



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

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Line Configuration : Near End Closed -> Offset Driver -> Far End Open.

Unit and Constant Definition

cycle := 2·π·rad

Hz := cycle·sec⁻¹

Air Density : ρ := 1.205·kg·m⁻³

Speed of Sound : c := 344·m·sec⁻¹



Part 1 : Thiele-Small Consistent Calculation

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

Series Resistance

R_{add} := 0.0·Ω

Driver Thiele / Small Parameters : Focal 8V 4412 Average Driver in Final TL Enclosure

f_d := 33.7·Hz

V_{ad} := 66.9·liter

Adjustments

R_e := 7.7·Ω

Q_{ed} := 0.44

R_e := R_e + R_{add}

L_{vc} := 0.9·mH

Q_{md} := 2.57

Q_{ed} := Q_{ed}·R_e·(R_e - R_{add})⁻¹

Bl := 9.2· $\frac{\text{newton}}{\text{amp}}$

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

S_d := 221.7·cm²

Q_{td} = 0.376

Power := 1·watt

(Input Power) Applied Voltage Reference ---> R_{ref} := 8·Ω

Enclosure Geometry Definition

Reference : Derivation and Correlation of a Viscous Damping Model Used in the Design of a Transmission Line Loudspeaker System

by Martin J. King, 3/04/01

The following dimension were derived from "Figure 18 : Cabinet Construction Details and Dimensions (inches)" of the referenced article. This is the most accurate model for the Focal 8V 4412 two-way transmission line enclosure. All of the required input data has been entered below directly into the Geometry Definition section of the worksheet. No variable definitions have been used to describe the enclosure geometry.

Transmission Line Definition (0 lb/ft³ < D < 1 lb/ft³)

n_closed := 4 (n_closed > 1)

n_open := 9 (n_open > 1)

Geometry Definition

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

Section Length	Initial Area	Final Area	Stuffing Density
L _{c0} := 1·in	S _{c0,0} := 3·S _d	S _{c0,1} := 3·S _d	D _{c0} := 0.4875·lb·ft ⁻³
L _{c1} := 1·in	S _{c1,0} := 3·S _d	S _{c1,1} := 3·S _d	D _{c1} := 0.4875·lb·ft ⁻³
L _{c2} := 2·in	S _{c2,0} := 3·S _d	S _{c2,1} := 3·S _d	D _{c2} := 0.4875·lb·ft ⁻³
L _{c3} := 1·in	S _{c3,0} := 3·S _d	S _{c3,1} := 3·S _d	D _{c3} := 0.4875·lb·ft ⁻³
L _{c4} := 1·in	S _{c4,0} := 3·S _d	S _{c4,1} := 3·S _d	D _{c4} := 0.4875·lb·ft ⁻³

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

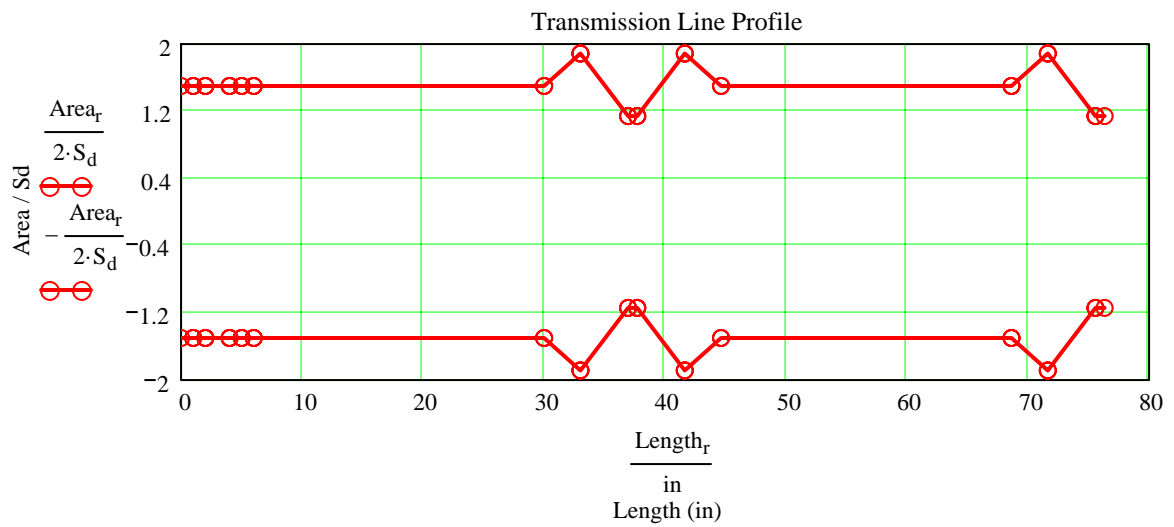
Section Length	Initial Area	Final Area	Stuffing Density
L _{o0} := 24·in	S _{o0,0} := 3·S _d	S _{o0,1} := 3·S _d	D _{o0} := 0.4875·lb·ft ⁻³
L _{o1} := 3·in	S _{o1,0} := 3·S _d	S _{o1,1} := 3.7715·S _d	D _{o1} := 0.4875·lb·ft ⁻³
L _{o2} := 3.9375·in	S _{o2,0} := 3.7715·S _d	S _{o2,1} := 2.2857·S _d	D _{o2} := 0.4875·lb·ft ⁻³
L _{o3} := 0.75·in	S _{o3,0} := 2.2857·S _d	S _{o3,1} := 2.2857·S _d	D _{o3} := 0.4875·lb·ft ⁻³
L _{o4} := 3.9375·in	S _{o4,0} := 2.2857·S _d	S _{o4,1} := 3.7715·S _d	D _{o4} := 0.4875·lb·ft ⁻³
L _{o5} := 3·in	S _{o5,0} := 3.7715·S _d	S _{o5,1} := 3·S _d	D _{o5} := 0.4875·lb·ft ⁻³
L _{o6} := 24·in	S _{o6,0} := 3·S _d	S _{o6,1} := 3·S _d	D _{o6} := 0.4875·lb·ft ⁻³
L _{o7} := 3·in	S _{o7,0} := 3·S _d	S _{o7,1} := 3.7715·S _d	D _{o7} := 0.4875·lb·ft ⁻³
L _{o8} := 3.9375·in	S _{o8,0} := 3.7715·S _d	S _{o8,1} := 2.2857·S _d	D _{o8} := 0.4875·lb·ft ⁻³
L _{o9} := 0.75·in	S _{o9,0} := 2.2857·S _d	S _{o9,1} := 2.2857·S _d	D _{o9} := 0.0000·lb·ft ⁻³

Total Length of the Transmission Line

$$\sum_{i=0}^{n_{\text{closed}}} L_{c_i} + \sum_{i=0}^{n_{\text{open}}} L_{o_i} = 76.313 \text{ in}$$

Total Amount of Stuffing

$$\sum_{r=0}^{n_{\text{closed}}} \left(\frac{S_{c_{r,0}} + S_{c_{r,1}}}{2} \cdot L_{c_r} \cdot D_{c_r} \right) + \sum_{r=0}^{n_{\text{open}}} \left(\frac{S_{o_{r,0}} + S_{o_{r,1}}}{2} \cdot L_{o_r} \cdot D_{o_r} \right) = 2.229 \text{ lb}$$

