Driver in a Back Loaded Horn - Acoustic and Electrical Response 7/03/09

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

Unit and Constant Definition

$cycle := 2 \cdot \pi \cdot rad$

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

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

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

Part 1 : Thiele-Small Consistent Calculation

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

Series Resistance

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

Driver Thiele / Small Parameters : Alpair 10 Properties

$f_d := 25 \cdot Hz$

$V_{ad} := 8.5 \cdot liter$

Adjustments

$R_e := 7.2 \cdot \Omega$

$Q_{ed} := 0.3$

$R_e := R_e + R_{add}$

$L_{vc} := 35 \cdot 10^{-3} \cdot mH$

$Q_{md} := 4.8$

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

$Bl := 5.63 \cdot T \cdot m$ Newton/Amp

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

$S_d := 65 \cdot cm^2$

$Q_{td} = 0.282$

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

Enclosure Geometry Definition

Coupling Chamber Geometry

$L := 11.5 \cdot in$ (Length)

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

$S_0 := 90 \cdot in^2$ (Area of the Closed End : S_0 > 0 m²)

$S_L := 90 \cdot in^2$ (Area of the Throat End : S_L > 0 m²)

$Density := 0.5 \cdot lb \cdot ft^{-3}$ (Stuffing density : 0 lb/ft³ < D < 1 lb/ft³)

Horn Geometry

$L_{horn} := 31.11 \cdot in$ (Length of Horn)

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

$S_{mouth} := 22 \cdot S_d$ (Mouth Area)

$S_{mouth} = 221.7 \cdot in^2$

Input Directly for Type = 0 or 1 (Input value for Type = 2 from below)

$S_{throat} := 2 \cdot S_d$ <---- Insert Throat Area

$S_{throat} = 20.2 \cdot in^2$

Input Calculation for Type = 2 (Ignored for Horn Type = 0 or 1)

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

$f_o := 22.925 \cdot Hz$ <---- Horn Flare Cut-off Frequency, iterate to ger desired S_{throat}/S_d

$\gamma := \frac{2 \cdot f_o}{c}$ $\gamma = 0.837\, m^{-1.000}$ (note f_o is automatically converted to rad/sec)

$$\frac{S_{mouth}}{S_d} \cdot \left(\cosh\left(\frac{\gamma}{2} \cdot L_{horn}\right) + M \cdot \sinh\left(\frac{\gamma}{2} \cdot L_{horn}\right)\right)^{-2} = 19.757$$

= S_{throat} / S_d (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 ($0\ lb/ft^3 < D < 1\ lb/ft^3$)

$n\_closed := 3$ (n_closed > 1)

$n\_open := 13$ (n_open > 1)

Coupling Chamber Geometry Definition

$TR := \left(S_L - S_0\right)\cdot L^{-1}$ $TR = 0.000\,m$

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

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

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

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

Horn Geometry Definition (Throat ---> Mouth)

$horn := 0, 1 .. 100$

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

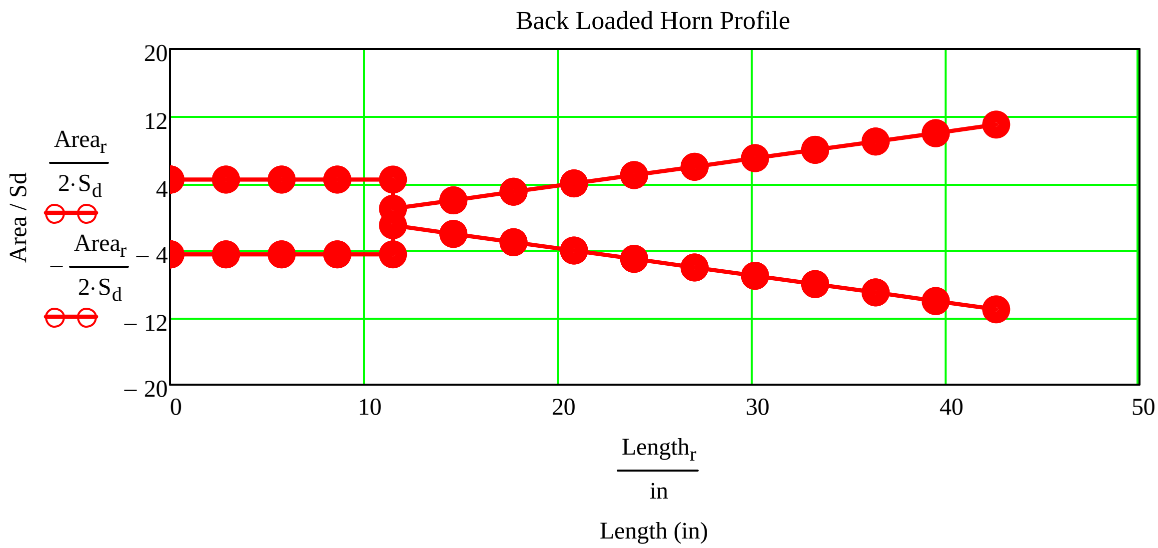
$$S_{1,horn} := \pi\cdot\left[\sqrt{\frac{S_{throat}}{\pi}} + \frac{horn}{10}\left(\sqrt{\frac{S_{mouth}}{\pi}} - \sqrt{\frac{S_{throat}}{\pi}}\right)\right]^2$$

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

$horn := 0 .. 9$

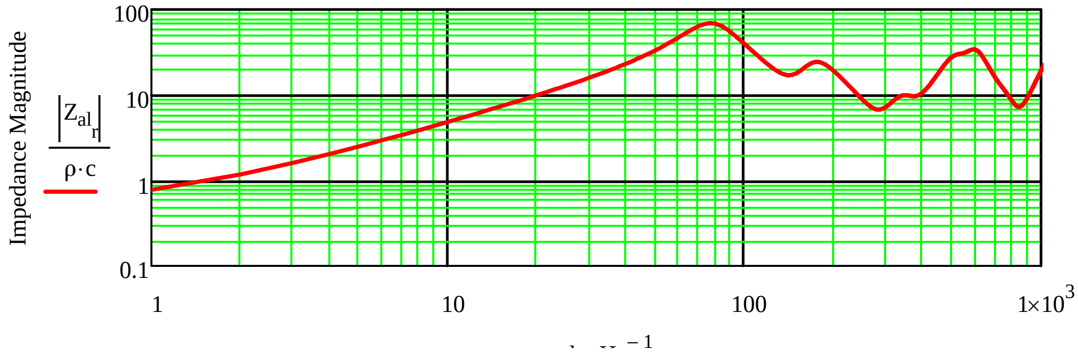
$L_{o_{4+horn}} := 0.1\cdot L_{horn}$ $S_{o_{4+horn,0}} := S_{type,horn}$

