



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

Copyright 2009 by Martin J. King. All Rights Reserved.

**Unit and Constant Definition**

cycle := 2 · π · rad

Air Density : ρ := 1.205 · kg · m<sup>-3</sup>

Hz := cycle · sec<sup>-1</sup>

Speed of Sound : c := 344 · m · sec<sup>-1</sup>



**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<sub>add</sub> := 0.0 · Ω

Driver Thiele / Small Parameters : Fostex FE-207E Driver Properties

f<sub>d</sub> := 39 · Hz

V<sub>ad</sub> := 56.25 · liter

Adjustments

R<sub>e</sub> := 6.73 · Ω

Q<sub>ed</sub> := 0.28

R<sub>e</sub> := R<sub>e</sub> + R<sub>add</sub>

L<sub>vc</sub> := 0 · mH

Q<sub>md</sub> := 3.86

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

Bl := 9.41 ·  $\frac{\text{newton}}{\text{amp}}$

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

S<sub>d</sub> := 206.1 · cm<sup>2</sup>

Q<sub>td</sub> = 0.261

Enclosure Geometry Definition

(Ref : Fostex Recommended Enclosure for FE-207E)

Lengths

L := 858 · mm

(Total Internal Length of Enclosure)

L<sub>top</sub> := 250 · mm

(Internal Length of Top Chamber)

t<sub>divider</sub> := 21 · mm

(Thickness of Dividing Panel)

L<sub>bot</sub> := 587 · mm

(Internal Length of Bottom Chamber)

L<sub>top</sub> + t<sub>divider</sub> + L<sub>bot</sub> = 858 mm <---- Must Equal Total Internal Length

z<sub>driver</sub> := 125 · mm

(Inside Distance from Top to Driver)

z<sub>port</sub> := 761 · mm

(Inside Distance from Top to Port)

## Areas

$S_0 := 250 \cdot \text{mm} \cdot 250 \cdot \text{mm}$	(Area of the Top End)
$S_L := 250 \cdot \text{mm} \cdot 250 \cdot \text{mm}$	(Area of the Bottom End)
$S_{\text{divider}} := 110 \cdot \text{mm} \cdot 110 \cdot \text{mm}$	(Area of Divider Internal Port)
$L_{\text{divider}} := 131 \cdot \text{mm}$	(Length of Divider Internal Port)
$S_{\text{port}} := 110 \cdot \text{mm} \cdot 110 \cdot \text{mm}$	(Area of Exit Port)
$L_{\text{port}} := 111 \cdot \text{mm}$	(Length of Exit Port)

## Stuffing Definition

$\text{Density}_1 := 0.2 \cdot \text{lb} \cdot \text{ft}^{-3}$	(Stuffing density in top chamber : $0 \text{ lb/ft}^3 < D_1 < 1 \text{ lb/ft}^3$ )
$\text{Density}_2 := 0.2 \cdot \text{lb} \cdot \text{ft}^{-3}$	(Stuffing density in bottom chamber : $0 \text{ lb/ft}^3 < D_2 < 1 \text{ lb/ft}^3$ )

## Power

Power := 1 · watt	(Input Power) Applied Voltage Reference ---> $R_{\text{ref}} := 8 \cdot \Omega$
-------------------	---

## End of Abbreviated User Input

### Calculated Detailed Input Values (Derived From User Input Data Entered Above)

$TR := (S_L - S_0) \cdot L^{-1}$	$TR = 0 \text{ m}$
$L_D := L_{\text{top}} - z_{\text{driver}}$	(Length from Driver to Near Edge of Divider)
$S_D := S_0 + TR \cdot (L_{\text{top}})$	(Area at Near Edge of Plate)
$L_T := L - L_{\text{top}} - t_{\text{divider}}$	(Length from Far Edge of Divider to Bottom)
$S_T := S_0 + TR \cdot (L - L_T)$	(Area at Far Edge of Divider)
$L_P := z_{\text{port}} - L_{\text{top}} - t_{\text{divider}}$	(Length from Far Edge of Divider to Port Centerline)
$S_P := S_T + TR \cdot (L_P)$	(Area at Port Center Line)
$L_{\text{port}} := L_{\text{port}} + 0.6 \cdot \sqrt{\frac{S_{\text{port}}}{\pi}}$	(Corrected Port Length)
$L_B := L_T - L_P$	(Length from Port Centerline to Bottom)

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

**Ported Box Definition**

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

n_top := 4	(n_top > 1)
n_open := 12	(n_open > 1)
n_bottom := 4	(n_bottom > 1)
n_port := 4	(n_port > 1)

**Closed End of Transmission Line (Driver ----> Closed End)**

Section Length	Initial Area	Final Area	Stuffing Density
$L_{c_0} := z_{driver} \cdot (n_{top} + 1)^{-1}$	$S_{c_{0,0}} := S_0 + TR \cdot z_{driver}$	$S_{c_{0,1}} := S_{c_{0,0}} - TR \cdot L_{c_0}$	$D_{c_0} := \text{Density}_1$
$L_{c_1} := z_{driver} \cdot (n_{top} + 1)^{-1}$	$S_{c_{1,0}} := S_{c_{0,1}}$	$S_{c_{1,1}} := S_{c_{1,0}} - TR \cdot L_{c_1}$	$D_{c_1} := \text{Density}_1$
$L_{c_2} := z_{driver} \cdot (n_{top} + 1)^{-1}$	$S_{c_{2,0}} := S_{c_{1,1}}$	$S_{c_{2,1}} := S_{c_{2,0}} - TR \cdot L_{c_2}$	$D_{c_2} := \text{Density}_1$
$L_{c_3} := z_{driver} \cdot (n_{top} + 1)^{-1}$	$S_{c_{3,0}} := S_{c_{2,1}}$	$S_{c_{3,1}} := S_{c_{3,0}} - TR \cdot L_{c_3}$	$D_{c_3} := \text{Density}_1$
$L_{c_4} := z_{driver} \cdot (n_{top} + 1)^{-1}$	$S_{c_{4,0}} := S_{c_{3,1}}$	$S_{c_{4,1}} := S_0$	$D_{c_4} := \text{Density}_1$

**Open End of Transmission Line (Driver ----> Divider)**

Section Length	Initial Area	Final Area	Stuffing Density
$L_{o_0} := L_D \cdot (n_{open} - 7)^{-1}$	$S_{o_{0,0}} := S_0$	$S_{o_{0,1}} := S_{o_{0,0}} + TR \cdot L_{o_0}$	$D_{o_0} := \text{Density}_1$
$L_{o_1} := L_D \cdot (n_{open} - 7)^{-1}$	$S_{o_{1,0}} := S_{o_{0,1}}$	$S_{o_{1,1}} := S_{o_{1,0}} + TR \cdot L_{o_1}$	$D_{o_1} := \text{Density}_1$
$L_{o_2} := L_D \cdot (n_{open} - 7)^{-1}$	$S_{o_{2,0}} := S_{o_{1,1}}$	$S_{o_{2,1}} := S_{o_{2,0}} + TR \cdot L_{o_2}$	$D_{o_2} := \text{Density}_1$
$L_{o_3} := L_D \cdot (n_{open} - 7)^{-1}$	$S_{o_{3,0}} := S_{o_{2,1}}$	$S_{o_{3,1}} := S_{o_{3,0}} + TR \cdot L_{o_3}$	$D_{o_3} := \text{Density}_1$
$L_{o_4} := L_D \cdot (n_{open} - 7)^{-1}$	$S_{o_{4,0}} := S_{o_{3,1}}$	$S_{o_{4,1}} := S_{o_{4,0}} + TR \cdot L_{o_4}$	$D_{o_4} := \text{Density}_1$

**Divider Port**

(Internal Port Driver End ----> Internal Port Terminus End)

