



Software : by Martin J. King
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Line Configuration : Near End Open -> Driver in the Line -> Far End Open

Unit and Constant Definition

$$\text{cycle} := 2 \cdot \pi \cdot \text{rad} \quad \text{Hz} := \text{cycle} \cdot \text{sec}^{-1}$$

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

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



Part 1 : Thiele-Small Consistent Calculation

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

Woofer Series Resistance

$$R_{\text{add}} := 0 \cdot \Omega$$

Input Power

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

Extended Range Driver Thiele / Small Parameters : Fostex FE127E

$$f_d := 70.4 \cdot \text{Hz} \quad V_{\text{ad}} := 9.9 \cdot \text{liter}$$

$$R_e := 6.5 \cdot \Omega \quad Q_{\text{ed}} := 0.50$$

$$L_{\text{vc}} := 0 \cdot \text{mH} \quad Q_{\text{md}} := 3.33$$

$$Bl := 4.14 \cdot \frac{\text{newton}}{\text{amp}} \quad Q_{\text{td}} := \left(\frac{1}{Q_{\text{ed}}} + \frac{1}{Q_{\text{md}}} \right)^{-1}$$

$$S_d := 0.00665 \cdot \text{m}^2 \quad Q_{\text{td}} = 0.435$$



Bass Driver Thiele / Small Parameters : 2 x Eminence 15A 15 inch" Woofer

$$f_d := 19 \cdot \text{Hz} \quad V_{\text{ad}} := 460 \cdot \text{liter}$$

$$R_e := 2.35 \cdot \Omega \quad Q_{\text{ed}} := 0.38$$

$$L_{\text{vc}} := 0.6 \cdot \text{mH} \quad Q_{\text{md}} := 3.19$$

$$Bl := 8.7 \cdot \frac{\text{newton}}{\text{amp}} \quad Q_{\text{td}} := \left(\frac{1}{Q_{\text{ed}}} + \frac{1}{Q_{\text{md}}} \right)^{-1}$$

$$S_d := 660 \cdot \text{cm}^2 \quad Q_{\text{td}} = 0.340$$

Adjustments

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

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

H Frame Enclosure Geometry Definition : Model of Internal Air Volume

$L_{\text{w}} := 14 \cdot \text{in}$	(Total Length of the H Frame)
$\xi := 0.5$	(Fraction of the Total Length of the Front Cavity : $0.001 < \xi < 0.999$)
$S_0 := 12 \cdot \text{in} \cdot 24 \cdot \text{in}$	(Area of the Driver End)
$S_L := 12 \cdot \text{in} \cdot 24 \cdot \text{in}$	(Area of the Open End)
$\text{Density}_F := 0 \cdot \text{lb} \cdot \text{ft}^{-3}$	(Front Stuffing Density : $0 \text{ lb/ft}^3 < D < 1 \text{ lb/ft}^3$)
$\text{Density}_R := 0 \cdot \text{lb} \cdot \text{ft}^{-3}$	(Rear Stuffing Density : $0 \text{ lb/ft}^3 < D < 1 \text{ lb/ft}^3$)

Instructions :

1. If a Zobel is used, set L_{vc} equal to zero in driver inputs above. If no Zobel is used, enter a value for L_{vc}
2. Select the crossover frequencies, orders, and types below.
3. Scroll down to the applicable crossover sections below and fill in the values of the circuit components.
 - a. The theoretical values are shown to the right of each schematic.
 - b. Theoretical values are calculated using only the driver's DC resistance, a textbook solution.
 - c. Enter the actual component values, these should correspond to available components.
 - d. Iterate the actual component values to optimize the crossover responses.
 - e. You can mix the crossover orders and types by using only half of each pair of schematics.
4. Purchase the optimized actual component values and construct the crossover per the schematics.

