



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 : Alpair 10 Properties

f_d := 40 · Hz

V_{ad} := 19.5 · liter

Adjustments

R_e := 5.4 · Ω

Q_{ed} := 0.39

R_e := R_e + R_{add}

L_{vc} := 70.23 · 10⁻³ · mH

Q_{md} := 2.24

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

Bl := 5.83 · $\frac{\text{newton}}{\text{amp}}$

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

S_d := 90 · cm²

Q_{td} = 0.332

Power := 1 · watt

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

Enclosure Geometry Definition - Half of the Enclosure (model only top half of coupling chamber)

Coupling Chamber Geometry

$L := 13 \cdot \text{in}$	(Length)
$\xi := 0.999$	(Driver Position Ratio : $0.001 < \xi < 0.999$)
$S_0 := 2.75 \cdot 8 \cdot \text{in}^2$	(Area of the Closed End : $S_0 > 0 \text{ m}^2$)
$S_L := 2.75 \cdot 8 \cdot \text{in}^2$	(Area of the Throat End : $S_L > 0 \text{ m}^2$)
Density := $0.5 \cdot \text{lb} \cdot \text{ft}^{-3}$	(Stuffing density : $0 \text{ lb/ft}^3 < D < 1 \text{ lb/ft}^3$)

Horn Geometry

$L_{\text{horn}} := 77.75 \cdot \text{in}$	(Length of Horn)
type := 0	(Horn Type : 0 = linear, 1 = conical, 2 = hyperbolic - exponential)
$S_{\text{throat}} := 0.5 \cdot S_d$	(Throat Area)
$S_{\text{throat}} = 7.0 \text{ in}^2$	
Input Directly for Type = 0 or 1	(Input value for Type = 2 from below)
$S_{\text{mouth}} := 5.000 \cdot S_d$	<---- Insert Mouth Area
$S_{\text{mouth}} = 69.8 \text{ in}^2$	
Input Calculation for Type = 2	(Ignored for Horn Type = 0 or 1)
$M := 1$	($M > 0$, $M = 1$ for pure exponential flare)
$f_0 := 31.925 \cdot \text{Hz}$	<---- Horn Flare Cut-off Frequency, iterate to get desired S_{mouth}/S_d
$\gamma := \frac{2 \cdot f_0}{c}$	$\gamma = 1.166 \text{ m}^{-1}$ (note f_0 is automatically converted to rad/sec)

$$\frac{S_{\text{throat}}}{S_d} \cdot \left(\cosh\left(\frac{\gamma}{2} \cdot L_{\text{horn}}\right) + M \cdot \sinh\left(\frac{\gamma}{2} \cdot L_{\text{horn}}\right) \right)^2 = 5.003 = S_{\text{mouth}} / S_d \text{ (insert above for throat area)}$$

End of Abbreviated User Input

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

BLH Enclosure Definition (0 lb/ft³ < D < 1 lb/ft³)

$$n_{\text{closed}} := 3 \quad (n_{\text{closed}} > 1)$$

$$n_{\text{open}} := 13 \quad (n_{\text{open}} > 1)$$

Coupling Chamber Geometry Definition

$$TR := (S_L - S_0) \cdot L^{-1} \quad TR = 0.000 \text{ m}$$

Closed End of Coupling Chamber (Driver ----> Closed End)

Section Length	Initial Area	Final Area	Stuffing Density
$L_{c_0} := 0.25 \cdot \xi \cdot L$	$S_{c_{0,0}} := S_0 + TR \cdot \xi \cdot L$	$S_{c_{0,1}} := S_{c_{0,0}} - TR \cdot L_{c_0}$	$D_{c_0} := \text{Density}$
$L_{c_1} := 0.25 \cdot \xi \cdot L$	$S_{c_{1,0}} := S_{c_{0,1}}$	$S_{c_{1,1}} := S_{c_{1,0}} - TR \cdot L_{c_1}$	$D_{c_1} := \text{Density}$
$L_{c_2} := 0.25 \cdot \xi \cdot L$	$S_{c_{2,0}} := S_{c_{1,1}}$	$S_{c_{2,1}} := S_{c_{2,0}} - TR \cdot L_{c_2}$	$D_{c_2} := \text{Density}$
$L_{c_3} := 0.25 \cdot \xi \cdot L$	$S_{c_{3,0}} := S_{c_{2,1}}$	$S_{c_{3,1}} := S_0$	$D_{c_3} := \text{Density}$

Open End of Coupling Chamber (Driver ----> Throat End)

Section Length	Initial Area	Final Area	Stuffing Density
$L_{o_0} := 0.25 \cdot (1 - \xi) \cdot L$	$S_{o_{0,0}} := S_{c_{0,0}}$	$S_{o_{0,1}} := S_{o_{0,0}} + TR \cdot L_{o_0}$	$D_{o_0} := \text{Density}$
$L_{o_1} := 0.25 \cdot (1 - \xi) \cdot L$	$S_{o_{1,0}} := S_{o_{0,1}}$	$S_{o_{1,1}} := S_{o_{1,0}} + TR \cdot L_{o_1}$	$D_{o_1} := \text{Density}$
$L_{o_2} := 0.25 \cdot (1 - \xi) \cdot L$	$S_{o_{2,0}} := S_{o_{1,1}}$	$S_{o_{2,1}} := S_{o_{2,0}} + TR \cdot L_{o_2}$	$D_{o_2} := \text{Density}$
$L_{o_3} := 0.25 \cdot (1 - \xi) \cdot L$	$S_{o_{3,0}} := S_{o_{2,1}}$	$S_{o_{3,1}} := S_L$	$D_{o_3} := \text{Density}$

Horn Geometry Definition (Throat ----> Mouth)

$$\text{horn} := 0, 1 \dots 10$$

$$S_{0,\text{horn}} := S_{\text{throat}} + \frac{\text{horn}}{10} (S_{\text{mouth}} - S_{\text{throat}})$$

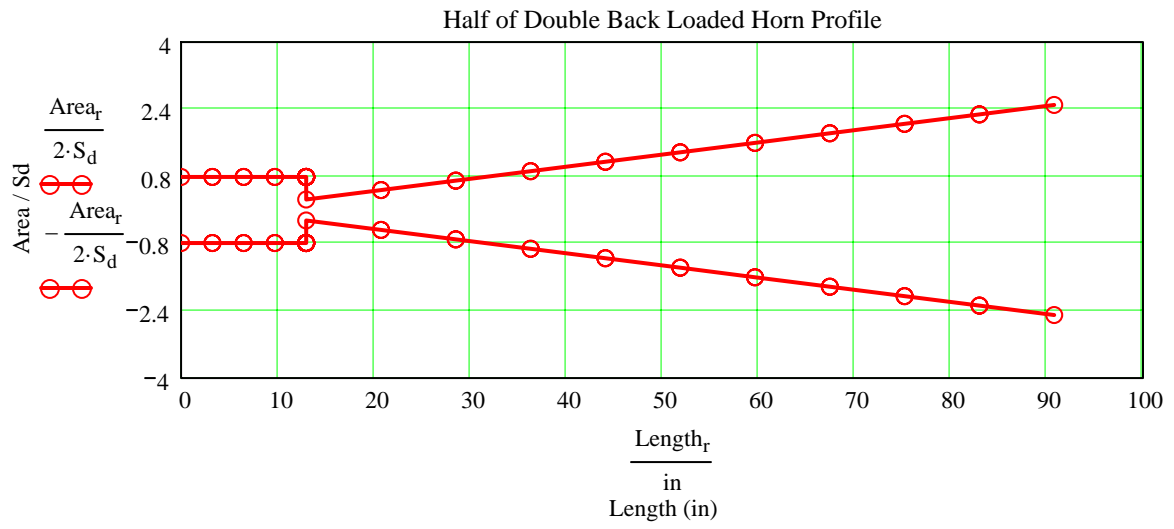
$$S_{1,\text{horn}} := \pi \cdot \left[\sqrt{\frac{S_{\text{throat}}}{\pi}} + \frac{\text{horn}}{10} \left(\sqrt{\frac{S_{\text{mouth}}}{\pi}} - \sqrt{\frac{S_{\text{throat}}}{\pi}} \right) \right]^2$$