Section Length	Initial Area	Final Area	Stuffing Density
$L_{o_5} := 0.6 \cdot \sqrt{\frac{S_{divider}}{\pi}}$	$S_{o_{5,0}} := S_{divider}$	$S_{o_{5,1}} := S_{divider}$	$D_{o_5} := \text{Density}_1$
$L_{o_6} := L_{divider}$	$S_{o_{6,0}} := S_{divider}$	$S_{o_{6,1}} := S_{divider}$	$D_{o_6} := 0 \cdot \text{lb} \cdot \text{ft}^{-3}$
$L_{o_7} := 0.6 \cdot \sqrt{\frac{S_{divider}}{\pi}}$	$S_{o_{7,0}} := S_{divider}$	$S_{o_{7,1}} := S_{divider}$	$D_{o_7} := \text{Density}_2$

**Open End of Transmission Line (Divider Terminus End ---> External Port Centerline)**

Section Length	Initial Area	Final Area	Stuffing Density
$L_{o_8} := L_P \cdot (n_{open} - 7)^{-1}$	$S_{o_{8,0}} := S_T$	$S_{o_{8,1}} := S_{o_{8,0}} + TR \cdot L_{o_8}$	$D_{o_8} := \text{Density}_2$
$L_{o_9} := L_P \cdot (n_{open} - 7)^{-1}$	$S_{o_{9,0}} := S_{o_{8,1}}$	$S_{o_{9,1}} := S_{o_{9,0}} + TR \cdot L_{o_9}$	$D_{o_9} := \text{Density}_2$
$L_{o_{10}} := L_P \cdot (n_{open} - 7)^{-1}$	$S_{o_{10,0}} := S_{o_{9,1}}$	$S_{o_{10,1}} := S_{o_{10,0}} + TR \cdot L_{o_{10}}$	$D_{o_{10}} := \text{Density}_2$
$L_{o_{11}} := L_P \cdot (n_{open} - 7)^{-1}$	$S_{o_{11,0}} := S_{o_{10,1}}$	$S_{o_{11,1}} := S_{o_{11,0}} + TR \cdot L_{o_{11}}$	$D_{o_{11}} := \text{Density}_2$
$L_{o_{12}} := L_P \cdot (n_{open} - 7)^{-1}$	$S_{o_{12,0}} := S_{o_{11,1}}$	$S_{o_{12,1}} := S_{o_{12,0}} + TR \cdot L_{o_{12}}$	$D_{o_{12}} := \text{Density}_2$

**Bottom Section of Enclosure (External Port Centerline ---> Bottom of Enclosure)**

Section Length	Initial Area	Final Area	Stuffing Density
$L_{b_0} := L_B \cdot (n_{bottom} + 1)^{-1}$	$S_{b_{0,0}} := S_P$	$S_{b_{0,1}} := S_{b_{0,0}} + TR \cdot L_{b_0}$	$D_{b_0} := \text{Density}_2$
$L_{b_1} := L_B \cdot (n_{bottom} + 1)^{-1}$	$S_{b_{1,0}} := S_{b_{0,1}}$	$S_{b_{1,1}} := S_{b_{1,0}} + TR \cdot L_{b_1}$	$D_{b_1} := \text{Density}_2$
$L_{b_2} := L_B \cdot (n_{bottom} + 1)^{-1}$	$S_{b_{2,0}} := S_{b_{1,1}}$	$S_{b_{2,1}} := S_{b_{2,0}} + TR \cdot L_{b_2}$	$D_{b_2} := \text{Density}_2$
$L_{b_3} := L_B \cdot (n_{bottom} + 1)^{-1}$	$S_{b_{3,0}} := S_{b_{2,1}}$	$S_{b_{3,1}} := S_{b_{3,0}} + TR \cdot L_{b_3}$	$D_{b_3} := \text{Density}_2$
$L_{b_4} := L_B \cdot (n_{bottom} + 1)^{-1}$	$S_{b_{4,0}} := S_{b_{3,1}}$	$S_{b_{4,1}} := S_L$	$D_{b_4} := \text{Density}_2$

**Port Section of Enclosure (External Port Inside ---> External Port Outside)**

Section Length	Initial Area	Final Area	Stuffing Density
$L_{p_0} := L_{port} \cdot (n_{port} + 1)^{-1}$	$S_{p_{0,0}} := S_{port}$	$S_{p_{0,1}} := S_{port}$	$D_{p_0} := 0 \cdot \text{lb} \cdot \text{ft}^{-3}$
$L_{p_1} := L_{port} \cdot (n_{port} + 1)^{-1}$	$S_{p_{1,0}} := S_{port}$	$S_{p_{1,1}} := S_{port}$	$D_{p_1} := 0 \cdot \text{lb} \cdot \text{ft}^{-3}$
$L_{p_2} := L_{port} \cdot (n_{port} + 1)^{-1}$	$S_{p_{2,0}} := S_{port}$	$S_{p_{2,1}} := S_{port}$	$D_{p_2} := 0 \cdot \text{lb} \cdot \text{ft}^{-3}$
$L_{p_3} := L_{port} \cdot (n_{port} + 1)^{-1}$	$S_{p_{3,0}} := S_{port}$	$S_{p_{3,1}} := S_{port}$	$D_{p_3} := 0 \cdot \text{lb} \cdot \text{ft}^{-3}$
$L_{p_4} := L_{port} \cdot (n_{port} + 1)^{-1}$	$S_{p_{4,0}} := S_{port}$	$S_{p_{4,1}} := S_{port}$	$D_{p_4} := 0 \cdot \text{lb} \cdot \text{ft}^{-3}$

**Total Amount of Stuffing**

$$\sum_{r=0}^{n_{top}} \left[ \frac{(S_{c_{r,0}} + S_{c_{r,1}})}{2} \cdot L_{c_r} \cdot D_{c_r} \right] + \sum_{r=0}^{n_{open}} \left[ \frac{(S_{o_{r,0}} + S_{o_{r,1}})}{2} \cdot L_{o_r} \cdot D_{o_r} \right] \dots = 0.376 \text{ lb}$$

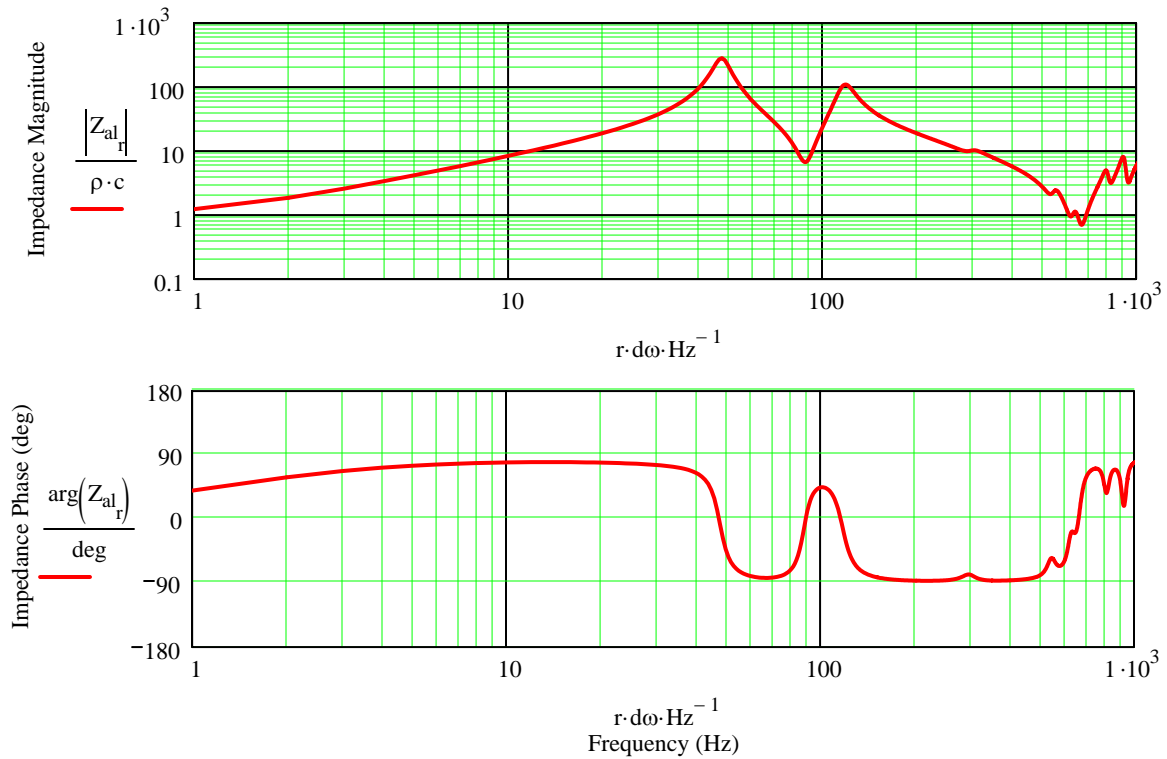
$$+ \sum_{r=0}^{n_{bottom}} \left[ \frac{(S_{b_{r,0}} + S_{b_{r,1}})}{2} \cdot L_{b_r} \cdot D_{b_r} \right] + \sum_{r=0}^{n_{port}} \left[ \frac{(S_{p_{r,0}} + S_{p_{r,1}})}{2} \cdot L_{p_r} \cdot D_{p_r} \right]$$

