Driver in a Double Bass Reflex Enclosure - Acoustic and Electrical Response 8/14/09

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

Unit and Constant Definition

$cycle := 2 \cdot \pi \cdot rad$ Air Density : $\rho := 1.205 \cdot kg \cdot m^{-3}$

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

Part 1 : Thiele-Small Consistent Calculation

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

Series Resistance

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

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

$f_d := 39 \cdot Hz$ $V_{ad} := 56.25 \cdot liter$ Adjustments

$R_e := 6.73 \cdot \Omega$ $Q_{ed} := 0.28$ $R_e := R_e + R_{add}$

$L_{vc} := 0 \cdot mH$ $Q_{md} := 3.86$ $Q_{ed} := Q_{ed} \cdot R_e \cdot (R_e - R_{add})^{-1}$

$Bl := 9.41 \cdot \frac{newton}{amp}$ $Q_{td} := \left(\frac{1}{Q_{ed}} + \frac{1}{Q_{md}}\right)^{-1}$

$S_d := 206.1 \cdot cm^2$ $Q_{td} = 0.261$

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

Lengths

$L := 858 \cdot mm$ (Total Internal Length of Enclosure)

$L_{top} := 250 \cdot mm$ (Internal Length of Top Chamber)

$t_{divider} := 21 \cdot mm$ (Thickness of Dividing Panel)

$L_{bot} := 587 \cdot mm$ (Internal Length of Bottom Chamber)

$L_{top} + t_{divider} + L_{bot} = 858\,mm$ <---- Must Equal Total Internal Length

$z_{driver} := 125 \cdot mm$ (Inside Distance from Top to Driver)

$z_{port} := 761 \cdot mm$ (Inside Distance from Top to Port)

Areas

$S_0 := 250 \cdot mm \cdot 250 \cdot mm$ (Area of the Top End)

$S_L := 250 \cdot mm \cdot 250 \cdot mm$ (Area of the Bottom End)

$S_{divider} := 110 \cdot mm \cdot 110 \cdot mm$ (Area of Divider Internal Port)

$L_{divider} := 131 \cdot mm$ (Length of Divider Internal Port)

$S_{port} := 110 \cdot mm \cdot 110 \cdot mm$ (Area of Exit Port)

$L_{port} := 111 \cdot mm$ (Length of Exit Port)

Stuffing Definition

$Density_1 := 0.2 \cdot lb \cdot ft^{-3}$ (Stuffing density in top chamber : 0 $lb/ft^3 < D_1 < 1\ lb/ft^3$)

$Density_2 := 0.2 \cdot lb \cdot ft^{-3}$ (Stuffing density in bottom chamber : 0 $lb/ft^3 < D_2 < 1\ lb/ft^3$)

Power

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

End of Abbreviated User Input

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

$TR := (S_L - S_0) \cdot L^{-1}$ $TR = 0\,m$

$L_D := L_{top} - z_{driver}$ (Length from Driver to Near Edge of Divider)

$S_D := S_0 + TR \cdot (L_{top})$ (Area at Near Edge of Plate)

$L_T := L - L_{top} - t_{divider}$ (Length from Far Edge of Divider to Bottom)

$S_T := S_0 + TR \cdot (L - L_T)$ (Area at Far Edge of Divider)

$L_P := z_{port} - L_{top} - t_{divider}$ (Length from Far Edge of Divider to Port Centerline)

$S_P := S_T + TR \cdot (L_P)$ (Area at Port Center Line)

$L_{port} := L_{port} + 0.6 \cdot \sqrt{\frac{S_{port}}{\pi}}$ (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 ($0\ \mathrm{lb/ft^3} < D < 1\ \mathrm{lb/ft^3}$)

$n\_top := 4$	(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
$L_{c_0} := z_{driver}\cdot(n\_top + 1)^{-1}$	$S_{c_{0,0}} := S_0 + TR\cdot z_{driver}$	$S_{c_{0,1}} := S_{c_{0,0}} - TR\cdot L_{c_0}$	$D_{c_0} := Density_1$
$L_{c_1} := z_{driver}\cdot(n\_top + 1)^{-1}$	$S_{c_{1,0}} := S_{c_{0,1}}$	$S_{c_{1,1}} := S_{c_{1,0}} - TR\cdot L_{c_1}$	$D_{c_1} := Density_1$
$L_{c_2} := z_{driver}\cdot(n\_top + 1)^{-1}$	$S_{c_{2,0}} := S_{c_{1,1}}$	$S_{c_{2,1}} := S_{c_{2,0}} - TR\cdot L_{c_2}$	$D_{c_2} := Density_1$
$L_{c_3} := z_{driver}\cdot(n\_top + 1)^{-1}$	$S_{c_{3,0}} := S_{c_{2,1}}$	$S_{c_{3,1}} := S_{c_{3,0}} - TR\cdot L_{c_3}$	$D_{c_3} := Density_1$
$L_{c_4} := z_{driver}\cdot(n\_top + 1)^{-1}$	$S_{c_{4,0}} := S_{c_{3,1}}$	$S_{c_{4,1}} := S_0$	$D_{c_4} := Density_1$

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

Section Length	Initial Area	Final Area	Stuffing Density
$L_{o_0} := L_D\cdot(n\_open - 7)^{-1}$	$S_{o_{0,0}} := S_0$	$S_{o_{0,1}} := S_{o_{0,0}} + TR\cdot L_{o_0}$	$D_{o_0} := Density_1$
$L_{o_1} := L_D\cdot(n\_open - 7)^{-1}$	$S_{o_{1,0}} := S_{o_{0,1}}$	$S_{o_{1,1}} := S_{o_{1,0}} + TR\cdot L_{o_1}$	$D_{o_1} := Density_1$
$L_{o_2} := L_D\cdot(n\_open - 7)^{-1}$	$S_{o_{2,0}} := S_{o_{1,1}}$	$S_{o_{2,1}} := S_{o_{2,0}} + TR\cdot L_{o_2}$	$D_{o_2} := Density_1$
$L_{o_3} := L_D\cdot(n\_open - 7)^{-1}$	$S_{o_{3,0}} := S_{o_{2,1}}$	$S_{o_{3,1}} := S_{o_{3,0}} + TR\cdot L_{o_3}$	$D_{o_3} := Density_1$
$L_{o_4} := L_D\cdot(n\_open - 7)^{-1}$	$S_{o_{4,0}} := S_{o_{3,1}}$	$S_{o_{4,1}} := S_{o_{4,0}} + TR\cdot L_{o_4}$	$D_{o_4} := Density_1$

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

Section Length	Initial Area	Final Area	Stuffing Density
$L_{o_5} := 0.6\cdot\sqrt{\frac{S_{divider}}{\pi}}$	$S_{o_{5,0}} := S_{divider}$	$S_{o_{5,1}} := S_{divider}$	$D_{o_5} := Density_1$
$L_{o_6} := L_{divider}$	$S_{o_{6,0}} := S_{divider}$	$S_{o_{6,1}} := S_{divider}$	$D_{o_6} := 0\cdot lb\cdot ft^{-3}$
$L_{o_7} := 0.6\cdot\sqrt{\frac{S_{divider}}{\pi}}$	$S_{o_{7,0}} := S_{divider}$	$S_{o_{7,1}} := S_{divider}$	$D_{o_7} := Density_2$