$$S_{2,\text{horn}} := S_{\text{throat}} \cdot \left[\cosh \left[\frac{\gamma}{2} \cdot \left(\frac{\text{horn}}{10} \right) \cdot L_{\text{horn}} \right] + M \cdot \sinh \left[\frac{\gamma}{2} \cdot \left(\frac{\text{horn}}{10} \right) \cdot L_{\text{horn}} \right] \right]^2$$

$$\text{horn} := 0 \dots 9$$

$$L_{o_{4+\text{horn}}} := 0.1 \cdot L_{\text{horn}} \quad S_{o_{4+\text{horn},0}} := S_{\text{type, horn}}$$

$$D_{o_{4+\text{horn}}} := 0.25 \cdot \text{lb} \cdot \text{ft}^{-3} \quad S_{o_{4+\text{horn},1}} := S_{\text{type, horn}+1}$$

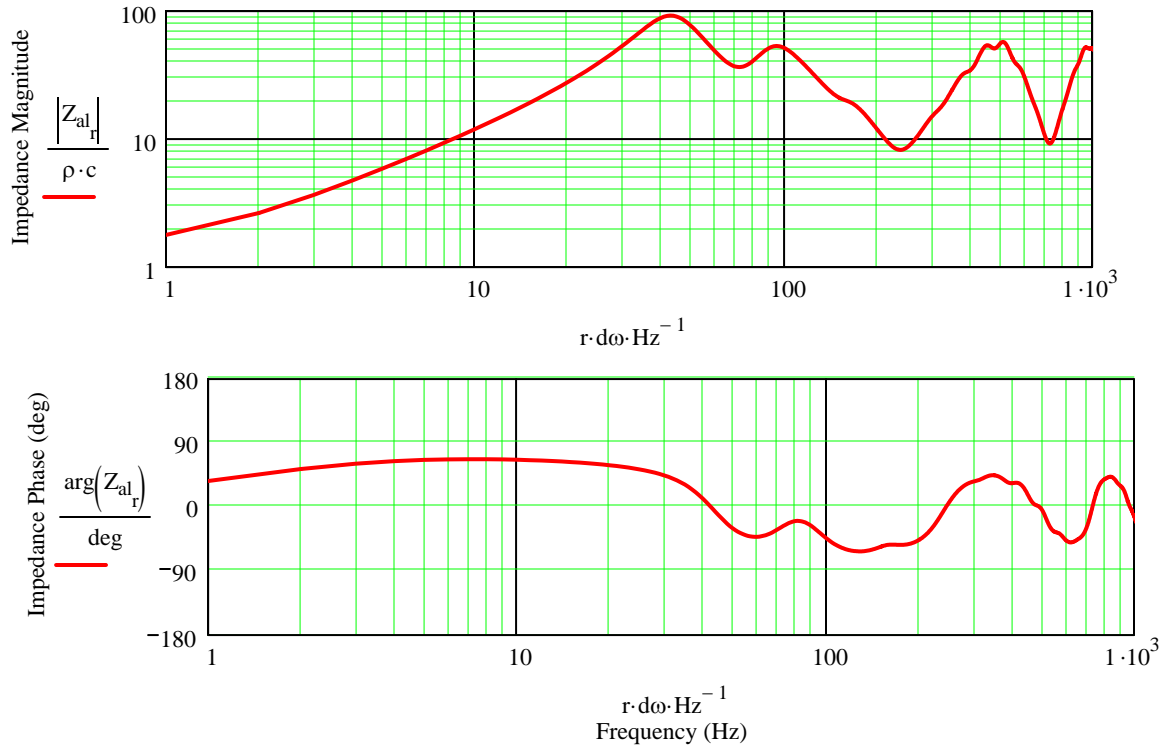


End of Detailed Input

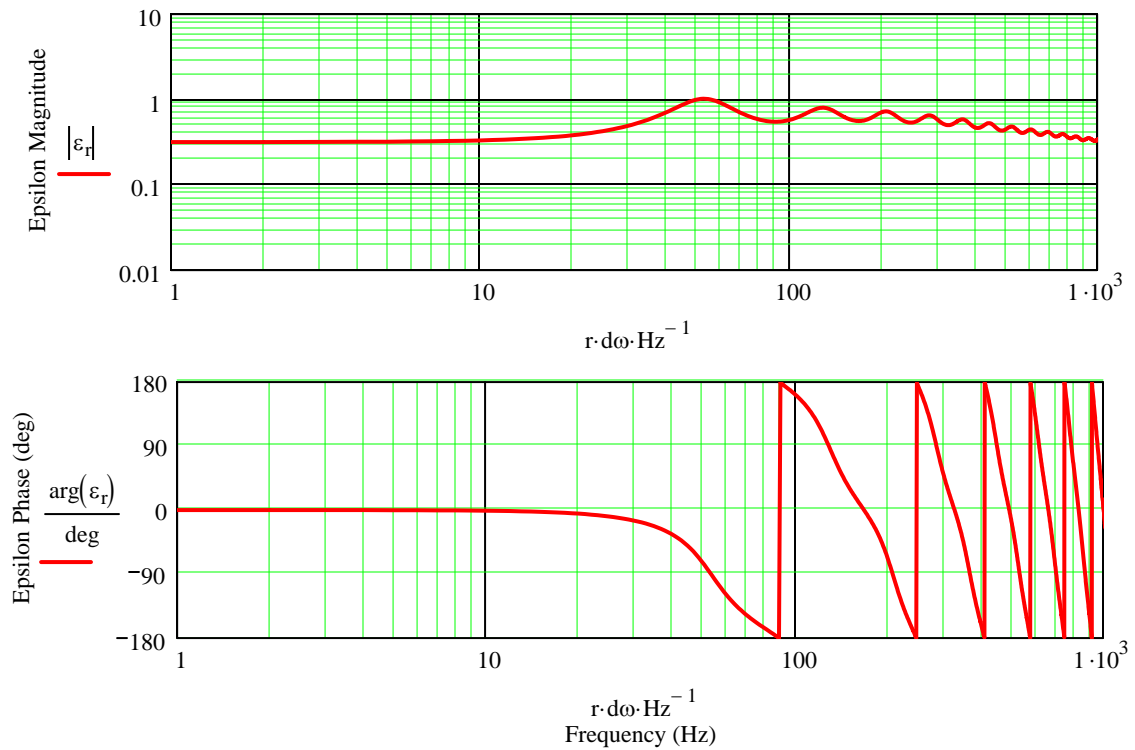
End of Part 1 Input



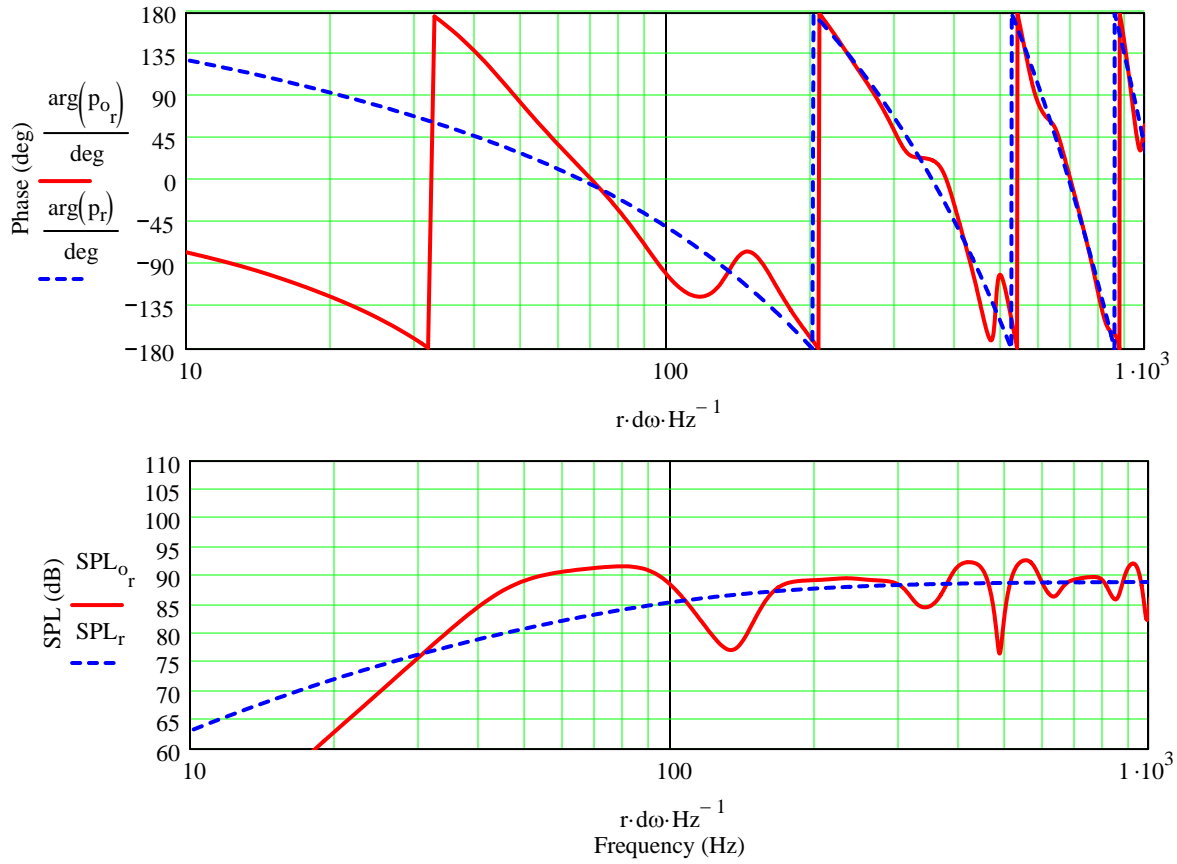
Resulting Acoustic Impedance for the Back Loaded Horn



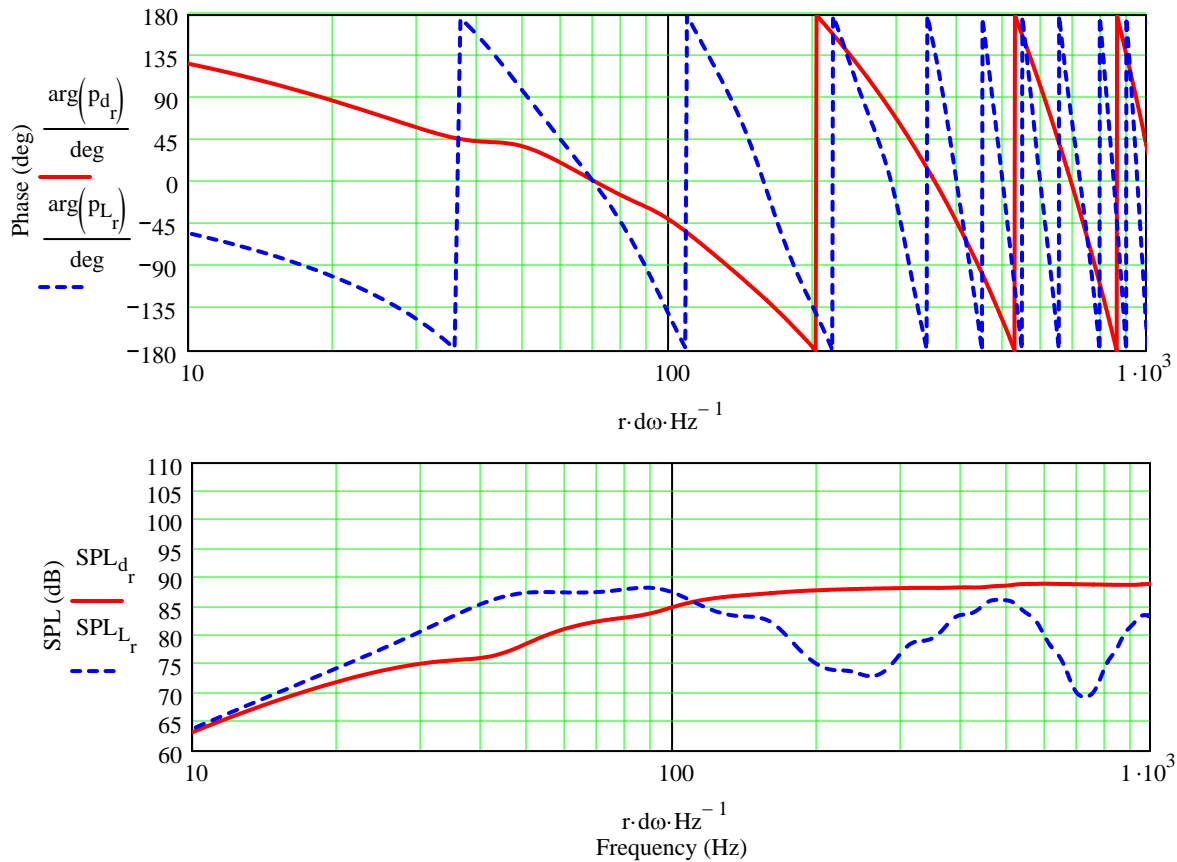
Velocity at the Terminus of the Back Loaded Horn for a 1 m/sec Excitation at the Driver