**End of Pre Formatted Default Input**

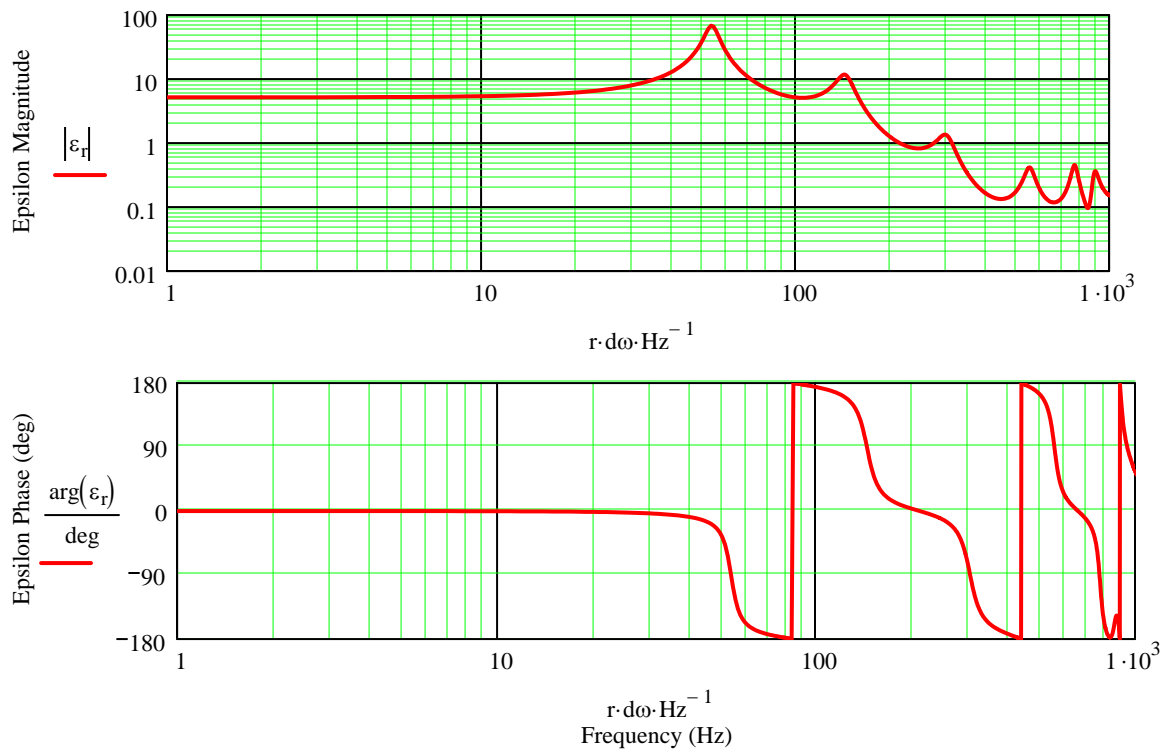
**End of Part 1 Input**



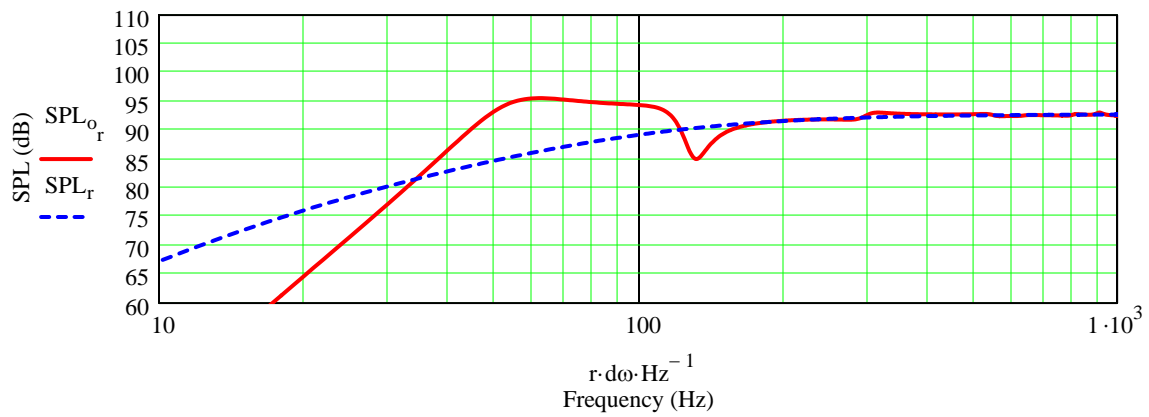
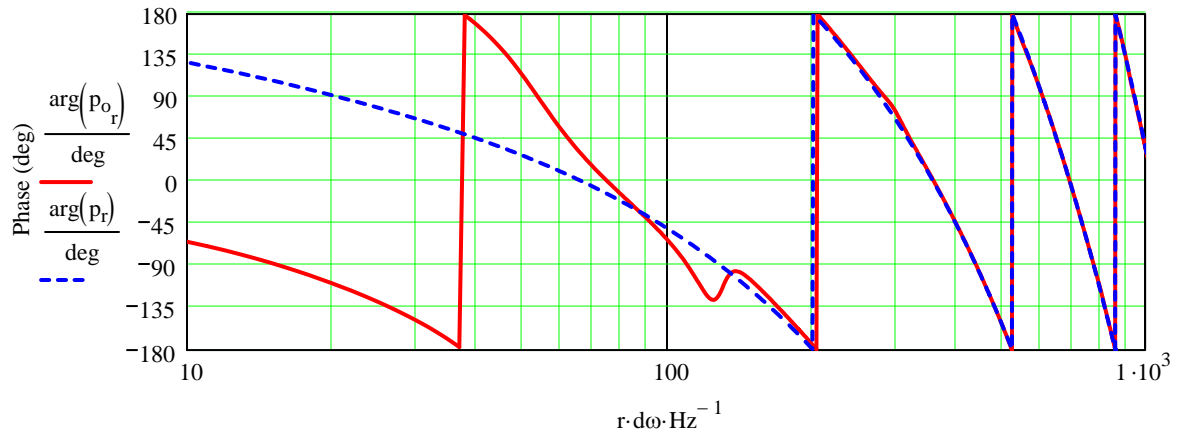
### Resulting Acoustic Impedance for the Enclosure