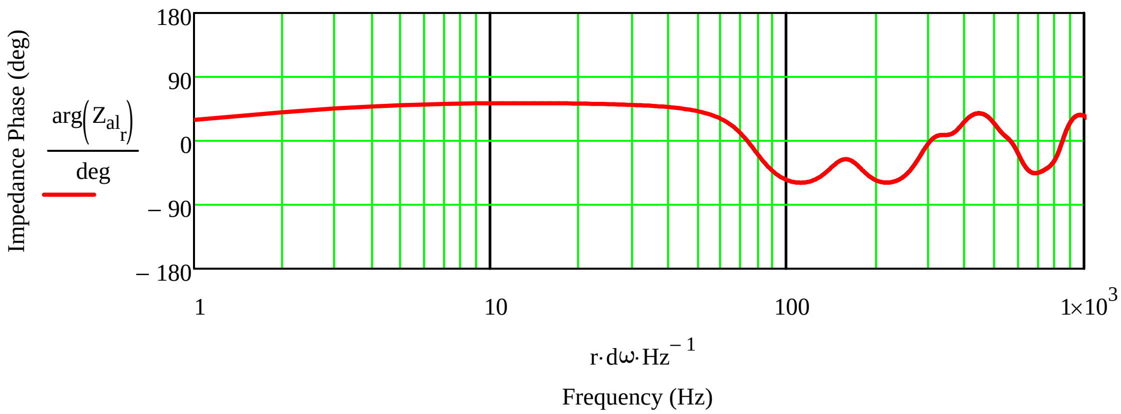
$D_{o_{4+horn}} := 0.25\cdot lb\cdot ft^{-3}$ $S_{o_{4+horn,1}} := S_{type,horn+1}$



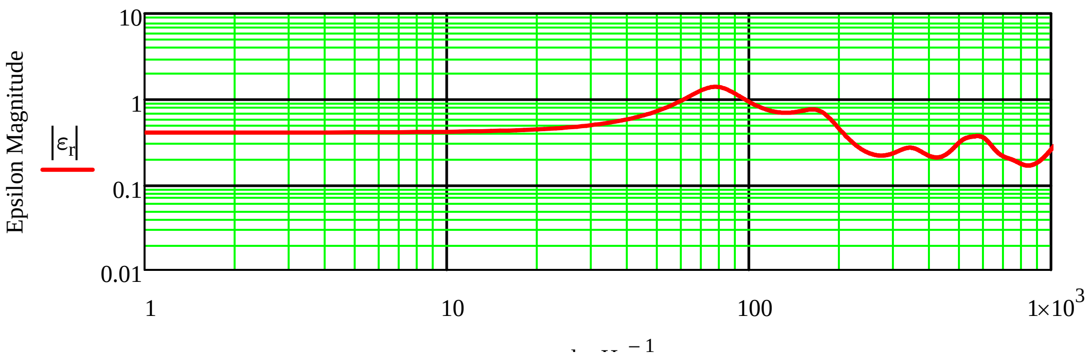
End of Detailed Input
End of Part 1 Input

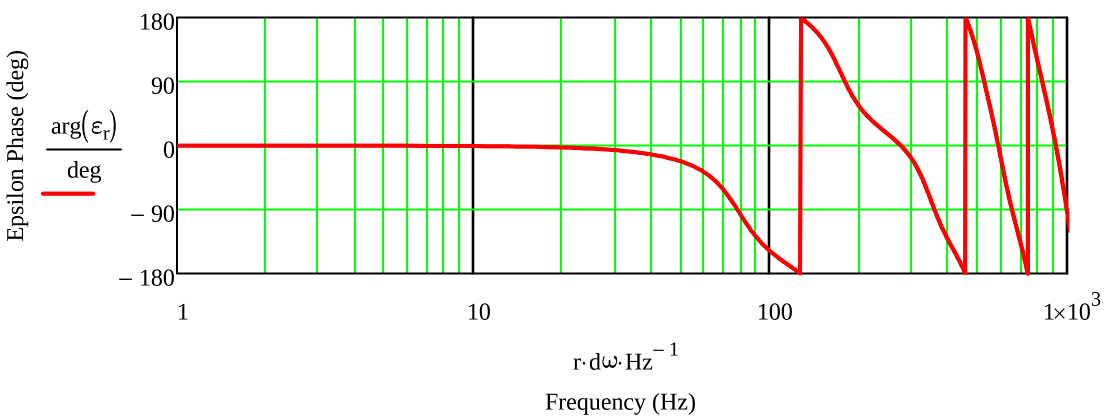
Resulting Acoustic Impedance for the Back Loaded Horn



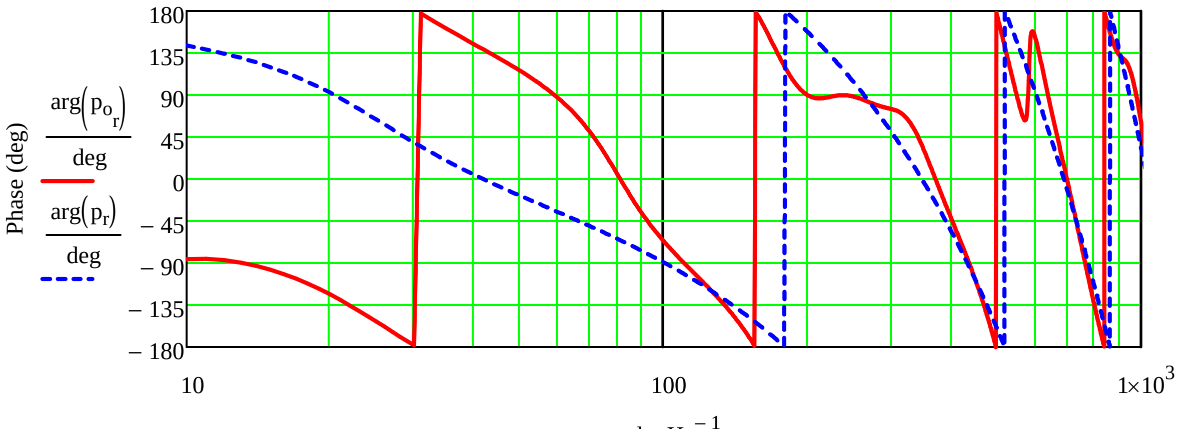


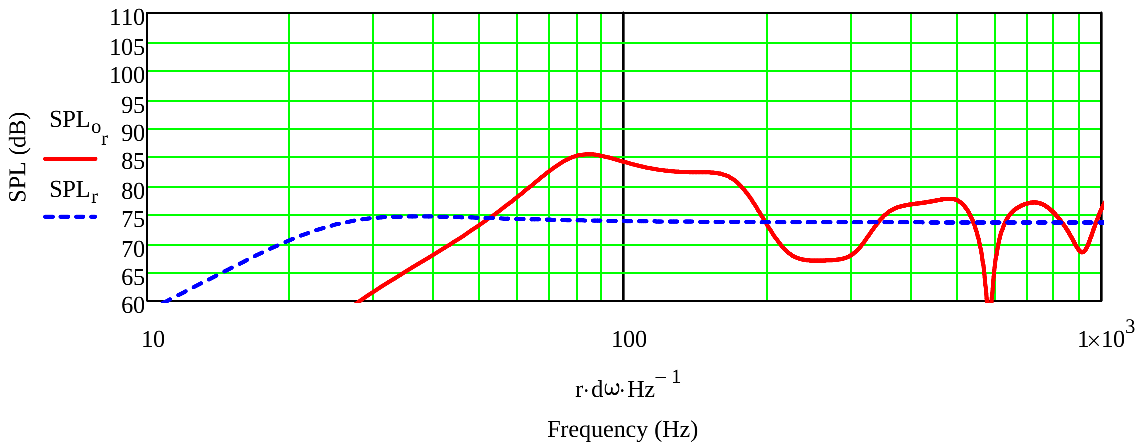
Velocity at the Terminus of the Back Loaded Horn for a 1 m/sec Excitation at the Driver