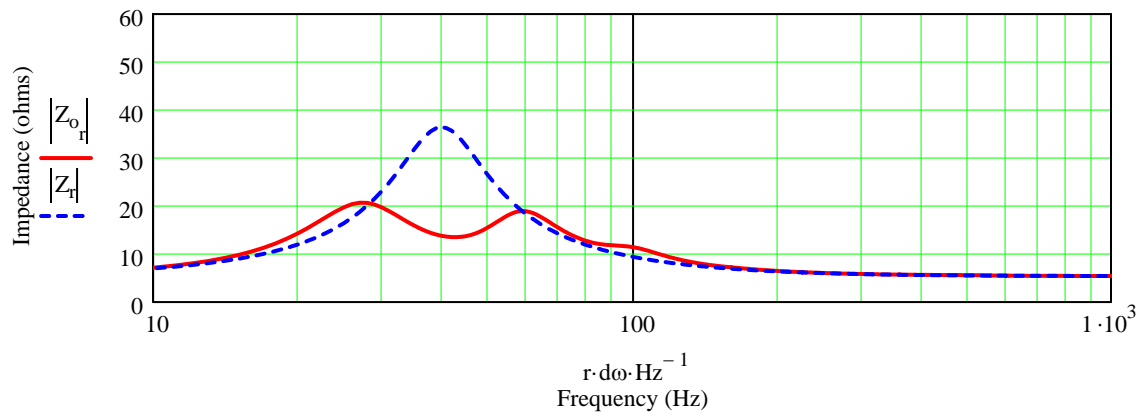
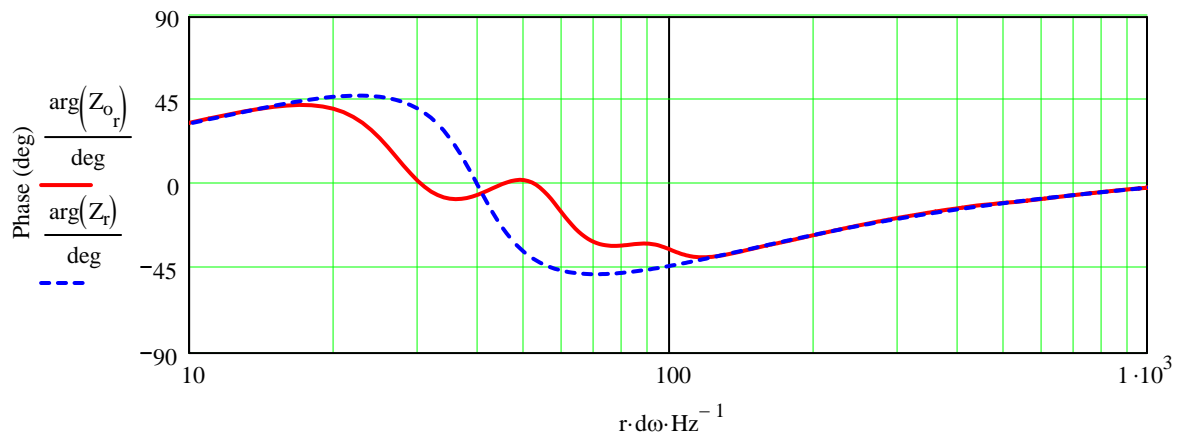
Far Field Back Loaded Horn System and Infinite Baffle Sound Pressure Level Responses



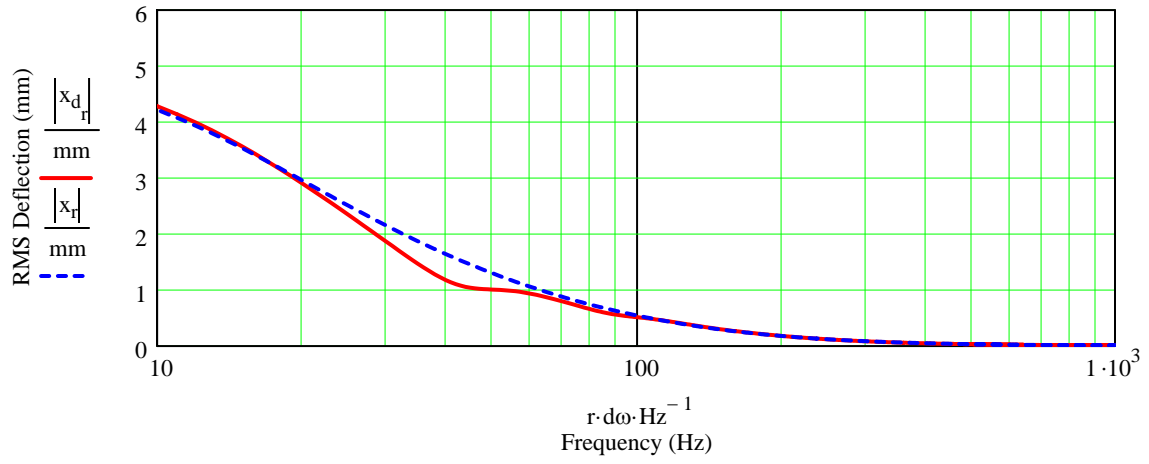
Woofer and Terminus Far Field Sound Pressure Level Responses



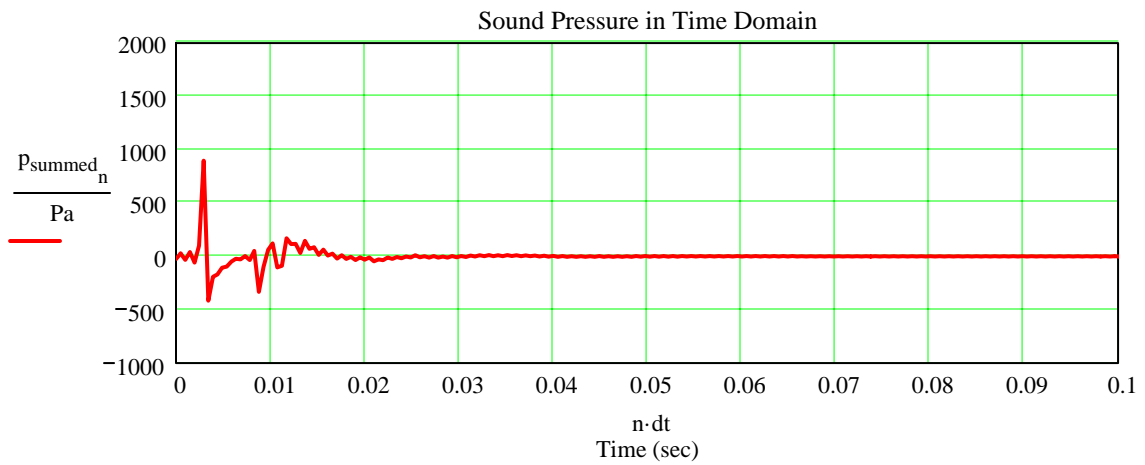
Back Loaded Horn System and Infinite Baffle Impedance



