Driver in a Mass Loaded Transmission Line - Acoustic and Electrical Response

8/14/0

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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

$R_{add} := 0.2 \cdot \Omega$

Driver Thiele / Small Parameters : Lowther DX3 Average Driver Properties

$f_d := 55 \cdot Hz$

$V_{ad} := 18.5 \cdot liter$

Adjustments

$R_e := 6.2 \cdot \Omega$

$Q_{ed} := 0.44$

$R_e := R_e + R_{add}$

$L_{vc} := 0.4 \cdot mH$

$Q_{md} := 6.16$

$Q_{ed} := Q_{ed} \cdot R_e \cdot (R_e - R_{ad}$

$Bl := 7.2 \cdot \frac{newton}{amp}$

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

$S_d := 138 \cdot cm^2$

$Q_{td} = 0.423$

Enclosure Geometry Definition : Model of Internal Air Volume

$L := 102 \cdot cm$ (Internal Height)

$z_{driver} := 19 \cdot cm$ (Driver Internal Distance From Top < Height)

$z_{port} := 98 \cdot cm$ (Port Internal Distance From Top < Height)

$S_0 := 18.5 \cdot cm \cdot 10 \cdot cm$ (Internal Area of the Top End, z = 0)

$S_L := 18.5 \cdot cm \cdot 10 \cdot cm$ (Internal Area of the Bottom End, z = L)

$Density := 0.35 \cdot lb \cdot ft^{-3}$ (Stuffing density : 0 lb/ft^3 < D < 1 lb/ft^3)

$r_{port} := 2.4 \cdot cm$ (Inside Radius of the Port)

$L_{port} := 9 \cdot cm$ (Length of the Port)

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

End of Abbreviated User Input

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

ML TL Definition (0 lb/ft3 < D < 1 lb/ft3)

$n\_top := 4$	(n_top > 1)	$x_{top} := z_{driver}$
$n\_open := 4$	(n_open > 1)	$x_{open} := z_{port} - z_{driver}$
$n\_bottom := 4$	(n_bottom > 1)	$x_{bottom} := L - z_{port}$
$n\_port := 4$	(n_port > 1)	$x_{port} := L_{port} + 0.6 \cdot r_{port}$

Geometry Definition

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

$S_D := S_0 + TR \cdot z_{driver}$ $\quad S_D = 0.019\ m^2$

$S_P := S_0 + TR \cdot z_{port}$ $\quad S_P = 0.019\ m^2$

Top Section of Enclosure (Driver ---> Top of Enclosure)

Section Length	Initial Area	Final Area	Stuffing Density
$L_{c_0} := x_{top} \cdot (n\_top + 1)^{-1}$	$S_{c_{0,0}} := S_D$	$S_{c_{0,1}} := S_{c_{0,0}} - TR \cdot L_{c_0}$	$D_{c_0} := Density$
$L_{c_1} := x_{top} \cdot (n\_top + 1)^{-1}$	$S_{c_{1,0}} := S_{c_{0,1}}$	$S_{c_{1,1}} := S_{c_{1,0}} - TR \cdot L_{c_1}$	$D_{c_1} := Density$
$L_{c_2} := x_{top} \cdot (n\_top + 1)^{-1}$	$S_{c_{2,0}} := S_{c_{1,1}}$	$S_{c_{2,1}} := S_{c_{2,0}} - TR \cdot L_{c_2}$	$D_{c_2} := Density$
$L_{c_3} := x_{top} \cdot (n\_top + 1)^{-1}$	$S_{c_{3,0}} := S_{c_{2,1}}$	$S_{c_{3,1}} := S_{c_{3,0}} - TR \cdot L_{c_3}$	$D_{c_3} := Density$
$L_{c_4} := x_{top} \cdot (n\_top + 1)^{-1}$	$S_{c_{4,0}} := S_{c_{3,1}}$	$S_{c_{4,1}} := S_0$	$D_{c_4} := Density$

Open Section of Enclosure (Driver ---> Port Position)

Section Length	Initial Area	Final Area	Stuffing Density
$L_{o_0} := x_{open} \cdot (n\_open + 1)^{-1}$	$S_{o_{0,0}} := S_D$	$S_{o_{0,1}} := S_{o_{0,0}} + TR \cdot L_{o_0}$	$D_{o_0} := Density$
$L_{o_1} := x_{open} \cdot (n\_open + 1)^{-1}$	$S_{o_{1,0}} := S_{o_{0,1}}$	$S_{o_{1,1}} := S_{o_{1,0}} + TR \cdot L_{o_1}$	$D_{o_1} := Density$
$L_{o_2} := x_{open} \cdot (n\_open + 1)^{-1}$	$S_{o_{2,0}} := S_{o_{1,1}}$	$S_{o_{2,1}} := S_{o_{2,0}} + TR \cdot L_{o_2}$	$D_{o_2} := Density$
$L_{o_3} := x_{open} \cdot (n\_open + 1)^{-1}$	$S_{o_{3,0}} := S_{o_{2,1}}$	$S_{o_{3,1}} := S_{o_{3,0}} + TR \cdot L_{o_3}$	$D_{o_3} := 0.0 \cdot lb \cdot ft^{-}$
$L_{o_4} := x_{open} \cdot (n\_open + 1)^{-1}$	$S_{o_{4,0}} := S_{o_{3,1}}$	$S_{o_{4,1}} := S_P$	$D_{o_4} := 0.0 \cdot lb \cdot ft^{-}$

Bottom Section of Enclosure (Port Position ---> Bottom of Enclosure)

Section Length	Initial Area	Final Area	Stuffing Density
$L_{b_0} := x_{bottom}\cdot(n\_bottom + 1)^{-1}$	$S_{b_{0,0}} := S_P$	$S_{b_{0,1}} := S_{b_{0,0}} + TR\cdot L_{b_0}$	$D_{b_0} := 0.0\cdot lb\cdot ft^{-}$
$L_{b_1} := x_{bottom}\cdot(n\_bottom + 1)^{-1}$	$S_{b_{1,0}} := S_{b_{0,1}}$	$S_{b_{1,1}} := S_{b_{1,0}} + TR\cdot L_{b_1}$	$D_{b_1} := 0.0\cdot lb\cdot ft^{-}$
$L_{b_2} := x_{bottom}\cdot(n\_bottom + 1)^{-1}$	$S_{b_{2,0}} := S_{b_{1,1}}$	$S_{b_{2,1}} := S_{b_{2,0}} + TR\cdot L_{b_2}$	$D_{b_2} := 0.0\cdot lb\cdot ft^{-}$
$L_{b_3} := x_{bottom}\cdot(n\_bottom + 1)^{-1}$	$S_{b_{3,0}} := S_{b_{2,1}}$	$S_{b_{3,1}} := S_{b_{3,0}} + TR\cdot L_{b_3}$	$D_{b_3} := 0.0\cdot lb\cdot ft^{-}$
$L_{b_4} := x_{bottom}\cdot(n\_bottom + 1)^{-1}$	$S_{b_{4,0}} := S_{b_{3,1}}$	$S_{b_{4,1}} := S_L$	$D_{b_4} := 0.0\cdot lb\cdot ft^{-}$

