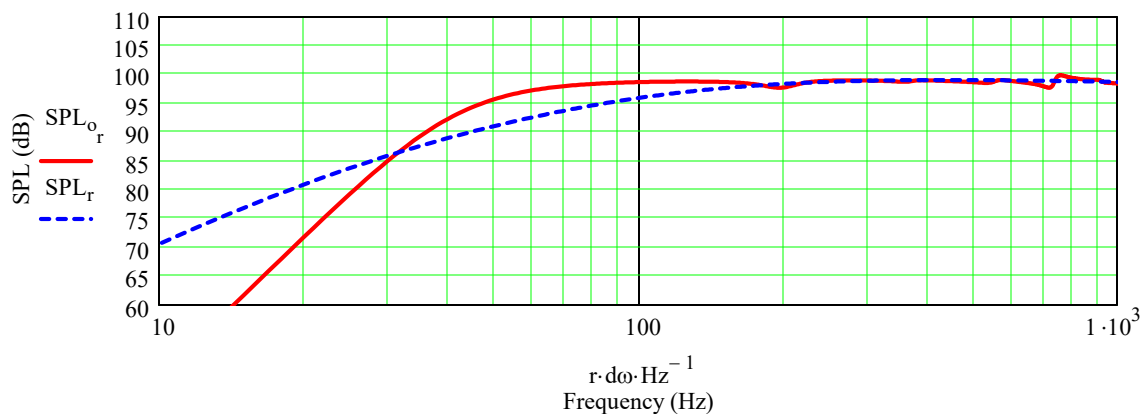
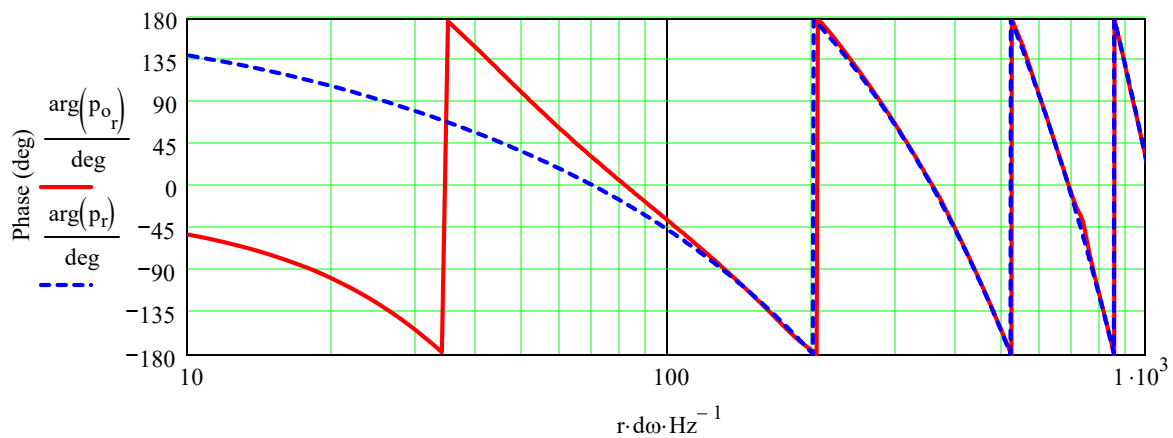
## Resulting Acoustic Impedance for the Enclosure



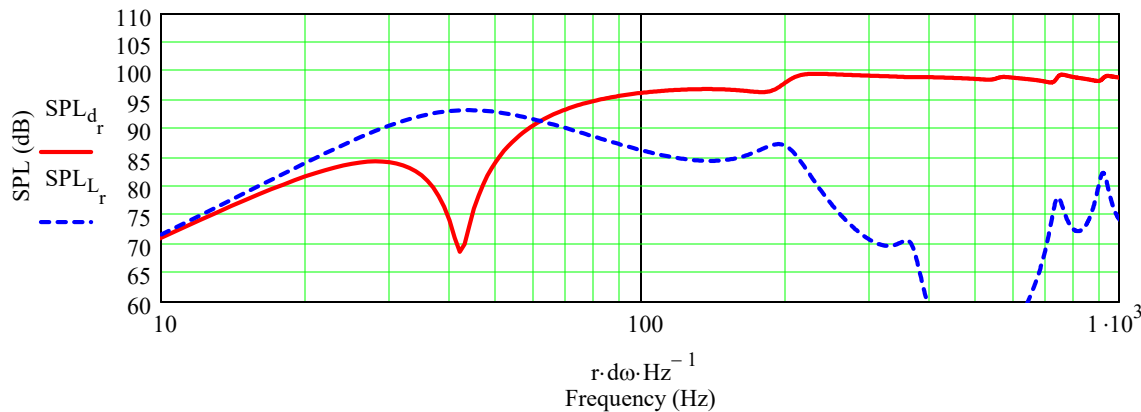
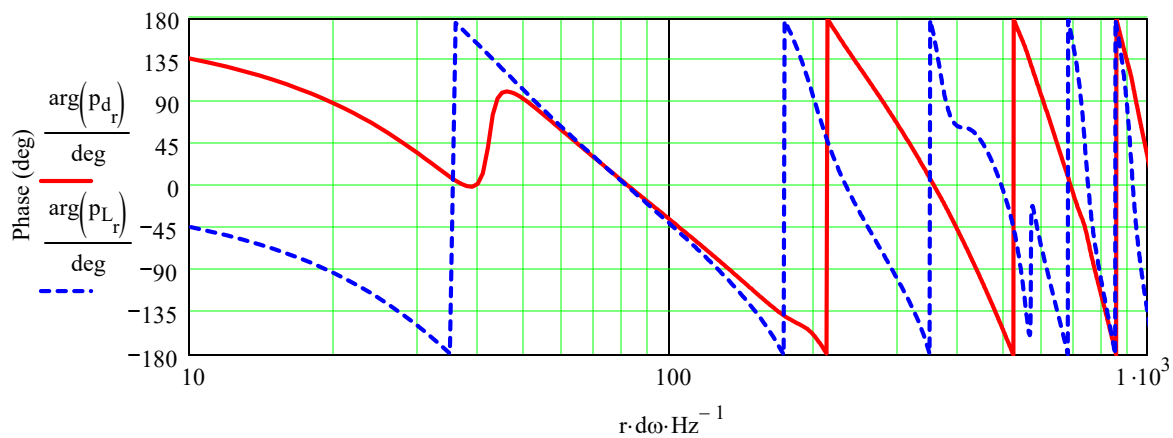
## Velocity at the Terminus of the ML TL for a 1 m/sec Excitation at the Driver Position