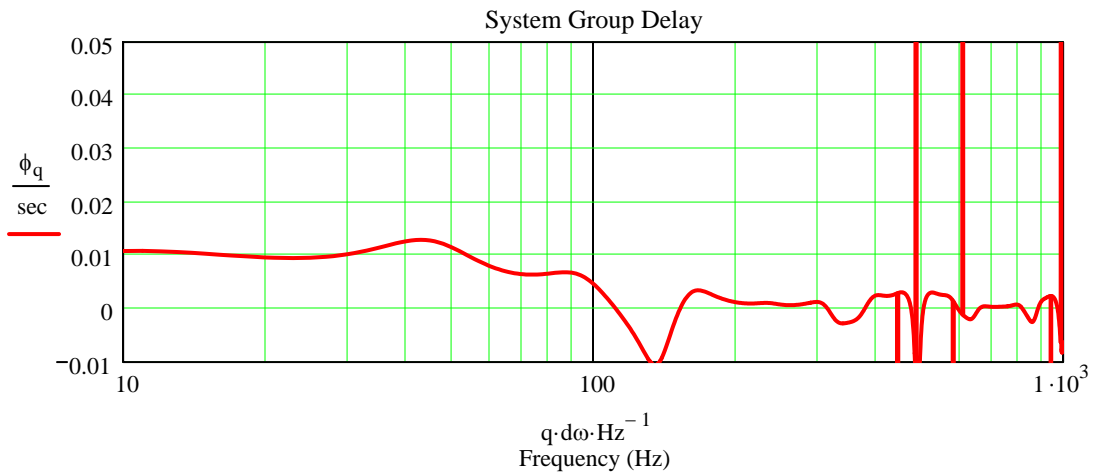
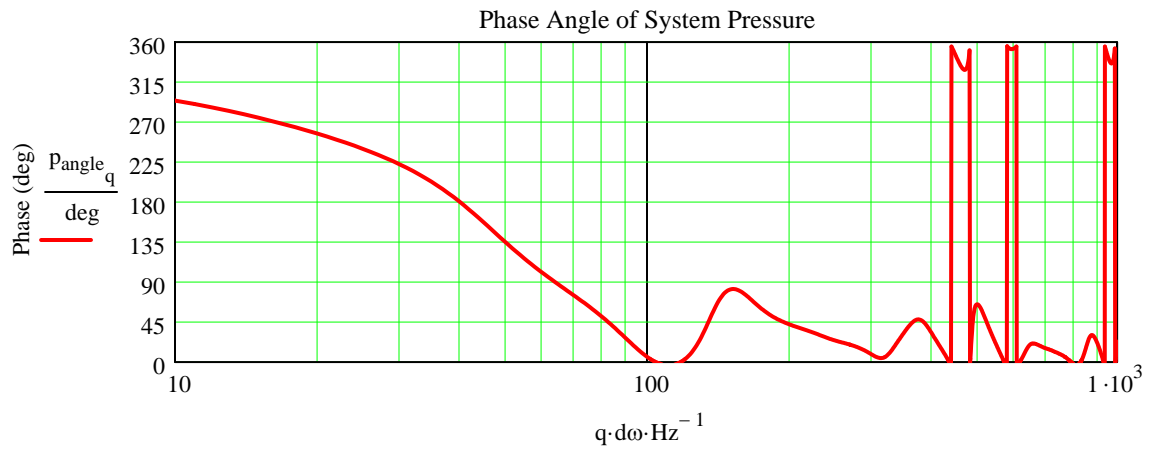
Woofer RMS Displacement



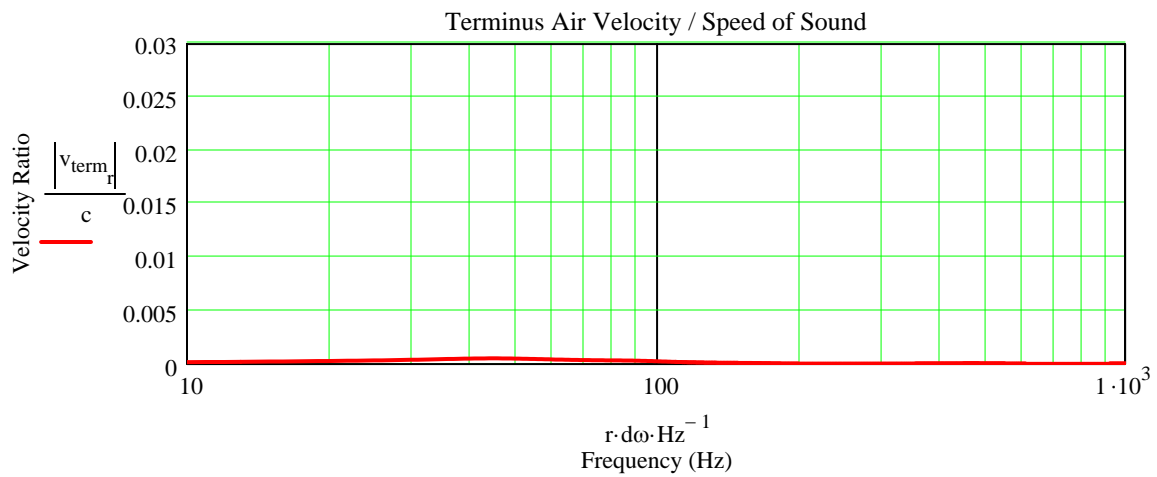
System Time Response for an Impulse Input



System Group Delay



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



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

- $X_0 := 2 \cdot \text{ft}$ (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 | |
|--------------------------------|---------------------------------|-----------------------|
| $y_{o_0} := 9 \cdot \text{in}$ | | (Bottom Right Corner) |
| $y_{o_1} := 9 \cdot \text{in}$ | $z_{o_1} := 60 \cdot \text{in}$ | (Top Right Corner) |
| $y_{o_2} := 0 \cdot \text{in}$ | $z_{o_2} := 60 \cdot \text{in}$ | (Top Left Corner) |
| $y_{o_3} := 0 \cdot \text{in}$ | | (Bottom Left Corner) |
| depth := 15·in | | (Depth of Enclosure) |

Driver Geometry Input

$y_{dc} := 4.5\text{-in}$ (Driver Center y Coordinate)
 $z_{dc} := 30\text{-in}$ (Driver Center z Coordinate)
 $n_{dvr} := 5$ (Number of Points Across Diameter)

Terminus Geometry Input

$y_{mc} := 4.5\text{-in}$ (Terminus Center y Coordinate)
 $z_{mc_t} := 55\text{-in}$ (Top Terminus Center z Coordinates)
 $z_{mc_b} := 5\text{-in}$ (Bottom Terminus Center z Coordinates)
 $w_{mth} := 8\text{-in}$ (Terminus Width)
 $n_{mth} := 7$ (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)
 $radius := 1\text{-m}$ (Calculation Radius, Effective Radius is Greater if y_p is Changed from Default)
 $\theta := 0\text{-deg}$ (0 deg is along the Driver's Axis, $-80\text{ deg} < \theta < 80\text{ deg}$)
 $z_p := z_{dc} + stand$ (Default Height is Equal to Driver Height)

$n_{listen} = 1$ (Listening Position Relative to the Room Corner)
 $X_p := 10\text{ft}$
 $Y_p := 7\text{-ft}$
 $Z_p := z_{dc} + stand$ (Default Height is Equal to Driver Height)
 $n_{listen} := 0$ (Method Selection)