Crossover Definition

For Even Order Crossovers : Type 1 = Linkwitz-Riley
 Type 2 = Bessel
 Type 3 = BEC
 Type 4 = Butterworth

Low Pass Filter

$$f_{\text{LP}} := 100 \cdot \text{Hz}$$

$$\text{LP}_{\text{order}} := 2$$

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

High Pass Filter

$$f_{\text{HP}} := 250 \cdot \text{Hz}$$

$$\text{HP}_{\text{order}} := 2$$

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

(Filter Frequency)

(Filter Order : 0, 1, 2, 3, or 4)

(Filter Type : 1, 2, 3, or 4 for even order only,
for odd order this entry is ignored)

Crossover Phase Connection

$$\text{LP}_{\text{phase}} := 1$$

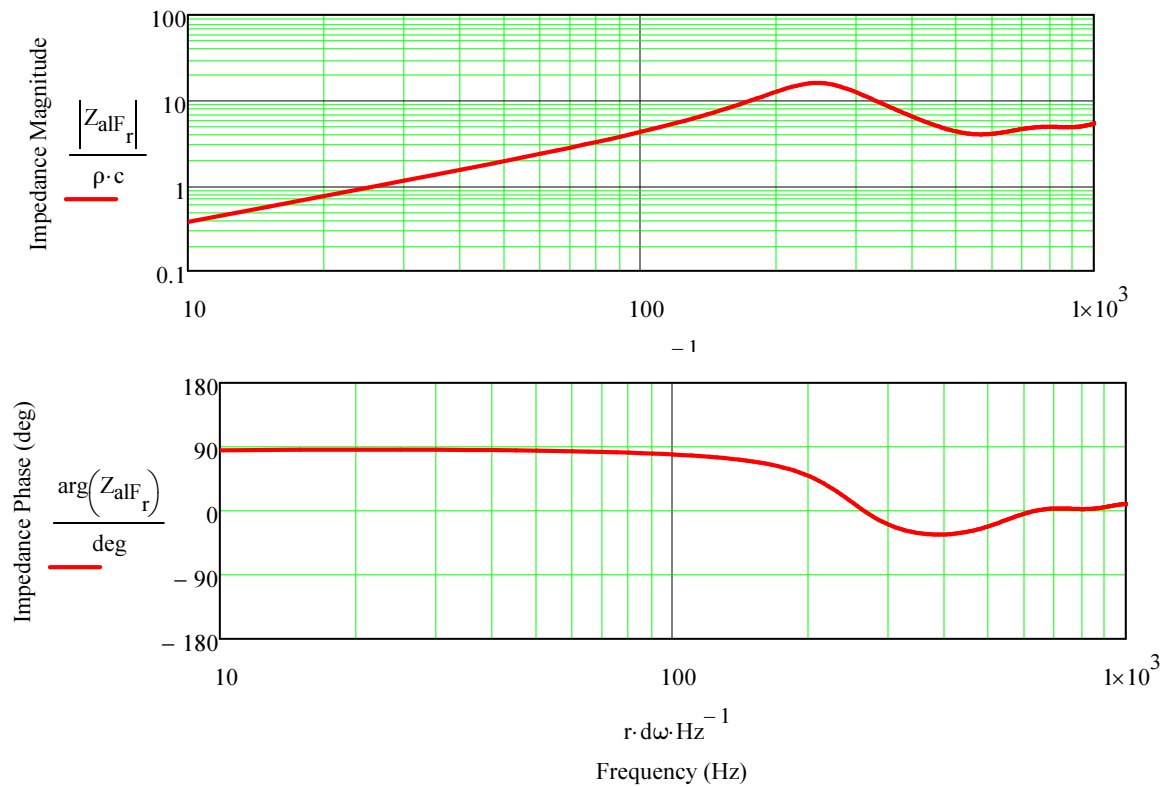
$$\text{HP}_{\text{phase}} := 1$$

(Phase : 1 = in phase, -1 = out of phase)