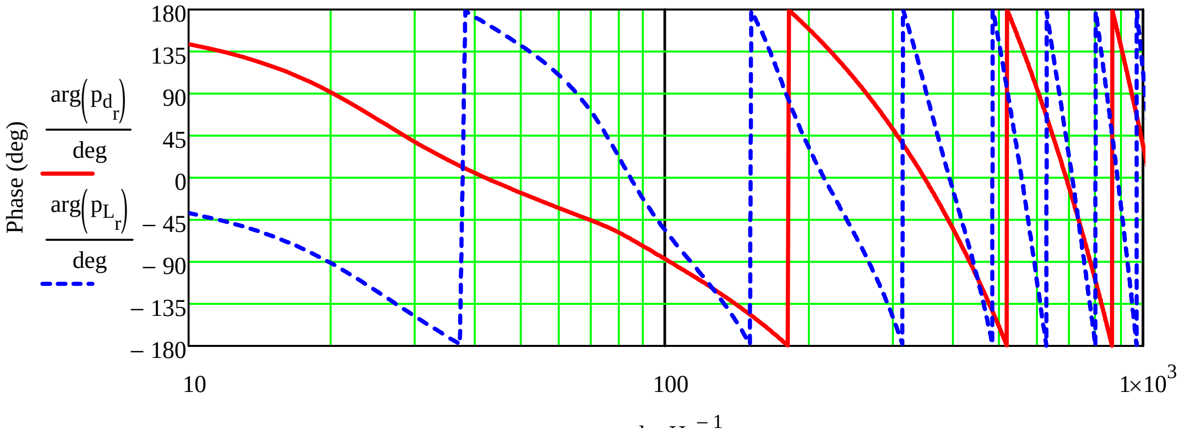


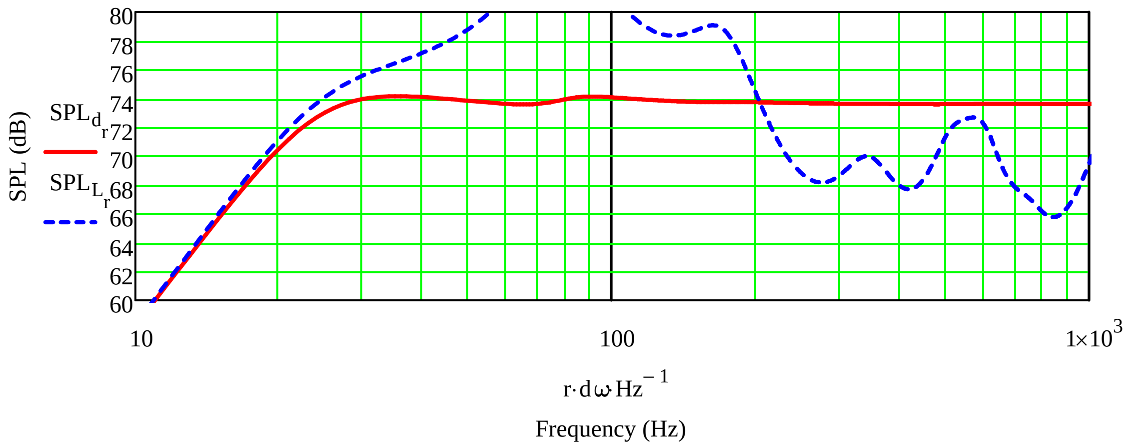
Far Field Back Loaded Horn System and Infinite Baffle Sound Pressure Level



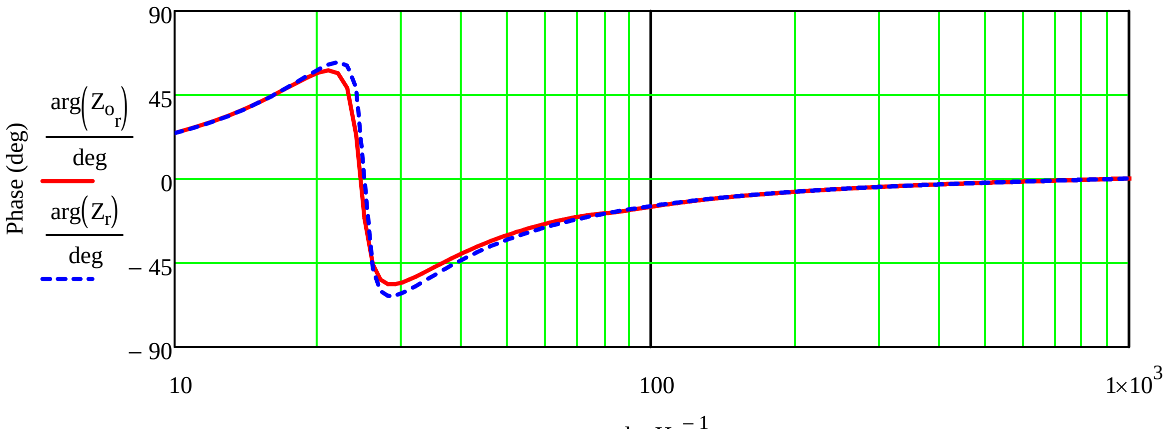


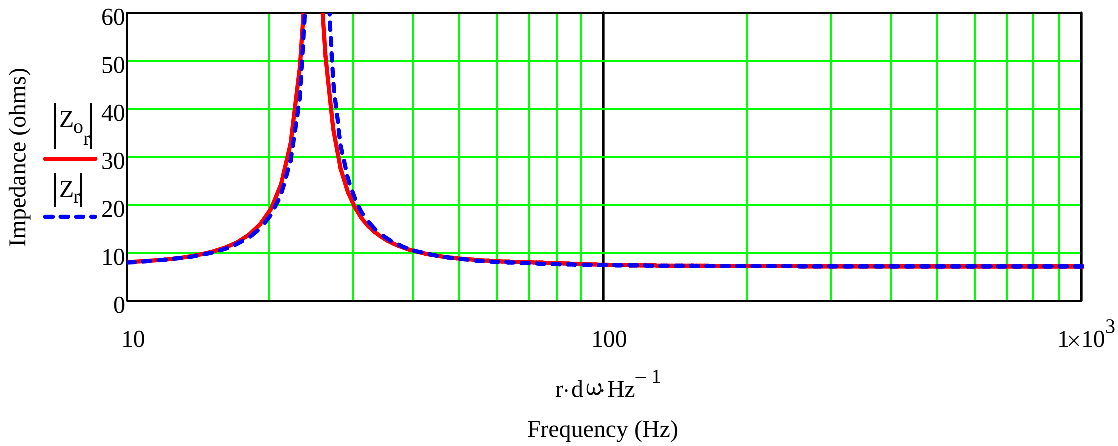
Woofer and Terminus Far Field Sound Pressure Level


Phase (deg)
arg(p_d_r)/deg
arg(p_L_r)/deg
180
135
90
45
0
– 45
– 90
– 135
– 180
10
100
1×10^3