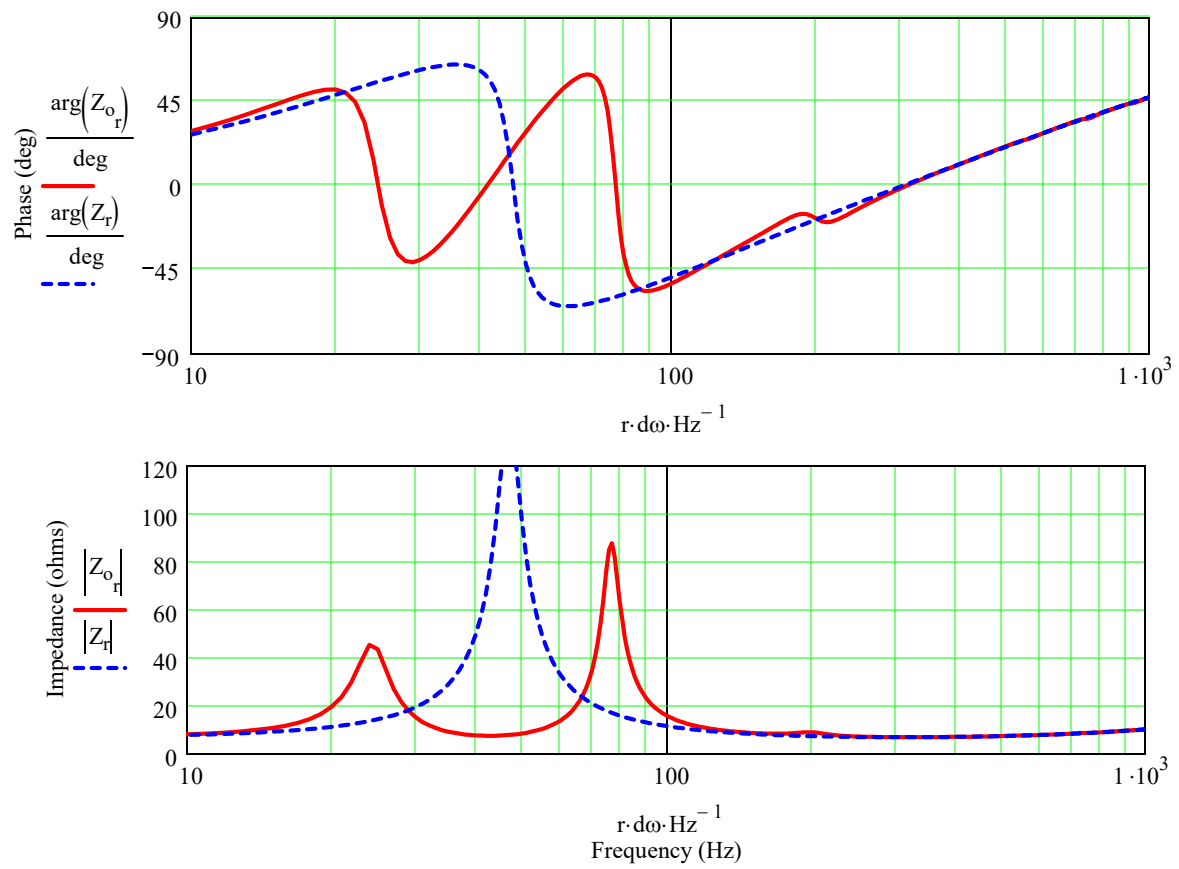
## Far Field ML TL System and Infinite Baffle Sound Pressure Level Responses



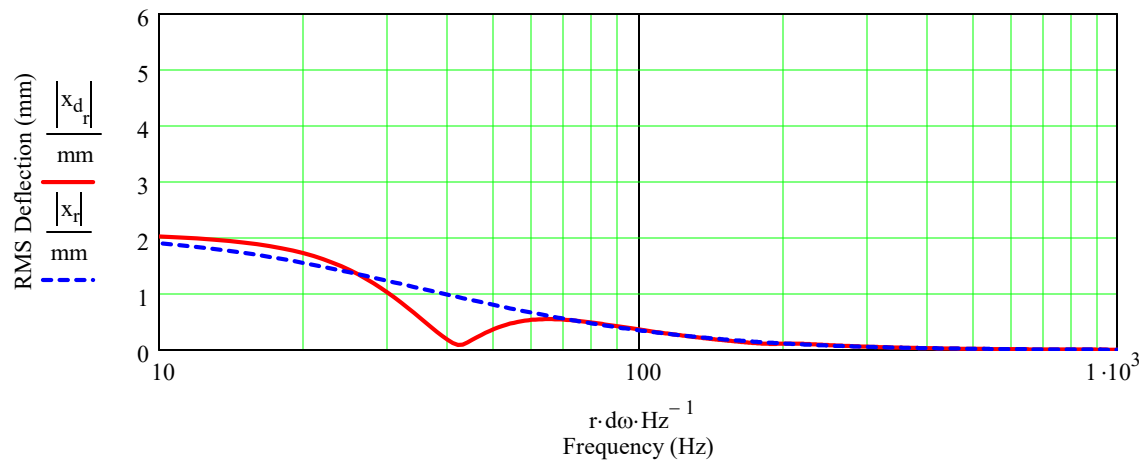
## Woofer and Terminus Far Field Sound Pressure Level Responses