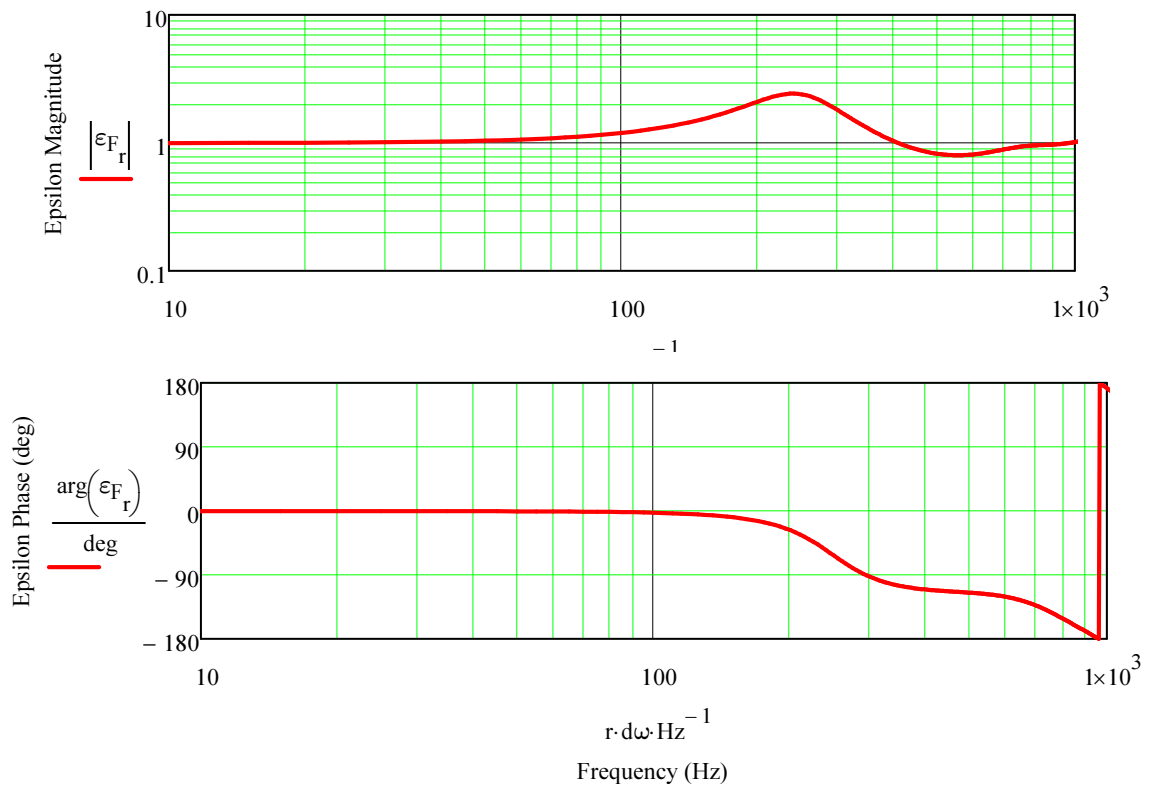
End of Abbreviated User Input



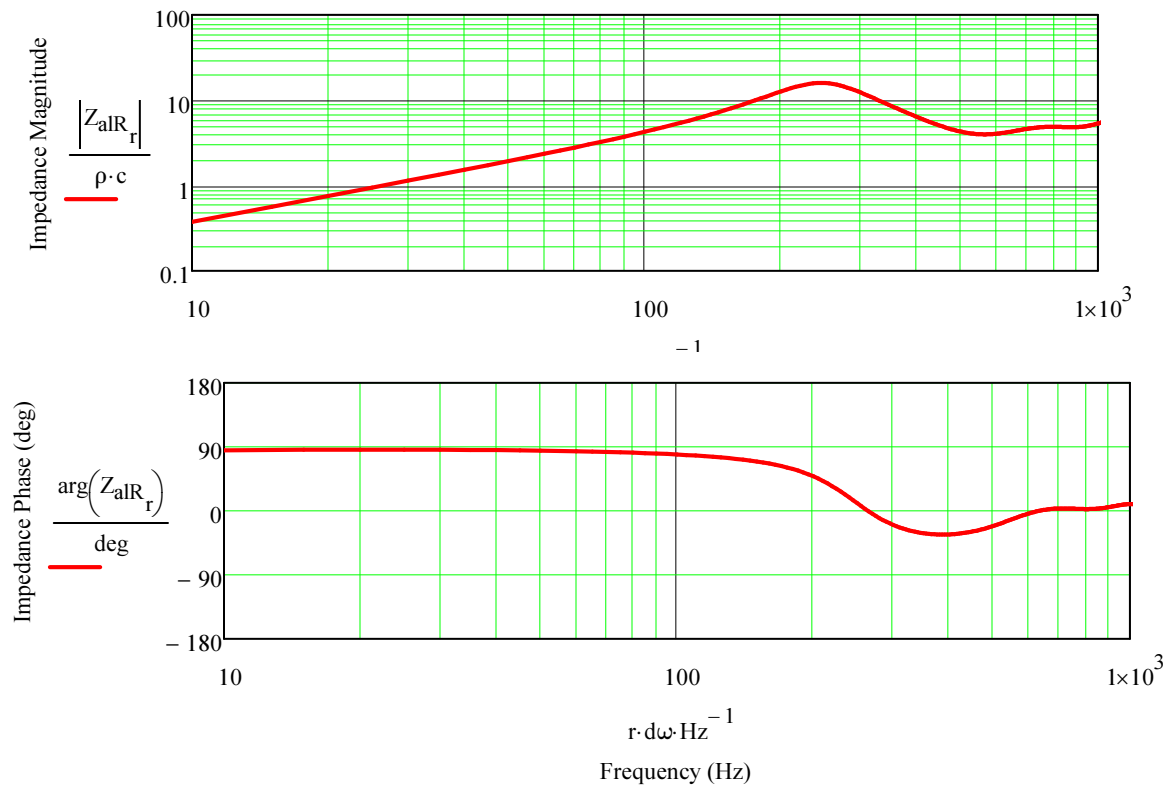
Resulting Acoustic Impedance for the H Frame - Front Cavity