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

Section Length	Initial Area	Final Area	Stuffing Density
$L_{p_0} := x_{port}\cdot(n\_port + 1)^{-1}$	$S_{p_{0,0}} := \pi\cdot r_{port}^{2}$	$S_{p_{0,1}} := \pi\cdot r_{port}^{2}$	$D_{p_0} := 0.0\cdot lb\cdot ft^{-}$
$L_{p_1} := x_{port}\cdot(n\_port + 1)^{-1}$	$S_{p_{1,0}} := S_{p_{0,1}}$	$S_{p_{1,1}} := \pi\cdot r_{port}^{2}$	$D_{p_1} := 0.0\cdot lb\cdot ft^{-}$
$L_{p_2} := x_{port}\cdot(n\_port + 1)^{-1}$	$S_{p_{2,0}} := S_{p_{1,1}}$	$S_{p_{2,1}} := \pi\cdot r_{port}^{2}$	$D_{p_2} := 0.0\cdot lb\cdot ft^{-}$
$L_{p_3} := x_{port}\cdot(n\_port + 1)^{-1}$	$S_{p_{3,0}} := S_{p_{2,1}}$	$S_{p_{3,1}} := \pi\cdot r_{port}^{2}$	$D_{p_3} := 0.0\cdot lb\cdot ft^{-}$
$L_{p_4} := x_{port}\cdot(n\_port + 1)^{-1}$	$S_{p_{4,0}} := S_{p_{3,1}}$	$S_{p_{4,1}} := \pi\cdot r_{port}^{2}$	$D_{p_4} := 0.0\cdot lb\cdot ft^{-}$

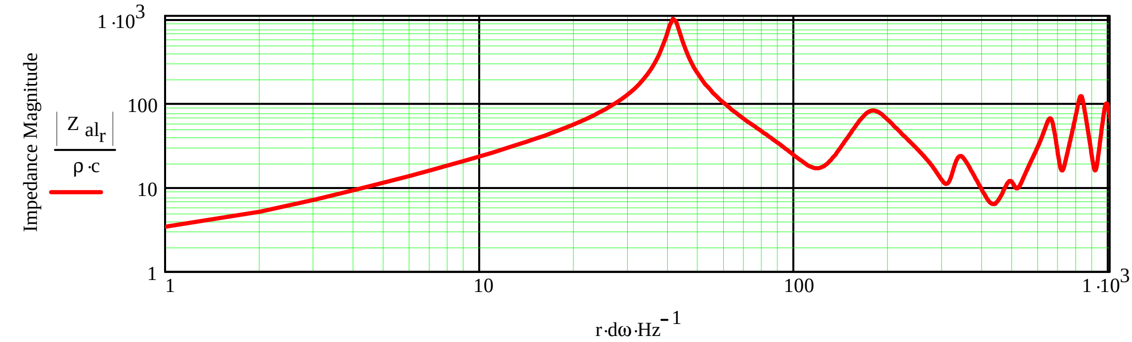
Total Amount of Stuffing

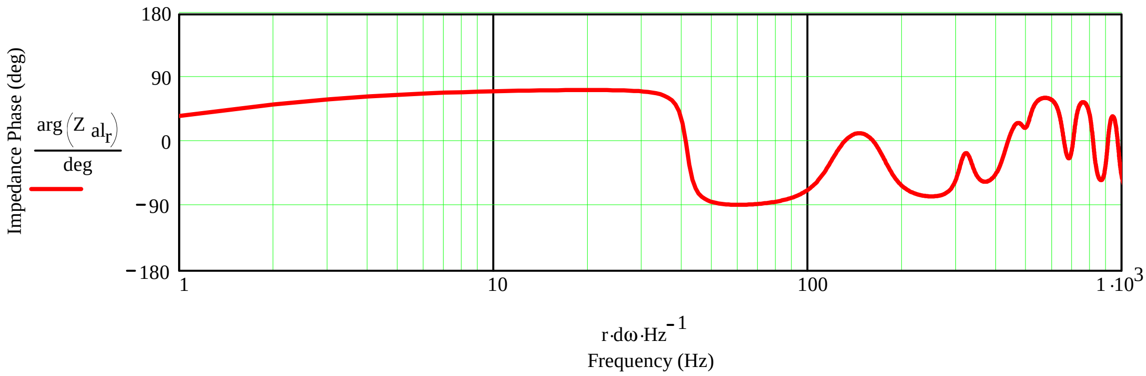
$$\left[\sum_{r=0}^{n\_top}\left[\frac{\left(S_{c_{r,0}} + S_{c_{r,1}}\right)}{2}\cdot L_{c_r}\cdot D_{c_r}\right]\right] + \left[\sum_{r=0}^{n\_open}\left[\frac{\left(S_{o_{r,0}} + S_{o_{r,1}}\right)}{2}\cdot L_{o_r}\cdot D_{o_r}\right]\right] \ldots + \left[\sum_{r=0}^{n\_bottom}\left[\frac{\left(S_{b_{r,0}} + S_{b_{r,1}}\right)}{2}\cdot L_{b_r}\cdot D_{b_r}\right]\right] + \left[\sum_{r=0}^{n\_port}\left[\frac{\left(S_{p_{r,0}} + S_{p_{r,1}}\right)}{2}\cdot L_{p_r}\cdot D_{p_r}\right]\right] = 0.152\, lb$$

End of Pre Formatted Default Input

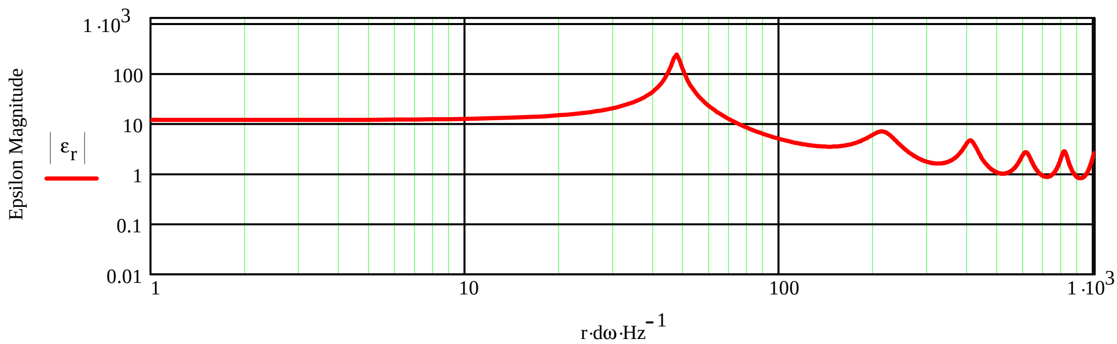
End of Part 1 Input

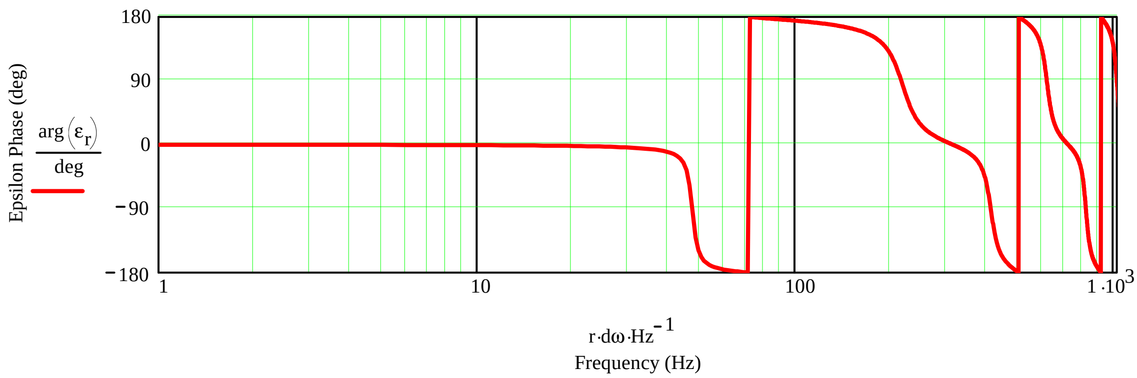
Resulting Acoustic Impedance for the Enclosure