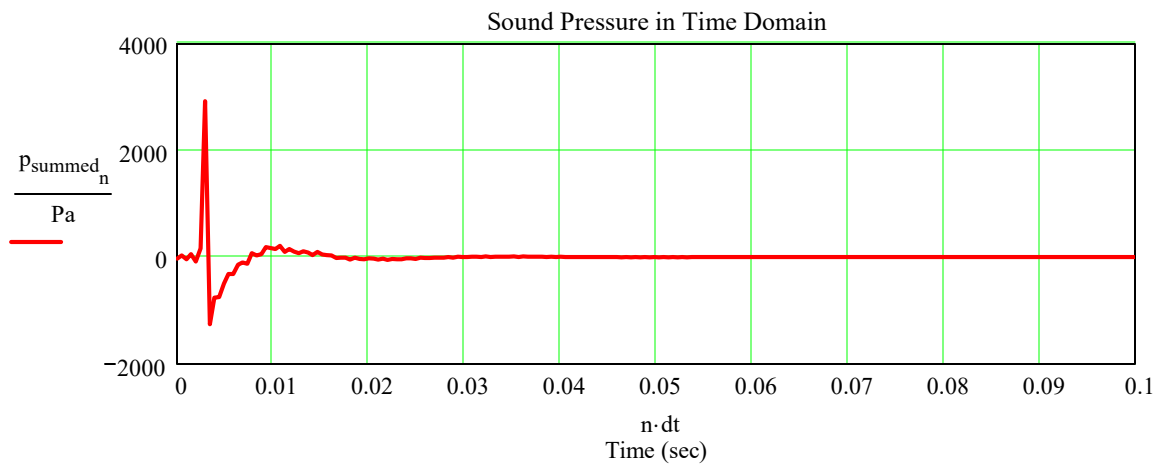
## ML TL System and Infinite Baffle Impedance



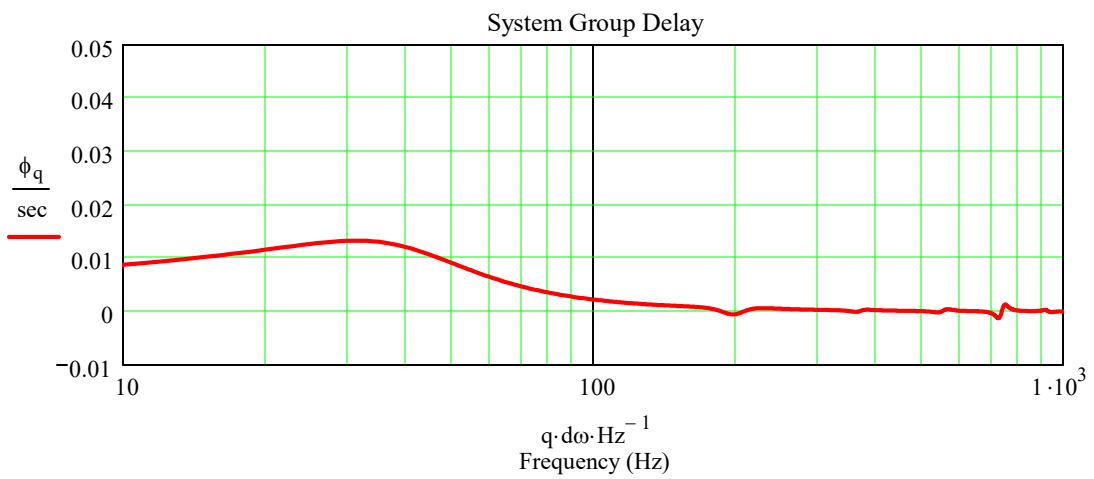
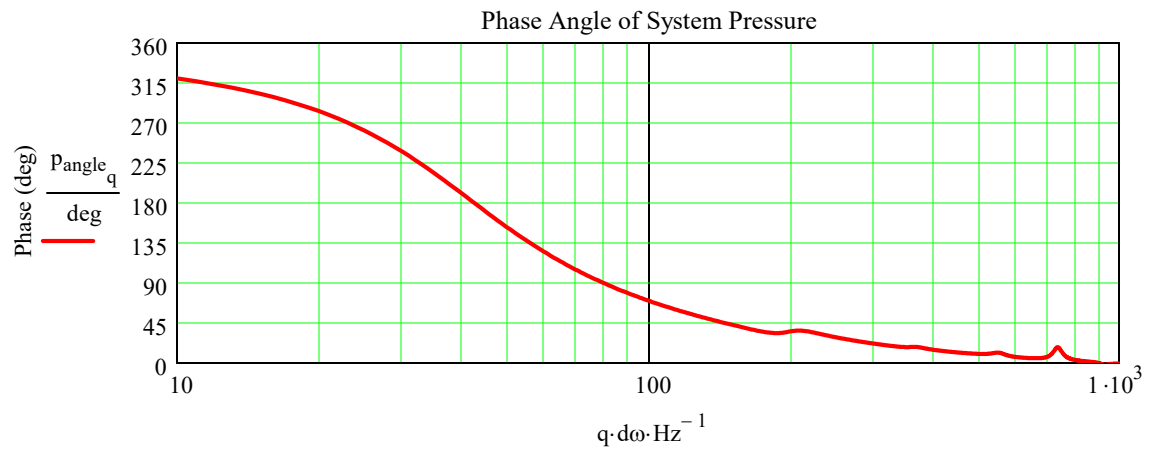
## Woofer RMS Displacement:



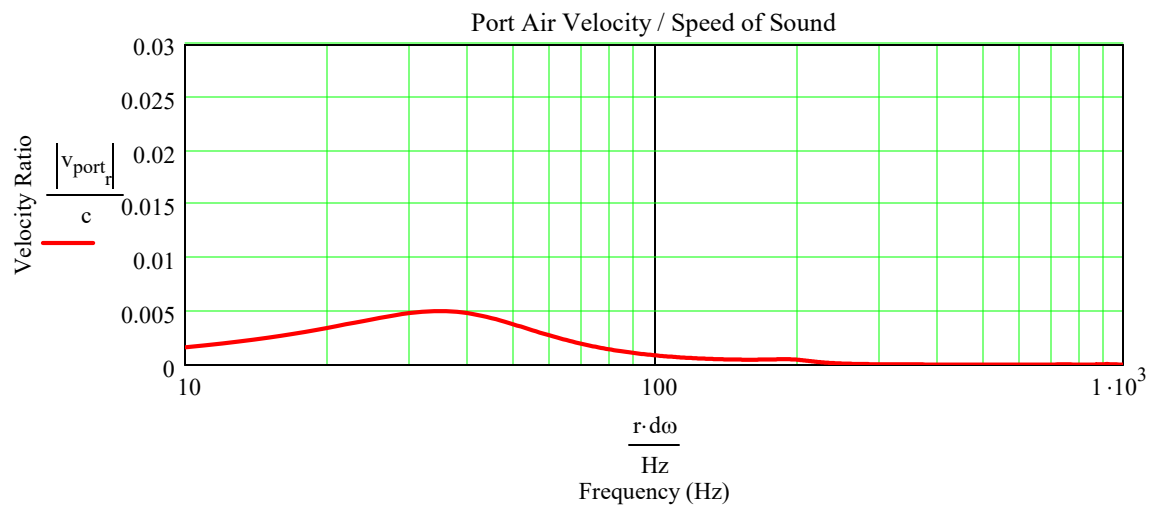
## System Time Response for an Impulse Input



## System Group Delay



Port Air Velocity (should be  $< 10 \text{ m/sec} / 344 \text{ m/sec} = 0.03$ )





## **Part 2 : Detailed SPL Response Calculation**

Calculation Includes :

- Position of Driver and Port on the Baffle.
- Baffle Step Defraction for the Driver and the Port.
- Room Reflections for the Driver and the Port.

### **Geometry**

Baffle Coordinate System :

- Origin is the lower left corner of the front baffle
- y = horizontal direction
- z = vertical direction

The variables num\_r, n\_drv, and n\_mth control the number of simple sources that are used in the calculations. Increasing each will improve accuracy at the expense of longer calculation times. Increase each variable until plotted SPL stops changing at which point the solution has converged.

### **Enclosure Geometry Input**

$X_0 := 2 \cdot \text{ft}$	(Front Baffle Distance from Rear Wall > Depth of Enclosure)
$Y_0 := 2 \cdot \text{ft}$	(Front Baffle Distance from Side Wall)
$\theta_0 := 45 \cdot \text{deg}$	(Rotation Towards Room Center)
$Z_0 := 8 \cdot \text{ft}$	(Floor to Ceiling Distance)
stand := 0·m	(Height from Floor to Bottom Edge of Front Baffle)
num_r := 10	(Number of Points per Unit Length of Baffle Edge)

### **Corner Coordinates**

Y coordinate	Z coordinate	
$y_{o_0} := 11 \cdot \text{in}$		(Bottom Right Corner)
$y_{o_1} := 11 \cdot \text{in}$	$z_{o_1} := 43.5 \cdot \text{in}$	(Top Right Corner)
$y_{o_2} := 0 \cdot \text{in}$	$z_{o_2} := 43.5 \cdot \text{in}$	(Top Left Corner)
$y_{o_3} := 0 \cdot \text{in}$		(Bottom Left Corner)
depth := 13.5·in		(Depth of Enclosure)

### Driver Geometry Input

$y_{dc} := 5.5 \cdot \text{in}$  (Driver Center y Coordinate)  
 $z_{dc} := 36.75 \cdot \text{in}$  (Driver Center z Coordinate)  
 $n_{dvr} := 5$  (Number of Points Across Diameter)

### Port Geometry Input

$y_{mc} := 5.5 \cdot \text{in}$  (Port Center y Coordinate)  
 $z_{mc} := 4.75 \cdot \text{in}$  (Port Center z Coordinate)  
 $n_{mth} := 4$  (Number of Points Across Diameter)  
Locate := 0 (0 = Front Baffle Port, 1 = Rear Baffle Port)

### Listening Position (Default Location is at 1 m Distance Along the Driver's Axis)

$n_{listen} = 0$  (Listening Position Relative to Speaker)  
 $radius := 1 \cdot \text{m}$  (Calculation Radius, Effective Radius is Greater if  $y_p$  is Changed from Default)  
 $\theta := 0 \cdot \text{deg}$  (0 deg is along the Driver's Axis,  $-80 \text{ deg} < \theta < 80 \text{ deg}$ )  
 $z_p := z_{dc}$  (Default Height is Equal to Driver Height)  
  
 $n_{listen} = 1$  (Listening Position Relative to the Room Corner)  
 $X_p := 10 \text{ft}$   
 $Y_p := 7 \cdot \text{ft}$   
 $Z_p := z_{dc} + \text{stand}$  (Default Height is Equal to Driver Height)  
 $n_{listen} := 0$  (Method Selection)