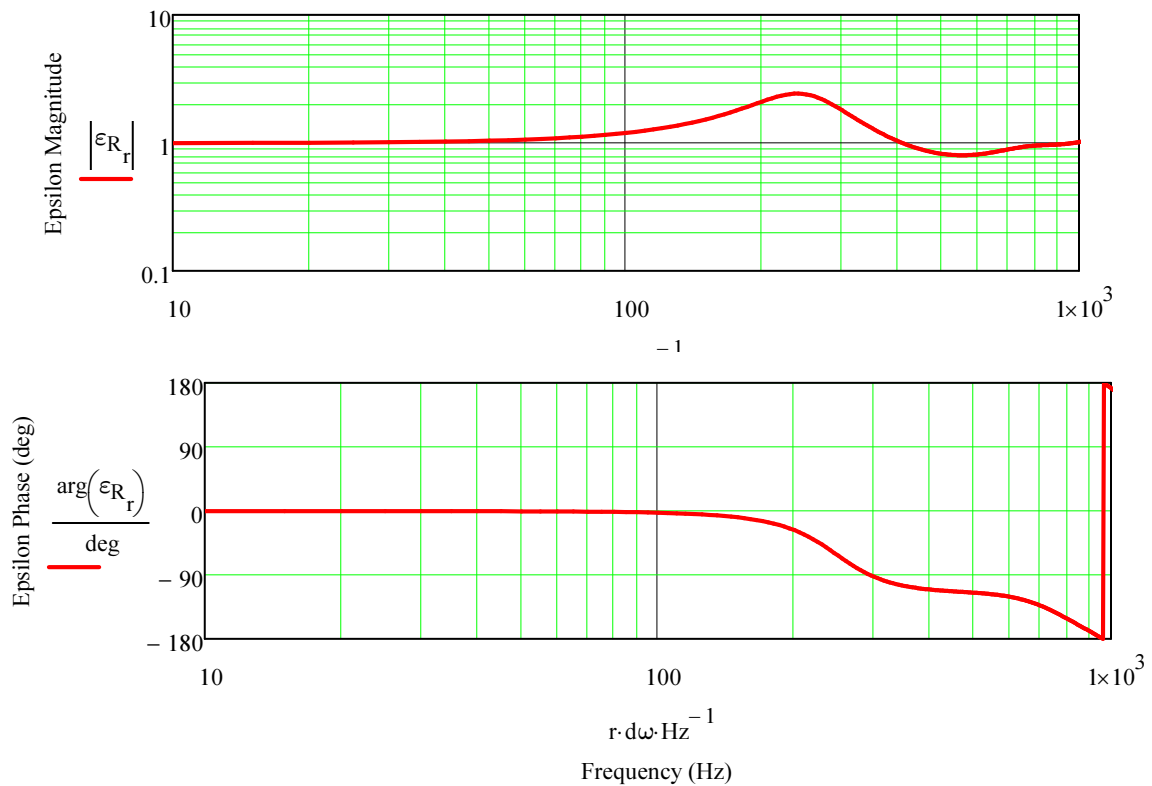
Velocity at the Terminus of the H Frame for a 1 m/sec Excitation at the Driver - Front Cavity