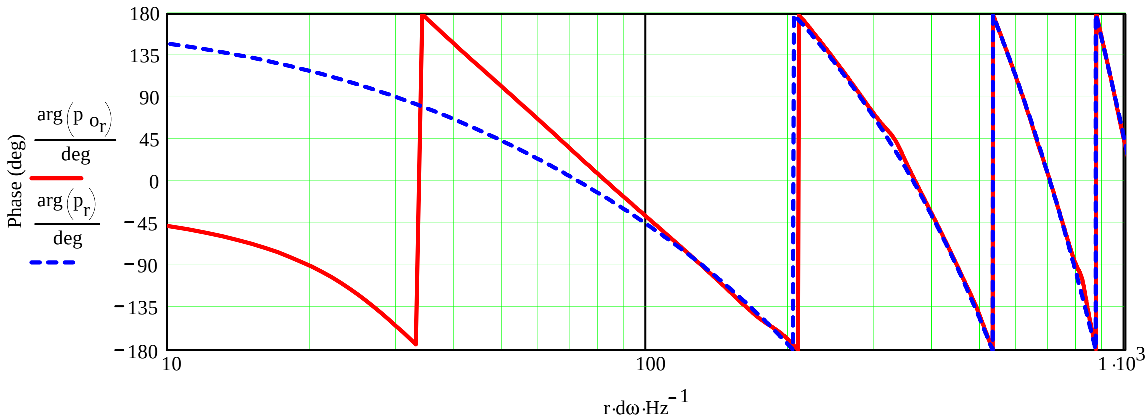


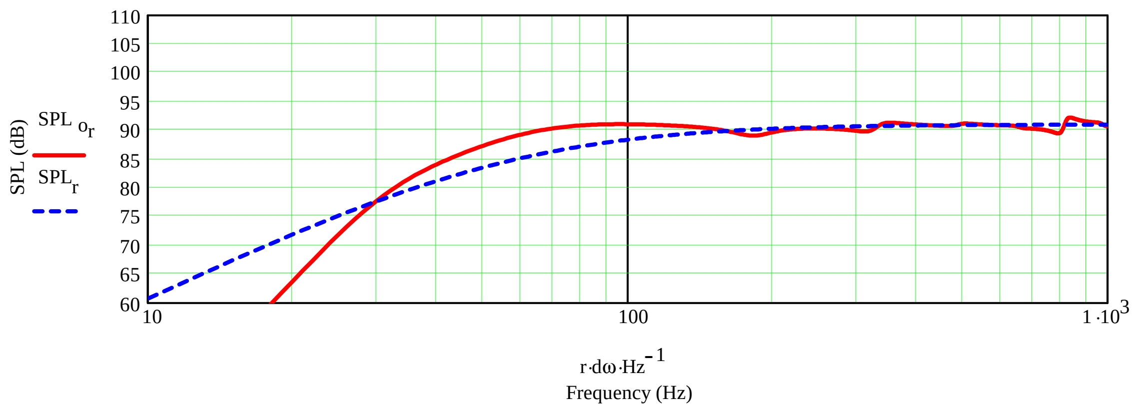
Velocity at the Terminus of the ML TL for a 1 m/sec Excitation at the Driver Position



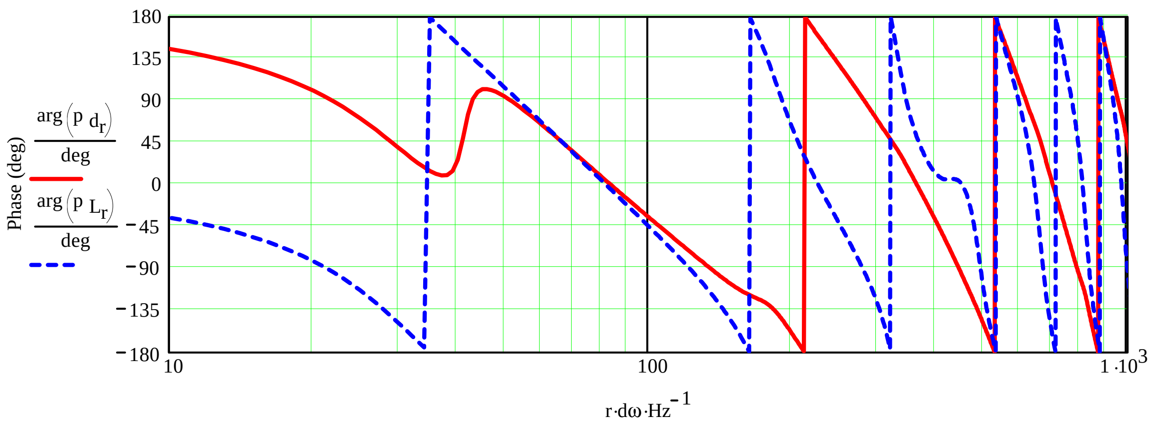


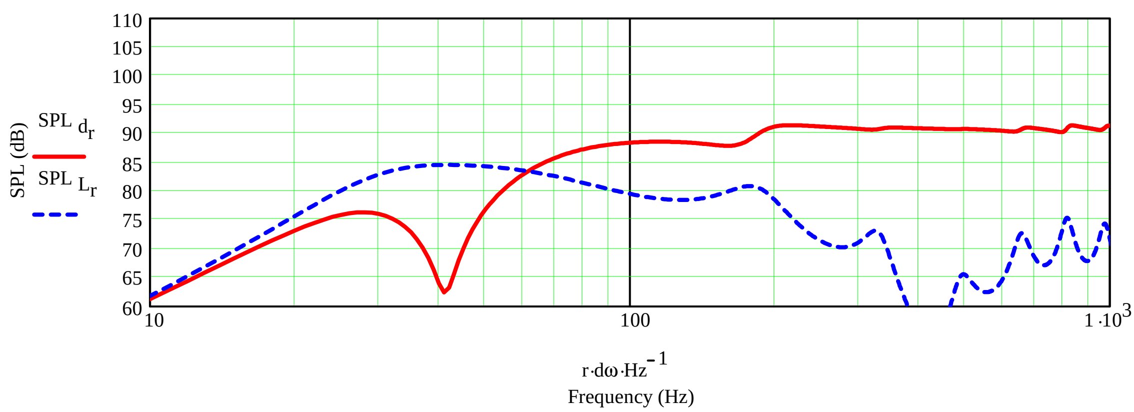
Far Field ML TL System and Infinite Baffle Sound Pressure Level Responses