### Floor Condition

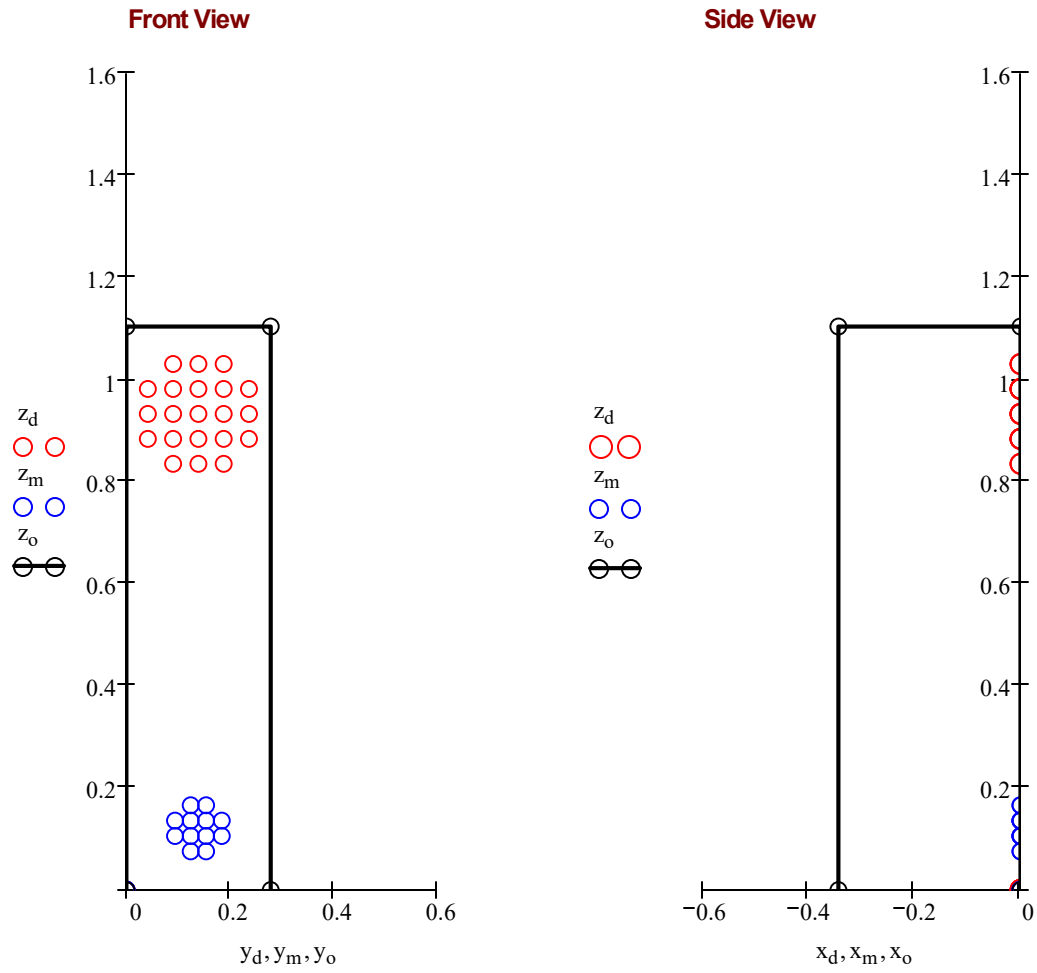
Reflect := 1 (0 = hardwood or concrete, 1 = carpeted)

### Reflective Surface Selections (if 1 reflective surface is included, if 0 reflective surface is removed)

$Inc_{floor} := 1$  (Floor,  $Z = 0$ )  
 $Inc_{rear} := 0$  (Rear Wall,  $X = 0$ )  
 $Inc_{side} := 0$  (Left Side Wall,  $Y = 0$ )  
 $Inc_{ceiling} := 0$  (Ceiling)



## Circular Driver and Circular Mouth Simple Source Pattern with Baffle Edge Outline



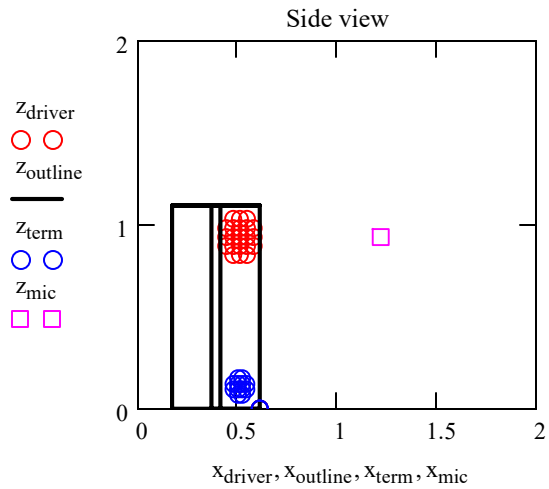
Red sources represent the driver.  
Blue sources represent the port.  
Black outline represents the baffle edge.  
Origin is at the bottom front left corner of the enclosure.



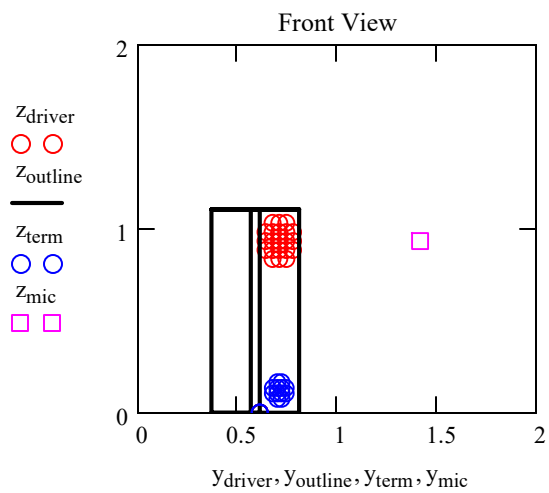
### Three Dimensional View

Axis Length (m)      axis := 2      <---- Change value of "axis" to rescale plots