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

Section Length	Initial Area	Final Area	Stuffing Density
$L_{o_8} := L_P \cdot (n\_open - 7)^{-1}$	$S_{o_{8,0}} := S_T$	$S_{o_{8,1}} := S_{o_{8,0}} + TR \cdot L_{o_8}$	$D_{o_8} := Density_2$
$L_{o_9} := L_P \cdot (n\_open - 7)^{-1}$	$S_{o_{9,0}} := S_{o_{8,1}}$	$S_{o_{9,1}} := S_{o_{9,0}} + TR \cdot L_{o_9}$	$D_{o_9} := Density_2$
$L_{o_{10}} := L_P \cdot (n\_open - 7)^{-1}$	$S_{o_{10,0}} := S_{o_{9,1}}$	$S_{o_{10,1}} := S_{o_{10,0}} + TR \cdot L_{o_{10}}$	$D_{o_{10}} := Density_2$
$L_{o_{11}} := L_P \cdot (n\_open - 7)^{-1}$	$S_{o_{11,0}} := S_{o_{10,1}}$	$S_{o_{11,1}} := S_{o_{11,0}} + TR \cdot L_{o_{11}}$	$D_{o_{11}} := Density_2$
$L_{o_{12}} := L_P \cdot (n\_open - 7)^{-1}$	$S_{o_{12,0}} := S_{o_{11,1}}$	$S_{o_{12,1}} := S_{o_{12,0}} + TR \cdot L_{o_{12}}$	$D_{o_{12}} := Density_2$

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

Section Length	Initial Area	Final Area	Stuffing Density
$L_{b_0} := L_B \cdot (n\_bottom + 1)^{-1}$	$S_{b_{0,0}} := S_P$	$S_{b_{0,1}} := S_{b_{0,0}} + TR \cdot L_{b_0}$	$D_{b_0} := Density_2$
$L_{b_1} := L_B \cdot (n\_bottom + 1)^{-1}$	$S_{b_{1,0}} := S_{b_{0,1}}$	$S_{b_{1,1}} := S_{b_{1,0}} + TR \cdot L_{b_1}$	$D_{b_1} := Density_2$
$L_{b_2} := L_B \cdot (n\_bottom + 1)^{-1}$	$S_{b_{2,0}} := S_{b_{1,1}}$	$S_{b_{2,1}} := S_{b_{2,0}} + TR \cdot L_{b_2}$	$D_{b_2} := Density_2$
$L_{b_3} := L_B \cdot (n\_bottom + 1)^{-1}$	$S_{b_{3,0}} := S_{b_{2,1}}$	$S_{b_{3,1}} := S_{b_{3,0}} + TR \cdot L_{b_3}$	$D_{b_3} := Density_2$
$L_{b_4} := L_B \cdot (n\_bottom + 1)^{-1}$	$S_{b_{4,0}} := S_{b_{3,1}}$	$S_{b_{4,1}} := S_L$	$D_{b_4} := Density_2$

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

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

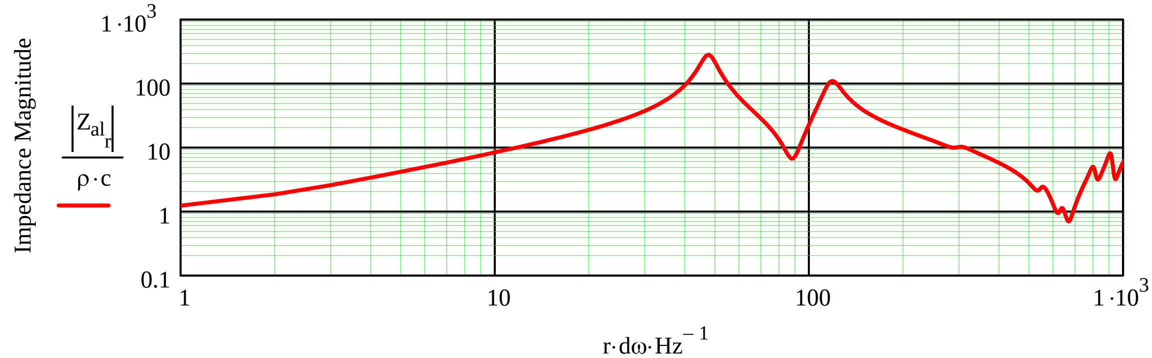
Total Amount of Stuffing

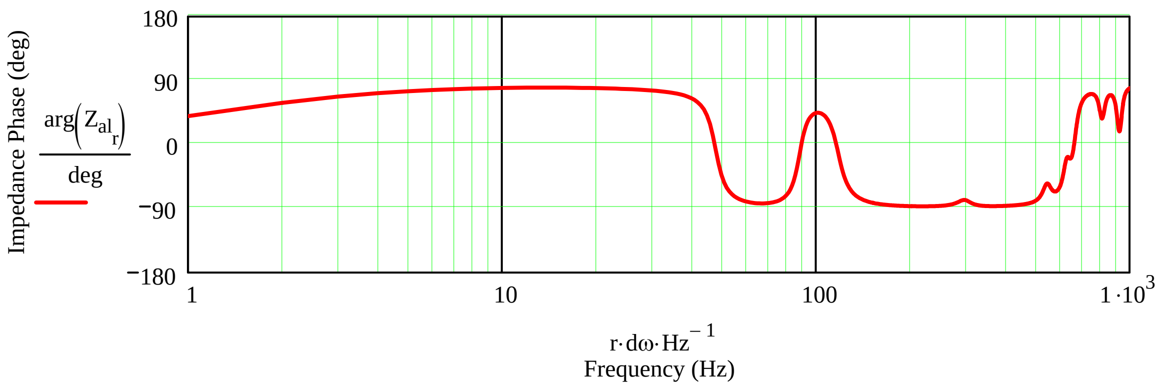
$$\sum_{r=0}^{n\_top}\left[\frac{\left(S_{c_{r,0}} + S_{c_{r,1}}\right)}{2} \cdot L_{c_r} \cdot D_{c_r}\right] + \sum_{r=0}^{n\_open}\left[\frac{\left(S_{o_{r,0}} + S_{o_{r,1}}\right)}{2} \cdot L_{o_r} \cdot D_{o_r}\right] \ldots + \sum_{r=0}^{n\_bottom}\left[\frac{\left(S_{b_{r,0}} + S_{b_{r,1}}\right)}{2} \cdot L_{b_r} \cdot D_{b_r}\right] + \sum_{r=0}^{n\_port}\left[\frac{\left(S_{p_{r,0}} + S_{p_{r,1}}\right)}{2} \cdot L_{p_r} \cdot D_{p_r}\right] = 0.376\ lb$$

