



Driver in a Back Loaded Horn - Acoustic and Electrical Response

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

Unit and Constant

Definition

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

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

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

:

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



Part 1 : Thiele-Small Consistent Calculation

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

Series

Resistance

$$R_{\text{add}} := 0.0 \cdot \Omega$$

Driver Thiele / Small Parameters : Vifa 10BGS Properties

$$f_d := 81 \cdot \text{Hz}$$

$$V_{\text{ad}} := 2.5 \cdot \text{liter}$$

Adjustment

s

$$R_e := 5.5 \cdot \Omega$$

$$Q_{\text{ed}} := 0.62$$

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

$$L_{\text{vc}} := 330 \cdot 10^{-3} \cdot \text{mH}$$

$$Q_{\text{md}} := 3.4$$

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

$$Bl := 3.8 \cdot \text{T} \cdot \text{m} \quad \text{Newton/Amp}$$

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

$$S_d := 38 \cdot \text{cm}^2$$

$$Q_{\text{td}} = 0.524$$

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

(Input Power) Applied Voltage
Reference --->

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

Enclosure Geometry

Definition

Coupling Chamber

Geometry

$$L_w := 15.35 \cdot \text{in}$$

(Length
)

$$\xi := 0.001$$

(Driver Position Ratio : $0.001 < \xi < 0.999$)

$$S_0 := 55.8 \cdot \text{in}^2$$

(Area of the Closed End : $S_0 > 0$

$$S_L := 55.8 \cdot \text{in}^2$$

m^2)
(Area of the Throat End : $S_L > 0$

$$\text{Density} := 0.01 \cdot \text{lb} \cdot \text{ft}^{-3}$$

m^2)
(Stuffing density : $0 \text{ lb/ft}^3 < D < 1 \text{ lb/ft}^3$)

Horn

Geometry

$$L_{\text{horn}} := 38.37 \cdot \text{in}$$

(Length of
Horn)

$$\text{type} := 1$$

(Horn Type : 0 = linear, 1 = conical, 2 = hyperbolic - exponential)

$$S_{\text{mouth}} := 29.5 \cdot S_d$$

(Mouth
Area)

$$S_{\text{mouth}} = 173.8 \cdot \text{in}^2$$

Input Directly for Type = 0 or
1

(Input value for Type = 2 from
below)

$$S_{\text{throat}} := 1 \cdot S_d$$

<---- Insert Throat
Area

$$S_{\text{throat}} = 5.9 \cdot \text{in}^2$$

Input Calculation for Type =
2

(Ignored for Horn Type = 0 or
1)

$$M := 0$$

($M > 0$, $M = 1$ for pure exponential
flare)

$$f_o := 22.925 \cdot \text{Hz}$$

<---- Horn Flare Cut-off Frequency, iterate to get desired

$$\gamma := \frac{2 \cdot f_o}{c} \quad \gamma = 0.837 \text{ m}^{-1.000}$$

S_{throat}/S_d
(note f_o is automatically converted to
rad/sec)

$$\frac{S_{\text{mouth}}}{S_d} \cdot \left(\cosh\left(\frac{\gamma}{2} \cdot L_{\text{horn}}\right) + M \cdot \sinh\left(\frac{\gamma}{2} \cdot L_{\text{horn}}\right) \right)^{-2} = 25.085 = S_{\text{throat}} / S_d \text{ (insert above for throat area)}$$

End of Abbreviated User

Input

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

BLH Enclosure

Definition

$$n_{\text{closed}} := 3$$

$$n_{\text{open}} := 13$$

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

$$\text{lb/ft}^3) \\ (n_{\text{closed}} > 1)$$

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

Coupling Chamber Geometry

Definition

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

$$TR = 0.000 \text{ m}$$

Closed End of Coupling Chamber

(Driver ---> Closed End)

Section

Initial

Final

Stuffing

$$L_{c_0} := 0.25 \cdot \xi \cdot L$$

$$S_{c_{0,0}} := S_0 + TR \cdot \xi \cdot L$$

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

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

$$L_{c_1} := 0.25 \cdot \xi \cdot L$$

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

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

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

$$L_{c_2} := 0.25 \cdot \xi \cdot L$$

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

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

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

$$L_{c_3} := 0.25 \cdot \xi \cdot L$$

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

$$S_{c_{3,1}} := S_0$$

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

Open End of Coupling Chamber

(Driver ---> Throat End)

Section

Initial

Final

Stuffing

$$L_{o_0} := 0.25 \cdot (1 - \xi) \cdot L$$

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

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

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

$$L_{o_1} := 0.25 \cdot (1 - \xi) \cdot L$$

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

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

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

$$L_{o_2} := 0.25 \cdot (1 - \xi) \cdot L$$

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

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

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

$$L_{o_3} := 0.25 \cdot (1 - \xi) \cdot L$$

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

$$S_{o_{3,1}} := S_L$$

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

Horn Geometry

Definition

$$\text{horn} := 0, 1 \dots 100$$

(Throat ---> Mouth)