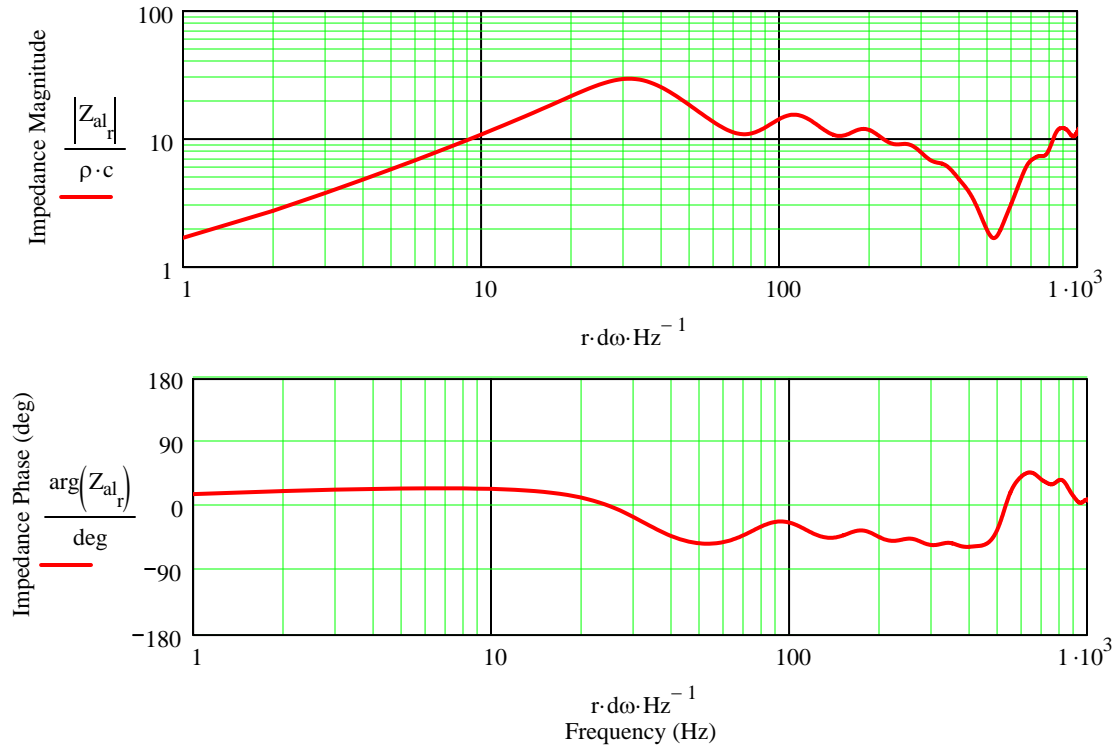


End of Detailed Input

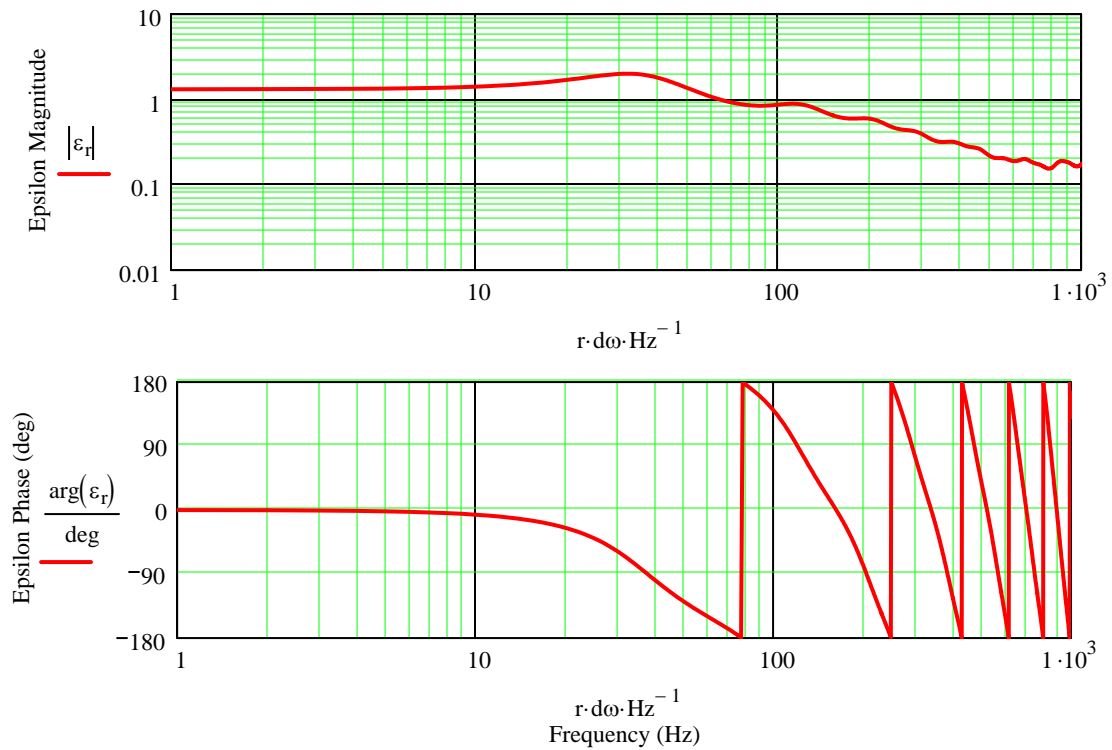
End of Part 1 Input



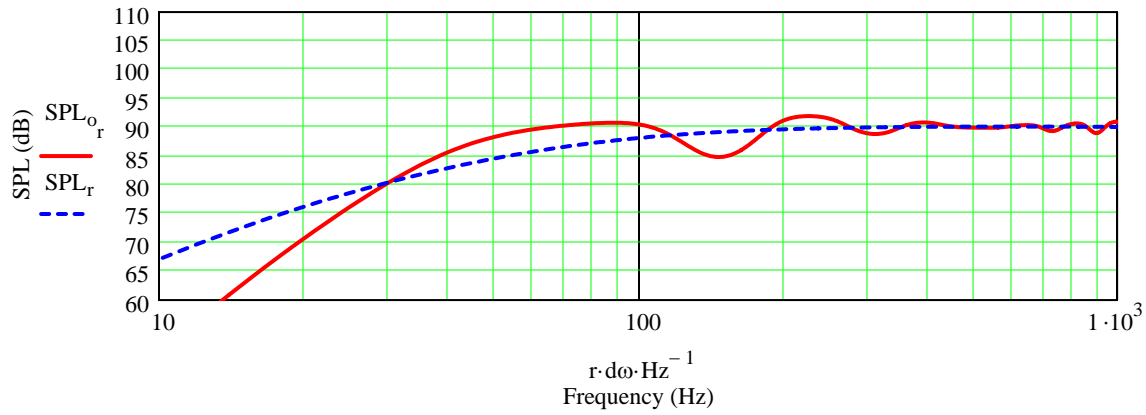
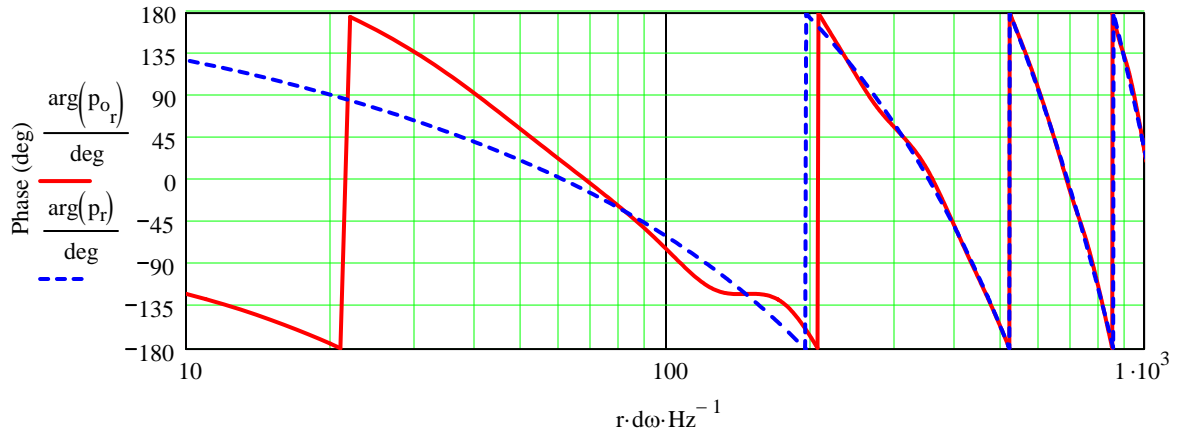
Resulting Acoustic Impedance for the Transmission Line



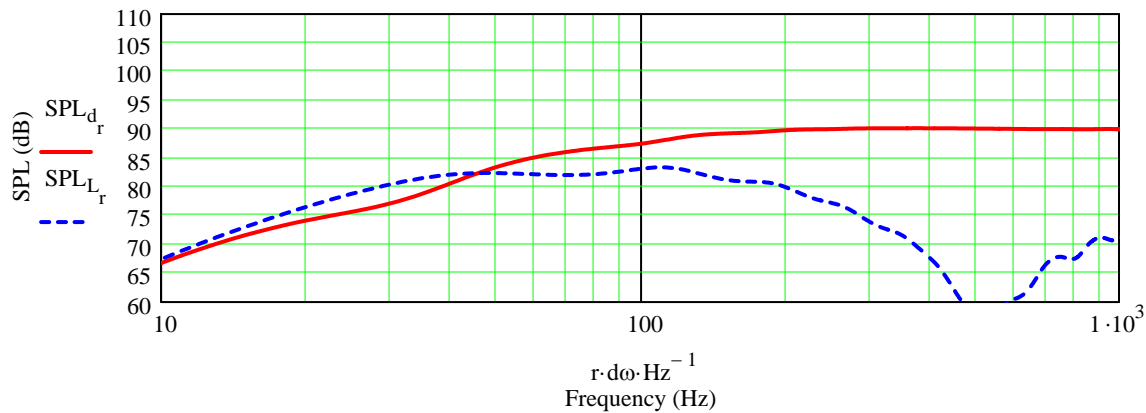