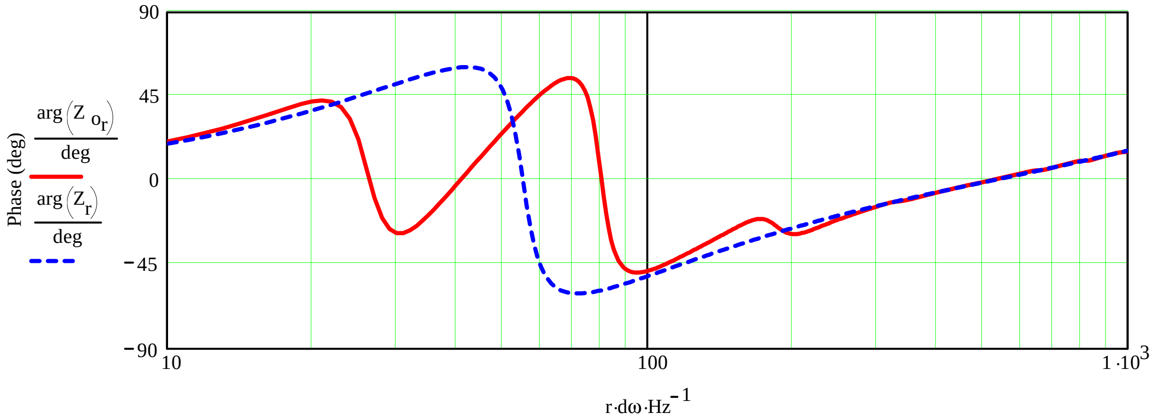


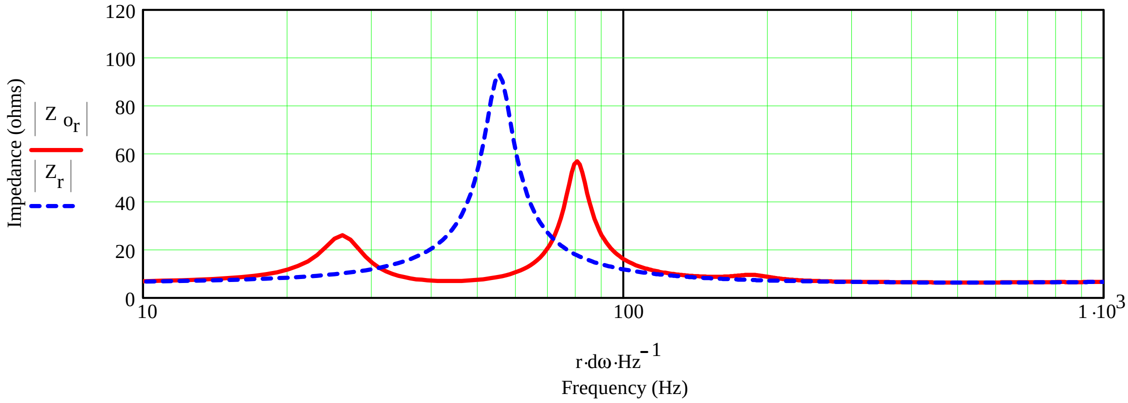
Woofer and Terminus Far Field Sound Pressure Level Responses