Floor Condition

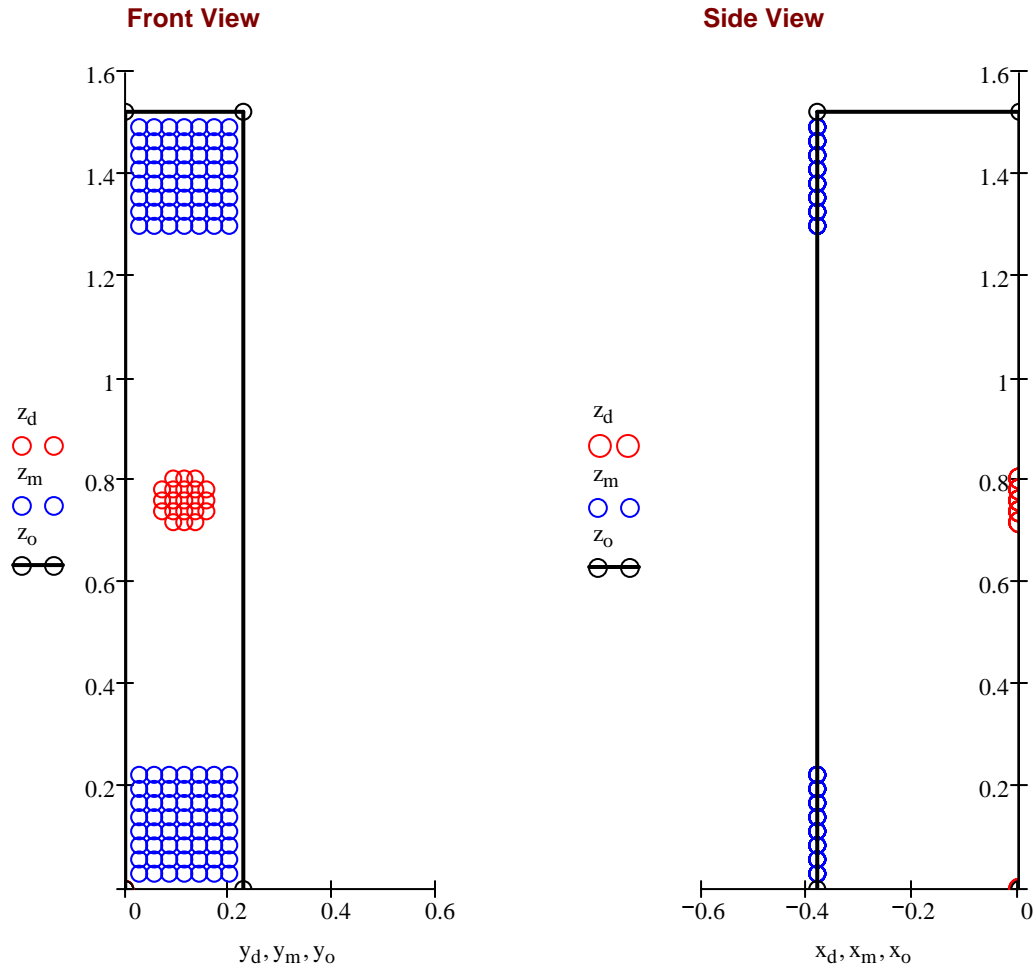
Reflect := 1 (0 = hardwood or concrete, 1 = carpeted)

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

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



Circular Driver and Terminus Simple Source Pattern with Baffle Edge Outline



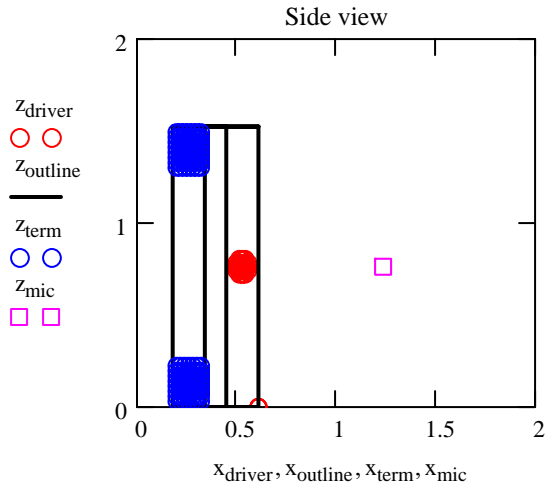
Red sources represent the driver.
Blue sources represent the terminus.
Black outline represents the baffle edge.
Origin is at the bottom front left corner of the enclosure.



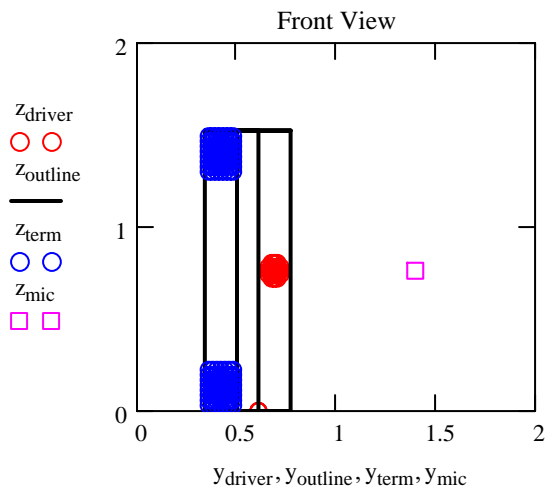
Three Dimensional View

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

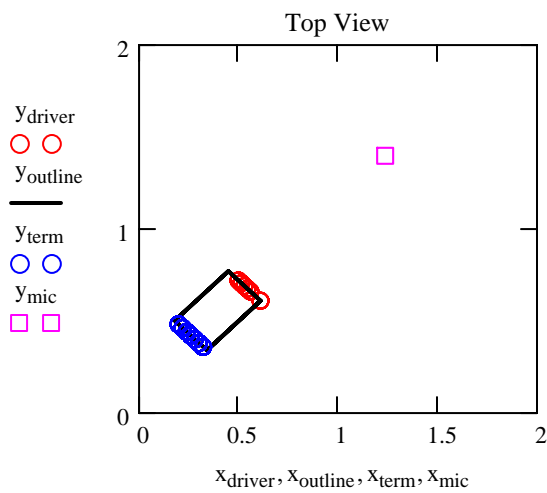
Room Corner is the Origin



Side View - looking out from side wall



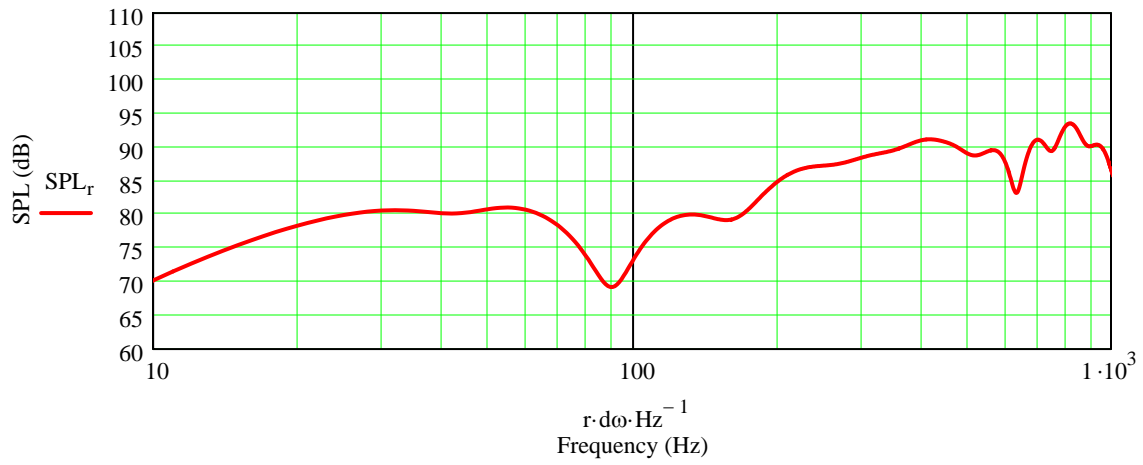
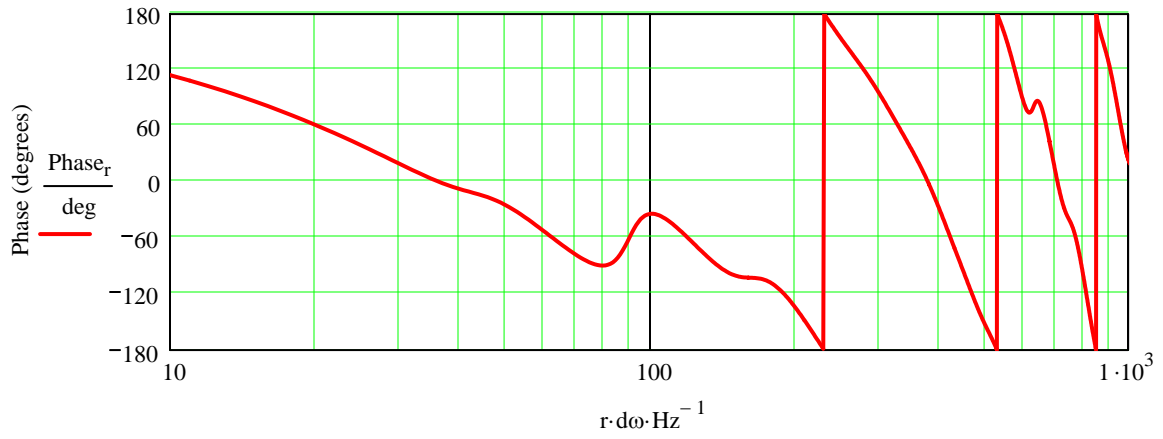
Front View - looking towards rear wall