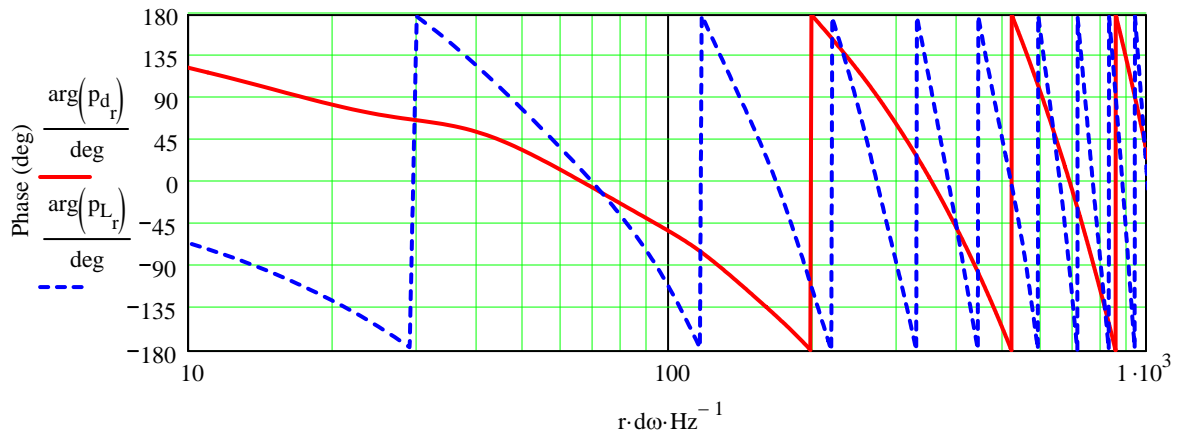
Velocity at the Terminus of the Transmission Line for a 1 m/sec Excitation at the Driver



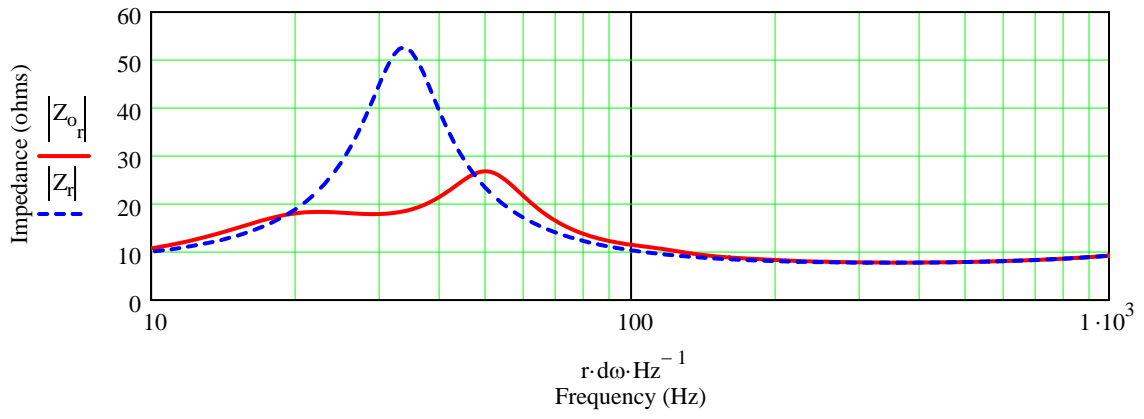
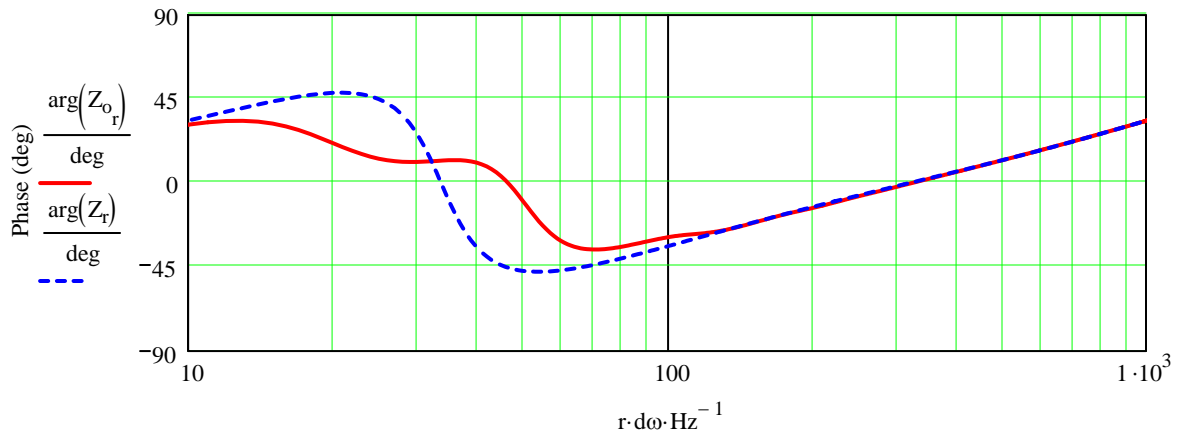
Far Field Transmission Line System and Infinite Baffle Sound Pressure Level Responses