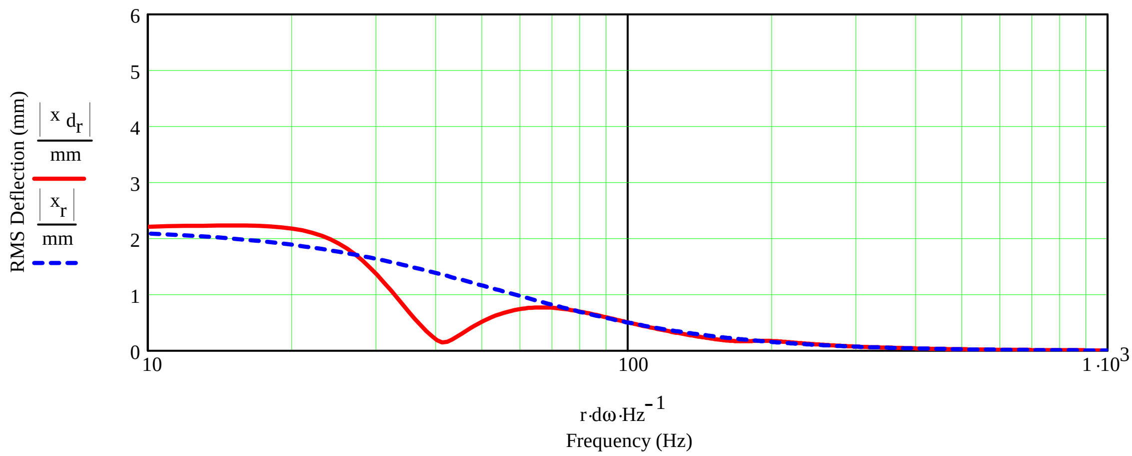


ML TL System and Infinite Baffle Impedance

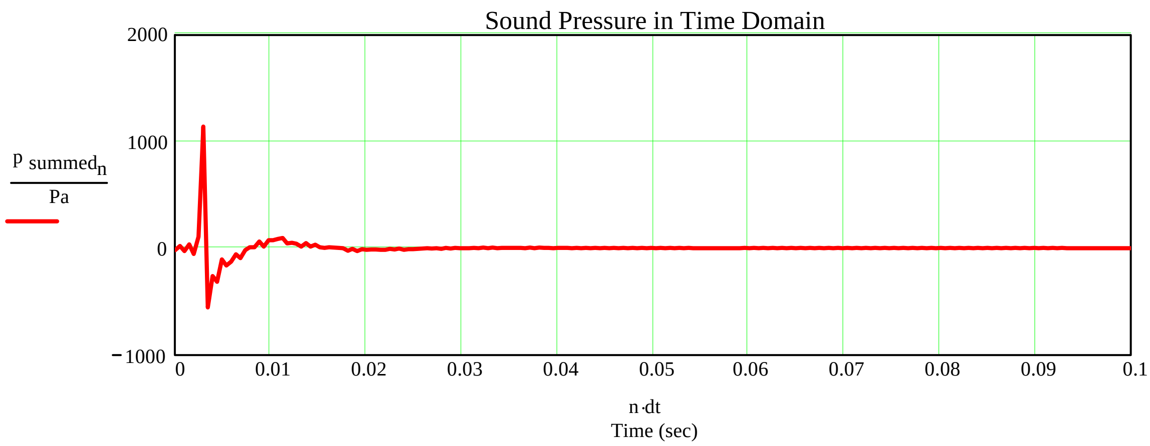




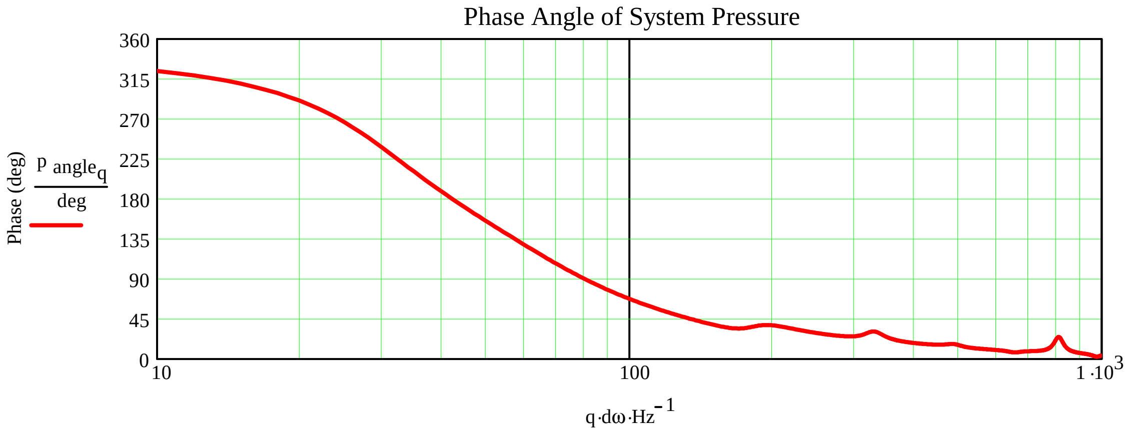
Woofer RMS Displacement

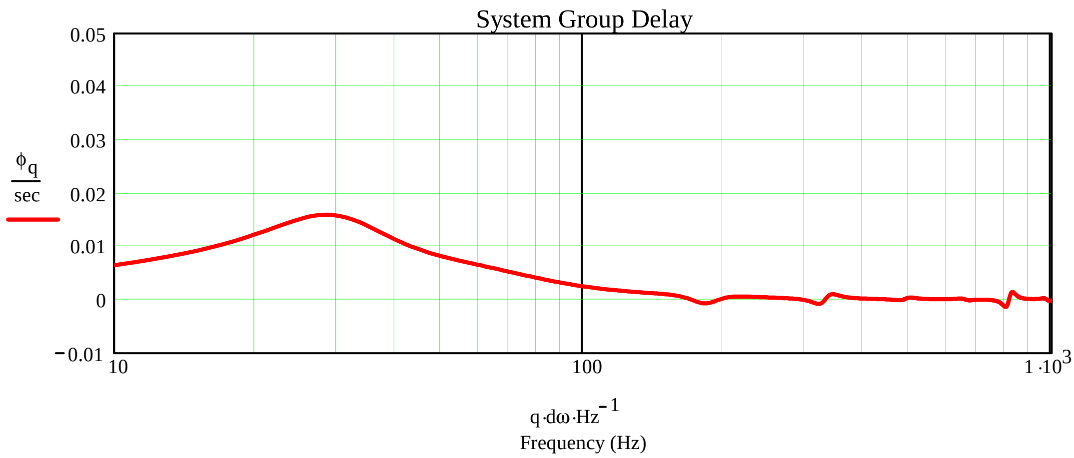


System Time Response for an Impulse Input

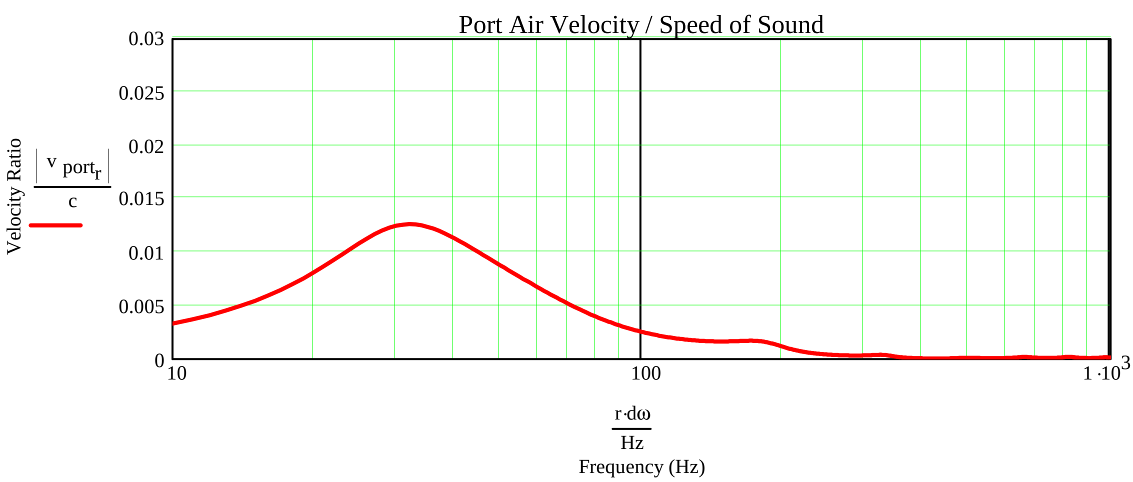


System Group Delay





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

$X_0 := 45 \cdot cm$	(Front Baffle Distance from Rear Wall > Depth of Enclosure)
$Y_0 := 35 \cdot cm$	(Front Baffle Distance from Side Wall)
$\theta_0 := 45 \cdot deg$	(Rotation Towards Room Center)
$Z_0 := 2.8 \cdot m$	(Floor to Ceiling Distance)
$stand := 0.7 \cdot m$	(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	
$y_{o_0} := 22.5 \cdot cm$		(Bottom Right Corner)
$y_{o_1} := 22.5 \cdot cm$	$z_{o_1} := 42 \cdot cm$	(Top Right Corner)
$y_{o_2} := 0 \cdot in$	$z_{o_2} := 42 \cdot cm$	(Top Left Corner)
$y_{o_3} := 0 \cdot in$		(Bottom Left Corner)
$depth := 38 \cdot cm$		(Depth of Enclosure)

Driver Geometry Input

$y_{dc} := 11.25 \cdot cm$	(Driver Center y Coordinate)
$z_{dc} := 22 \cdot cm$	(Driver Center z Coordinate)
n_dvr := 5	(Number of Points Across Diameter)

Port Geometry Input

$y_{mc} := 11.25 \cdot cm$	(Port Center y Coordinate)
$z_{mc} := 6 \cdot cm$	(Port Center z Coordinate)
n_mth := 4	(Number of Points Across Diameter)
Locate := 1	(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)
$radius := 1 \cdot m$	(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)
$X_p := 10\ ft$	
$Y_p := 7 \cdot ft$	
$Z_p := z_{dc} + stand$	(Default Height is Equal to Driver Height)

n_listen := 0	(Method Selection)

Floor Condition

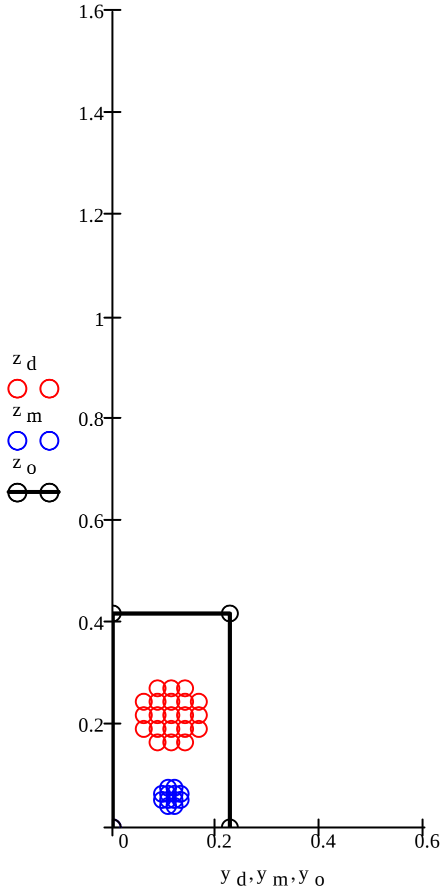
Reflect := 1	(0 = hardwood or concrete, 1 = carpeted)