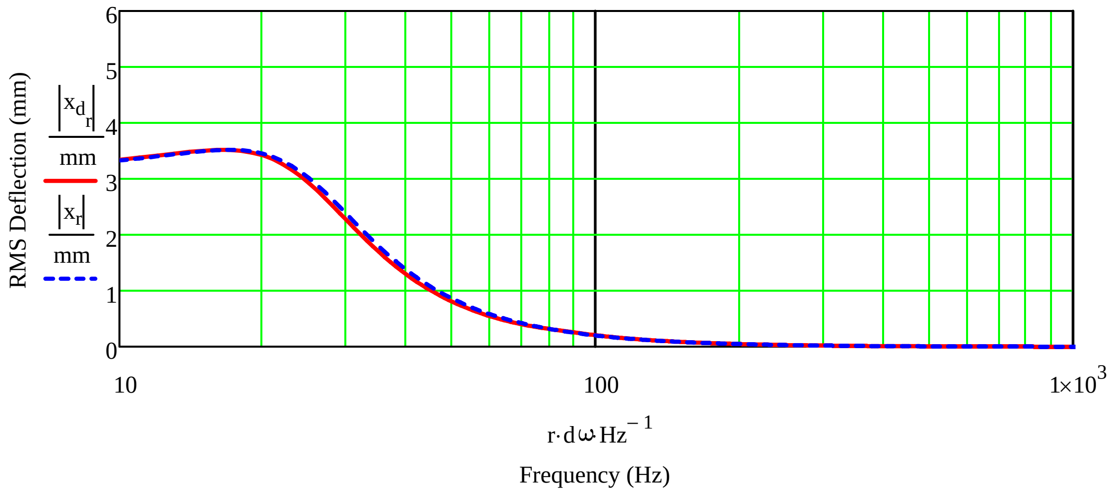

SPL (dB)
SPL_d_r
SPL_L_r
80
78
76
74
72
70
68
66
64
62
60
10
100
1×10^3
r·dω·Hz^−1
Frequency (Hz)