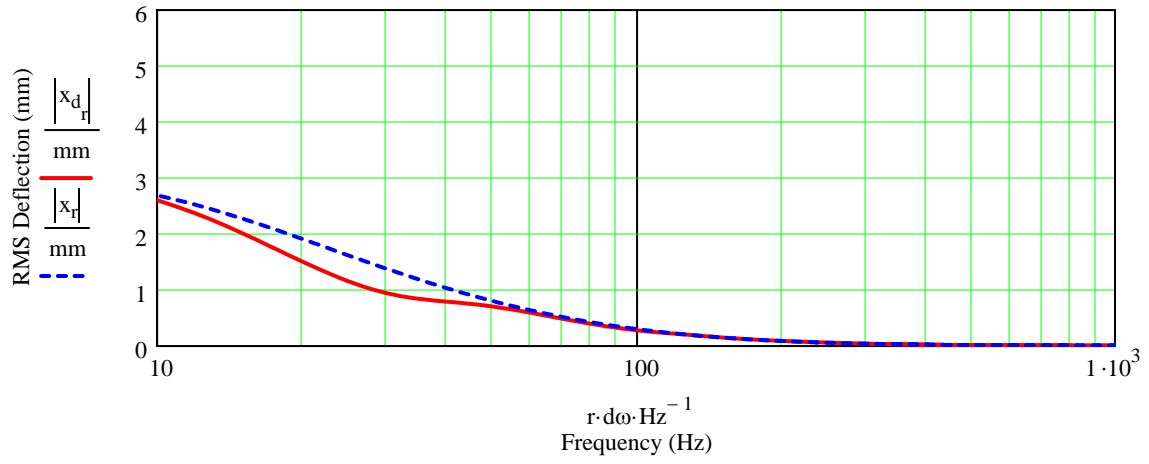
Woofer and Terminus Far Field Sound Pressure Level Responses



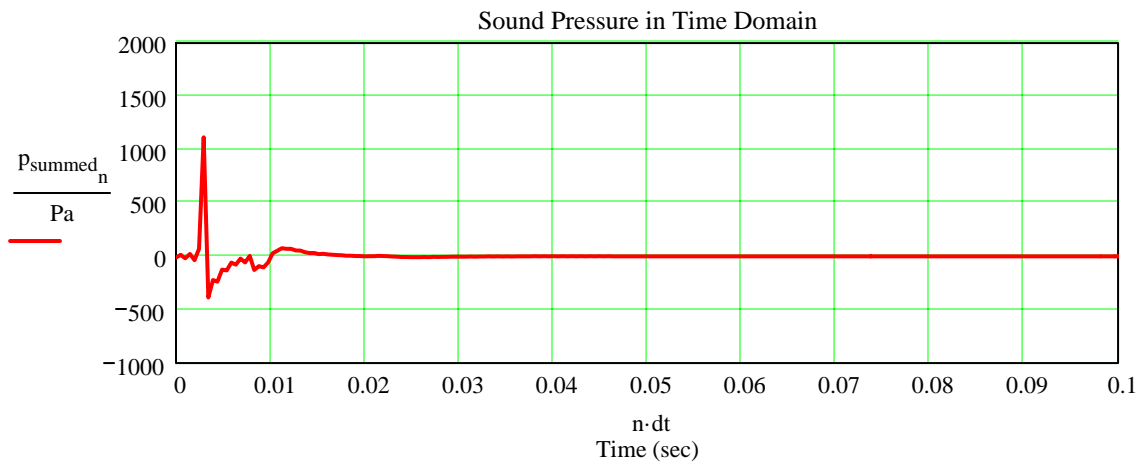
Transmission Line System and Infinite Baffle Impedance



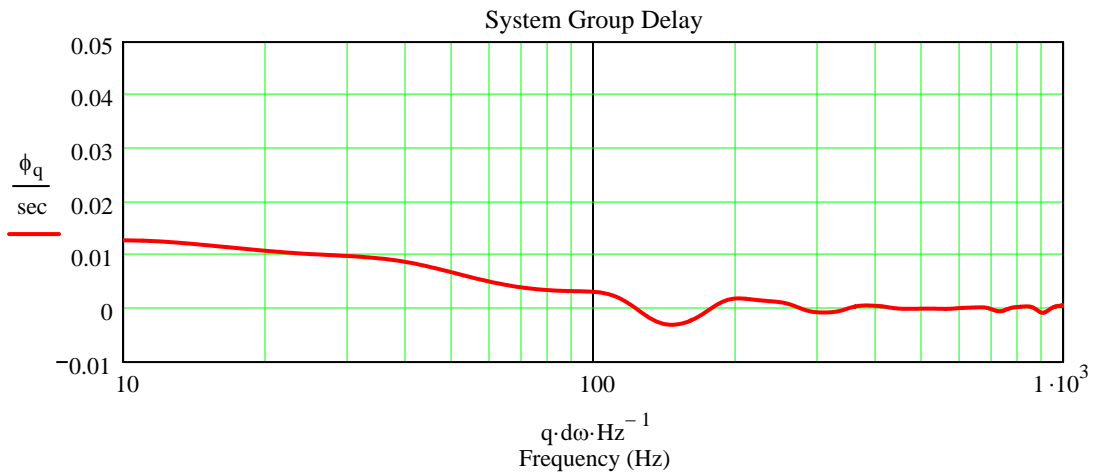
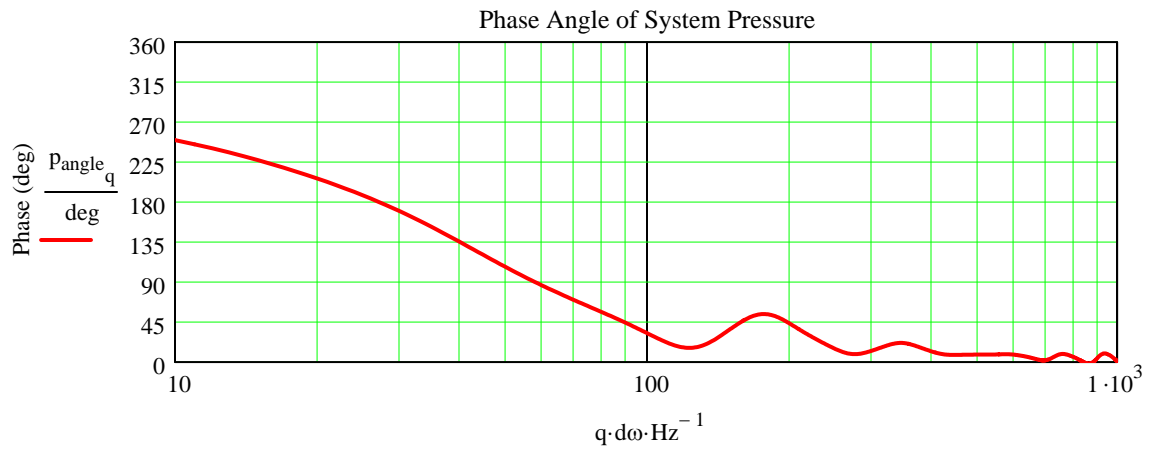
Woofer RMS Displacement