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

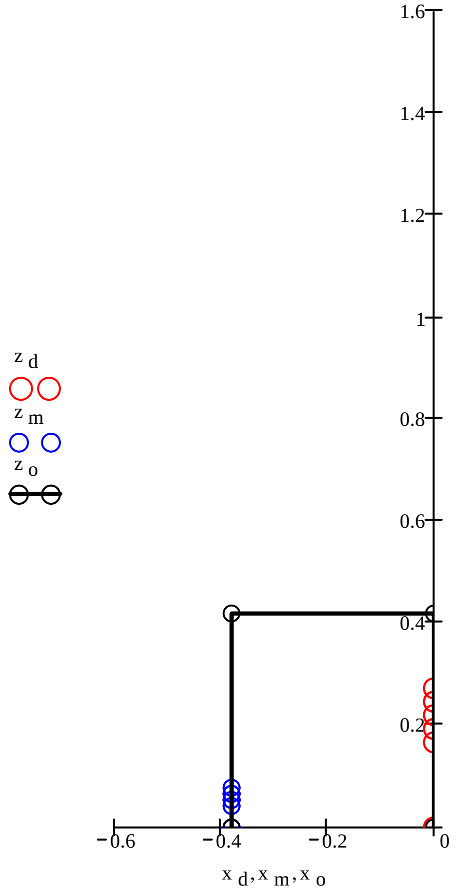
Inc_floor := 1	(Floor, Z = 0)
Inc_rear := 1	(Rear Wall, X = 0)
Inc_side := 1	(Left Side Wall, Y = 0)
Inc_ceiling := 1	(Ceiling)

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

Front View



Side View

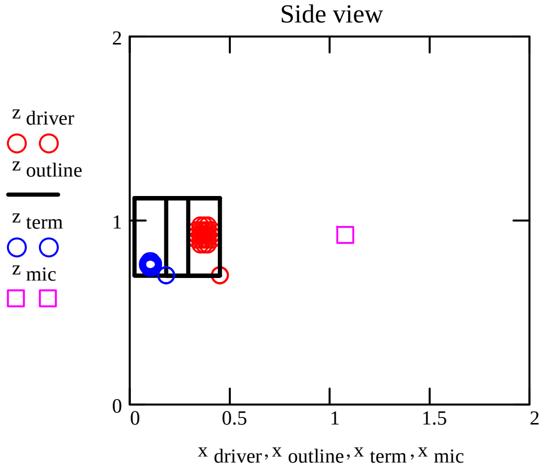


Red sources represent the driver.
Blue sources represent the port.
Black outline represents the baffle edge.
Origin is at the bottom front left corner of the enclosure.