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

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

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

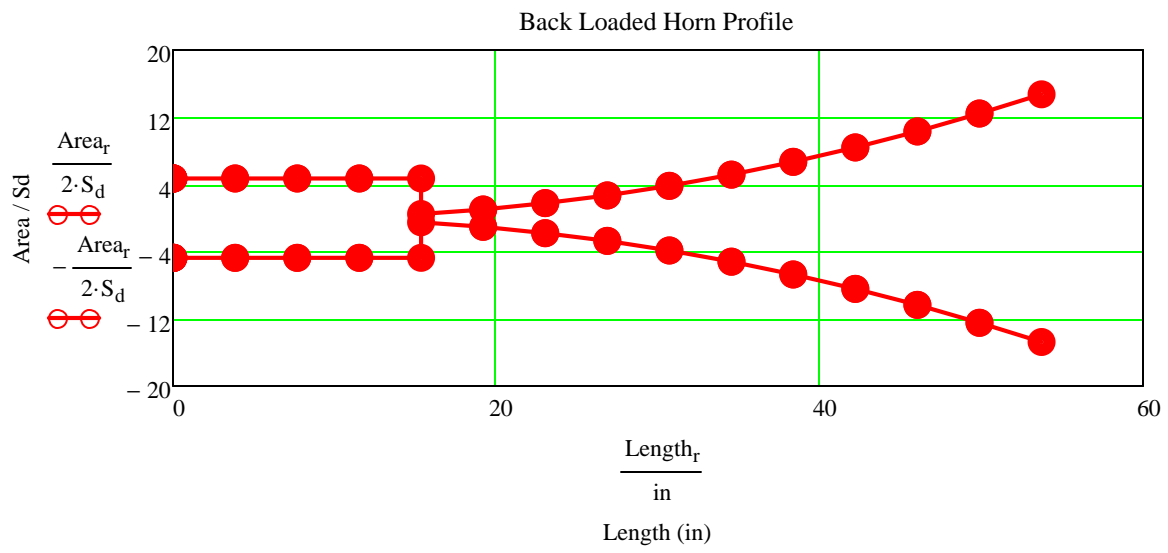
$$\text{horn} := 0 \dots 9$$

$$L_{o_{4+\text{horn}}} := 0.1 \cdot L_{\text{horn}}$$

$$S_{o_{4+\text{horn},0}} := S_{\text{type, horn}}$$

$$D_{o_{4+\text{horn}}} := 0.25 \cdot \text{lb} \cdot \text{ft}^{-3}$$

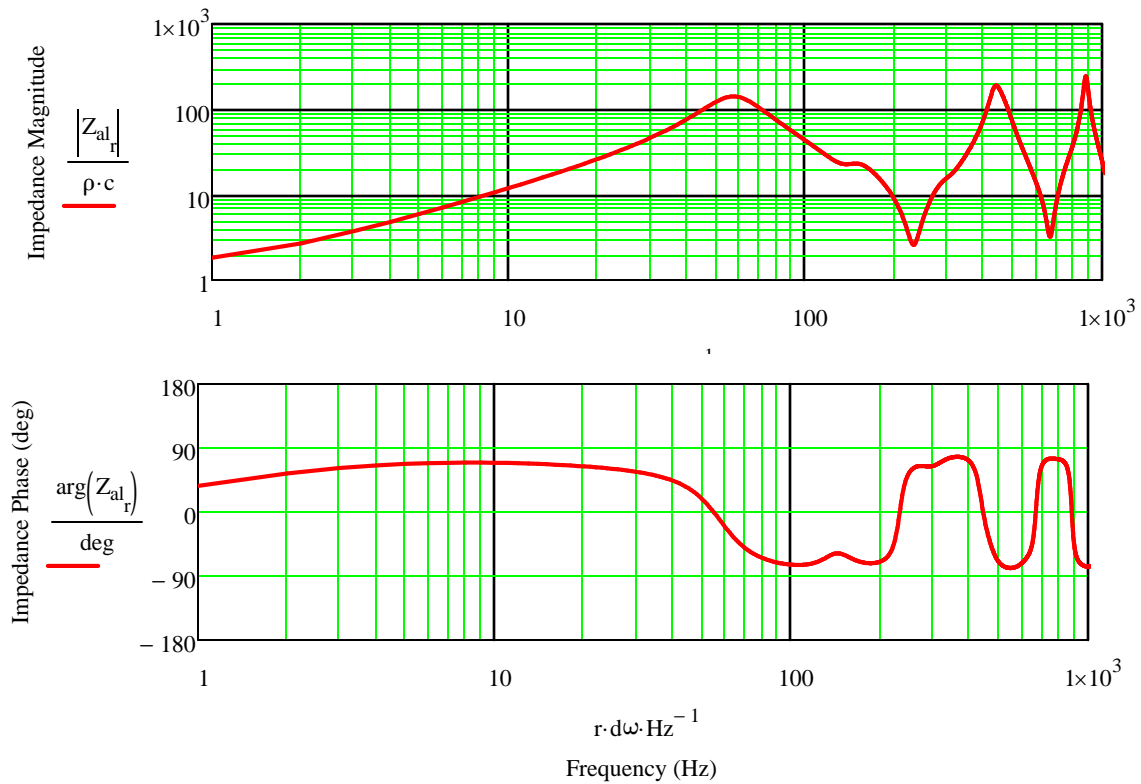
$$S_{o_{4+\text{horn},1}} := S_{\text{type, horn}+1}$$



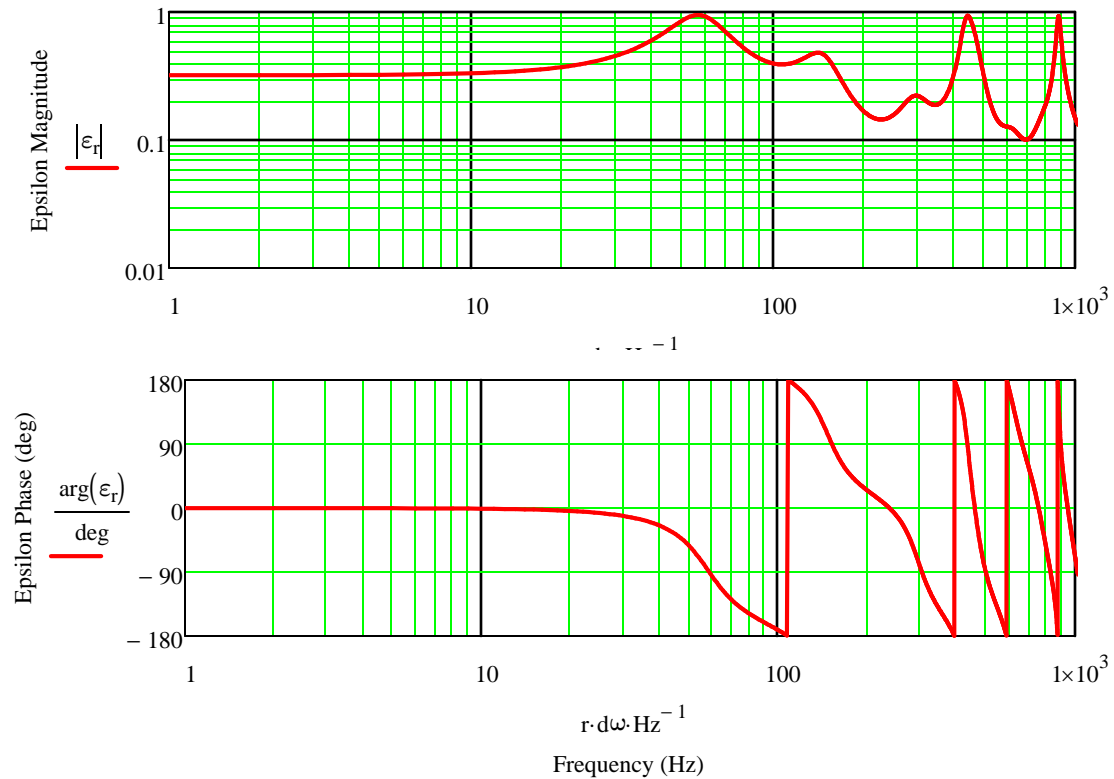
End of Detailed
Input
End of Part 1
Input



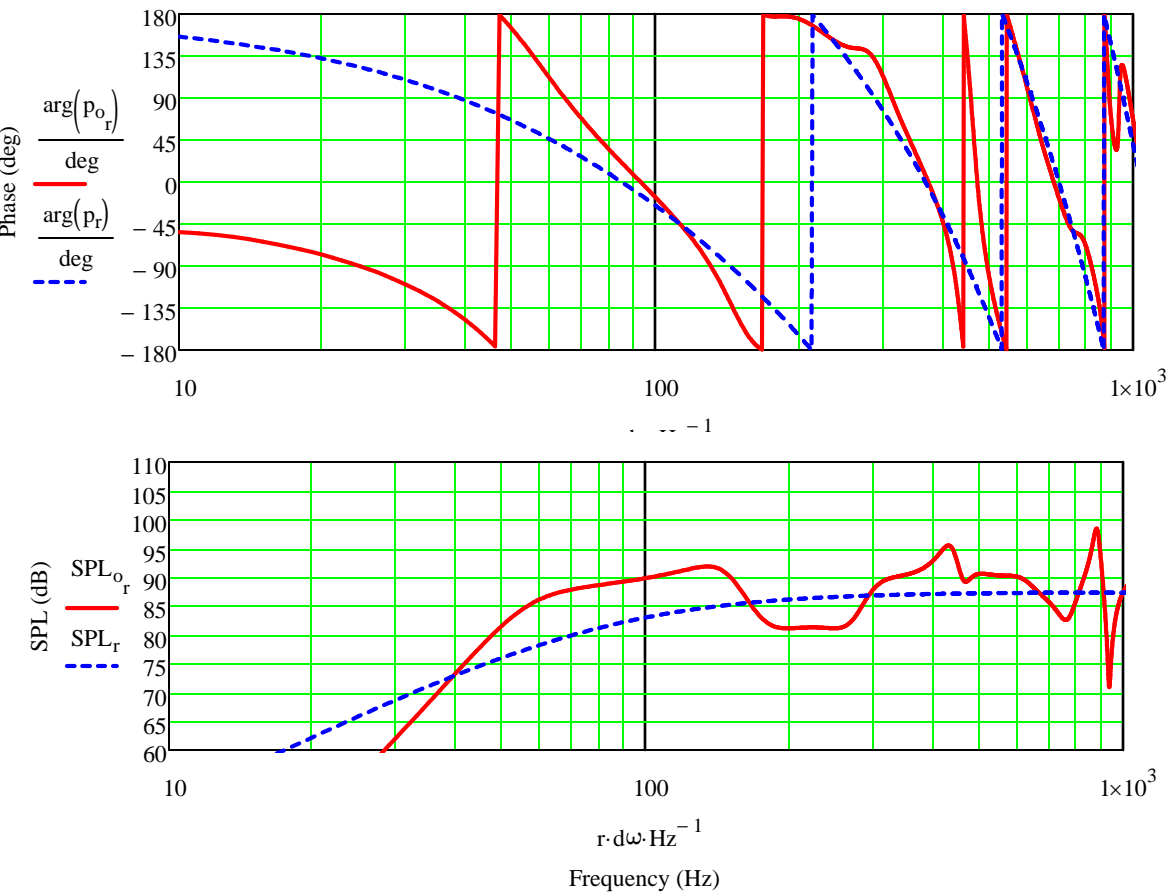
Resulting Acoustic Impedance for the Back Loaded Horn