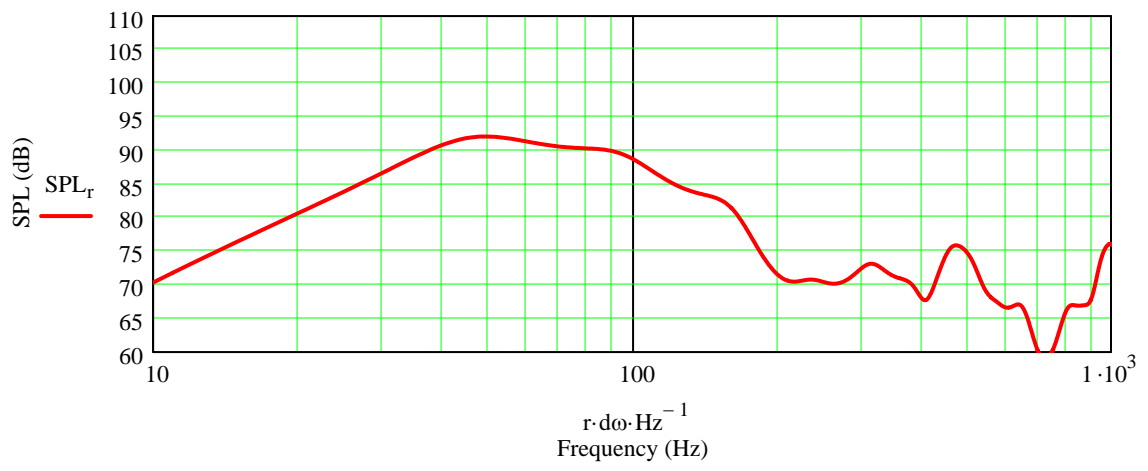
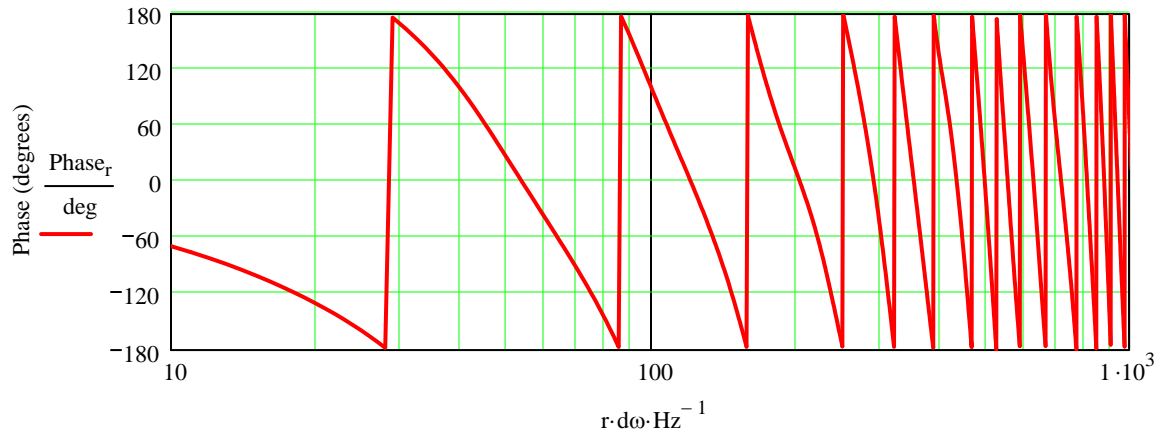
Top View - looking down from ceiling



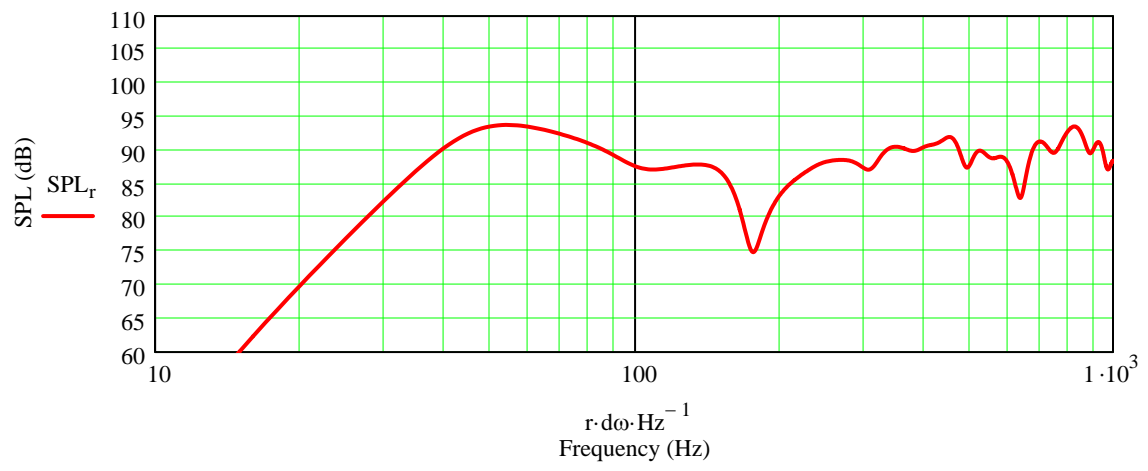
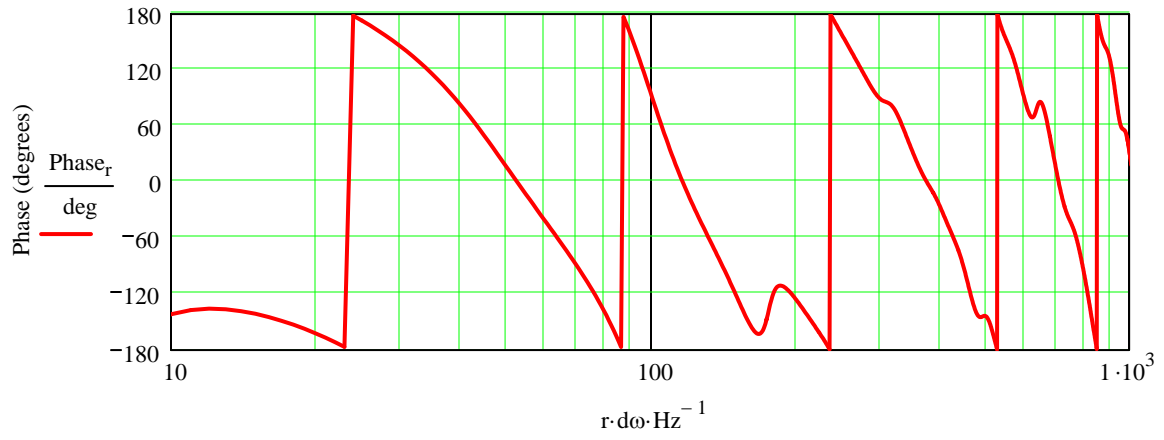
Plotted Baffle Step and Reflection SPL Response for the Circular Driver Source



Plotted Baffle Step and Reflection SPL Response for the 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.