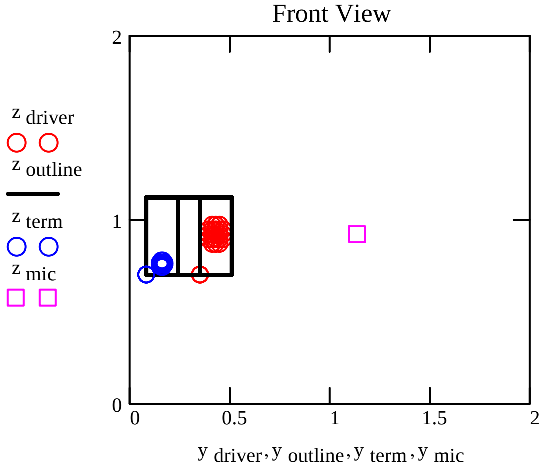
Three Dimensional View

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

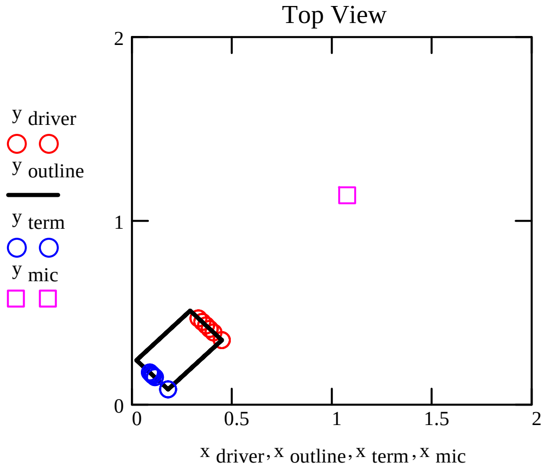
Room Corner is the Origin



Side View - looking out from side wall

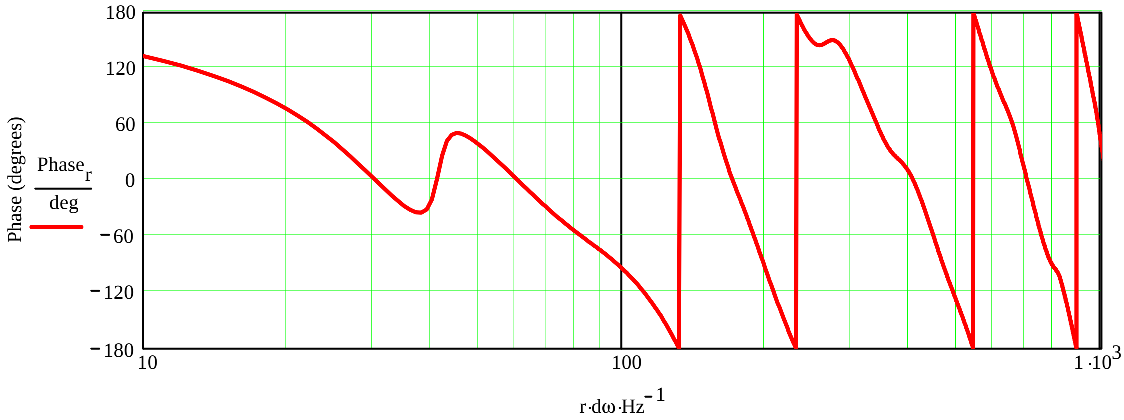


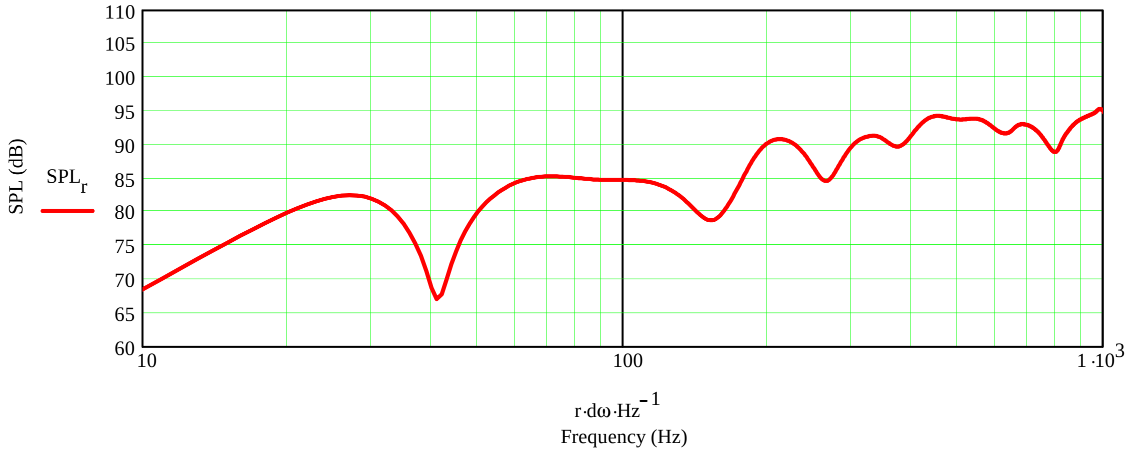
Front View - looking towards rear wall



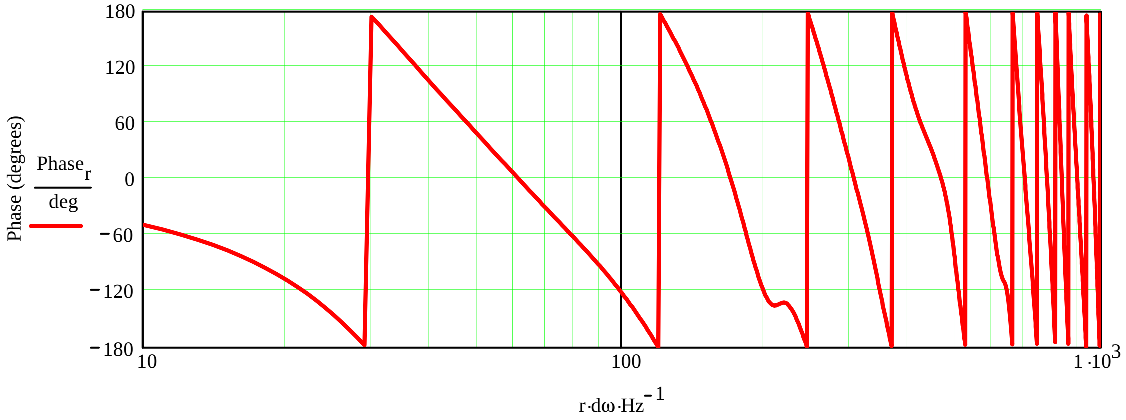
Top View - looking down from ceiling

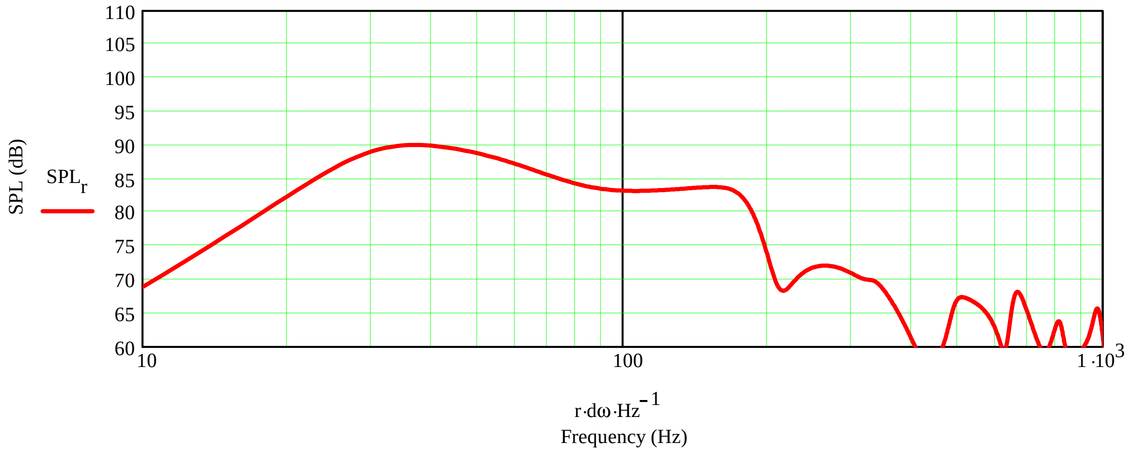
Plotted Baffle Step and Reflection SPL Response for the Circular Driver Source



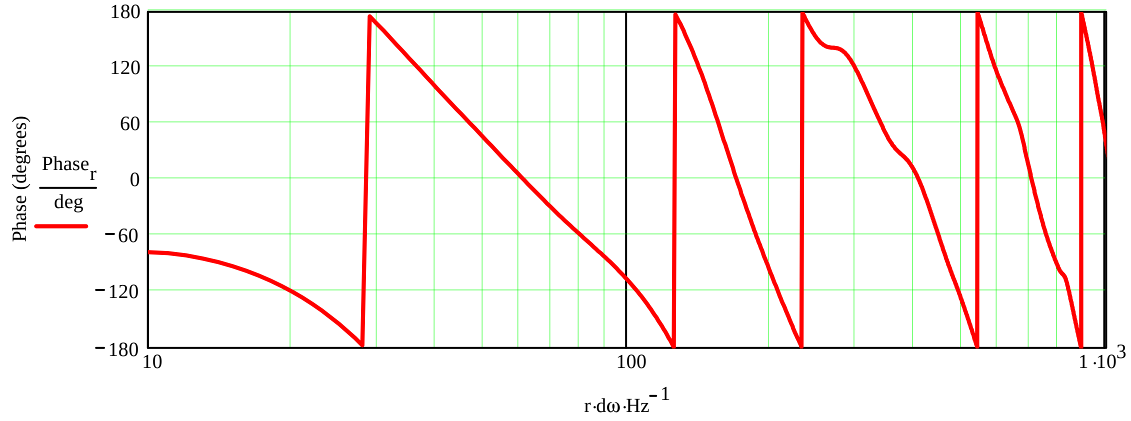


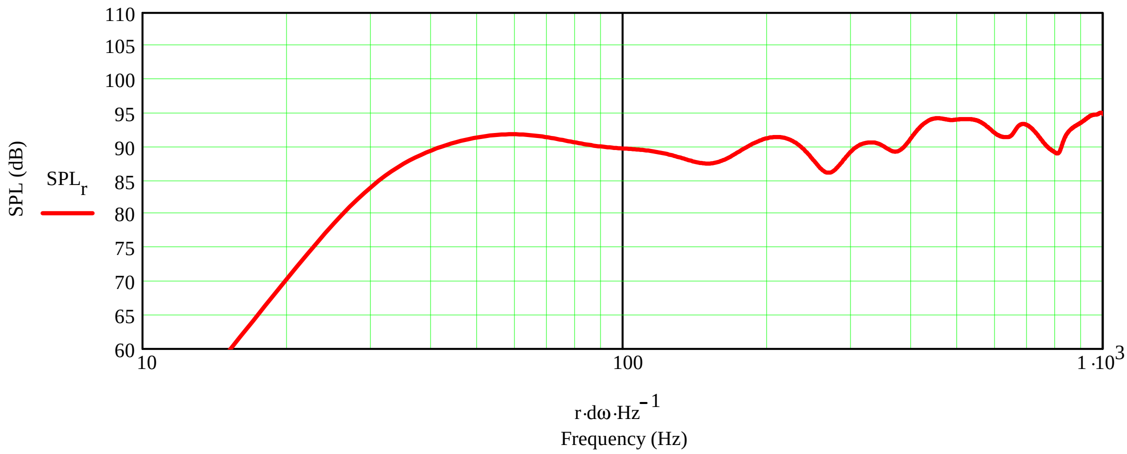
Plotted Baffle Step and Reflection SPL Response for the Circular Port Source





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.