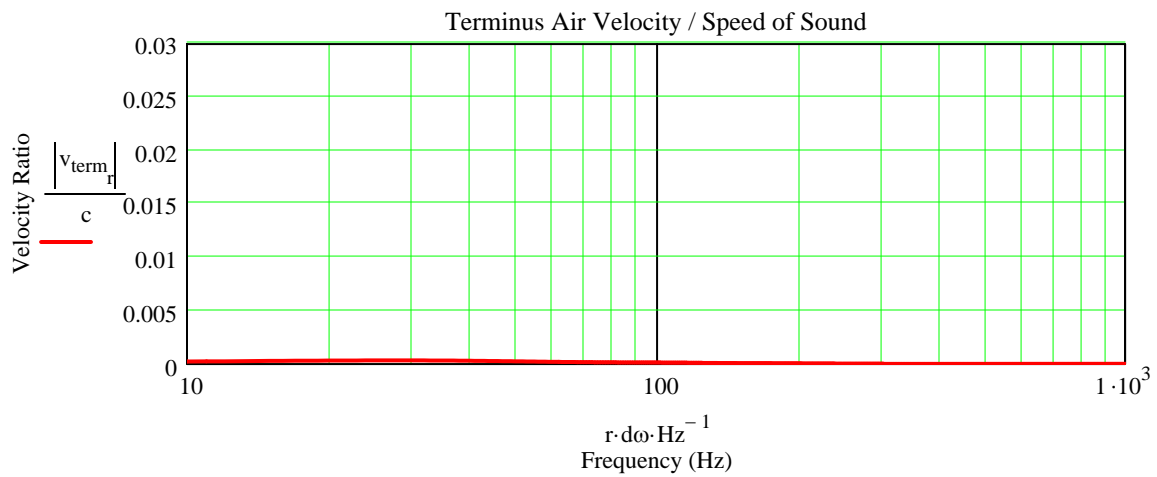
System Time Response for an Impulse Input



System Group Delay



Terminus 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 Terminus on the Baffle.
- Baffle Step Defraction for the Driver and the Terminus.
- Room Reflections for the Driver and the Terminus.

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

- $X_0 := 2.5\text{-ft}$ (Front Baffle Distance from Rear Wall > Depth of Enclosure)
- $Y_0 := 2\text{-ft}$ (Front Baffle Distance from Side Wall)
- $\theta_0 := 45\text{-deg}$ (Rotation Towards Room Center)
- $Z_0 := 8\text{-ft}$ (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 | |
|---------------------------|-----------------------------|-----------------------|
| $y_{o_0} := 15\text{-in}$ | | (Bottom Right Corner) |
| $y_{o_1} := 15\text{-in}$ | $z_{o_1} := 37.5\text{-in}$ | (Top Right Corner) |
| $y_{o_2} := 0\text{-in}$ | $z_{o_2} := 37.5\text{-in}$ | (Top Left Corner) |
| $y_{o_3} := 0\text{-in}$ | | (Bottom Left Corner) |
| depth := 18·in | | (Depth of Enclosure) |

Driver Geometry Input

$y_{dc} := 5.5625 \cdot \text{in}$ (Driver Center y Coordinate)
 $z_{dc} := 30.75 \cdot \text{in}$ (Driver Center z Coordinate)
 $n_{dvr} := 5$ (Number of Points Across Diameter)

Terminus Geometry Input

$y_{mc} := 7.5 \cdot \text{in}$ (Terminus Center y Coordinate)
 $z_{mc} := 33.75 \cdot \text{in}$ (Terminus Center z Coordinate)
 $w_{mth} := 13.5 \cdot \text{in}$ (Terminus Width)
 $n_{mth} := 10$ (Number of Points Across the Width)
 $Locate := 1$ (0 = Front Baffle Terminus, 1 = Rear Baffle Terminus)

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, $-80 \text{ deg} < \theta < 80 \text{ deg}$)
 $z_p := z_{dc} + \text{stand}$ (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