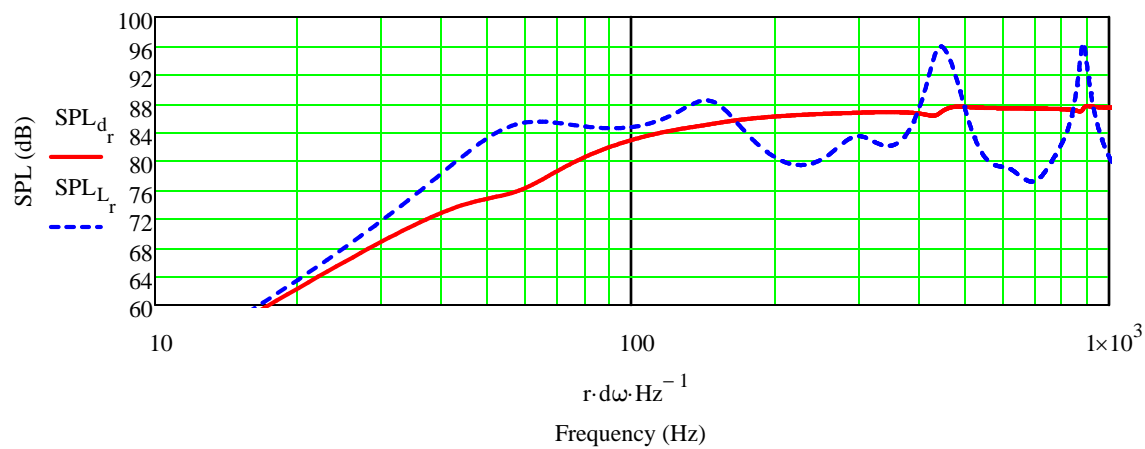
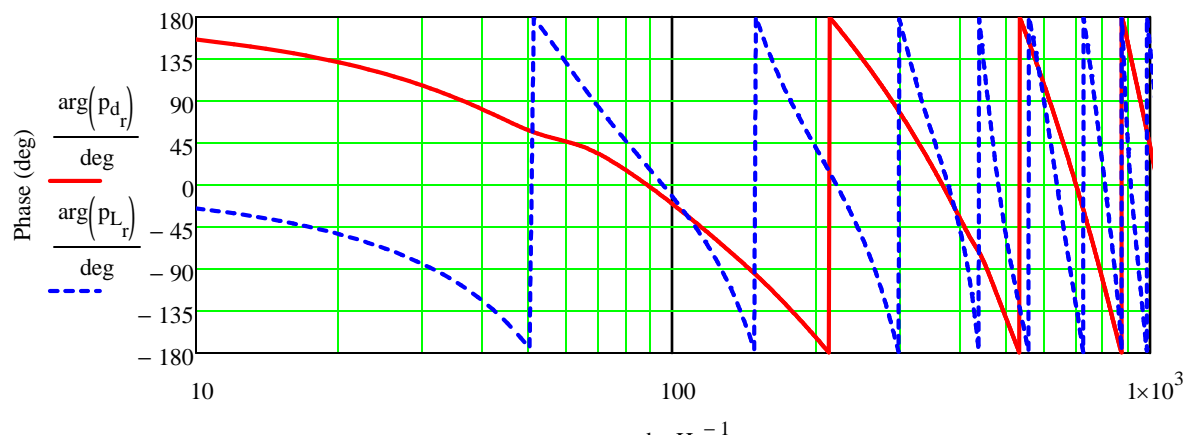
Velocity at the Terminus of the Back Loaded Horn for a 1 m/sec Excitation at the Driver



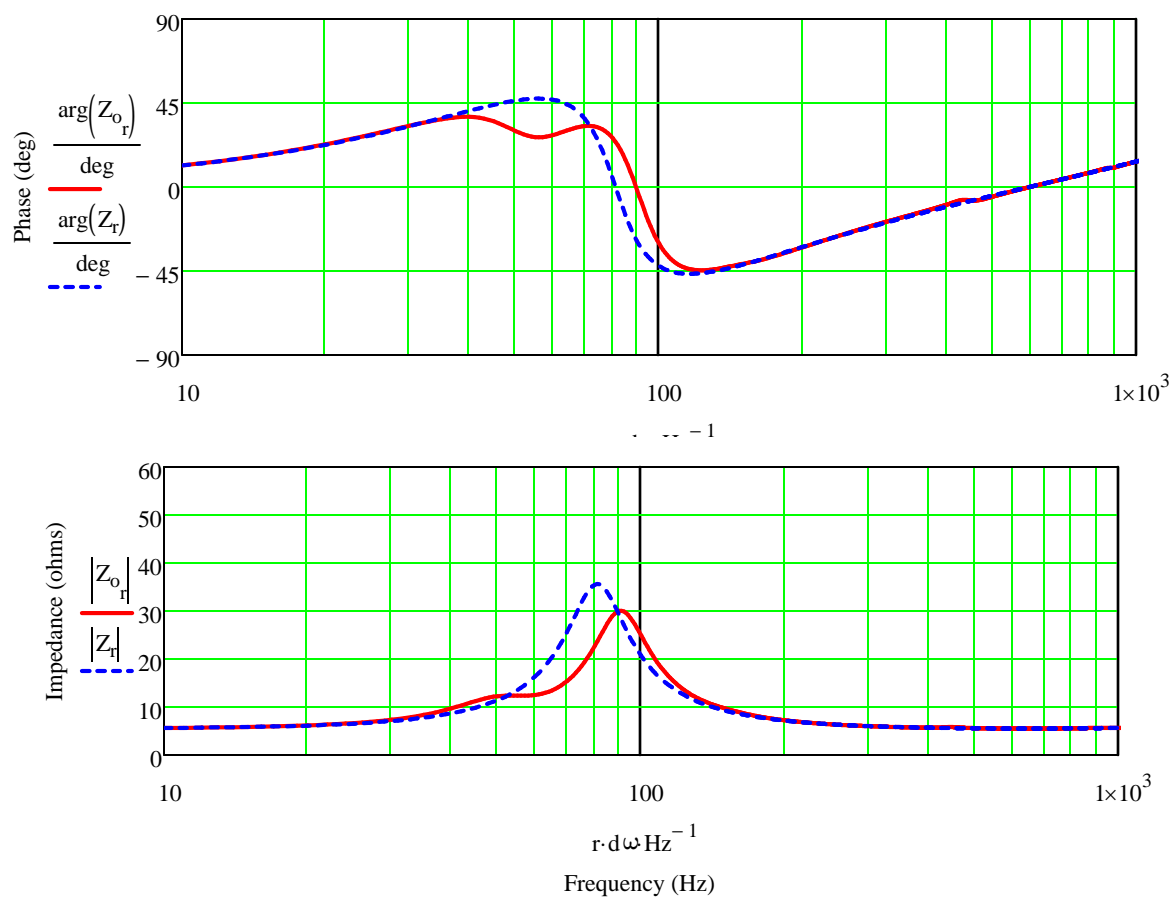
Far Field Back Loaded Horn System and Infinite Baffle Sound Pressure Level