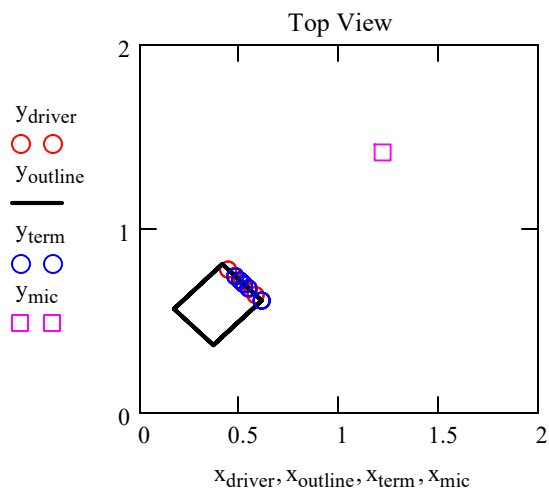
Room Corner is the Origin



Side View - looking out from side wall



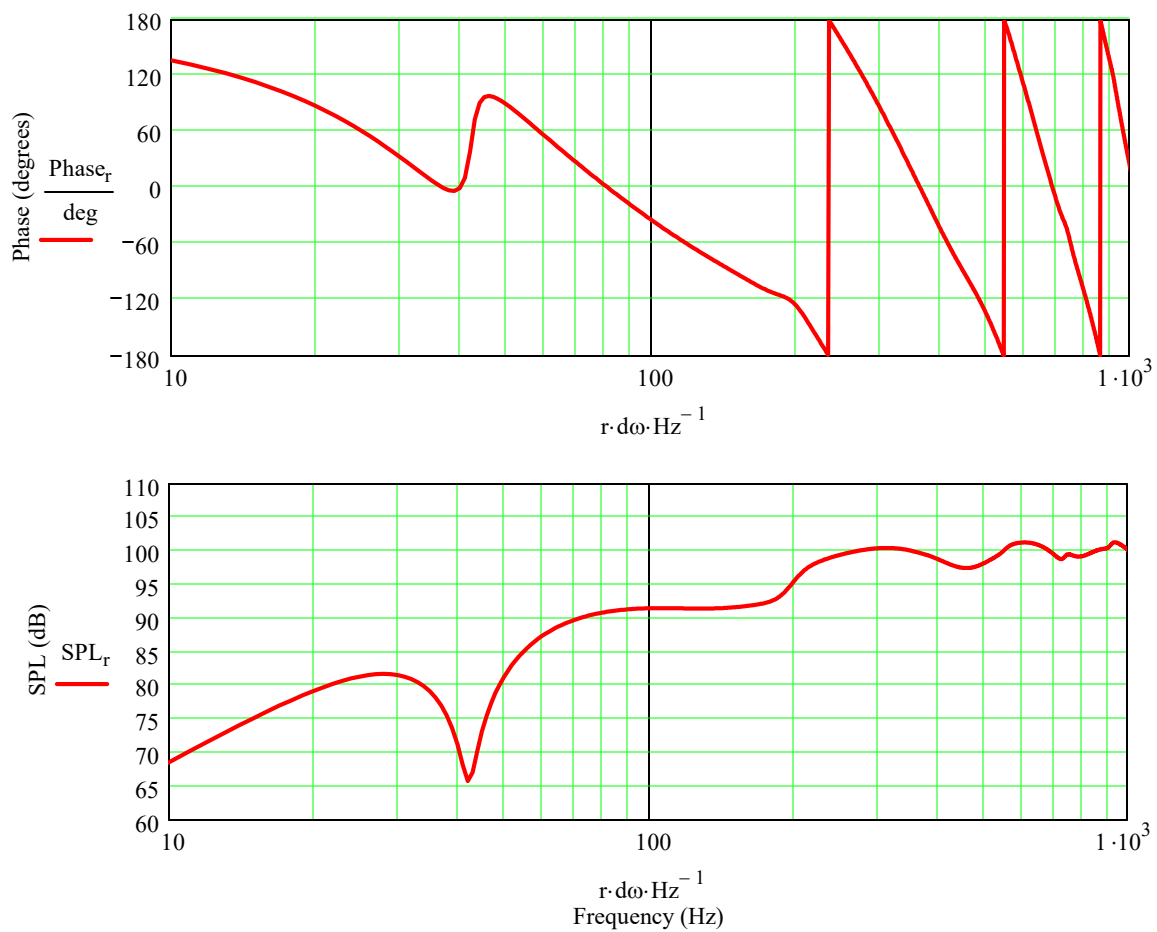
Front View - looking towards rear wall



Top View - looking down from ceiling

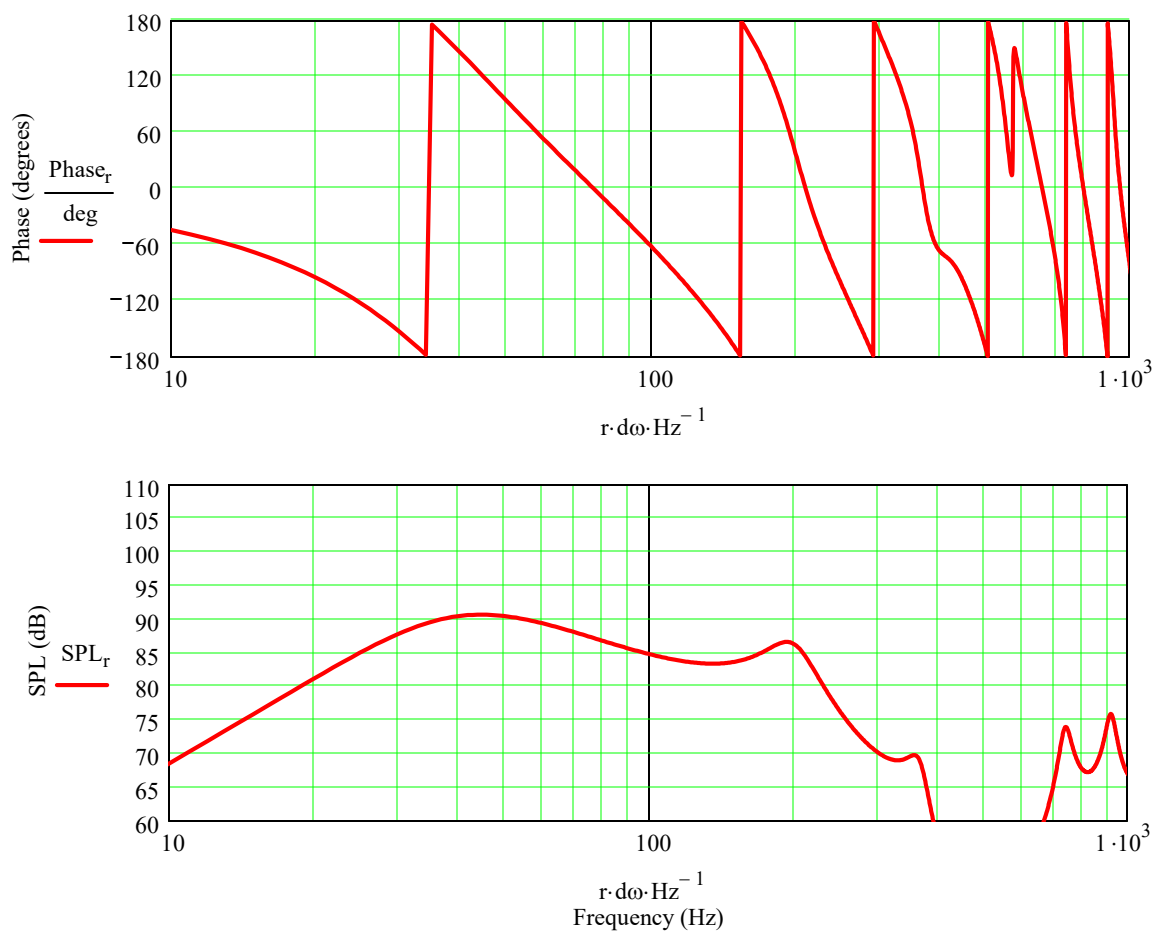


### Plotted Baffle Step and Reflection SPL Response for the Circular Driver Source

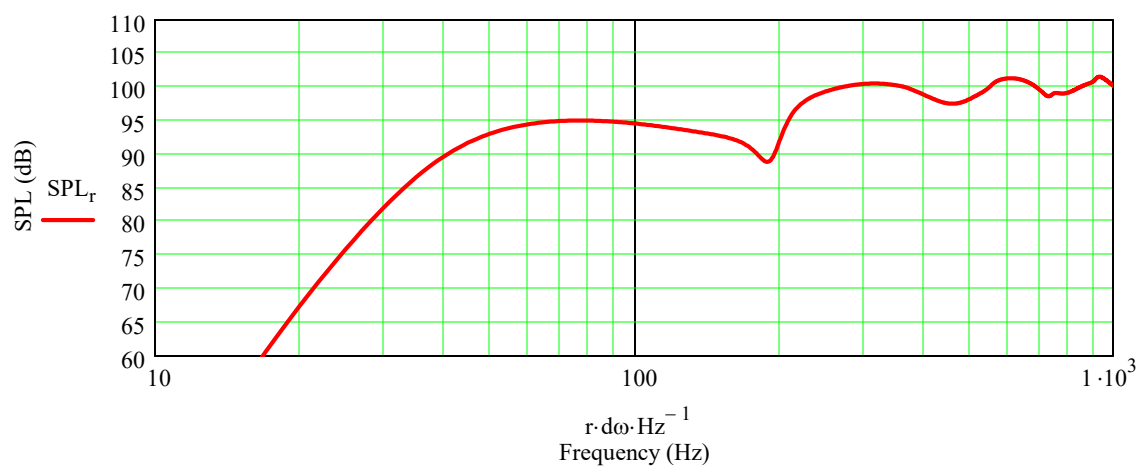