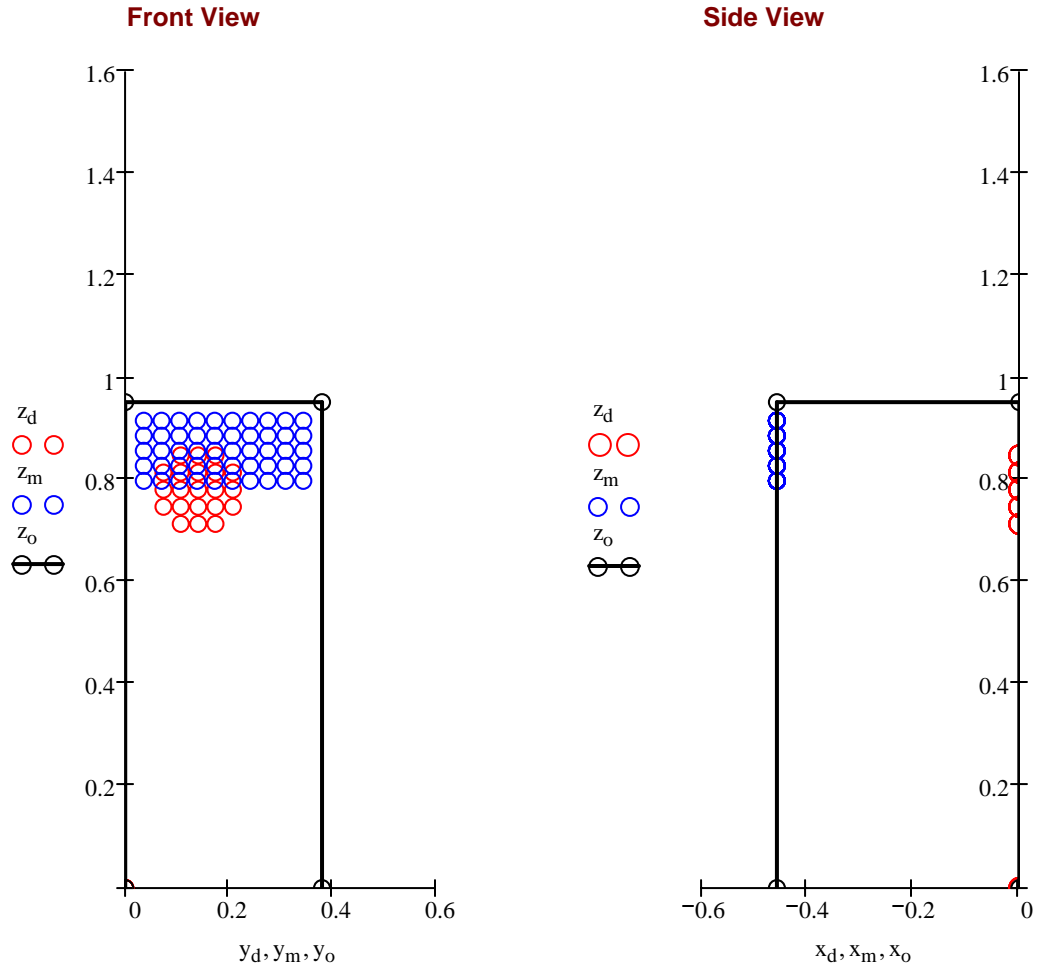
$Reflect := 1$ (0 = hardwood or concrete, 1 = carpeted)

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

$Inc_{floor} := 1$ (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 TL Terminus Simple Source Pattern with Baffle Edge Outline



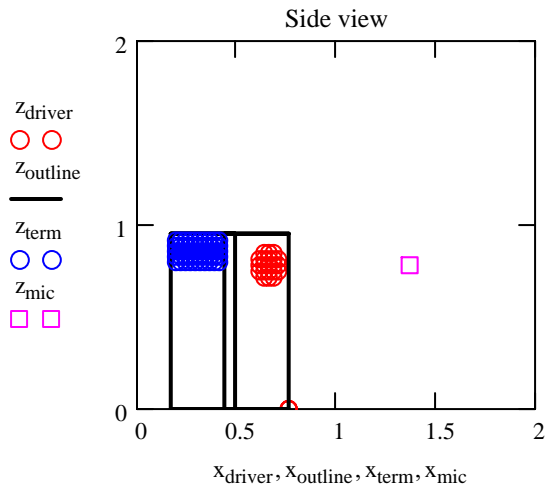
Red sources represent the driver.
Blue sources represent the terminus.
Black outline represents the baffle edge.
Origin is at the bottom front left corner of the enclosure.



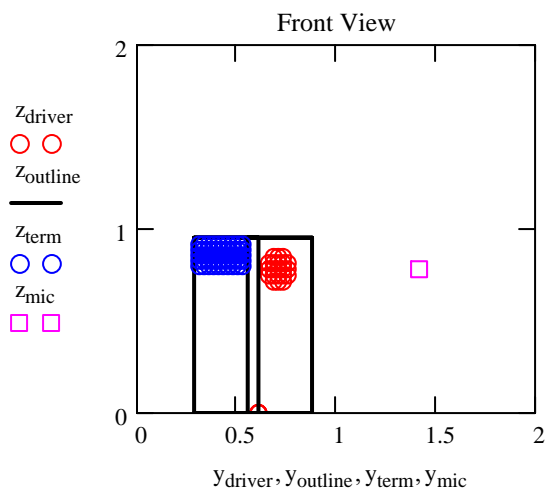
Three Dimensional View

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

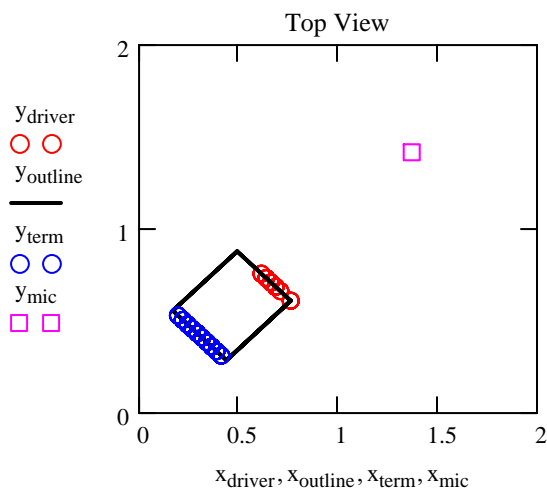
Room Corner is the Origin



Side View - looking out from side wall



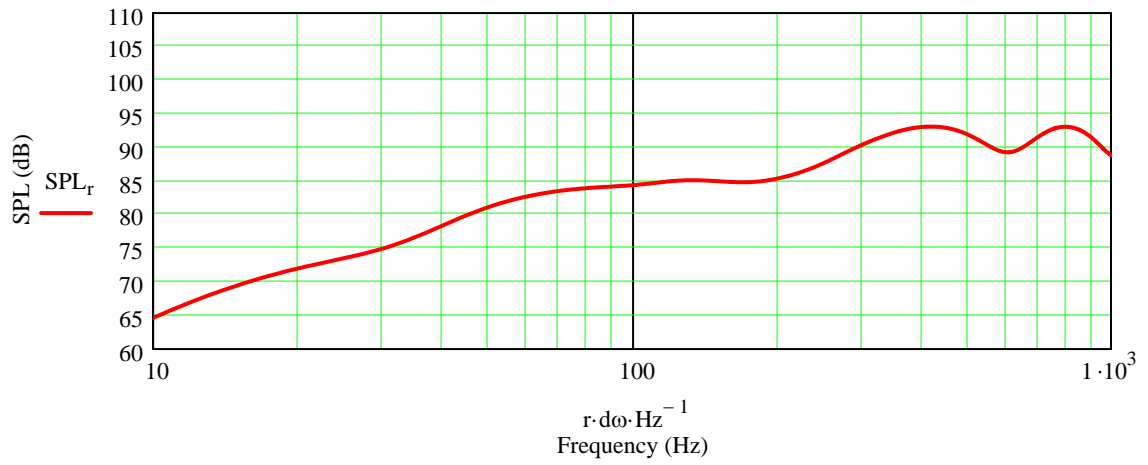
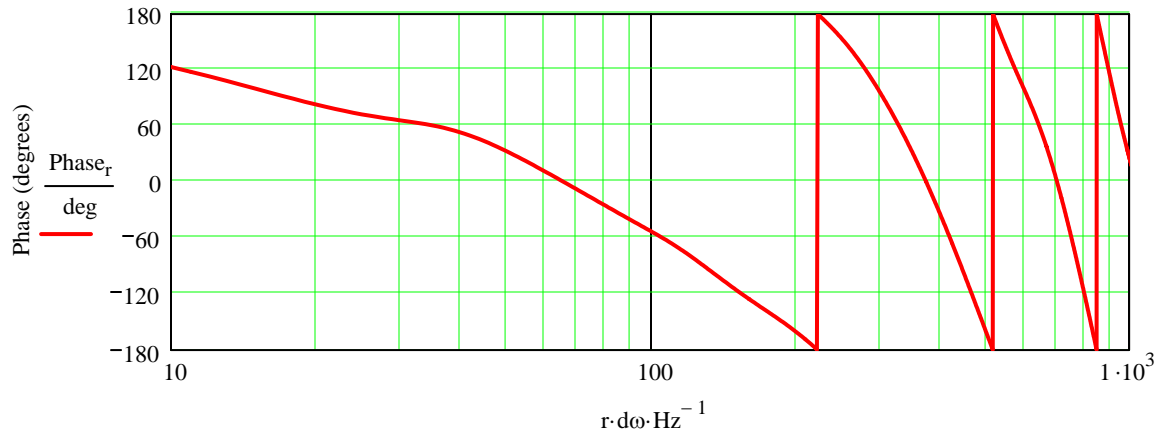
Front View - looking towards rear wall