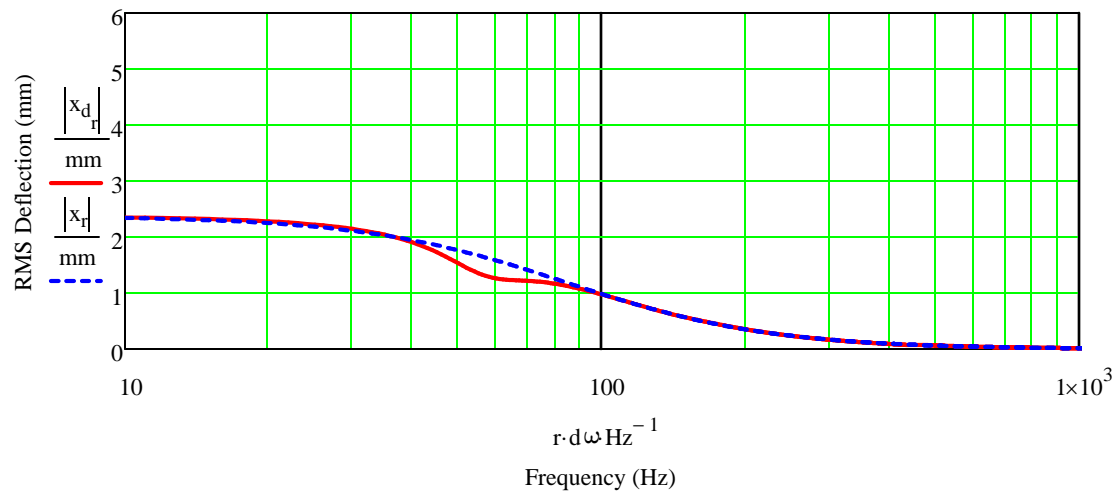
Woofer and Terminus Far Field Sound Pressure Level



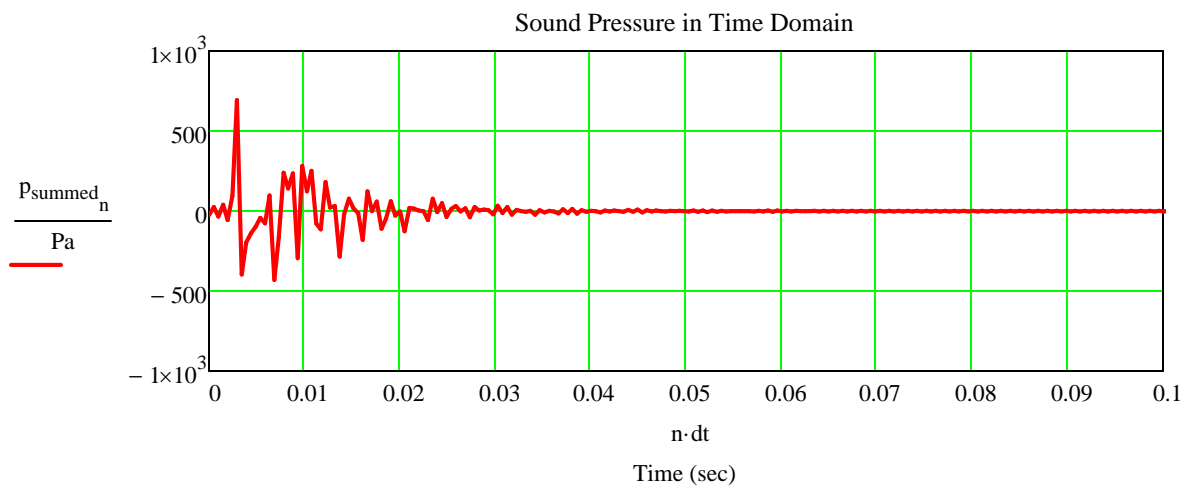
Back Loaded Horn System and Infinite Baffle Impedance



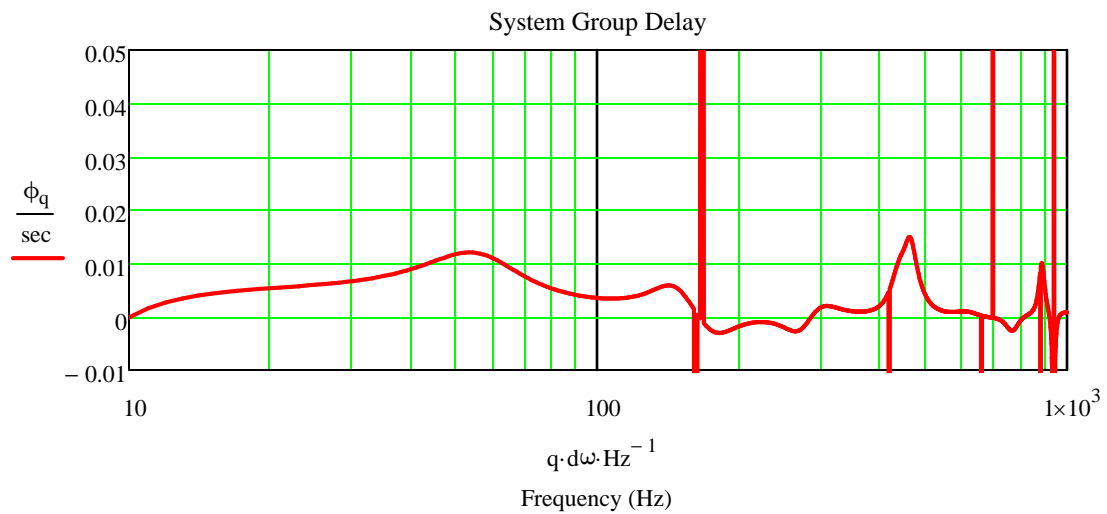
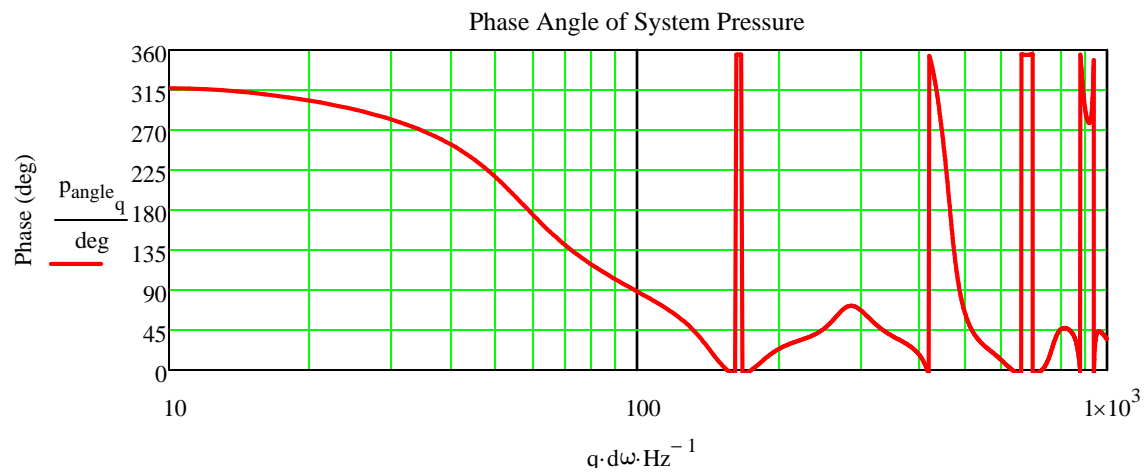
Woofer RMS Displacement