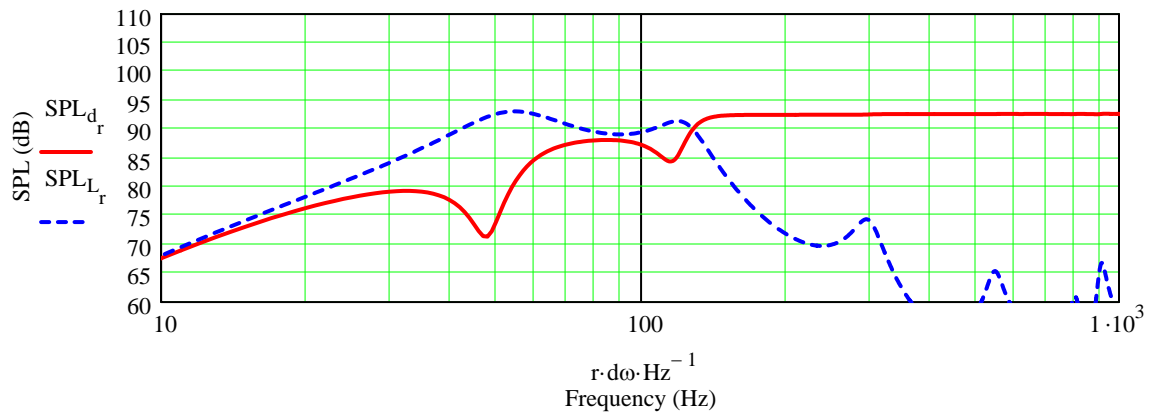
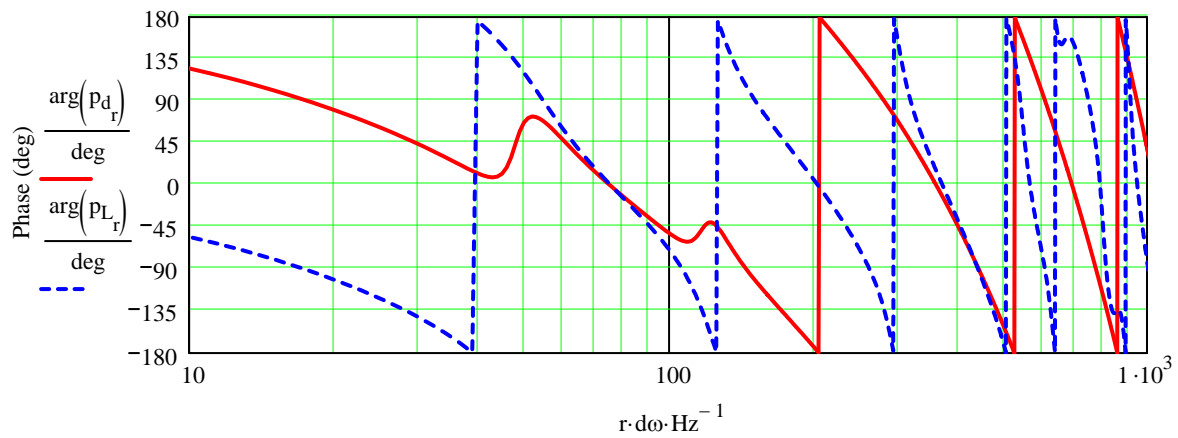
### Velocity at the Terminus of the Ported Box for a 1 m/sec Excitation at the Driver Position



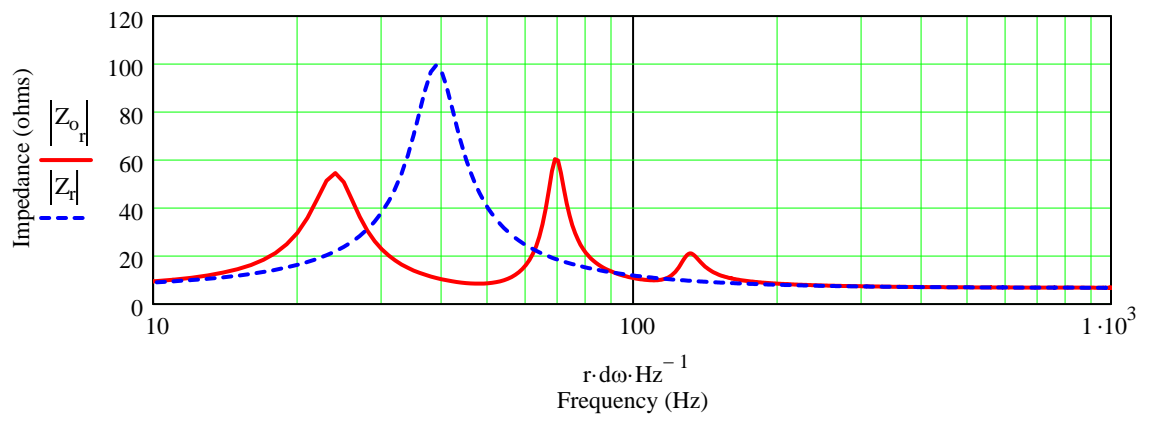
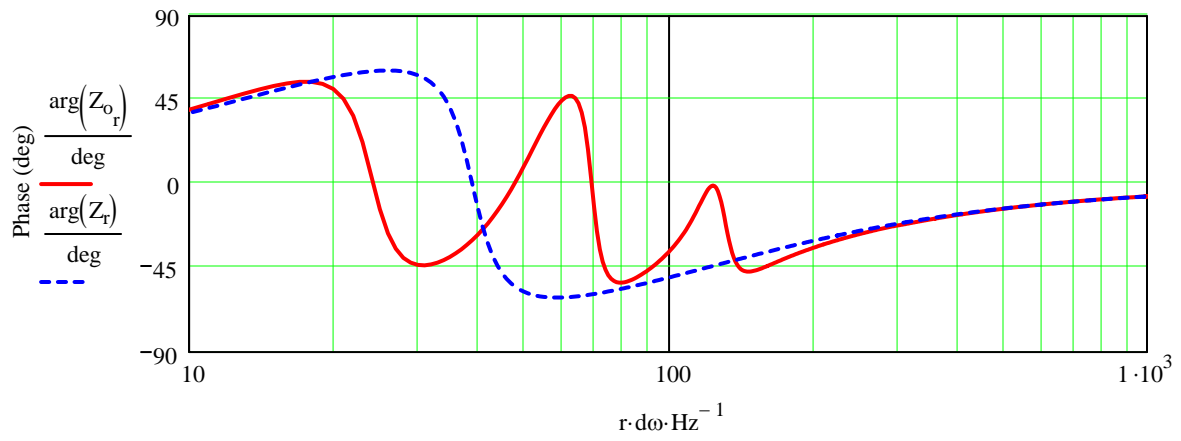
### Far Field Ported Box System and Infinite Baffle Sound Pressure Level Responses



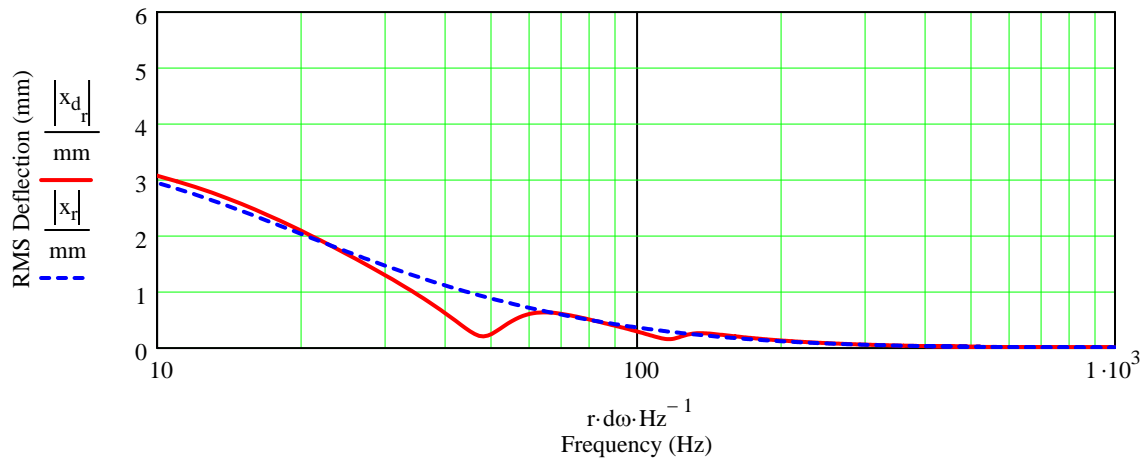
### Woofer and Terminus Far Field Sound Pressure Level Responses