Back Loaded Horn System and Infinite Baffle Impedance

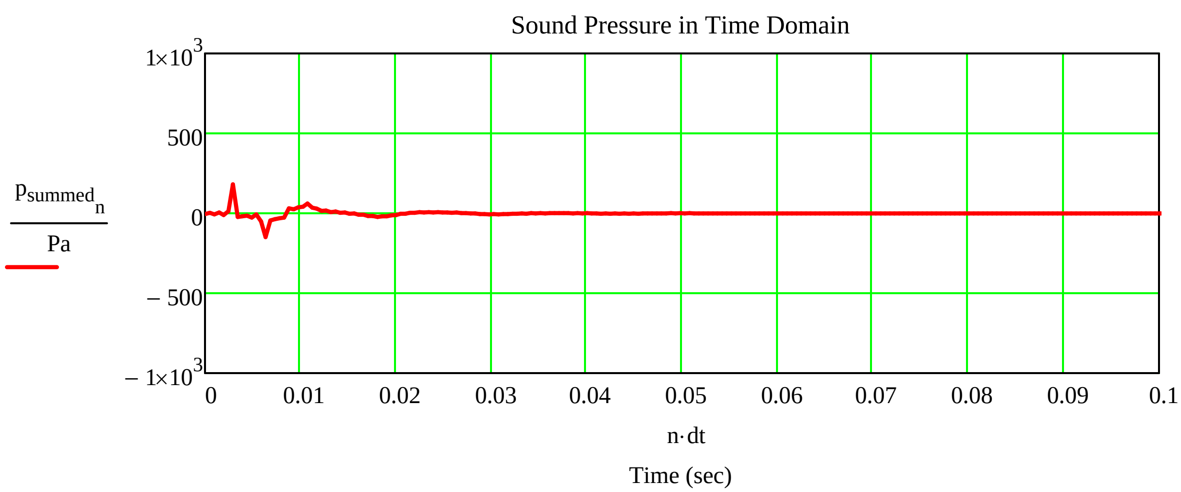




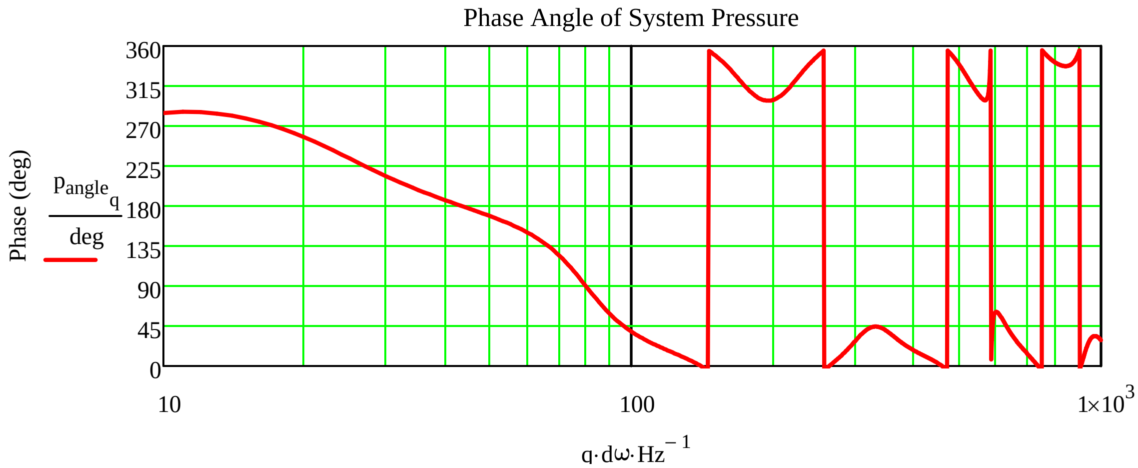
Woofer RMS Displacement

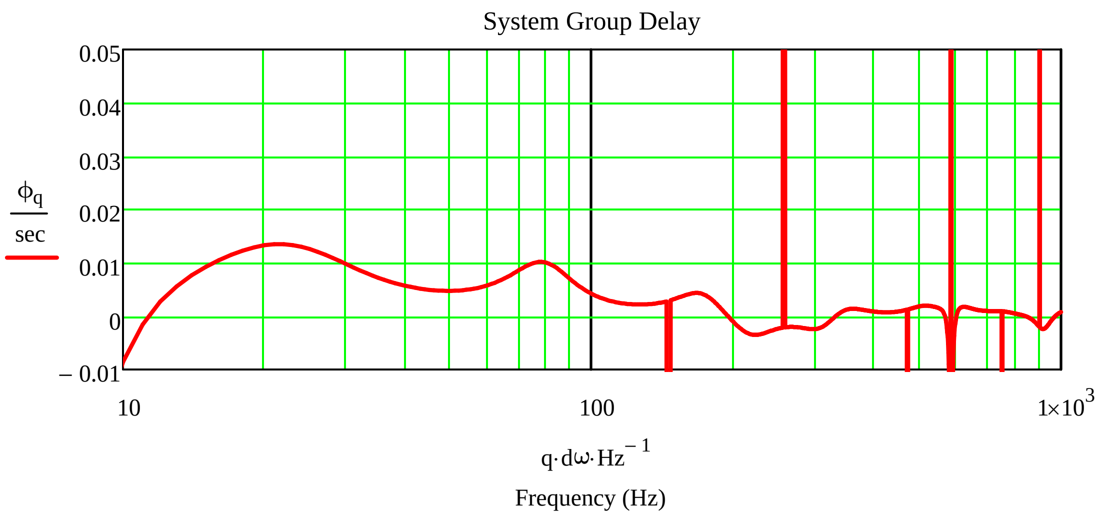


System Time Response for an Impulse Input

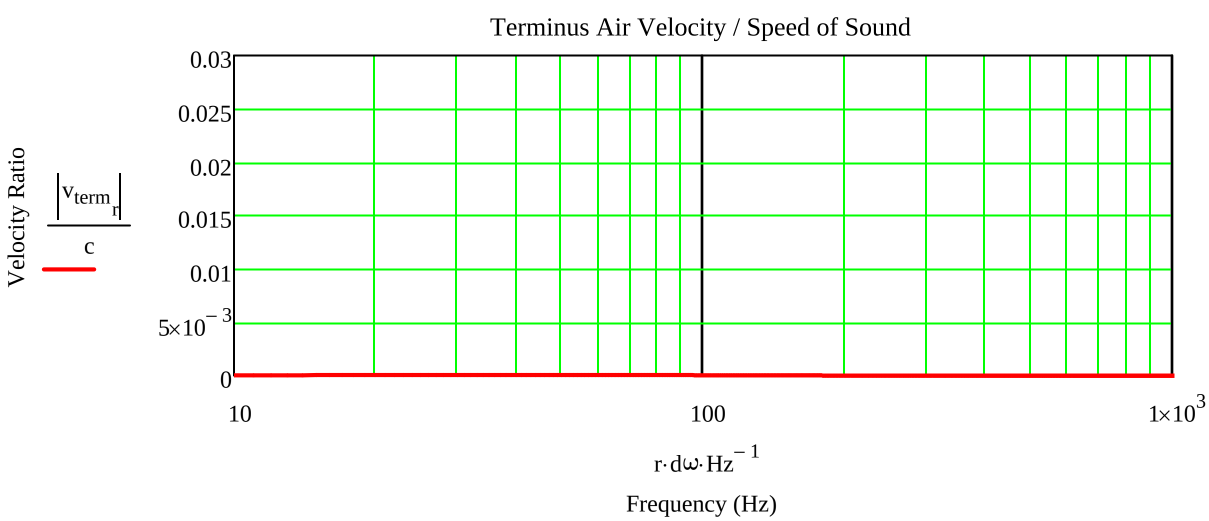


System Group Delay





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

$X_0 := 2 \cdot ft$	(Front Baffle Distance from Rear Wall > Depth of Enclosure)
$Y_0 := 2 \cdot ft$	(Front Baffle Distance from Side Wall)
$\theta_0 := 45 \cdot deg$	(Rotation Towards Room Center)
$Z_0 := 8 \cdot ft$	(Floor to Ceiling Distance)
$stand := 0 \cdot m$	(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	
$y_{o_0} := 10 \cdot in$		(Bottom Right Corner)
$y_{o_1} := 10 \cdot in$	$z_{o_1} := 37.5 \cdot in$	(Top Right Corner)
$y_{o_2} := 0 \cdot in$	$z_{o_2} := 37.5 \cdot in$	(Top Left Corner)
$y_{o_3} := 0 \cdot in$		(Bottom Left Corner)
$depth := 16.75 \cdot in$		(Depth of Enclosure)

Driver Geometry Input

$y_{dc} := 4.5 \cdot in$ (Driver Center x Coordinate)

$z_{dc} := 32.5 \cdot in$ (Driver Center y Coordinate)

n_dvr := 5 (Number of Points Across Diameter)

Terminus Geometry Input

$y_{mc} := 5 \cdot in$ (Terminus Center x Coordinate)

$z_{mc} := 11.06 \cdot in$ (Terminus Center y Coordinate)

$w_{mth} := 10 \cdot in$ (Terminus Width)

n_mth := 7 (Number of Points Across the Width)

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_listen = 0 (Listening Position Relative to Speaker)

$radius := 1 \cdot m$ (Calculation Radius, Effective Radius is Greater if y_p is Changed from Default)

$\theta := 0 \cdot deg$ (0 deg is along the Driver's Axis, -80 deg < θ < 80 deg)

$z_p := z_{dc}$ (Default Height is Equal to Driver Height)

n_listen = 1 (Listening Position Relative to the Room Corner)

$X_p := 10ft$

$Y_p := 7 \cdot ft$

$Z_p := z_{dc} + stand$ (Default Height is Equal to Driver Height)

n_listen := 0 (Method Selection)

Floor Condition

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

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

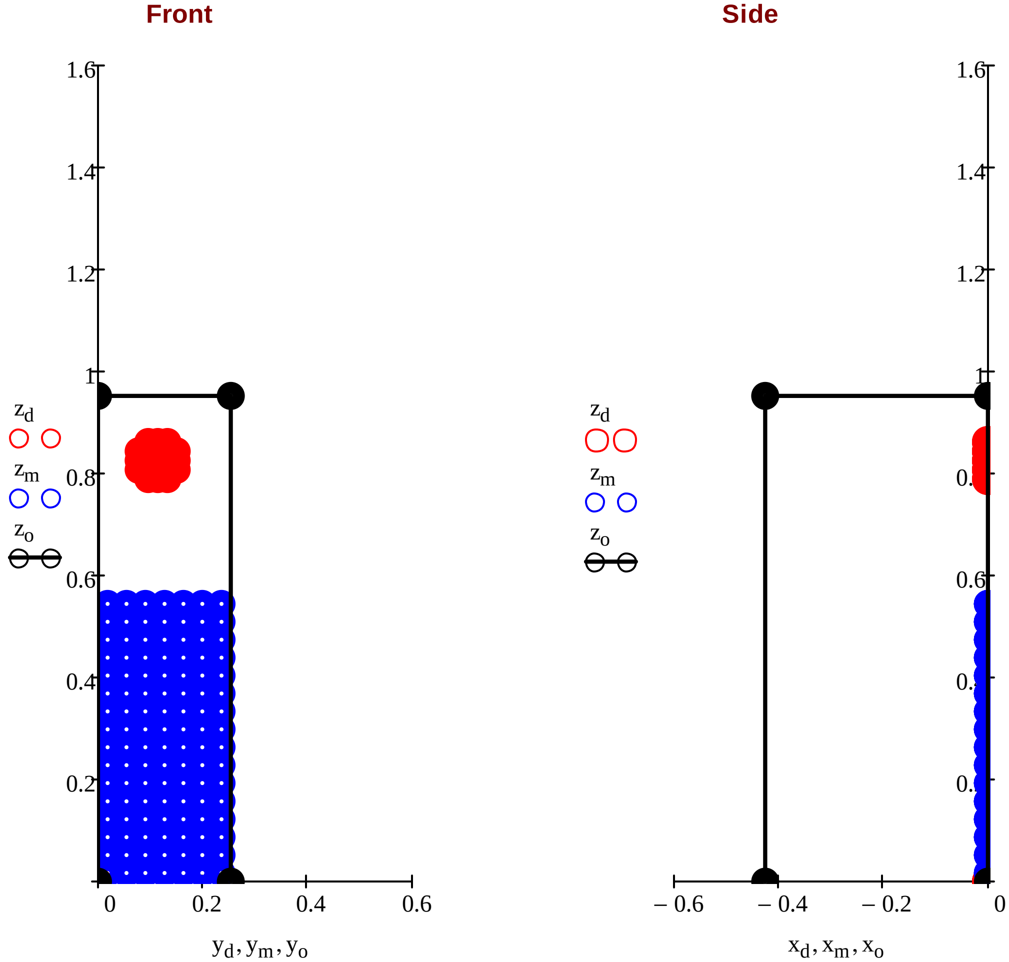
Inc_floor := 1 (Floor, Z = 0)