End of Pre Formatted Default Input

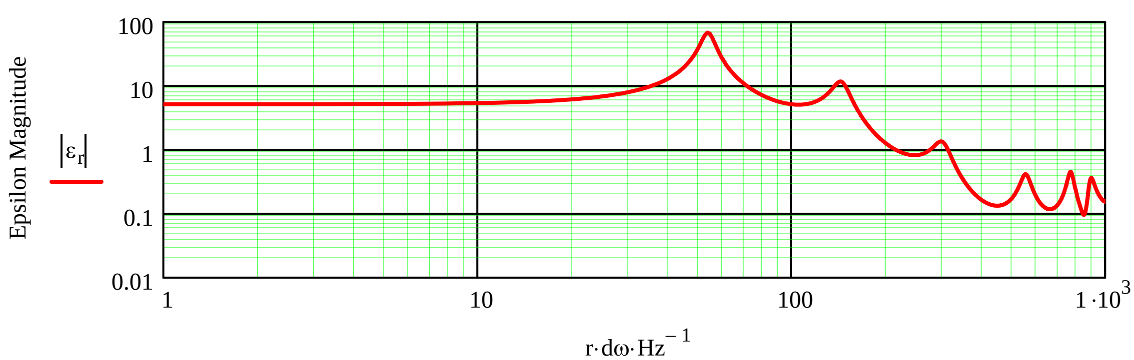
End of Part 1 Input

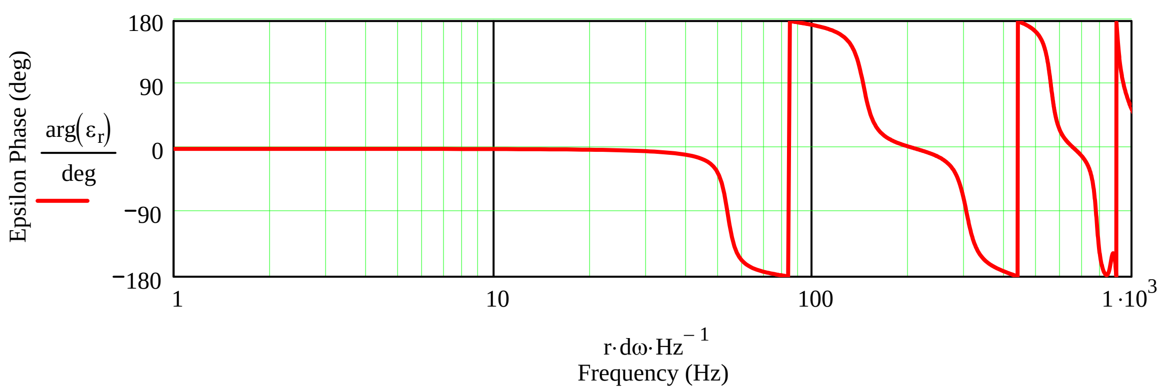
Resulting Acoustic Impedance for the Enclosure



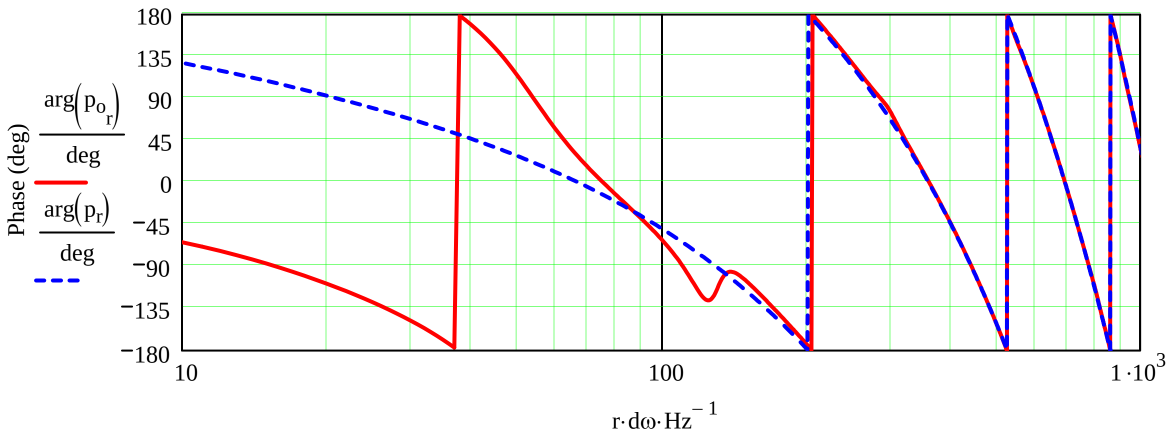


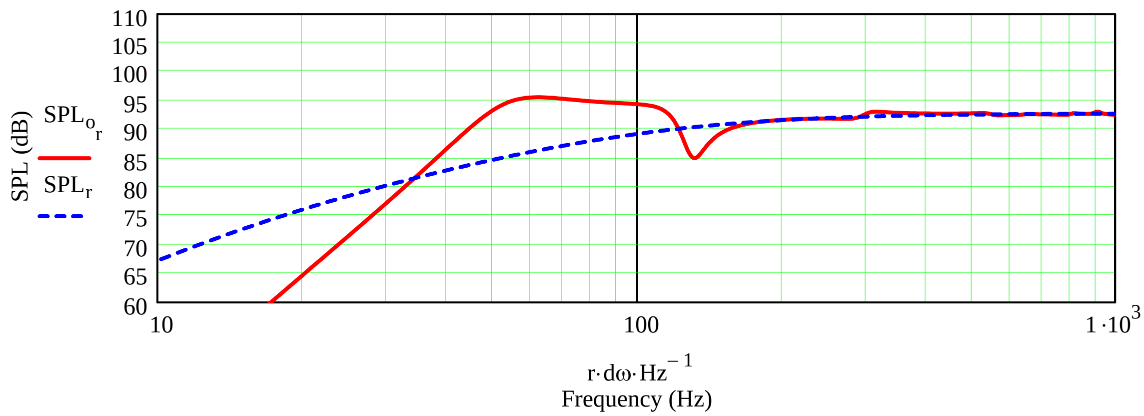
Velocity at the Terminus of the Ported Box for a 1 m/sec Excitation at the Driver Position