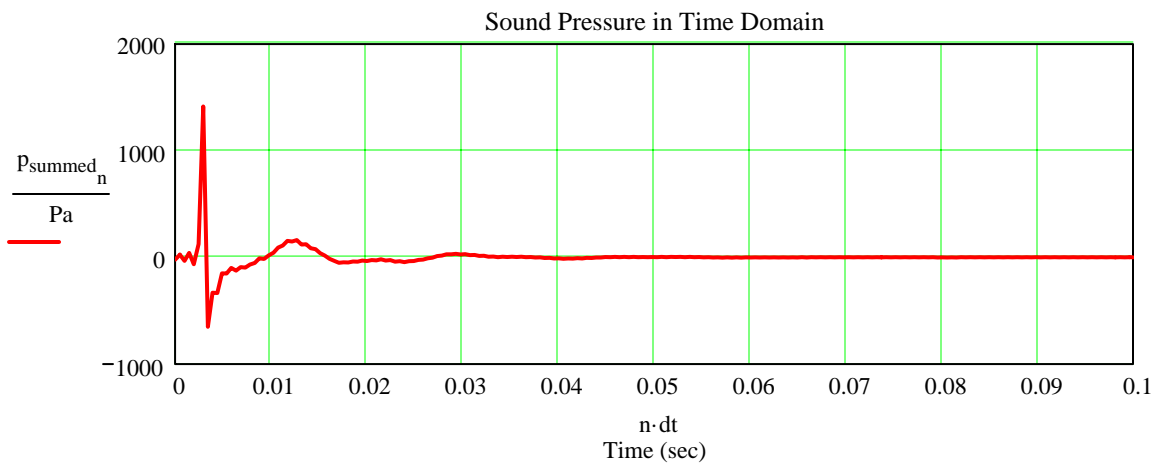
# Ported Box System and Infinite Baffle Impedance



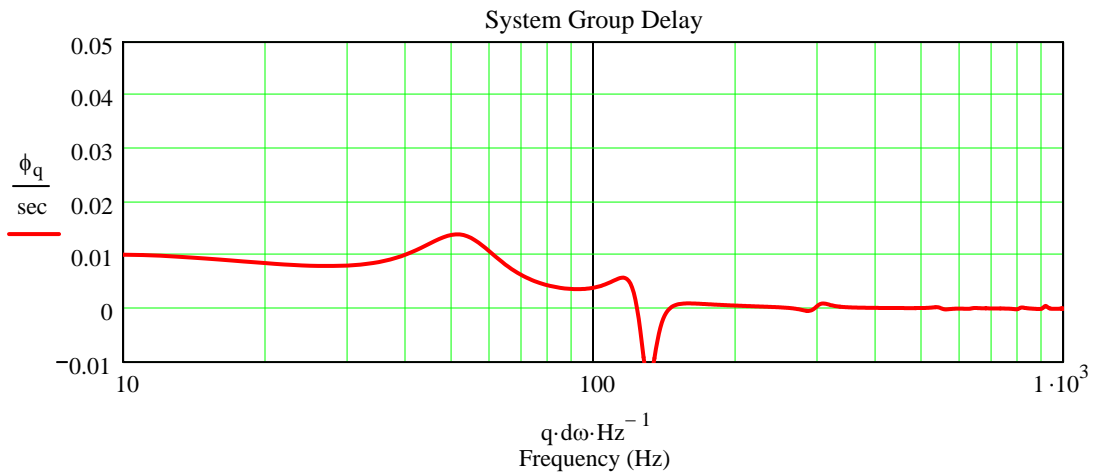
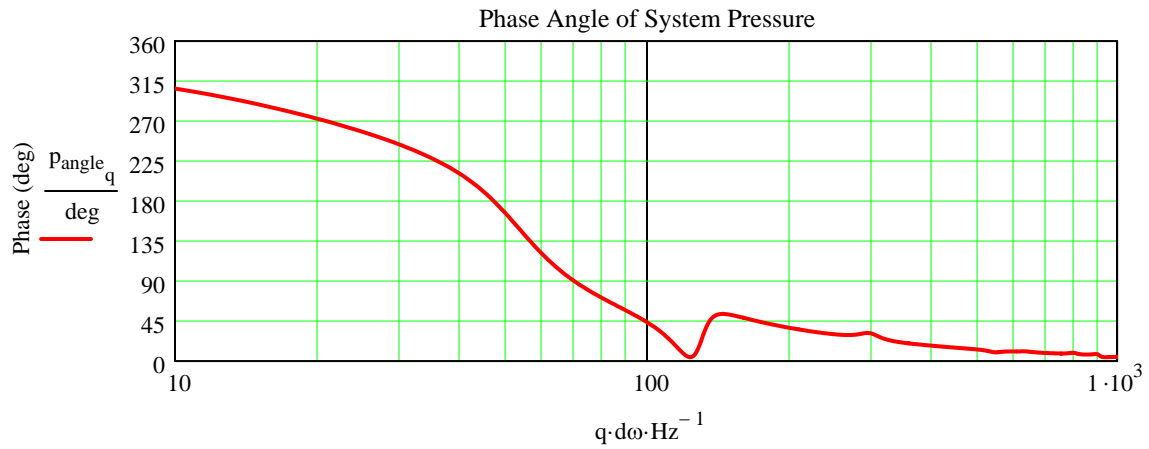
## Woofer RMS Displacement



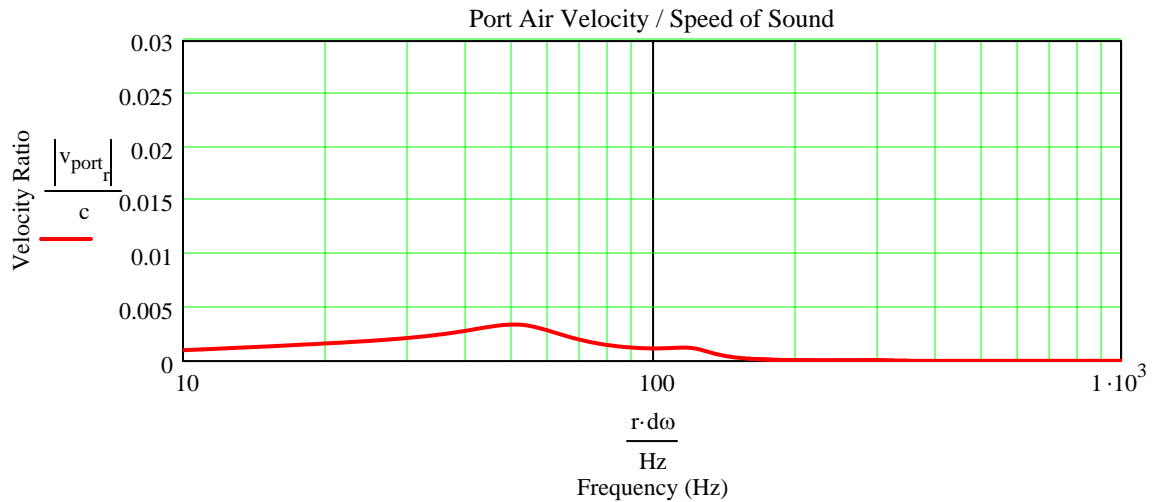
## System Time Response for an Impulse Input



## System Group Delay



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



## 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

$y_{o_0} := 292\cdot\text{mm}$  (Bottom Right Corner)

$y_{o_1} := 292\cdot\text{mm}$   $z_{o_1} := 900\cdot\text{mm}$  (Top Right Corner)

$y_{o_2} := 0\cdot\text{in}$   $z_{o_2} := 900\cdot\text{mm}$  (Top Left Corner)

$y_{o_3} := 0\cdot\text{in}$  (Bottom Left Corner)

depth := 320·mm (Depth of Enclosure)

### Driver Geometry Input

$y_{dc} := 146 \cdot \text{mm}$  (Driver Center y Coordinate)  
 $z_{dc} := 754 \cdot \text{mm}$  (Driver Center z Coordinate)  
 $n_{dvr} := 5$  (Number of Points Across Diameter)

### Port Geometry Input

$y_{mc} := 146 \cdot \text{mm}$  (Port Center y Coordinate)  
 $z_{mc} := 118 \cdot \text{mm}$  (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·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,  $-80 \text{ deg} < \theta < 80 \text{ deg}$ )  
 $z_p := z_{dc} + \text{stand}$  (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