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

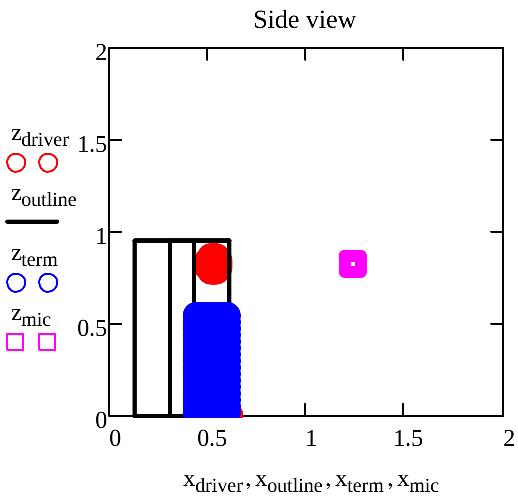


Red sources represent the driver.
Blue sources represent the terminus.
Black outline represents the baffle edge.
Origin is at the bottom front left corner of the enclosure.

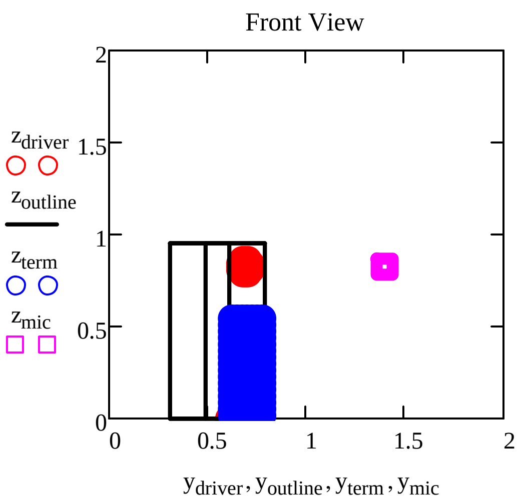
Three Dimensional View

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

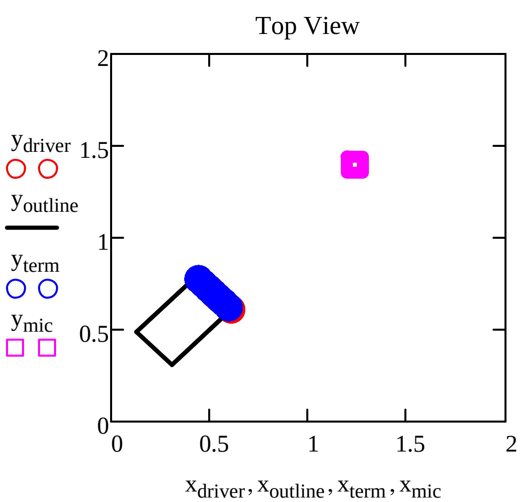
Room Corner is the Origin



Side View - looking out from side wall