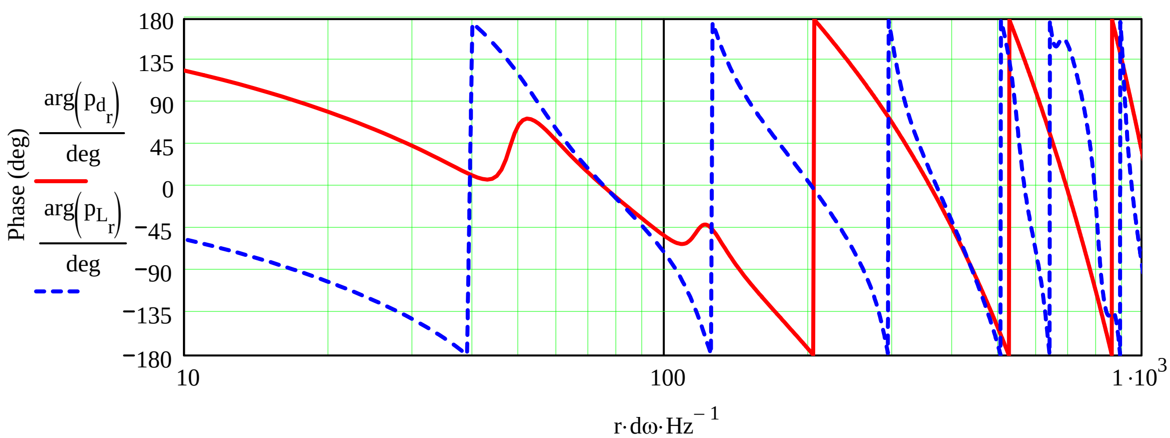


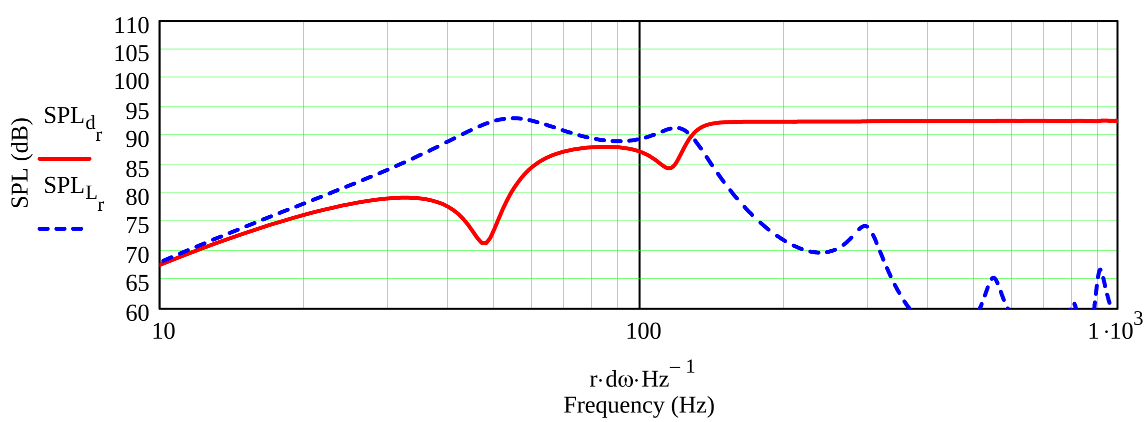
Far Field Ported Box System and Infinite Baffle Sound Pressure Level Responses



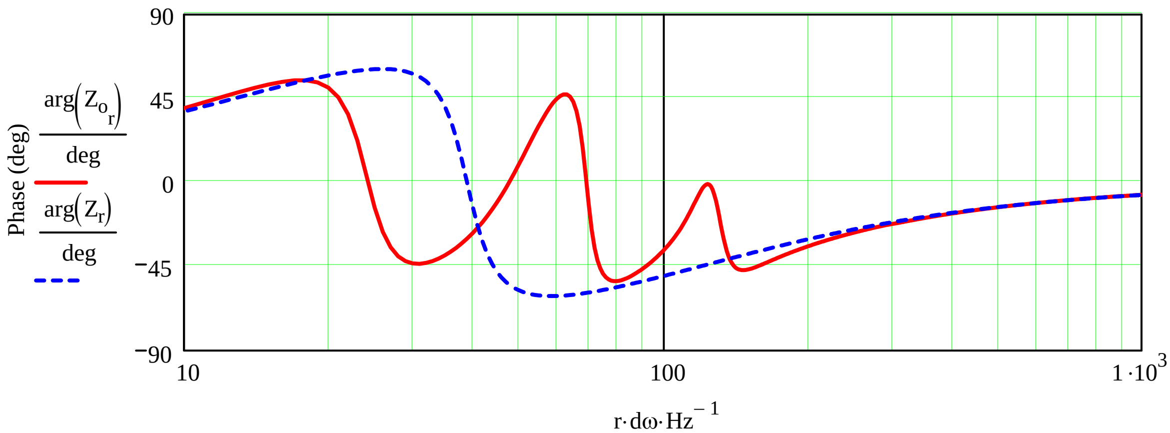


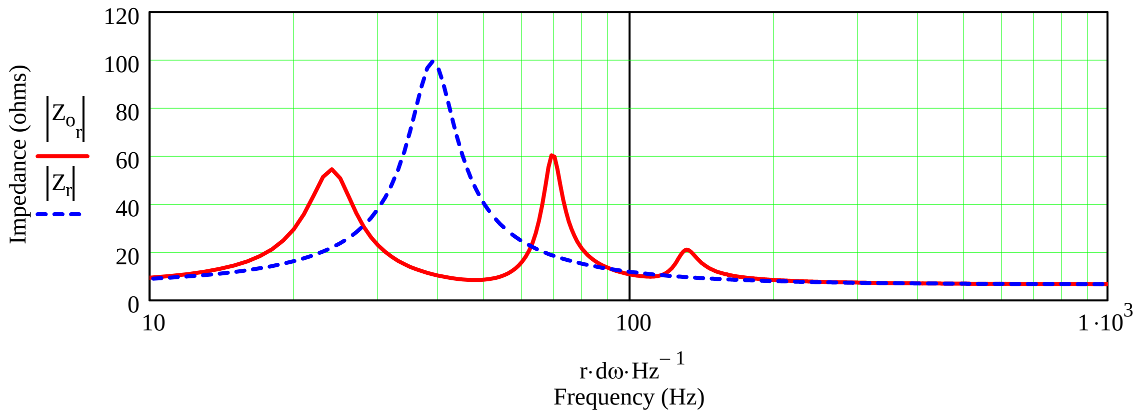
Woofer and Terminus Far Field Sound Pressure Level Responses