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

$\text{dB} := 0.1$ <--- Input dB of Attenuation

Calculated Component Values

User Assigned Component Values
Based on Calculated Values at Left

$$R_e \cdot \left(10^{\frac{\text{dB}}{20}} - 1 \right) = 0.063 \Omega$$

Parallel Resistor

Input Value --->

$$R_{\text{parallel}} := 0.1 \cdot \Omega$$

$$\frac{R_{\text{parallel}}}{f_{center}} = 0.040 \text{ mH}$$

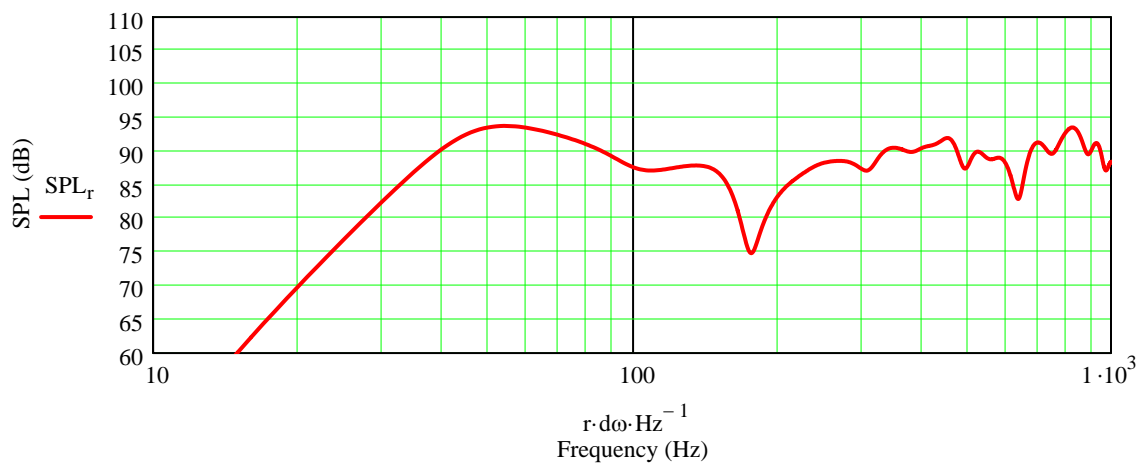
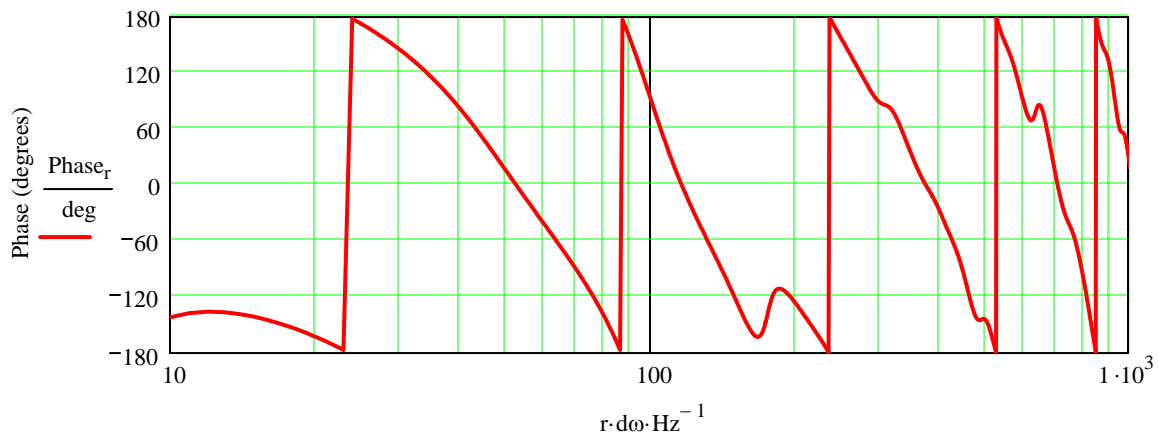
BSC Inductor

Input Value --->

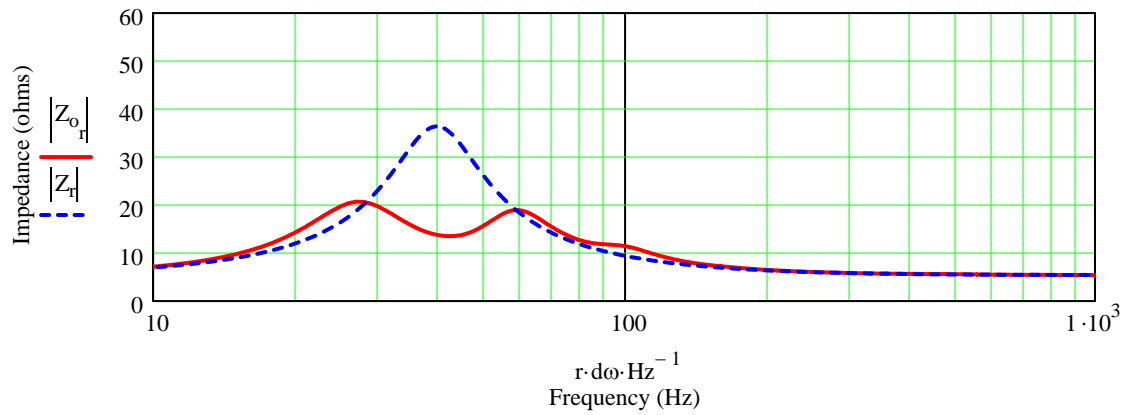
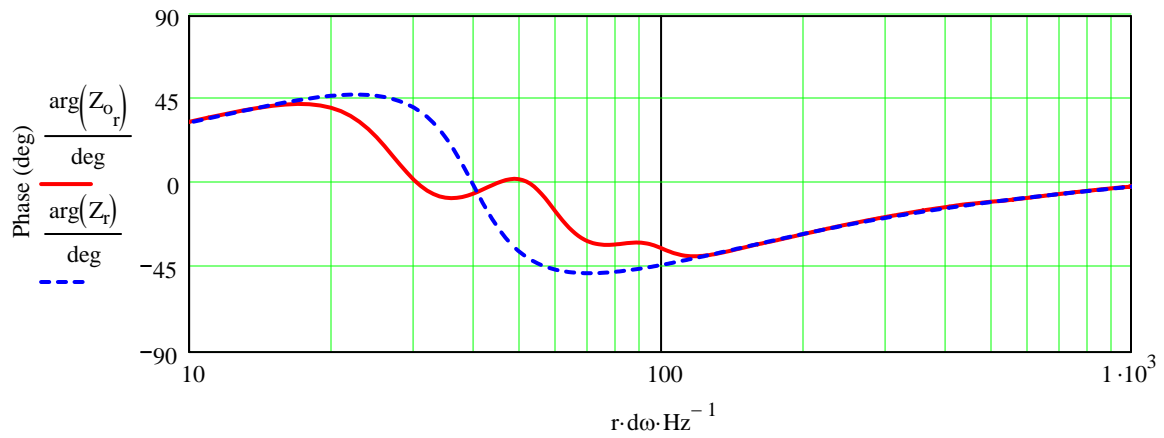
$$L_{\text{BSC}} := 0.001 \cdot \text{mH}$$



Plotted Corrected SPL Response for the System



Back Loaded Horn Corrected System and Infinite Baffle Impedance



System Time Response for an Impulse Input