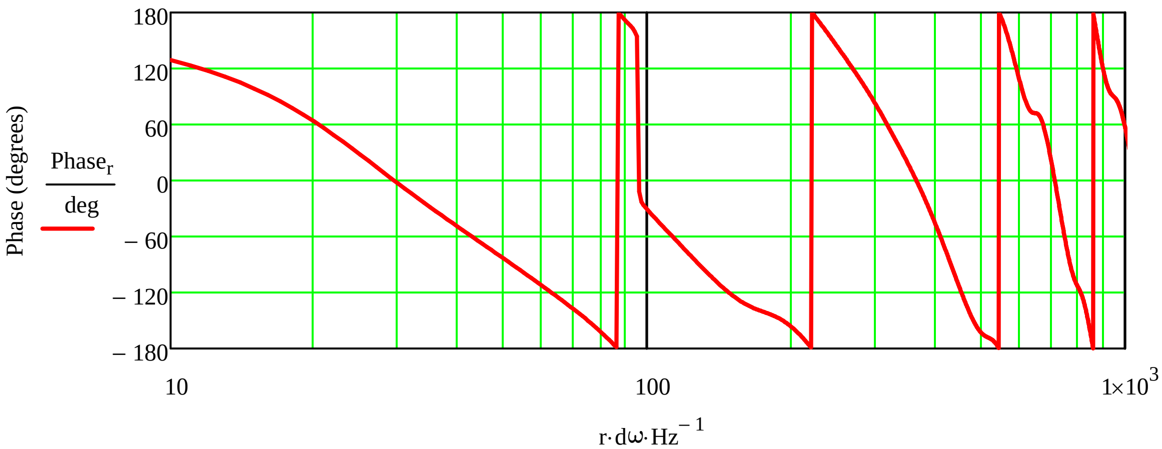


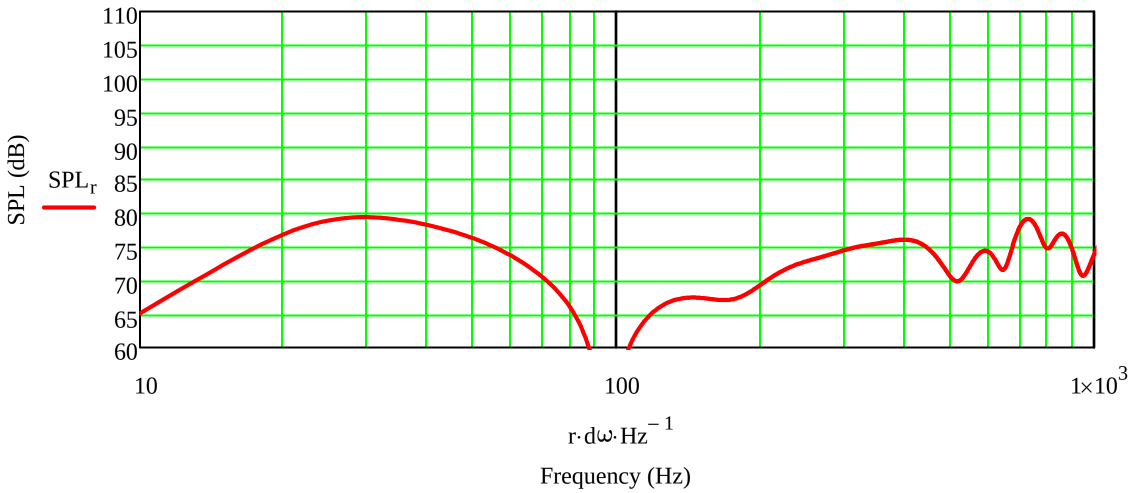
Front View - looking towards rear wall



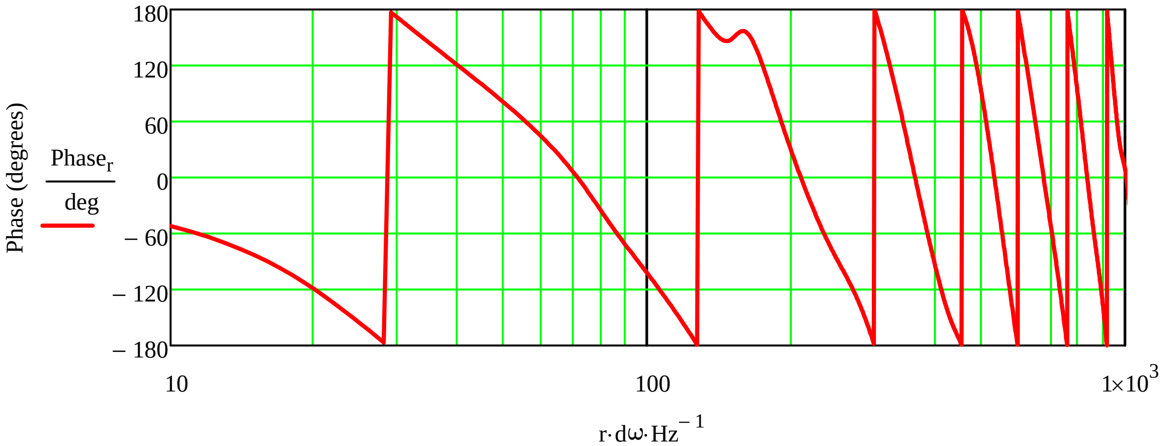
Top View - looking down from ceiling

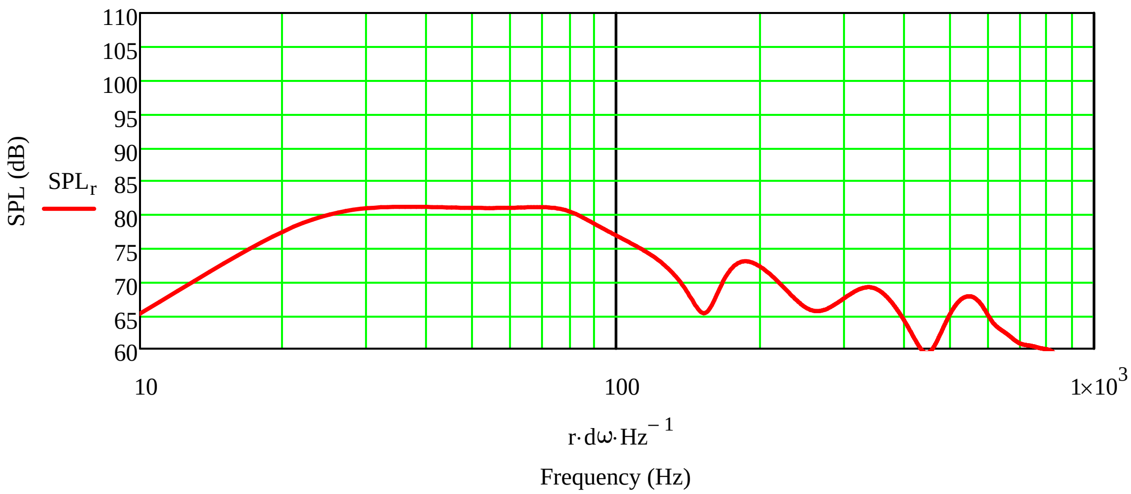
Plotted Baffle Step and Reflection SPL Response for the Circular Driver Source



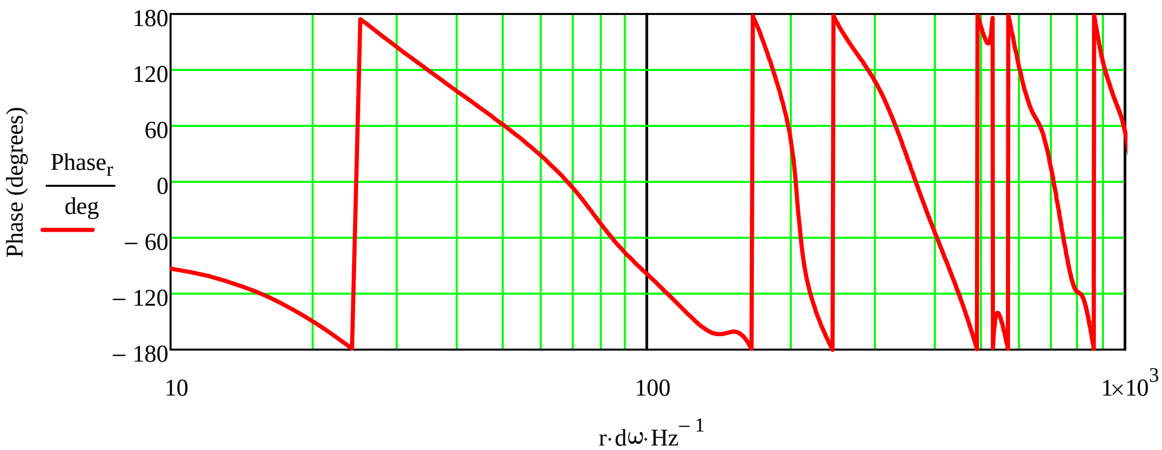


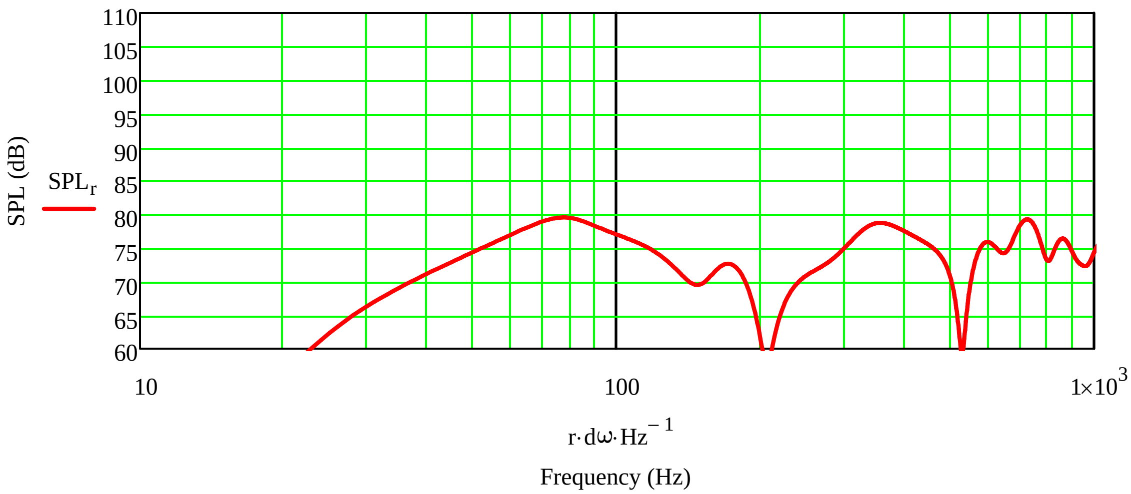
Plotted Baffle Step and Reflection SPL Response for the Terminus





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.