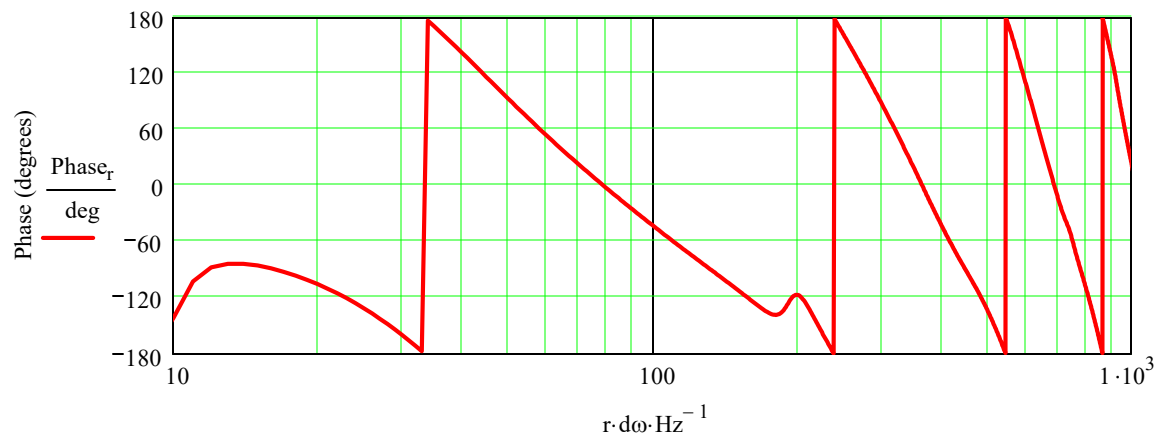




### Plotted Baffle Step and Reflection SPL Response for the Circular Port Source



### Plotted SPL Response for the System



**Part 3 : Baffle Step Correction Circuit Design**

Input Center Frequency of the Baffle Step and the desired dB of Attenuation.