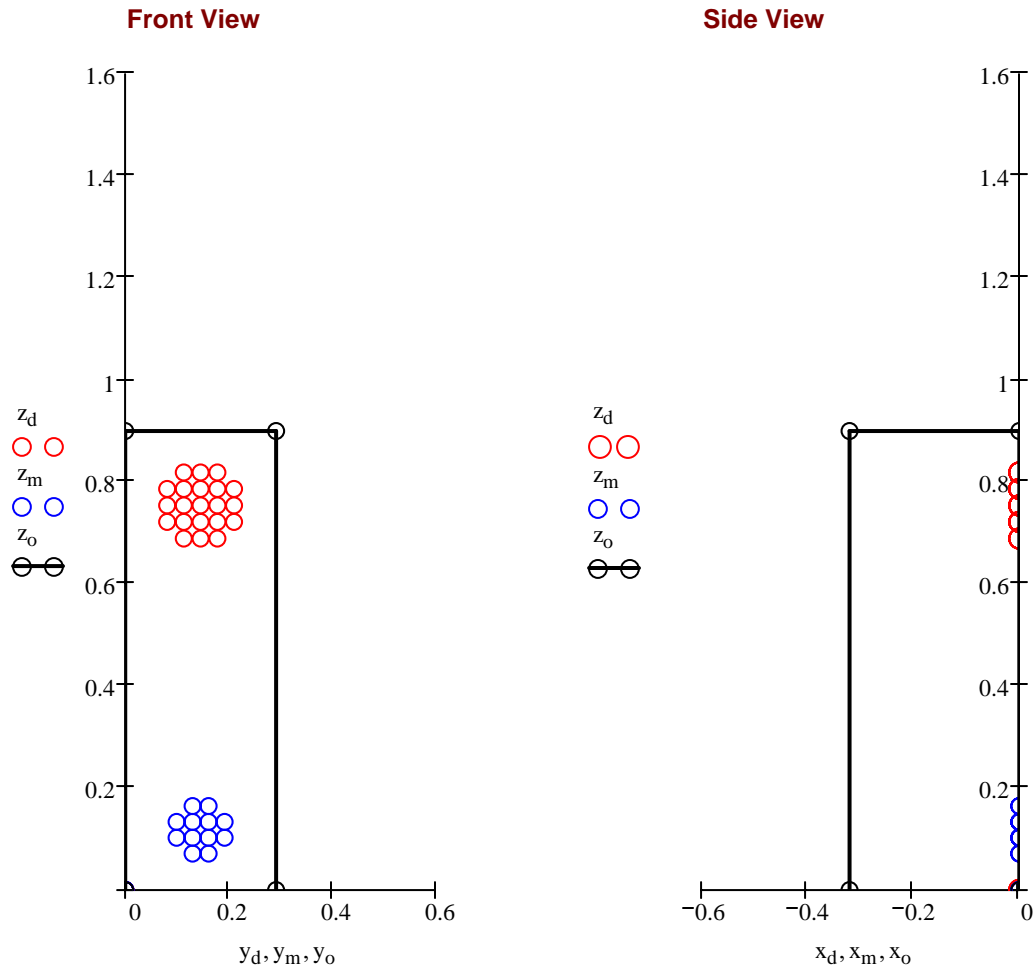
Reflect := 1 (0 = hardwood or concrete, 1 = carpeted)

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

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



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



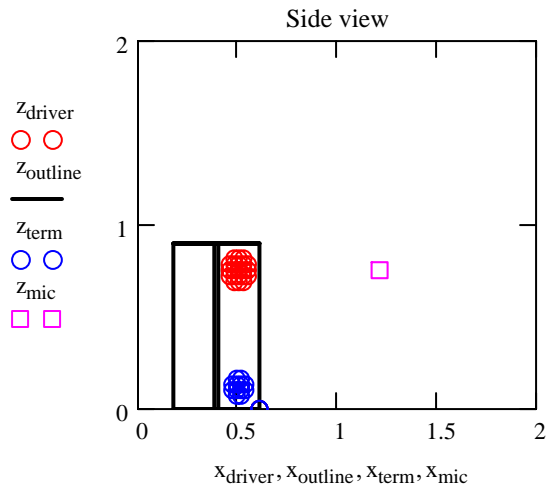
Red sources represent the driver.  
Blue sources represent the port.  
Black outline represents the baffle edge.  
Origin is at the bottom front left corner of the enclosure.



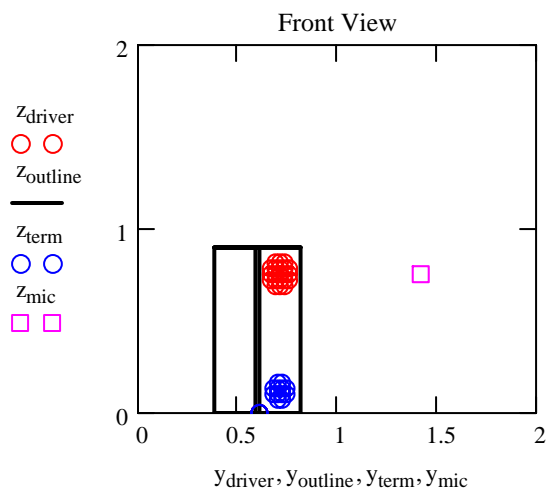
### Three Dimensional View

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

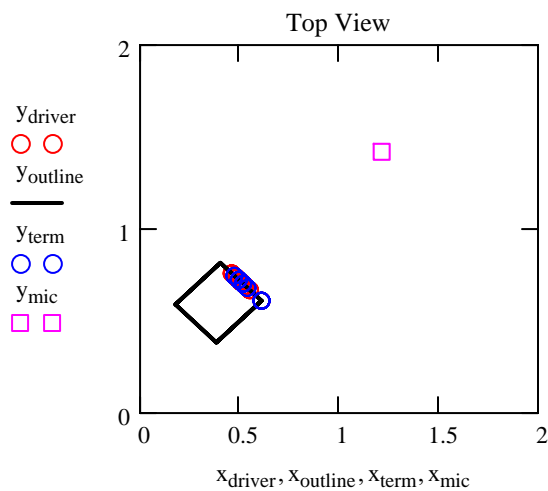
Room Corner is the Origin



Side View - looking out from side wall



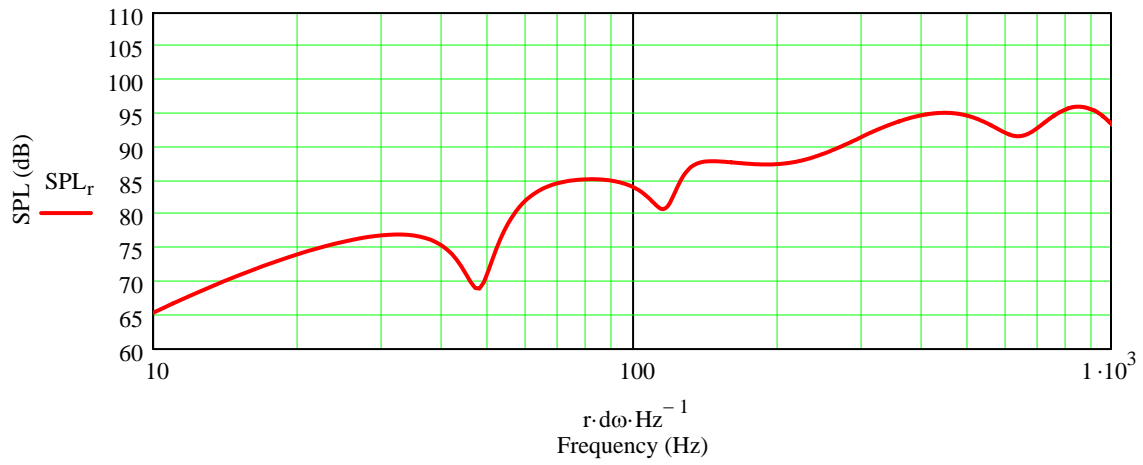
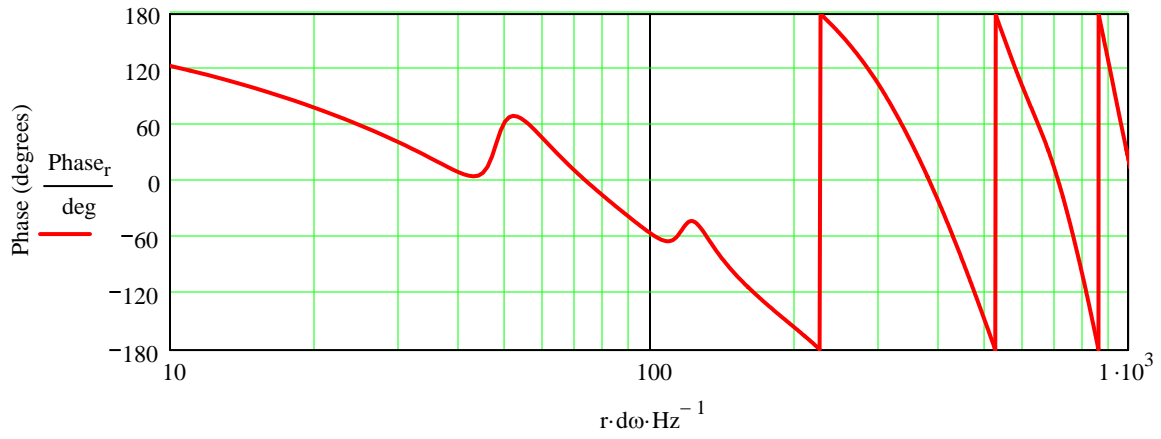
Front View - looking towards rear wall