$f_{center} := 450 \cdot Hz$ <--- Input Center Frequency

$dB := 5$ <--- Input dB of Attenuation

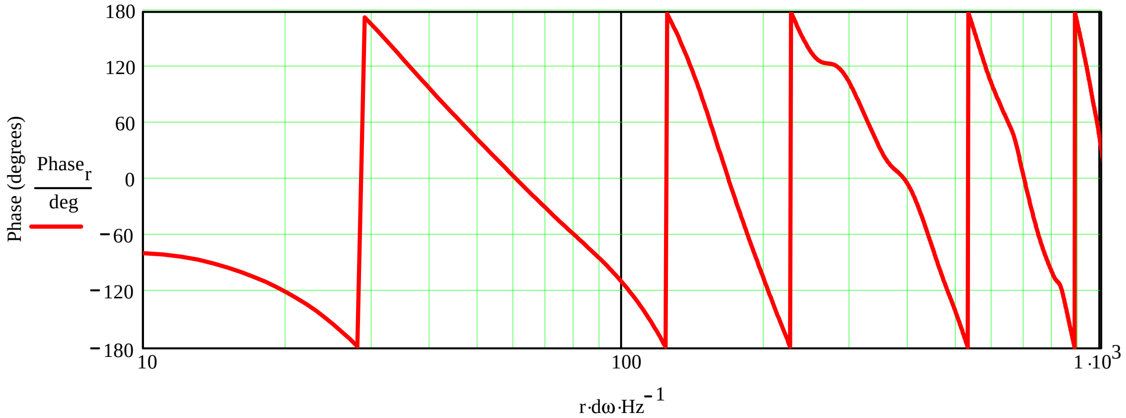
Calculated Component Values

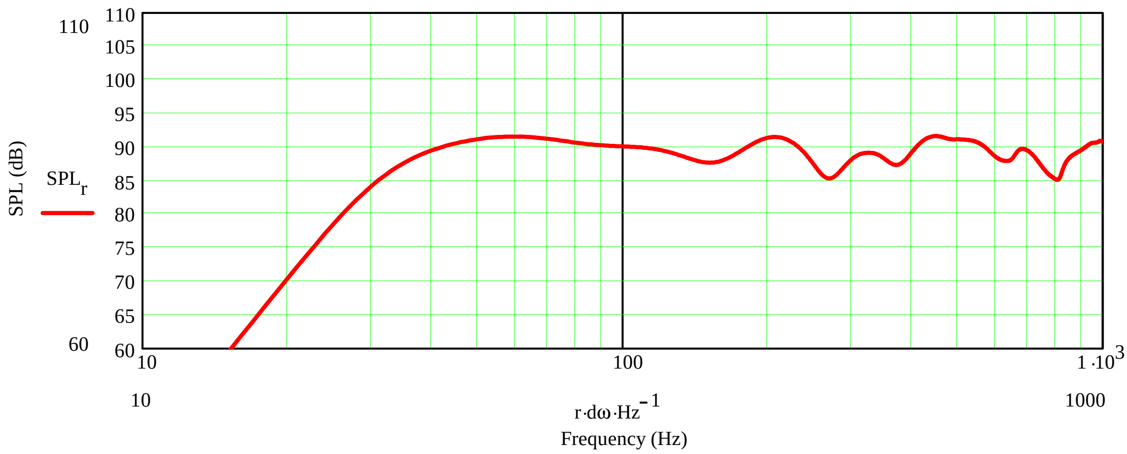
User Assigned Component Values
Based on Calculated Values at Left

$R_e \cdot \left(10^{\frac{dB}{20}} - 1\right) = 4.981\ \Omega$ Parallel Resistor Input Value ---> $R_{parallel} := 4.7 \cdot \Omega$

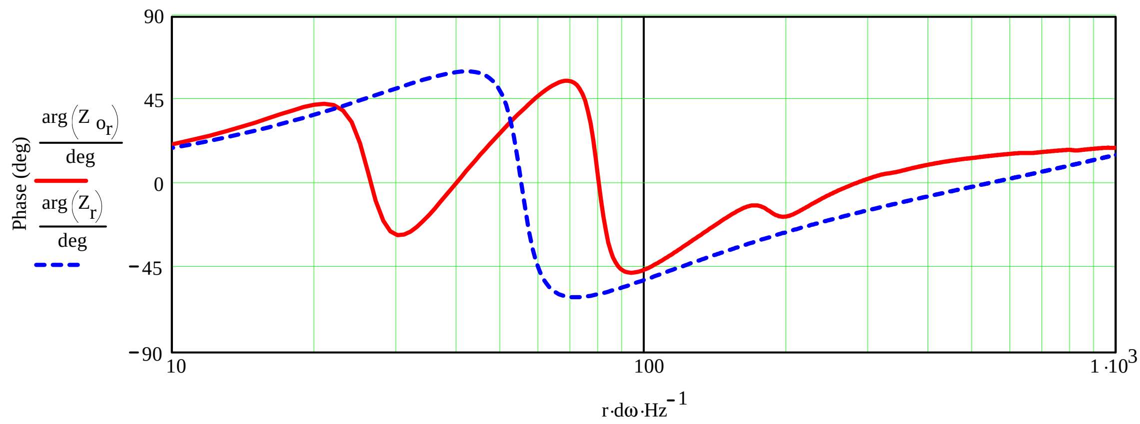
$\frac{R_{parallel}}{f_{center}} = 1.662 \cdot mH$ BSC Inductor Input Value ---> $L_{BSC} := 1.5 \cdot mH$

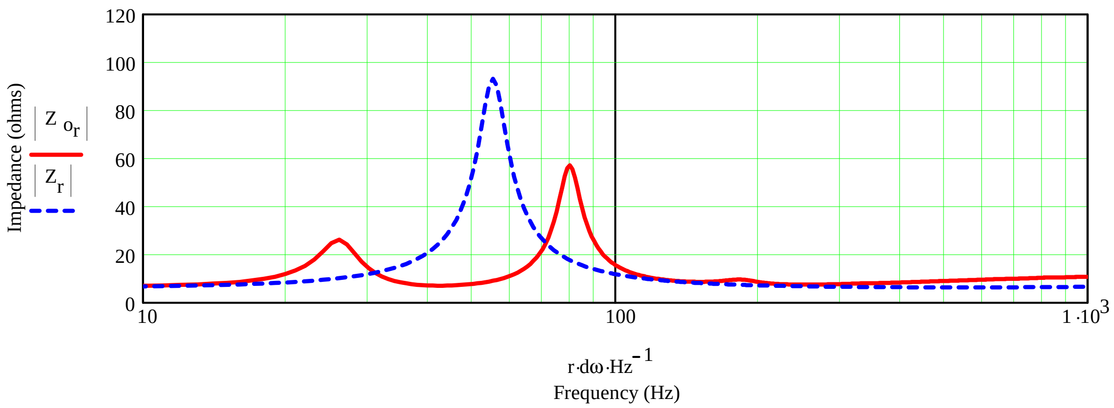
Plotted Corrected SPL Response for the System





ML TL Corrected System and Infinite Baffle Impedance





System Time Response for an Impulse Input