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

$dB := 0.1$ <--- Input dB of Attenuation

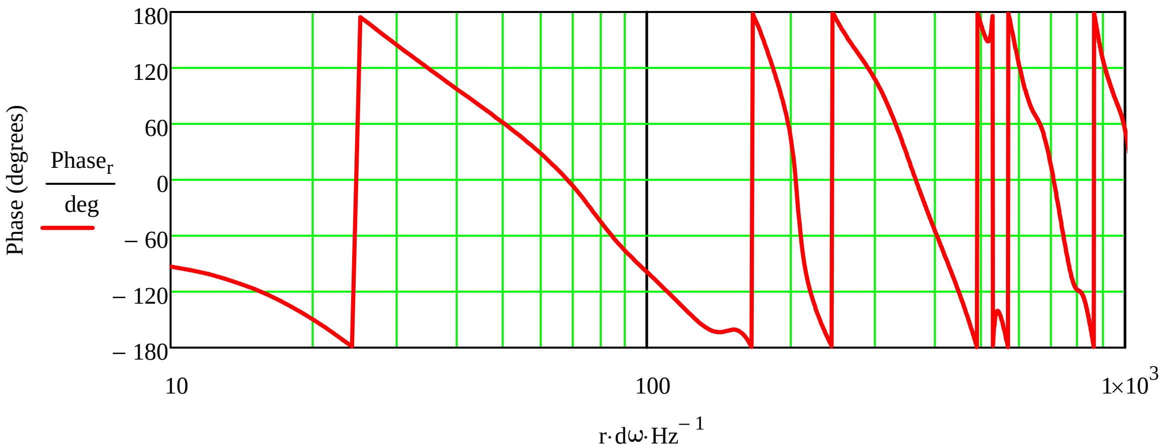
Calculated Component Values

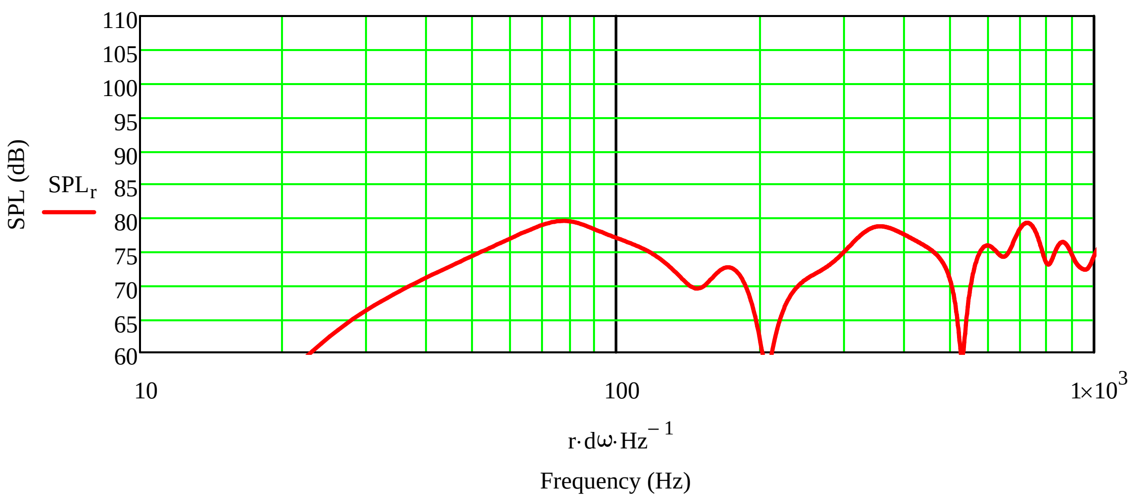
User Assigned Component Values Based on Calculated Values at Left

$R_e \cdot \left(10^{\frac{dB}{20}} - 1\right) = 0.083 \cdot \Omega$ Parallel Resistor Input Value ---> $R_{parallel} := 0.1 \cdot \Omega$

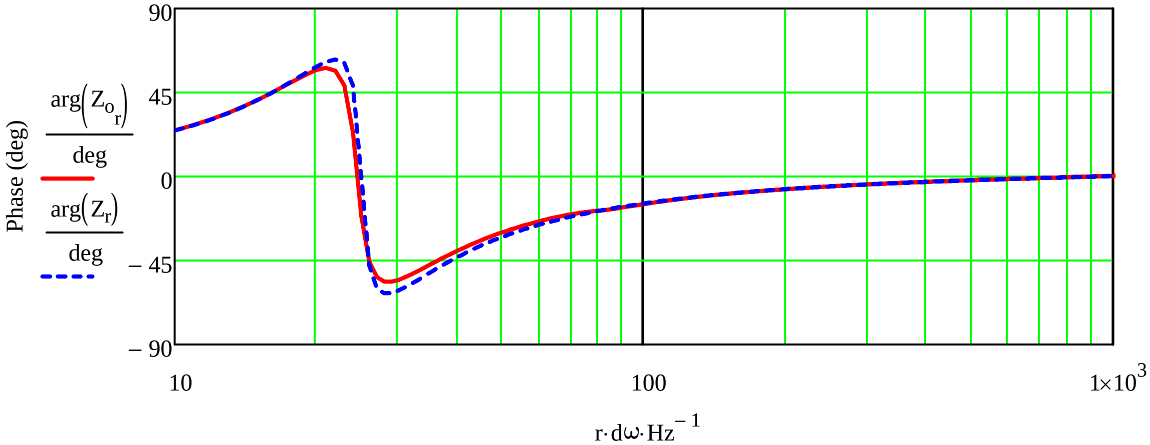
$\frac{R_{parallel}}{f_{center}} = 0.040 \cdot mH$ BSC Inductor Input Value ---> $L_{BSC} := 0.001 \cdot mH$

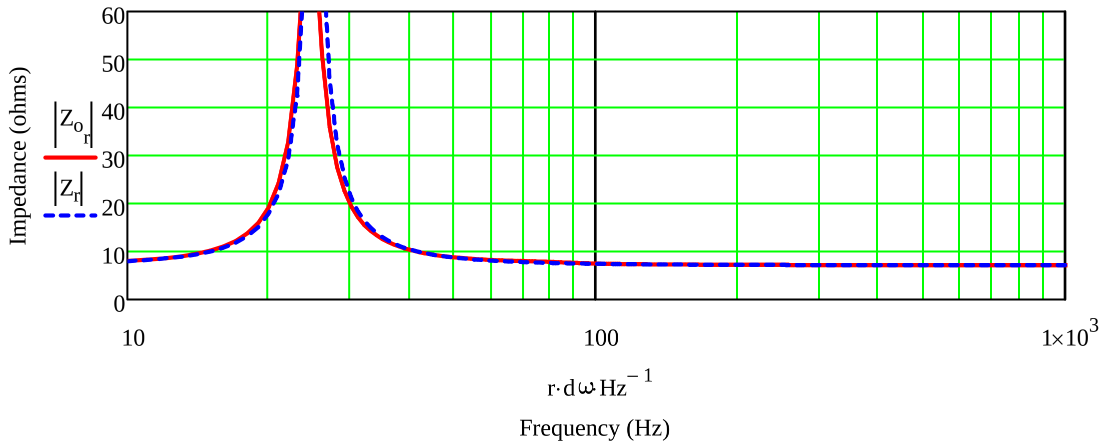
Plotted Corrected SPL Response for the System





Back Loaded Horn Corrected System and Infinite Baffle Impedance





System Time Response for an Impulse Input