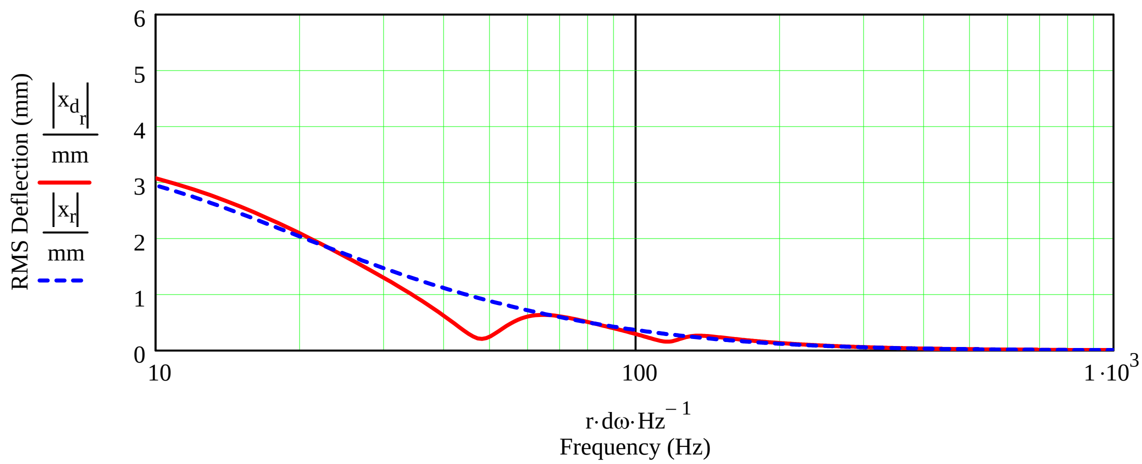


Ported Box System and Infinite Baffle Impedance

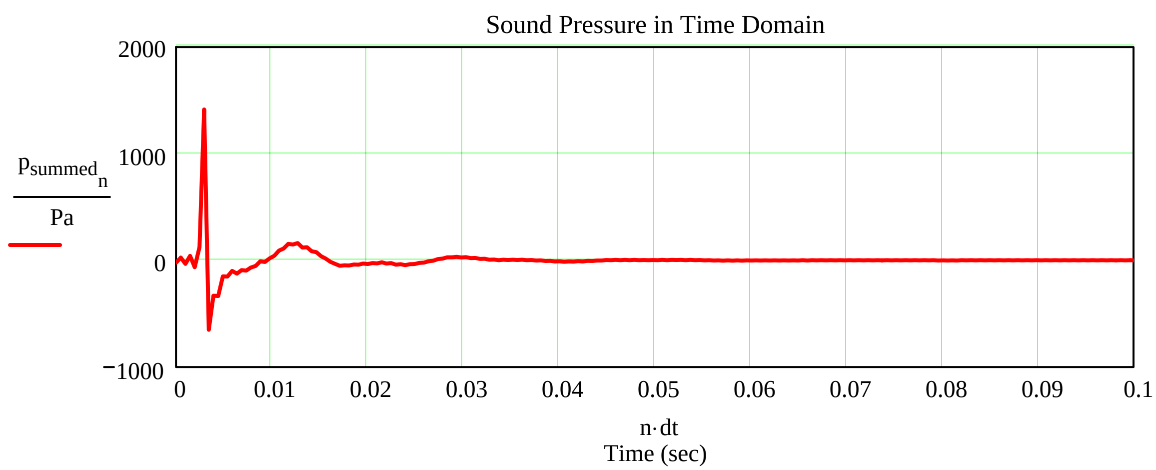




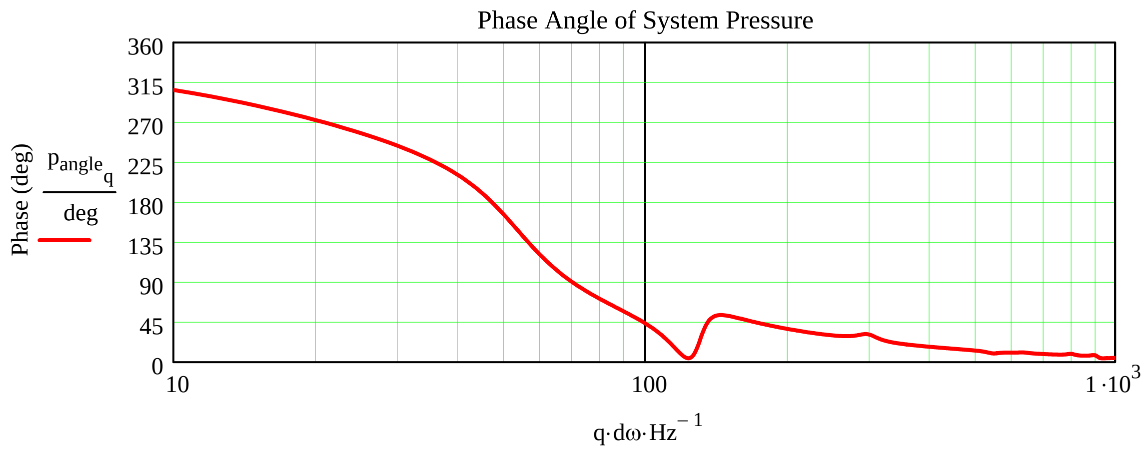
Woofer RMS Displacement

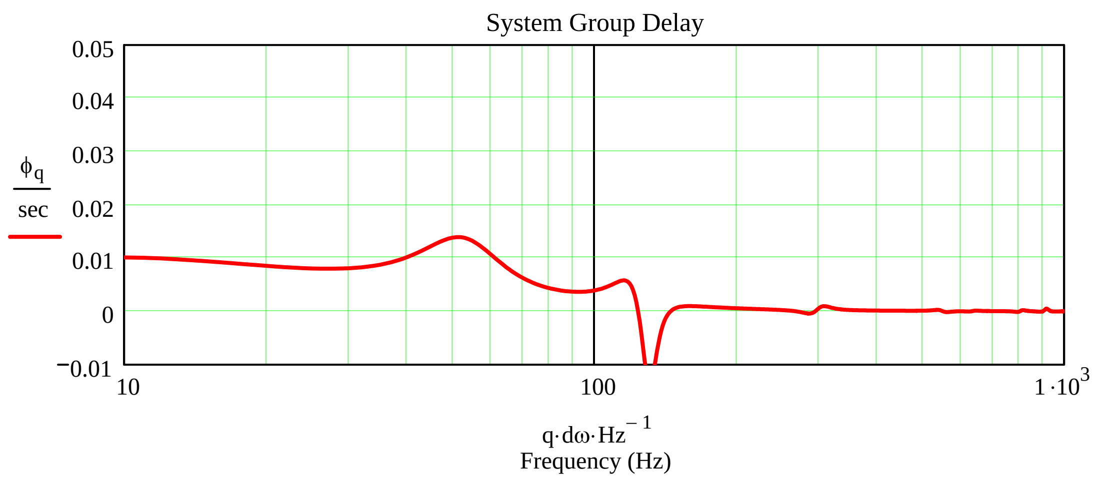


System Time Response for an Impulse Input

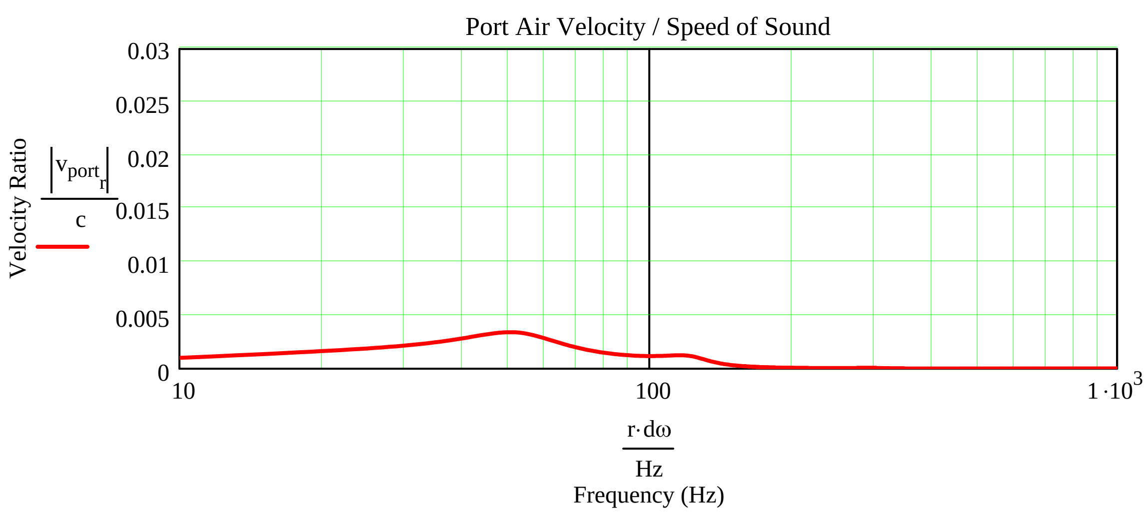


System Group Delay





Port Air Velocity (should be < 10 m/sec / 344 m/sec = 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

$X_0 := 2 \cdot ft$ (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	
$yo_0 := 292 \cdot mm$		(Bottom Right Corner)
$yo_1 := 292 \cdot mm$	$zo_1 := 900 \cdot mm$	(Top Right Corner)
$yo_2 := 0 \cdot in$	$zo_2 := 900 \cdot mm$	(Top Left Corner)
$yo_3 := 0 \cdot in$		(Bottom Left Corner)
$depth := 320 \cdot mm$		(Depth of Enclosure)

Driver Geometry Input

$y_{dc} := 146 \cdot mm$ (Driver Center y Coordinate)

$z_{dc} := 754 \cdot mm$ (Driver Center z Coordinate)

n_dvr := 5 (Number of Points Across Diameter)

Port Geometry Input

$y_{mc} := 146 \cdot mm$ (Port Center y Coordinate)

$z_{mc} := 118 \cdot mm$ (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)

$\theta := 0 \cdot deg$ (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)