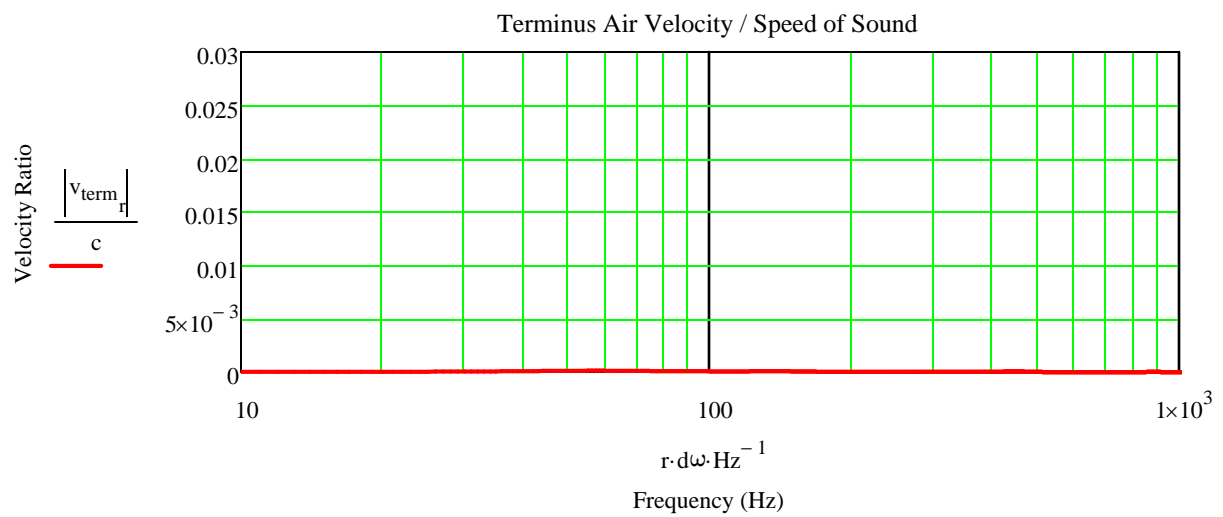
System Time Response for an Impulse Input



System Group Delay



Terminus Air Velocity (should be < 10 m/sec / 344 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

| | |
|-----------------------------------|-------------------------------------------------------------|
| $X_0 := 2 \cdot \text{ft}$ | (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 | |
|---------------------------------|-----------------------------------|-----------------------|
| $y_{o_0} := 10 \cdot \text{in}$ | | (Bottom Right Corner) |
| $y_{o_1} := 10 \cdot \text{in}$ | $z_{o_1} := 37.5 \cdot \text{in}$ | (Top Right Corner) |
| $y_{o_2} := 0 \cdot \text{in}$ | $z_{o_2} := 37.5 \cdot \text{in}$ | (Top Left Corner) |
| $y_{o_3} := 0 \cdot \text{in}$ | | (Bottom Left Corner) |
| depth := 16.75·in | | (Depth of Enclosure) |

Driver Geometry

Input

$y_{dc} := 4.5 \cdot \text{in}$ (Driver Center x Coordinate)
 $z_{dc} := 32.5 \cdot \text{in}$ (Driver Center y Coordinate)
 $n_{dvr} := 5$ (Number of Points Across Diameter)

Terminus Geometry

Input

$y_{mc} := 5 \cdot \text{in}$ (Terminus Center x Coordinate)
 $z_{mc} := 11.06 \cdot \text{in}$ (Terminus Center y Coordinate)
 $w_{mth} := 10 \cdot \text{in}$ (Terminus Width)
 $n_{mth} := 7$ (Number of Points Across the Width)
 $\text{Locate} := 0$ (0 = Front Baffle Terminus, 1 = Rear Baffle Terminus)

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

$n_{\text{listen}} =$ (Listening Position Relative to Speaker)
 $\hat{\text{radius}} := 1 \cdot \text{m}$ (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, $-80 \text{ deg} < \theta < 80$ deg)
 $z_p := z_{dc}$ (Default Height is Equal to Driver Height)
 $n_{\text{listen}} =$ (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)
 $n_{\text{listen}} := 0$ (Method Selection)

Floor

Condition

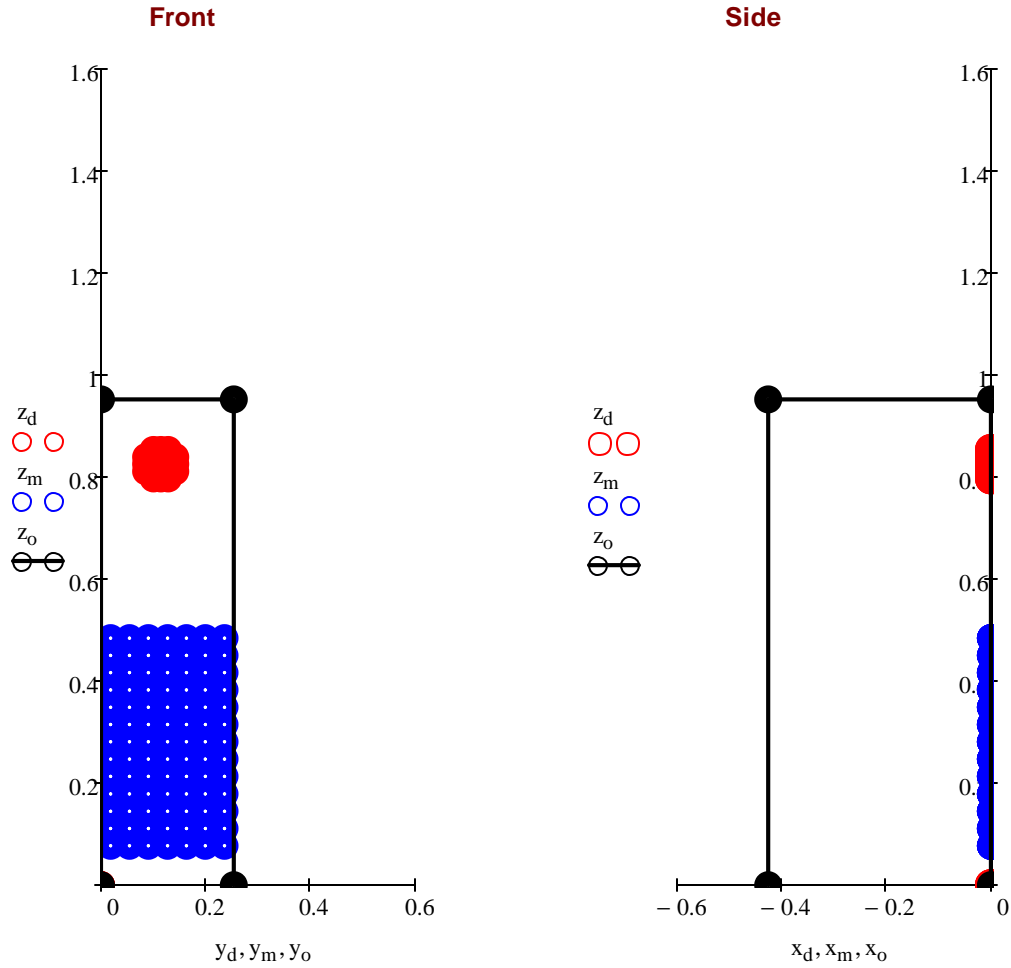
$\text{Reflect} := 1$ (0 = hardwood or concrete, 1 = carpeted)