$f_{center} := 640 \cdot \text{Hz}$  <--- Input Center Frequency

$\text{dB} := 7.65$  <--- Input dB of Attenuation

Calculated Component Values

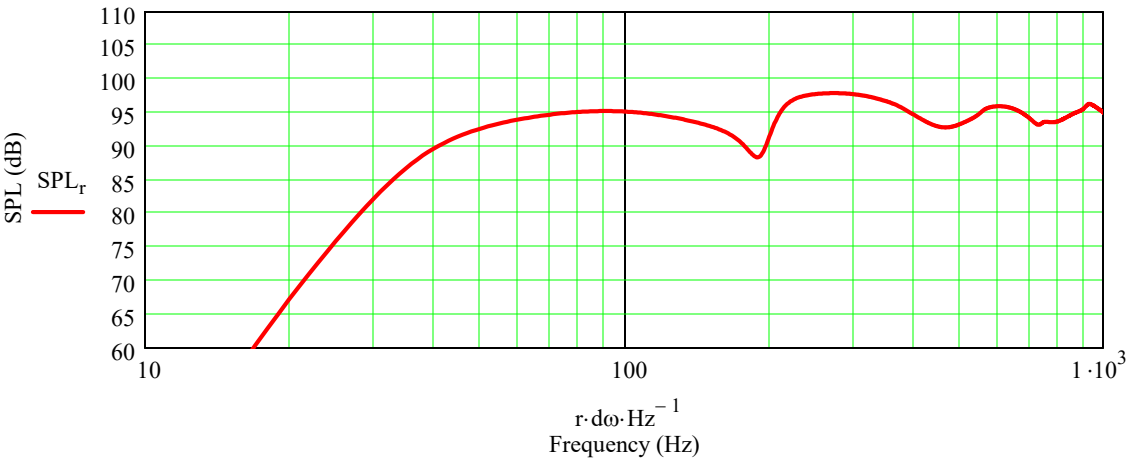
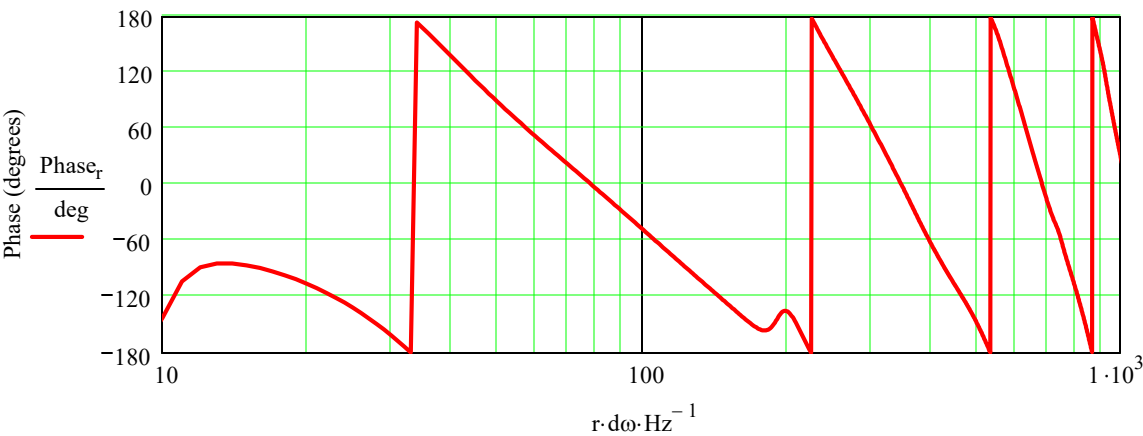
User Assigned Component Values  
Based on Calculated Values at Left

$R_c \cdot \left( 10^{\frac{\text{dB}}{20}} - 1 \right) = 9.748 \Omega$  Parallel Resistor      Input Value --->       $R_{parallel} := 10 \cdot \Omega$

$\frac{R_{parallel}}{f_{center}} = 2.487 \text{mH}$  BSC Inductor      Input Value --->       $L_{BSC} := 2.5 \cdot \text{mH}$

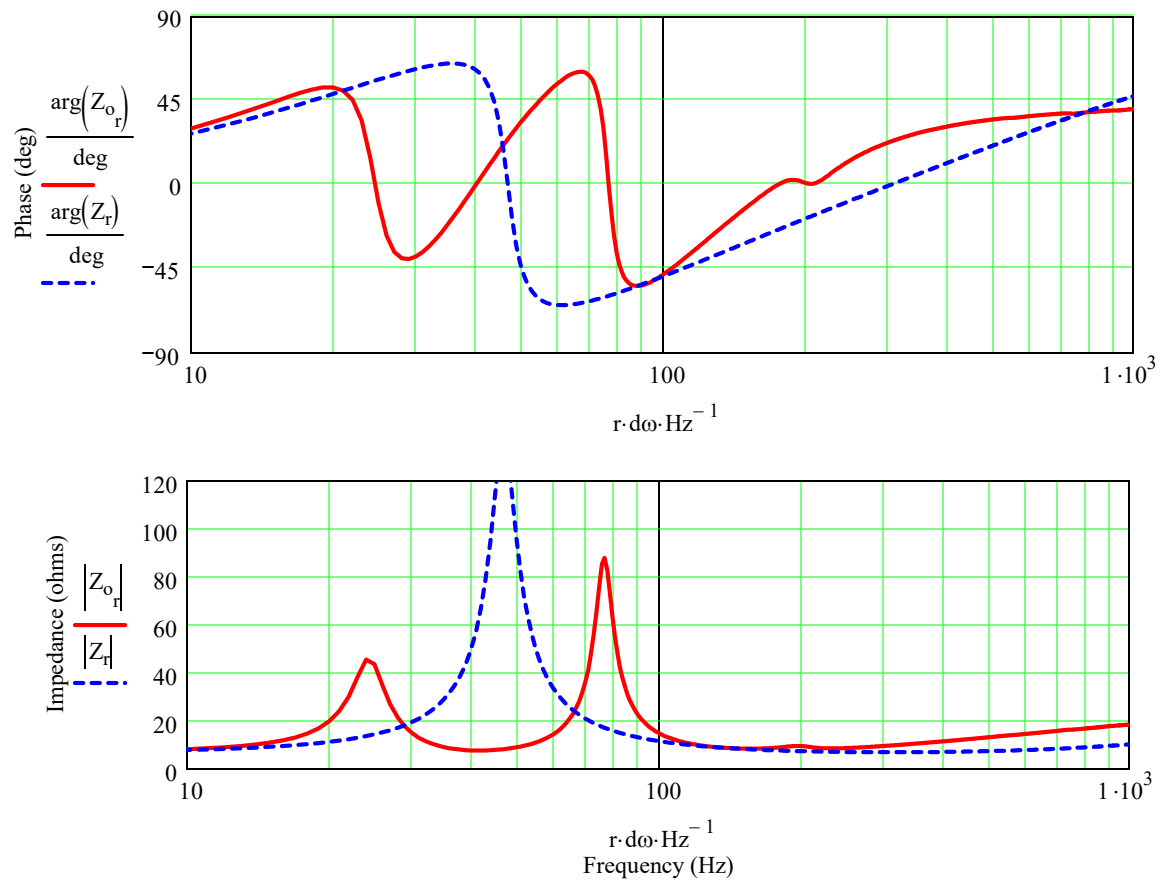


**Plotted Corrected SPL Response for the System**





## ML TL Corrected System and Infinite Baffle Impedance



## System Time Response for an Impulse Input