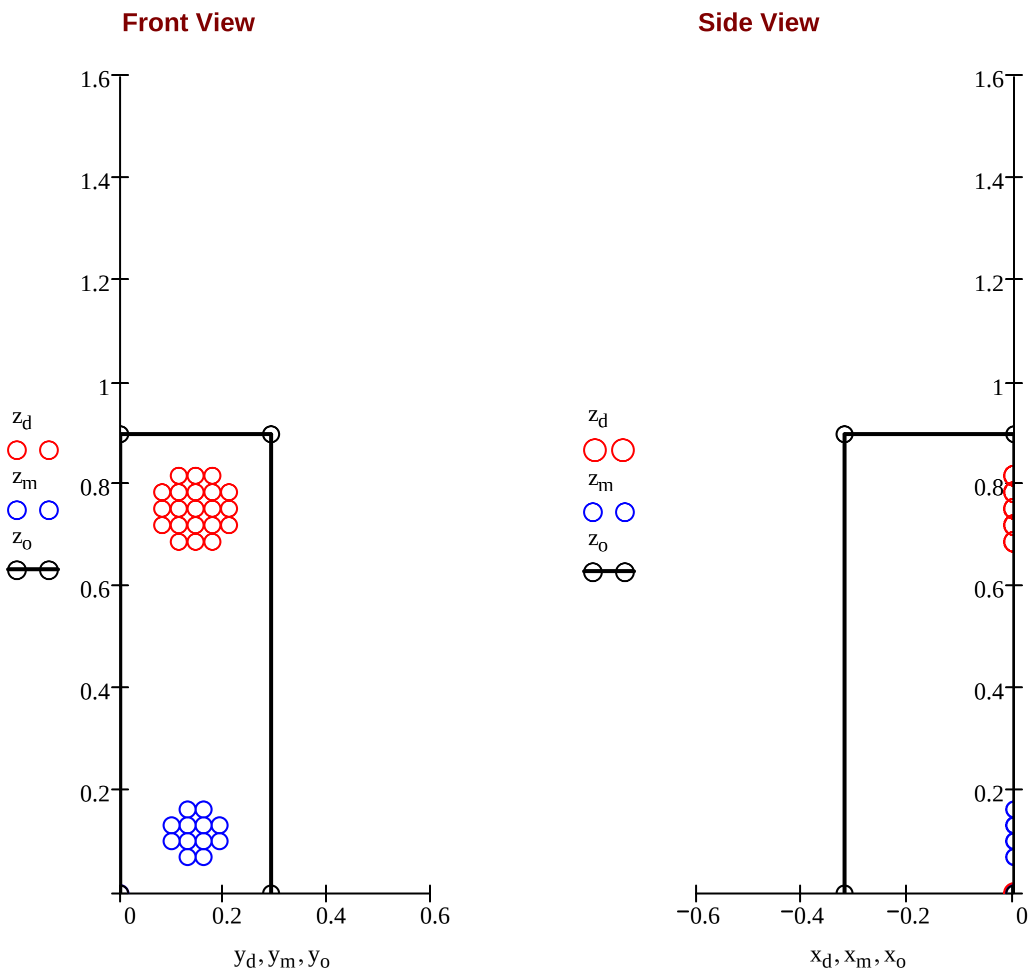
Inc_floor := 1 (Floor, Z = 0)

Inc_rear := 0 (Rear Wall, X = 0)

Inc_side := 0 (Left Side Wall, Y = 0)

Inc_ceiling := 0 (Ceiling)

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

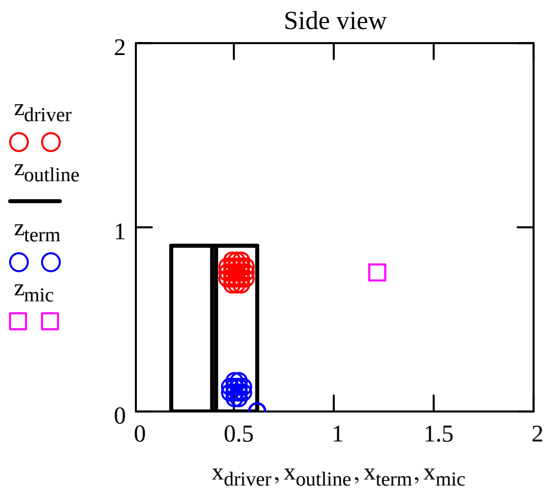


Red sources represent the driver.
Blue sources represent the port.
Black outline represents the baffle edge.
Origin is at the bottom front left corner of the enclosure.