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

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



Circular Driver and Terminus Simple Source Pattern with Baffle Edge Outline



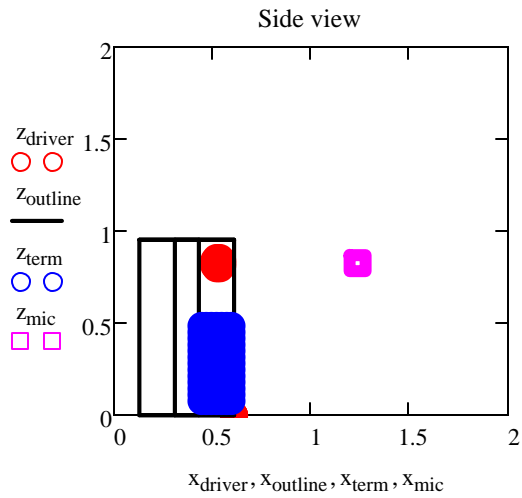
Red sources represent the driver.
Blue sources represent the terminus.
Black outline represents the baffle edge.
Origin is at the bottom front left corner of the enclosure.



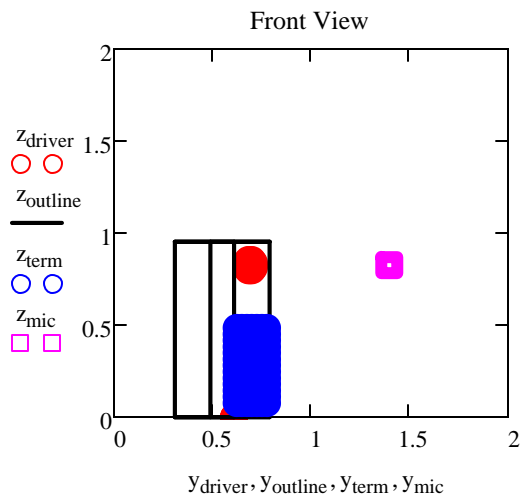
Three Dimensional View