Top View - looking down from ceiling

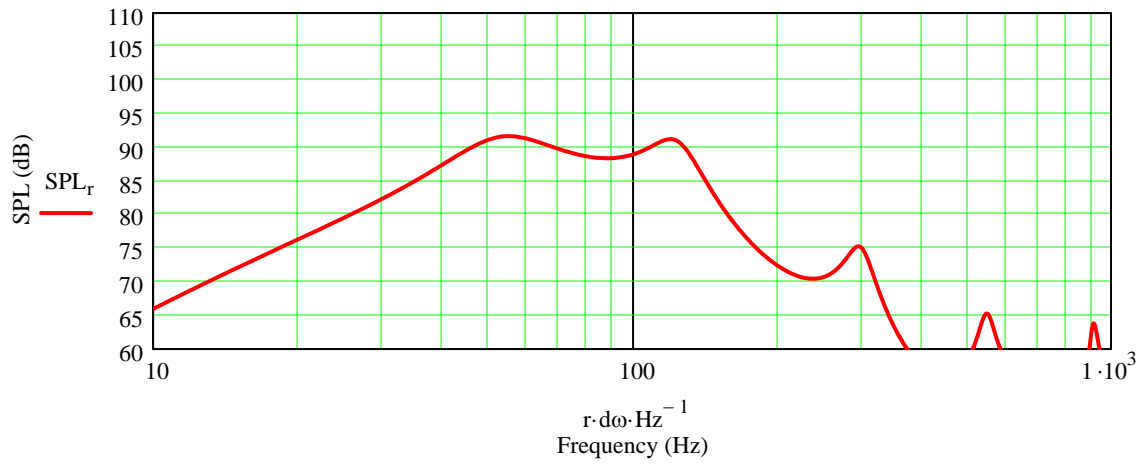
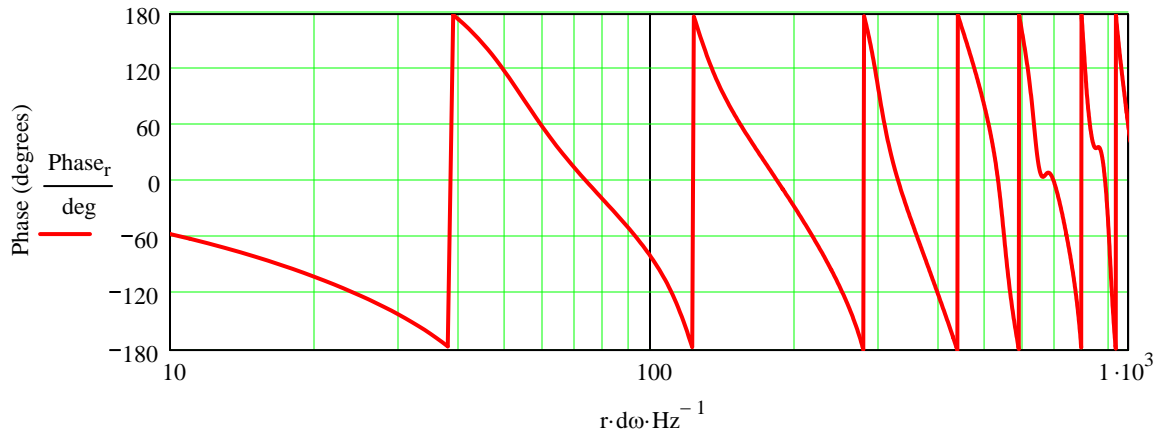


### Plotted Baffle Step and Reflection SPL Response for the Circular Driver Source

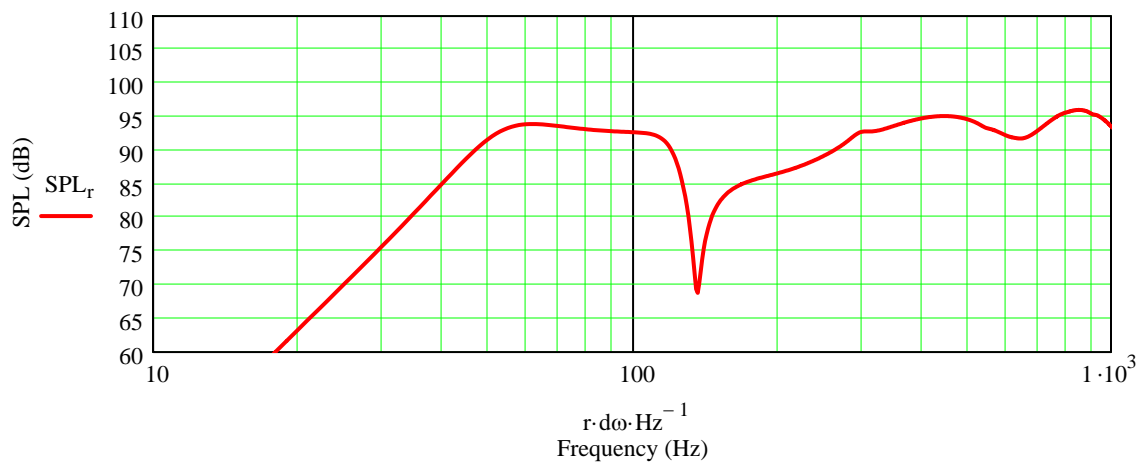
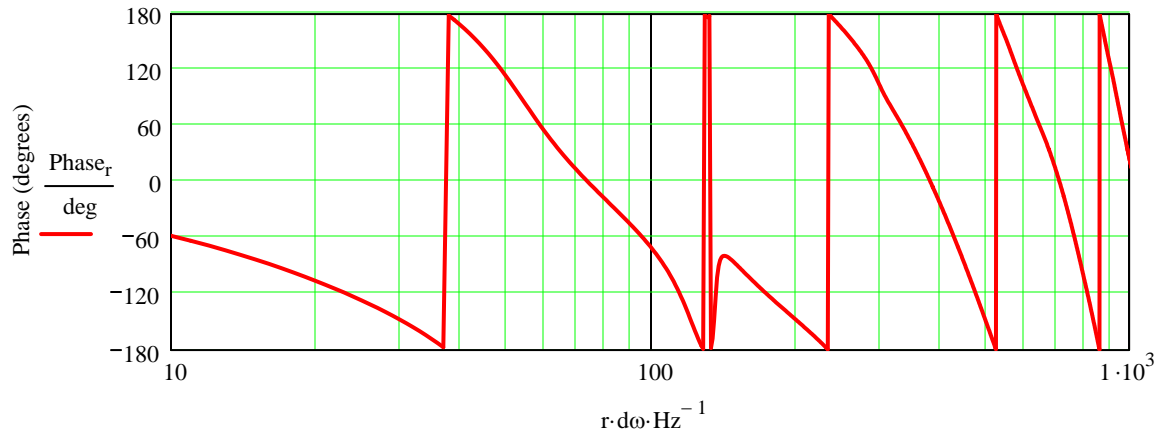