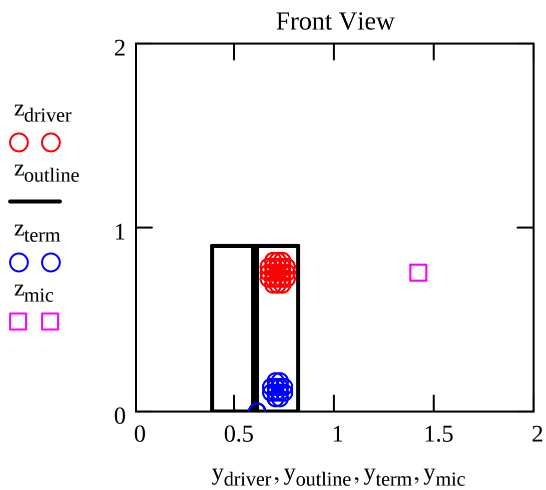
Three Dimensional View

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

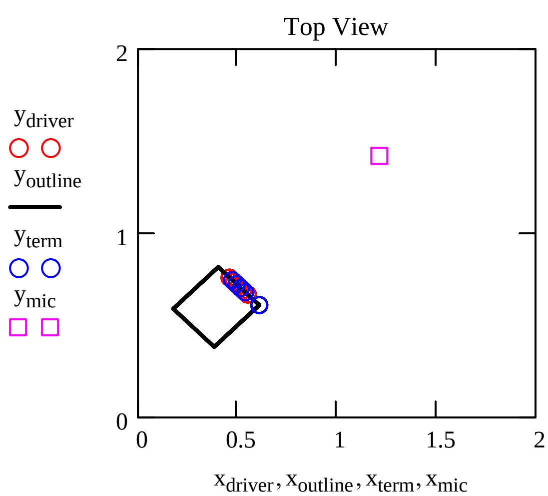
Room Corner is the Origin



Side View - looking out from side wall

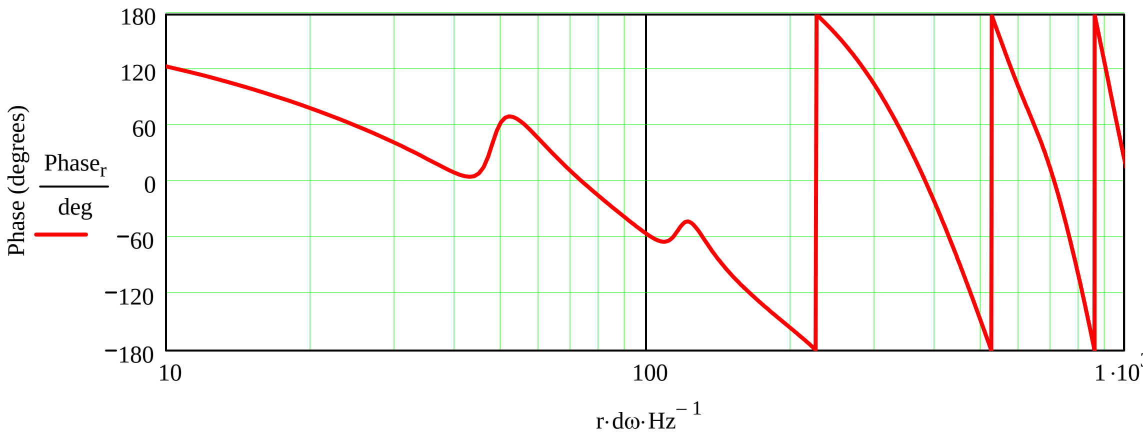


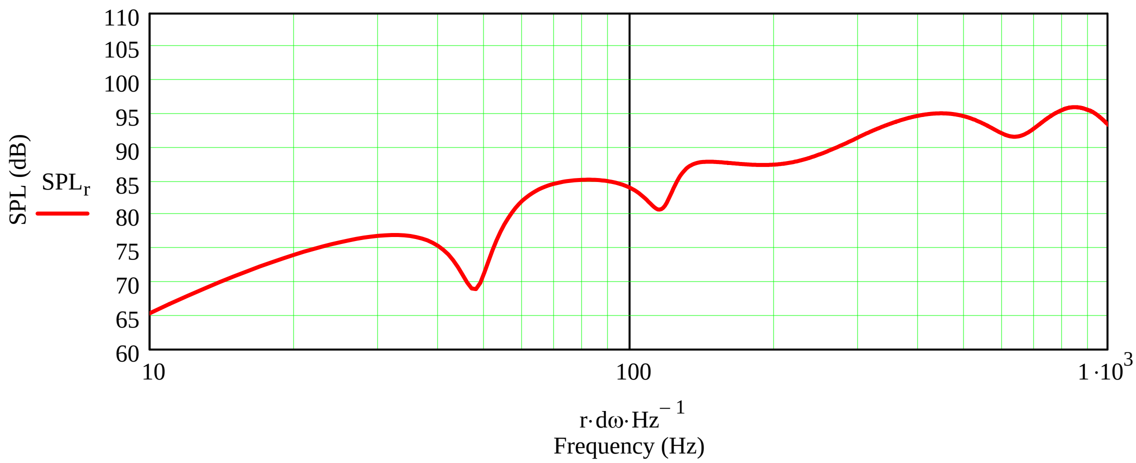
Front View - looking towards rear wall



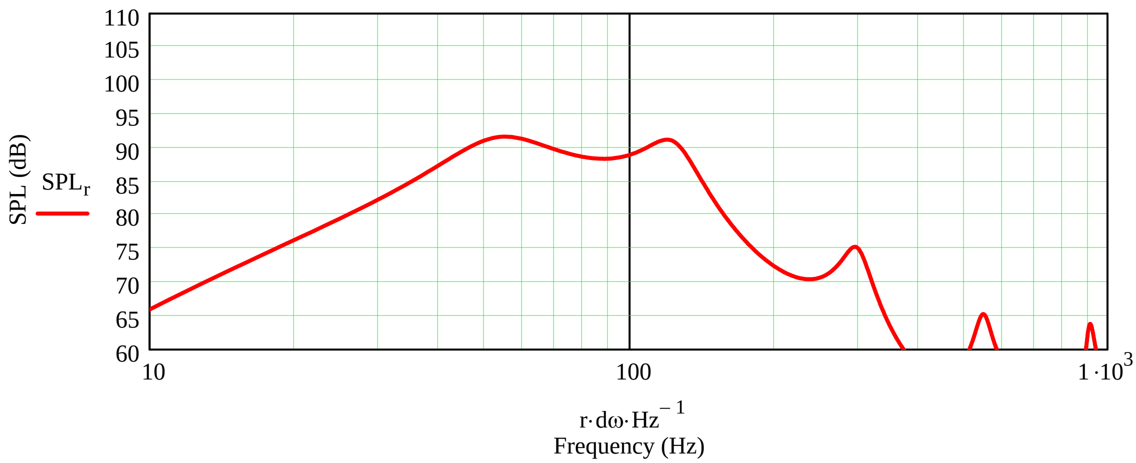
Top View - looking down from ceiling

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

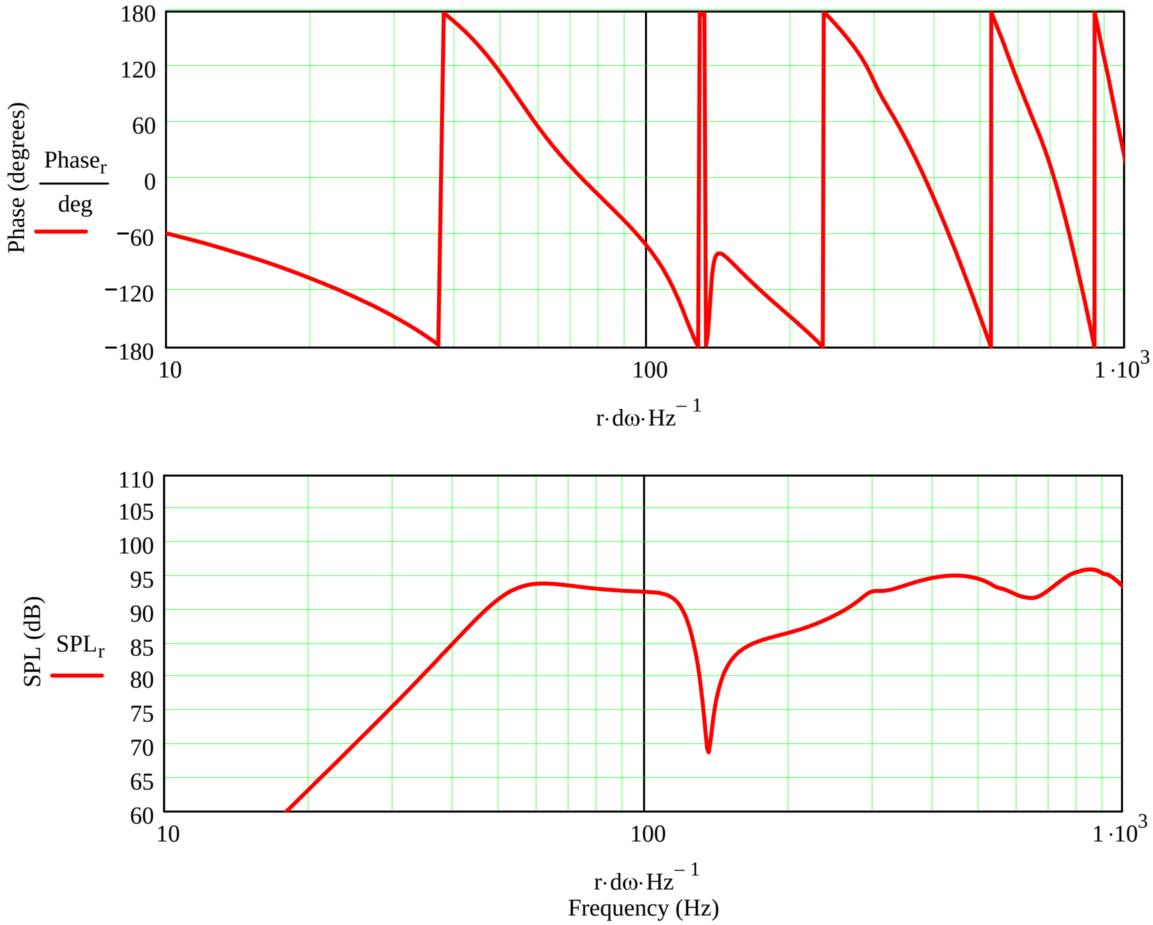




Plotted Baffle Step and Reflection SPL Response for the Circular Port Source



Plotted SPL Response for the System



Part 3 : Baffle Step Correction Circuit Design

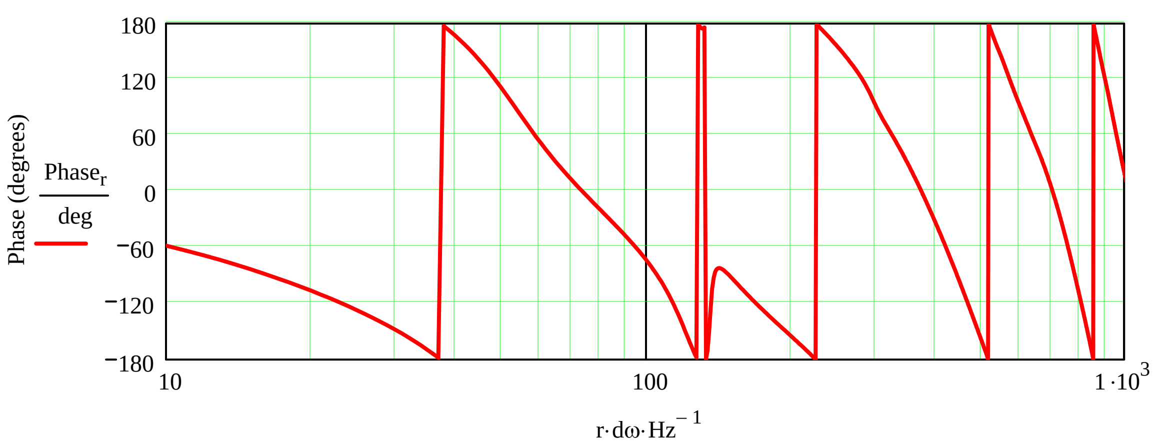