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

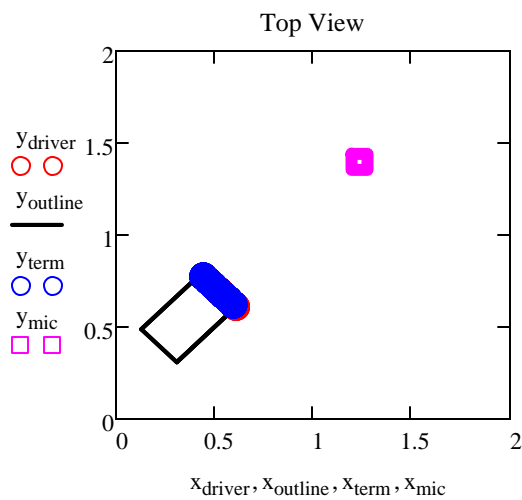
Room Corner is the Origin



Side View - looking out from side wall



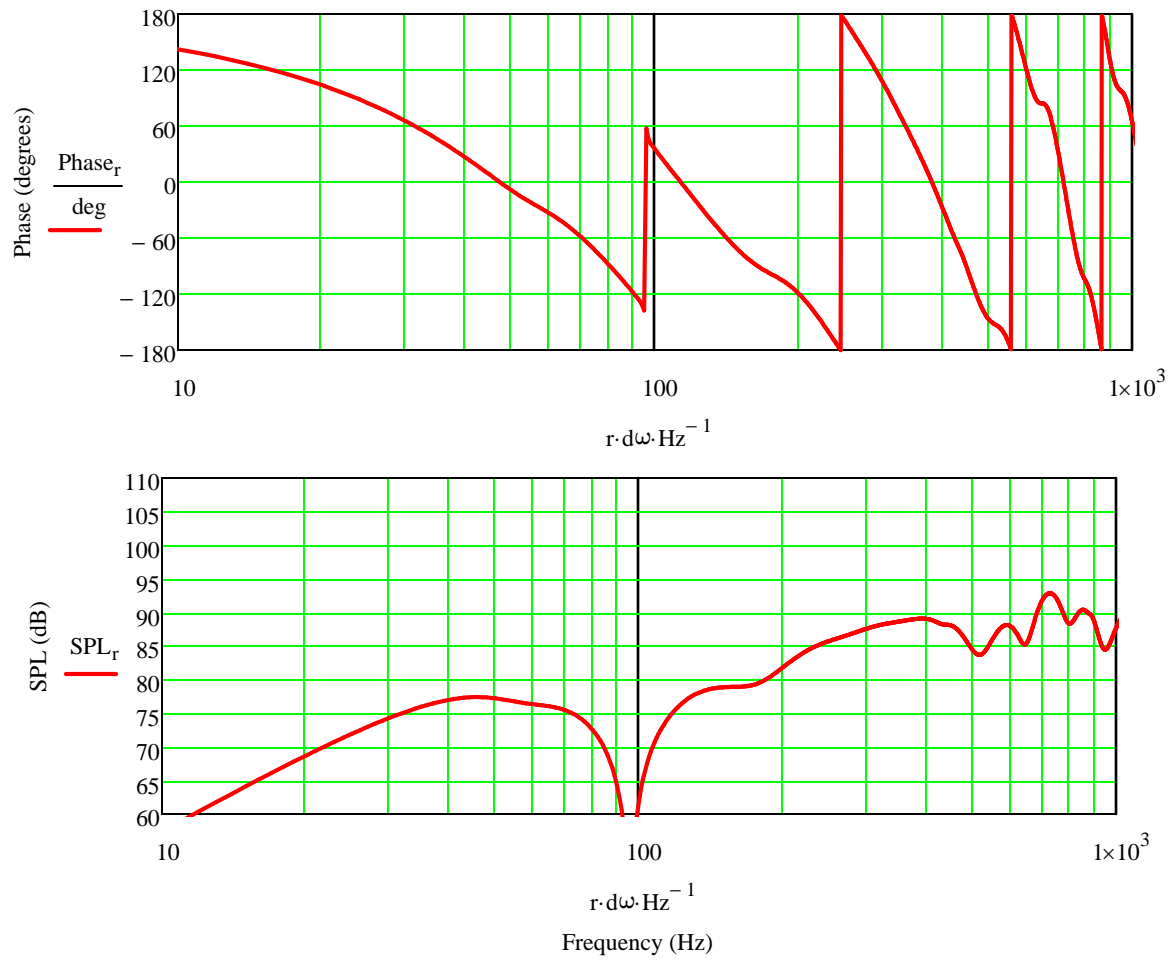
Front View - looking towards rear wall



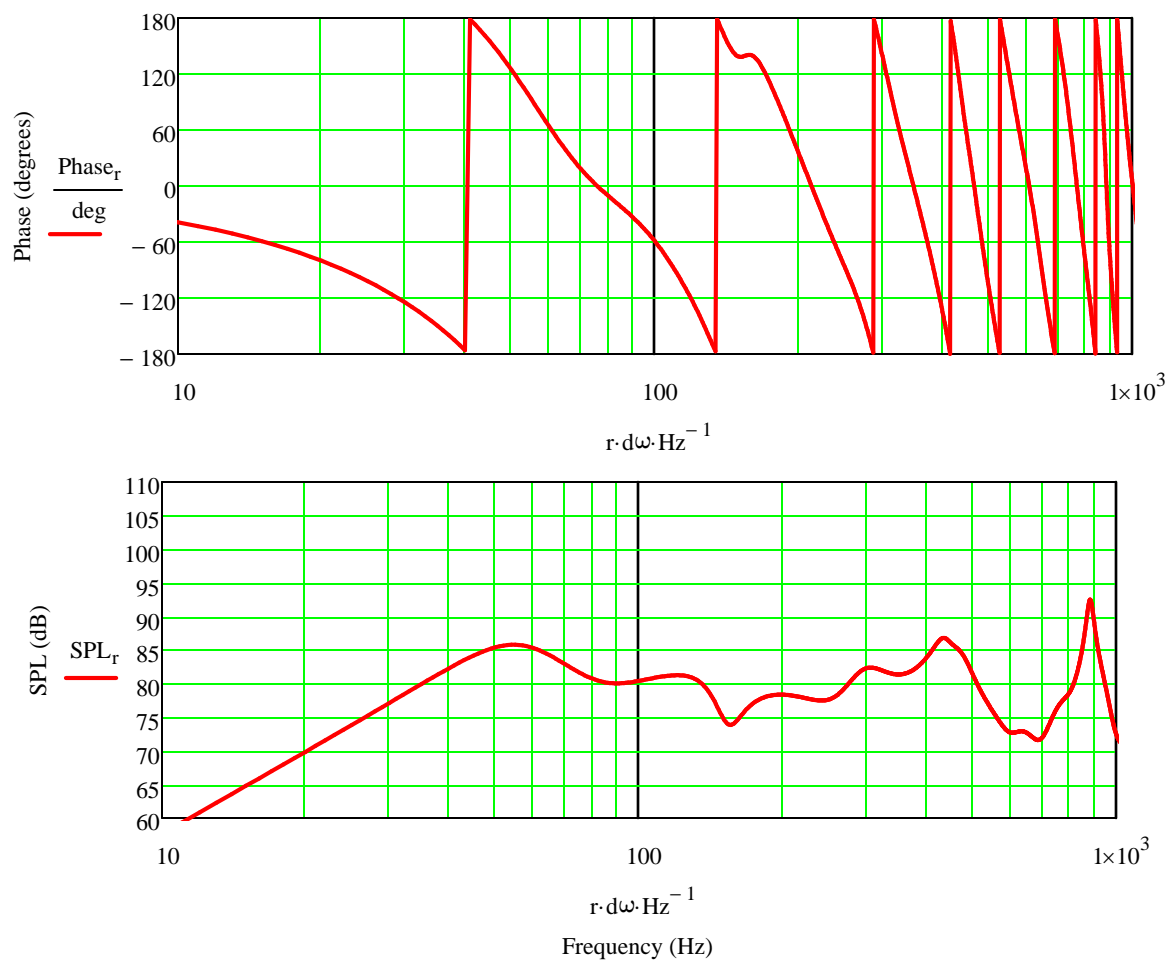
Top View - looking down from ceiling



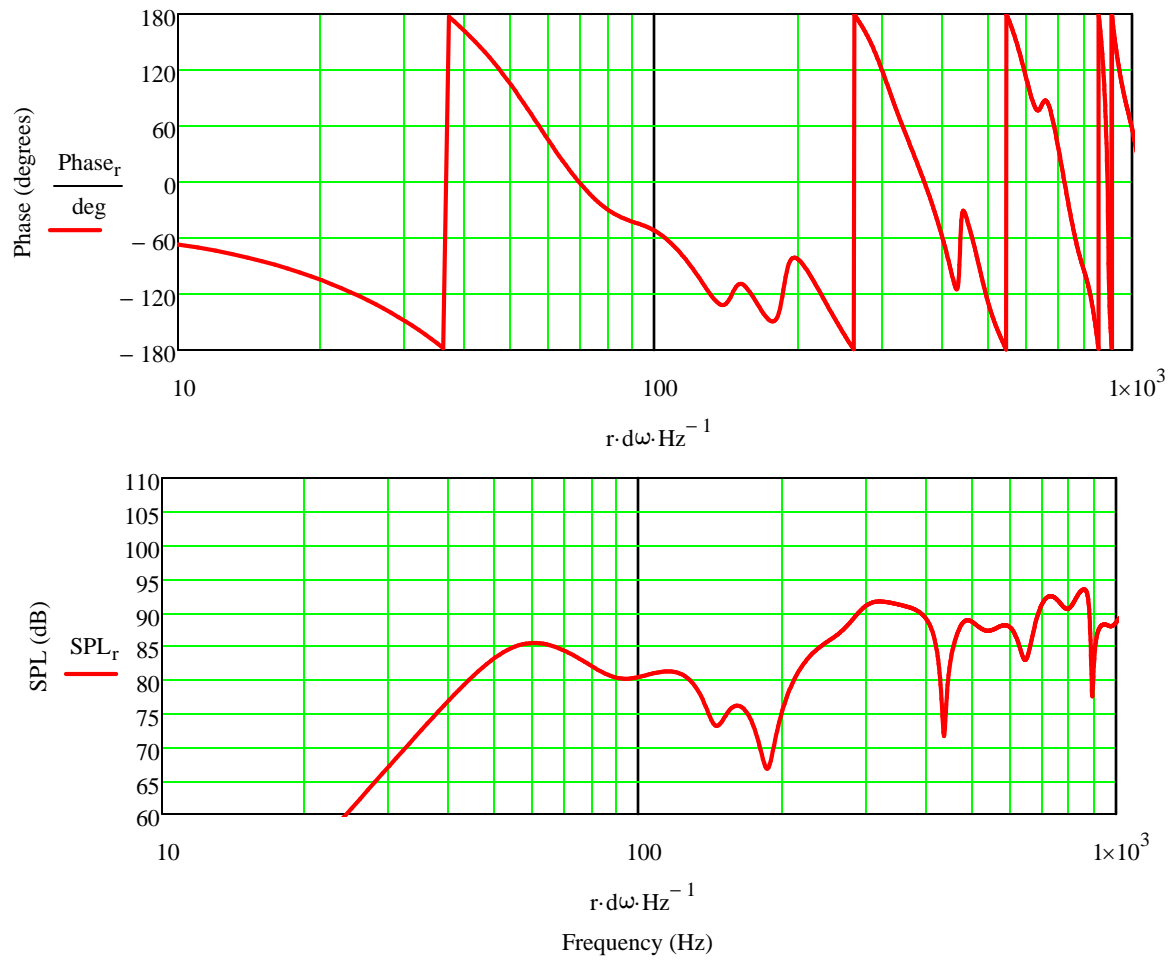
Plotted Baffle Step and Reflection SPL Response for the Circular Driver Source



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.