### Plotted Baffle Step and Reflection SPL Response for the Circular Port Source



### 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.

$f_{\text{center}} := 350 \cdot \text{Hz}$  <--- Input Center Frequency

$\text{dB} := 2$  <--- Input dB of Attenuation

Calculated Component Values

User Assigned Component Values  
Based on Calculated Values at Left

$$R_e \cdot \left( 10^{\frac{\text{dB}}{20}} - 1 \right) = 1.743 \Omega$$

Parallel Resistor

Input Value --->

$$R_{\text{parallel}} := 2 \cdot \Omega$$

$$\frac{R_{\text{parallel}}}{f_{\text{center}}} = 0.909 \text{ mH}$$

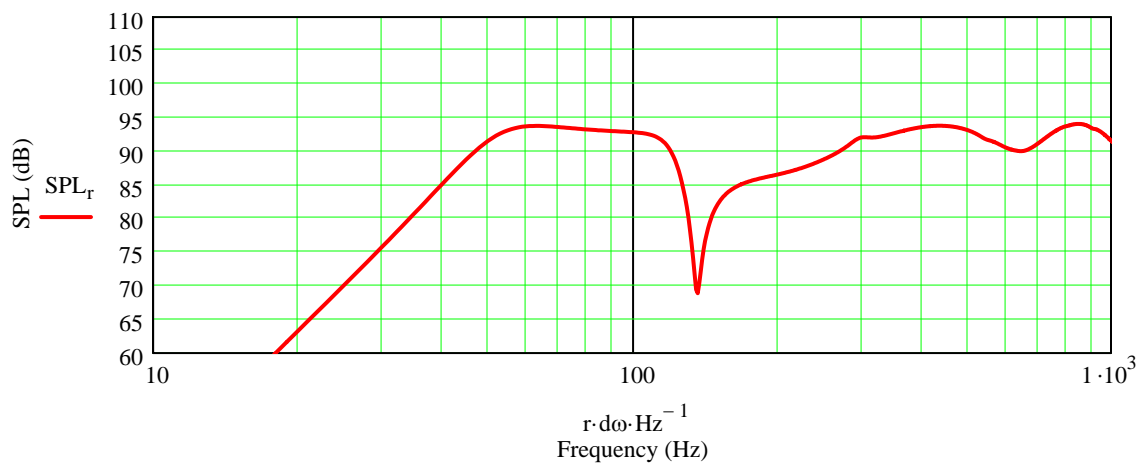
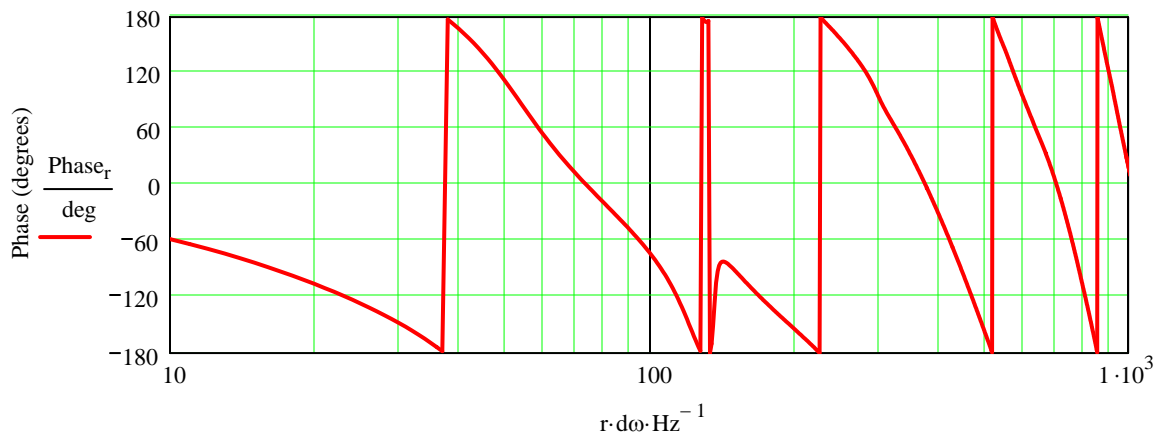
BSC Inductor

Input Value --->

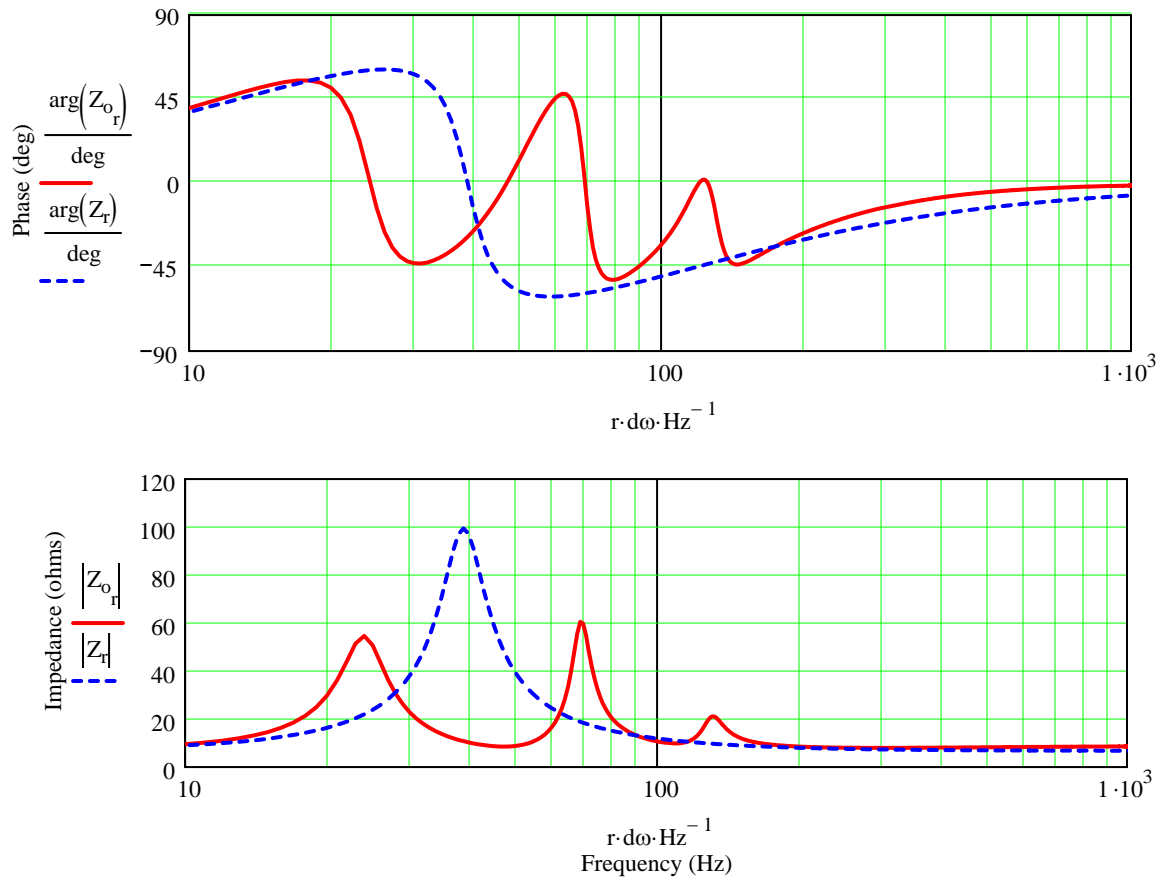
$$L_{\text{BSC}} := 1 \cdot \text{mH}$$



### Plotted Corrected SPL Response for the System



## Ported Box Corrected System and Infinite Baffle Impedance



## System Time Response for an Impulse Input