Input Center Frequency of the Baffle Step and the desired dB of Attenuation.

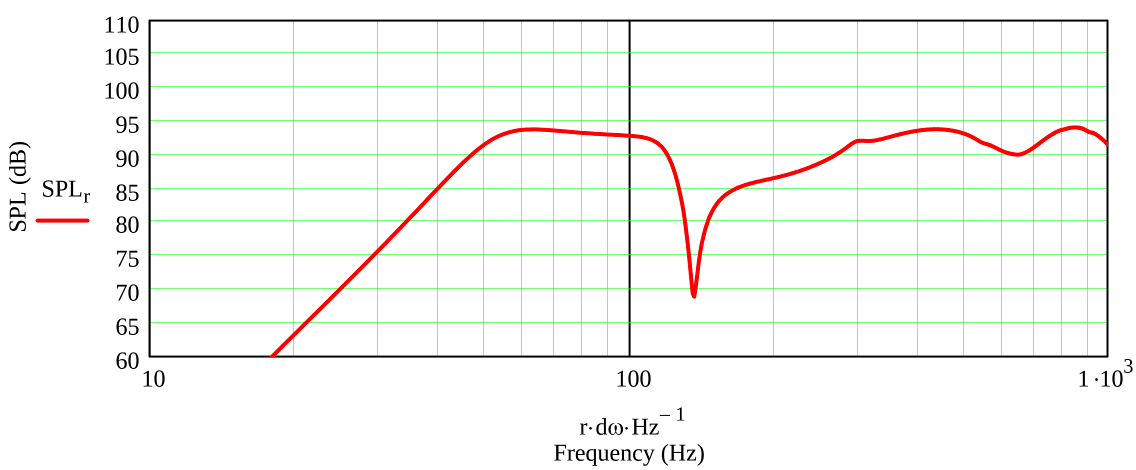
$f_{center} := 350 \cdot Hz$ <--- Input Center Frequency

$dB := 2$ <--- Input dB of Attenuation

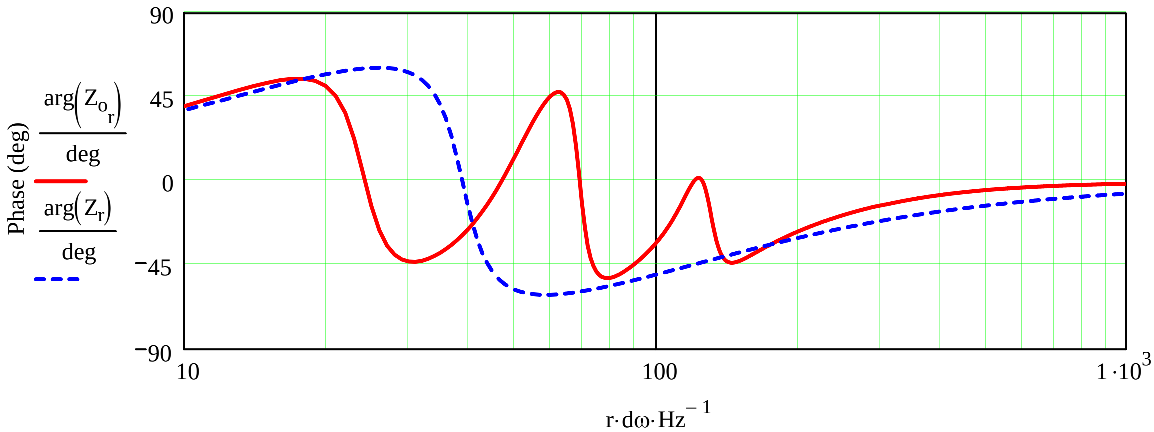
Calculated Component Values		User Assigned Component Values Based on Calculated Values at Left	
$R_e \cdot \left(10^{\frac{dB}{20}} - 1\right) = 1.743\,\Omega$	Parallel Resistor	Input Value --->	$R_{parallel} := 2 \cdot \Omega$
$\frac{R_{parallel}}{f_{center}} = 0.909\,mH$	BSC Inductor	Input Value --->	$L_{BSC} := 1 \cdot mH$

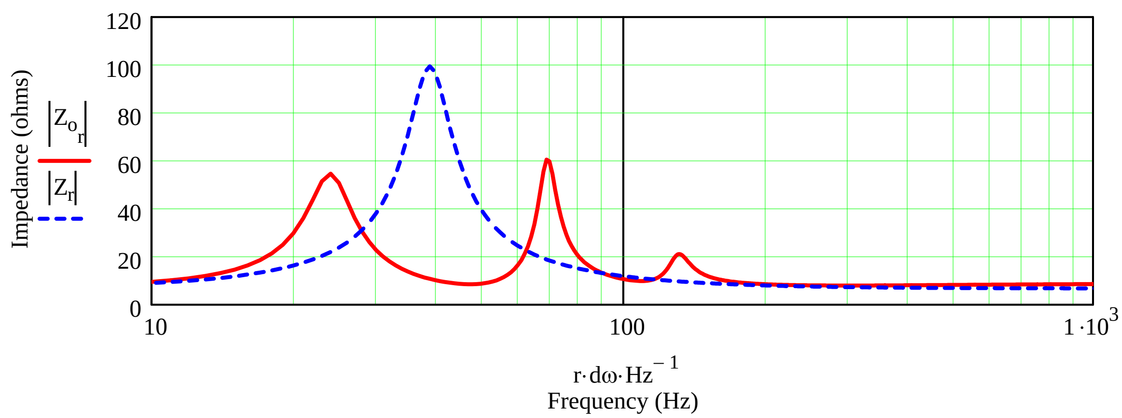
Plotted Corrected SPL Response for the System





Ported Box Corrected System and Infinite Baffle Impedance





System Time Response for an Impulse Input