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

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

Calculated Component Values

$$R_e \cdot \left(10^{\frac{\text{dB}}{20}} - 1 \right) = 0.064 \cdot \Omega$$

Parallel Resistor

User Assigned Component Values

Based on Calculated Values at Left

Input Value ---->

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

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

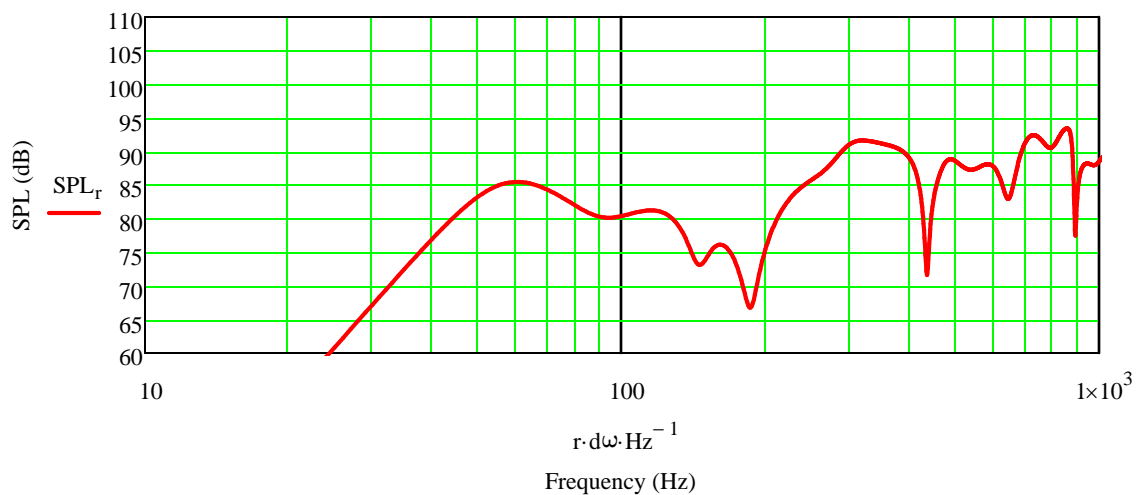
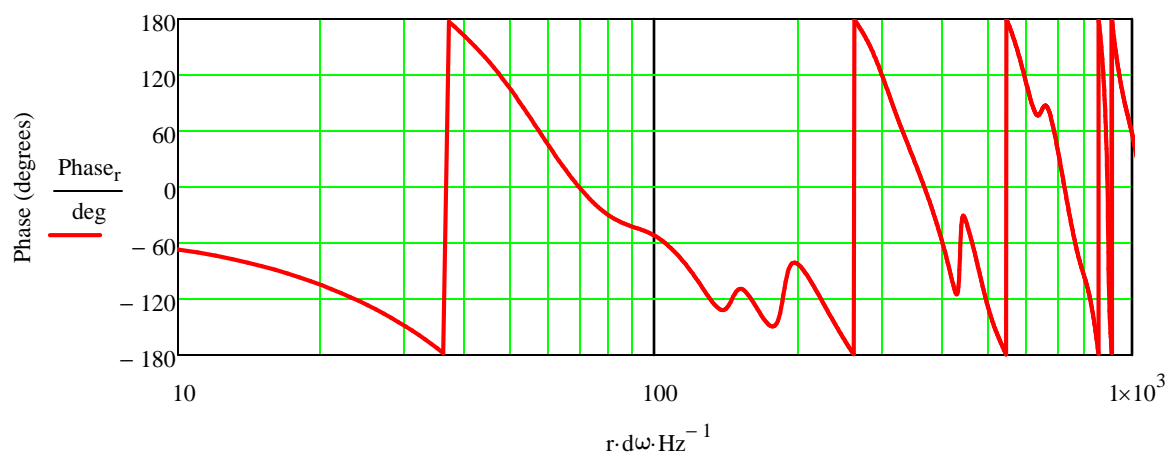
BSC Inductor

Input Value ---->

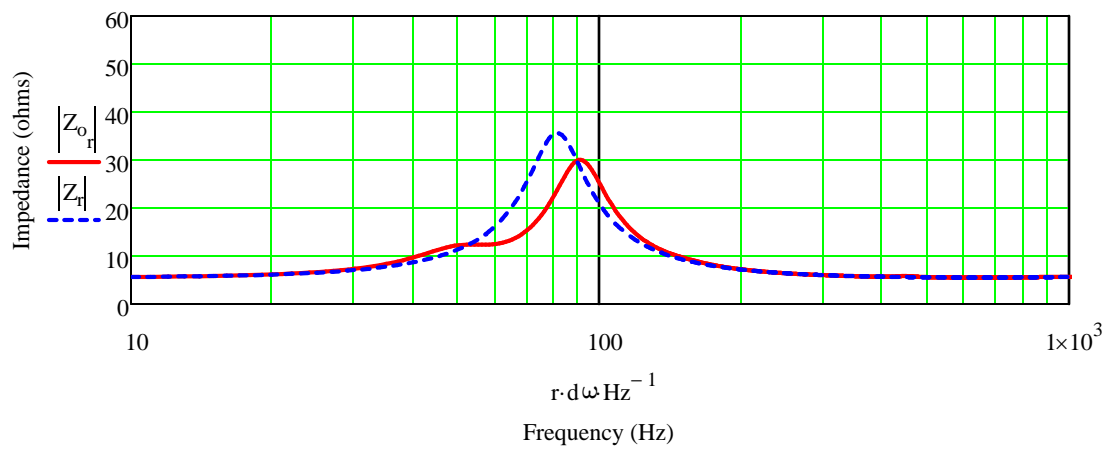
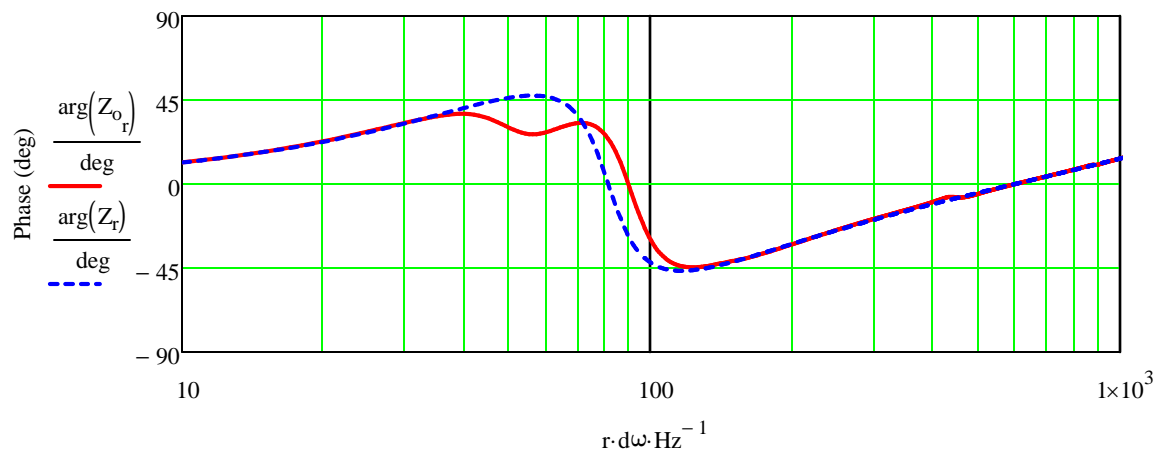
$$L_{\text{BSC}} := 0.001 \cdot \text{mH}$$



Plotted Corrected SPL Response for the System



Back Loaded Horn Corrected System and Infinite Baffle Impedance



System Time Response for an Impulse Input