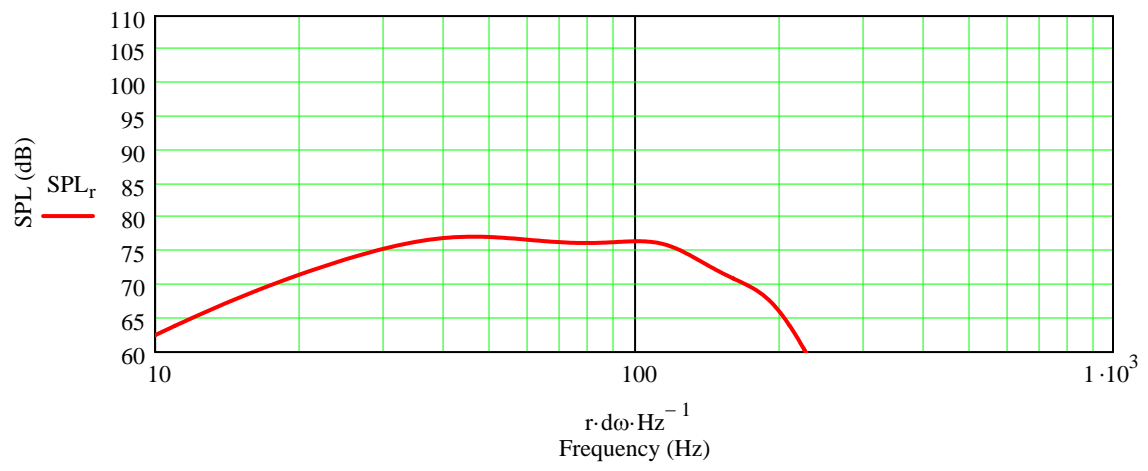
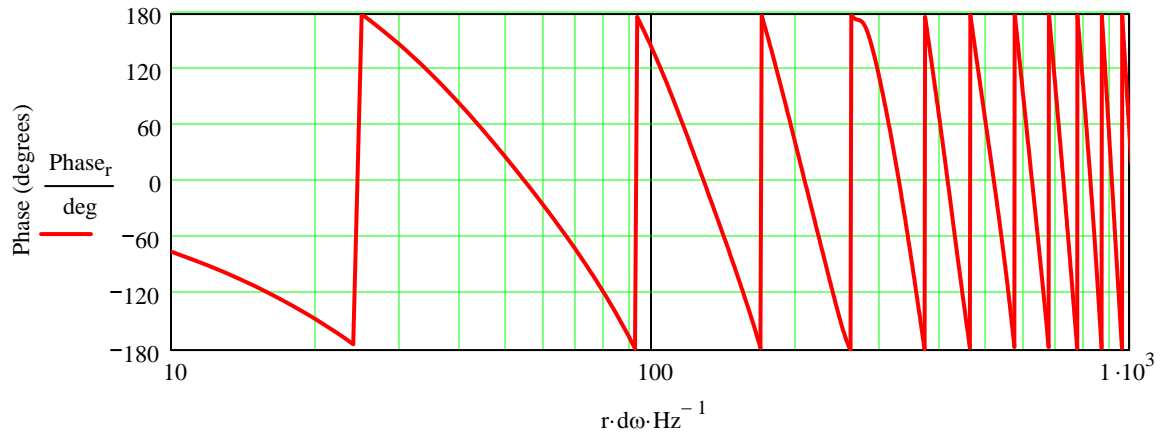
Top View - looking down from ceiling



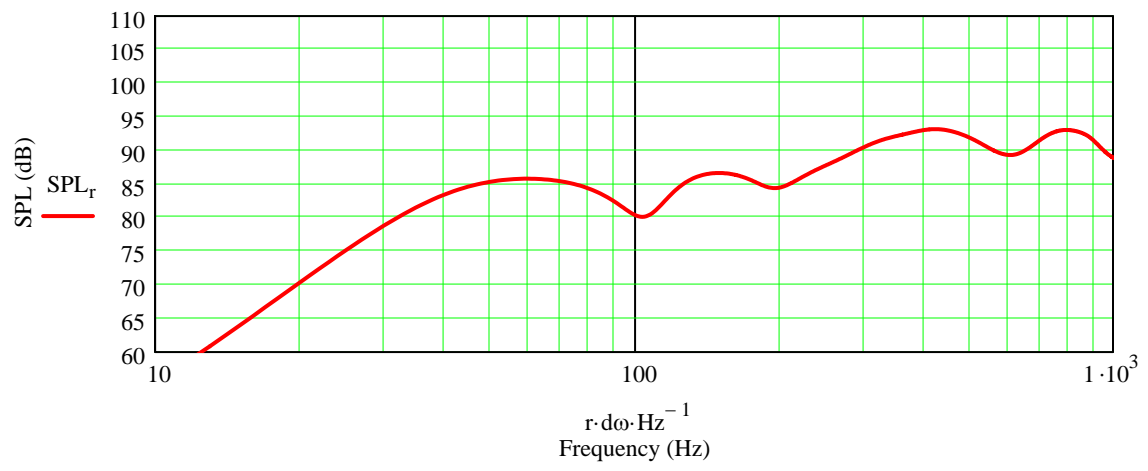
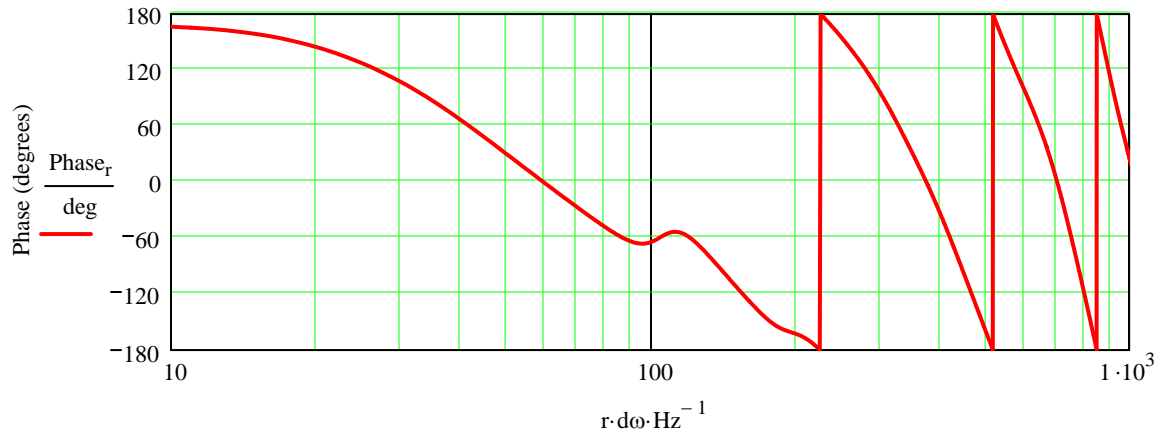
Plotted Baffle Step and Reflection SPL Response for the Circular Driver Source



Plotted Baffle Step and Reflection SPL Response for the TL Terminus



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.

$f_{\text{center}} := 400 \cdot \text{Hz}$ <--- Input Center Frequency

$\text{dB} := 6$ <--- Input dB of Attenuation

Calculated Component Values

User Assigned Component Values
Based on Calculated Values at Left

$$R_e \cdot \left(10^{\frac{\text{dB}}{20}} - 1 \right) = 7.664 \Omega$$

Parallel Resistor

Input Value --->

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

$$\frac{R_{\text{parallel}}}{f_{\text{center}}} = 3.183 \text{ mH}$$

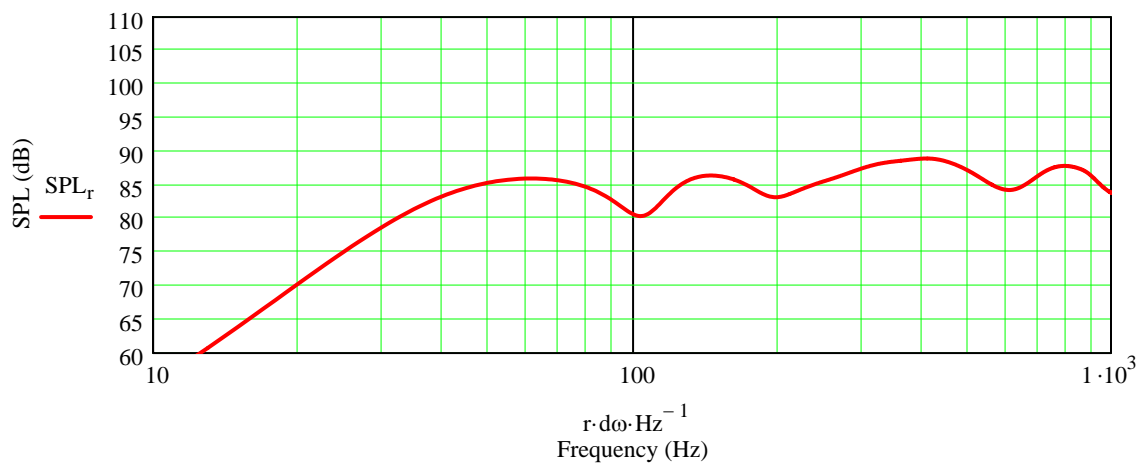
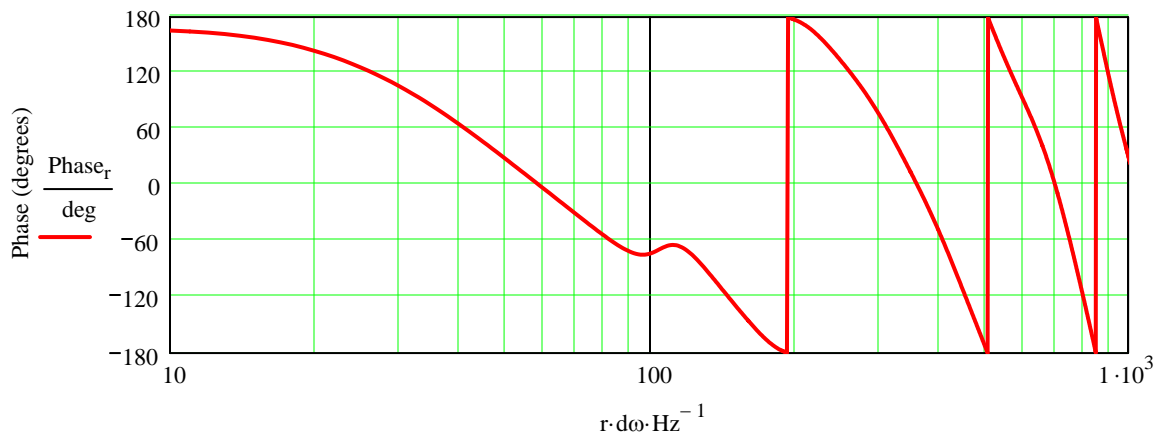
BSC Inductor

Input Value --->

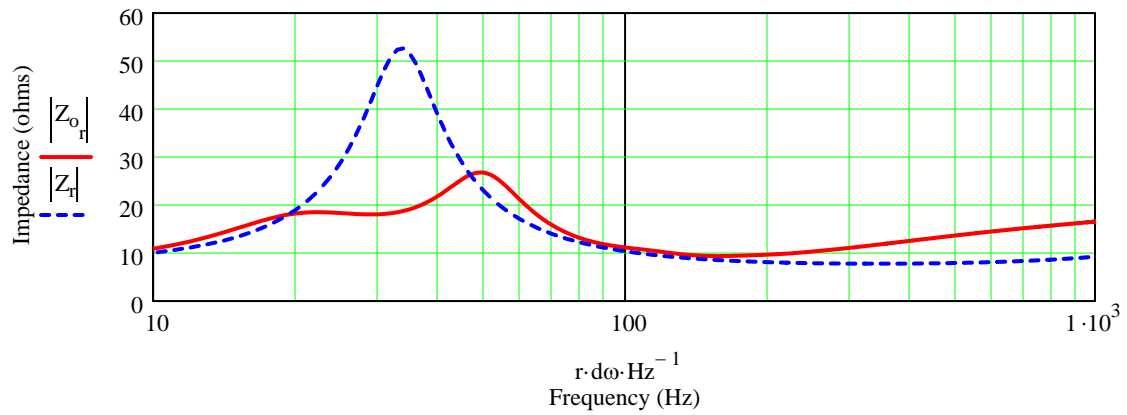
$$L_{\text{BSC}} := 3 \cdot \text{mH}$$



Plotted Corrected SPL Response for the System



Transmission Line Corrected System and Infinite Baffle Impedance



System Time Response for an Impulse Input