Resulting Acoustic Impedance for the H Frame - Rear Cavity



Velocity at the Terminus of the H Frame for a 1 m/sec Excitation at the Driver - Rear Cavity

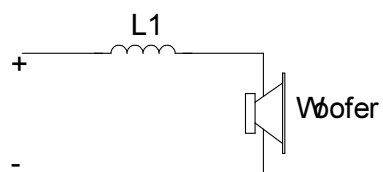
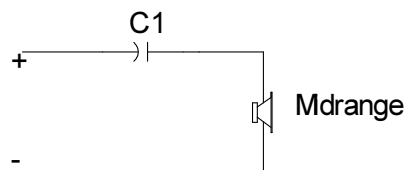




Crossover Definition - 1st Order High and Low Pass



Schematic




Theoretical Values

$$C_1 = 97.942 \cdot \mu\text{F}$$

$$L_1 = 3.740 \cdot \text{mH}$$

Enter Actual Component Values Below

High Pass

 $C_1 := 120 \cdot \mu\text{F}$

Low Pass

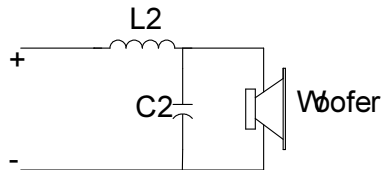
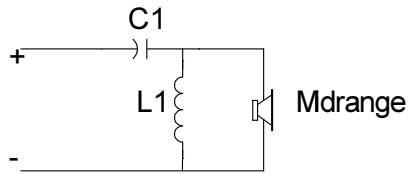
 $L_1 := 9 \cdot \text{mH}$ $R_1 := 0.3 \cdot \Omega$



Crossover Definition - 2nd Order High and Low Pass



Schematic



Theoretical Values

$$C_1 = 48.971 \cdot \mu\text{F}$$

$$L_1 = 8.276 \cdot \text{mH}$$

$$L_2 = 7.480 \cdot \text{mH}$$

$$C_2 = 338.628 \cdot \mu\text{F}$$

Enter Actual Component Values Below

High Pass

$$C_1 := 50 \cdot \mu\text{F}$$

$$L_1 := 7 \cdot \text{mH} \quad R_1 := 0.3 \cdot \Omega$$

Low Pass

$$L_2 := 9 \cdot \text{mH} \quad R_2 := 0.4 \cdot \Omega$$

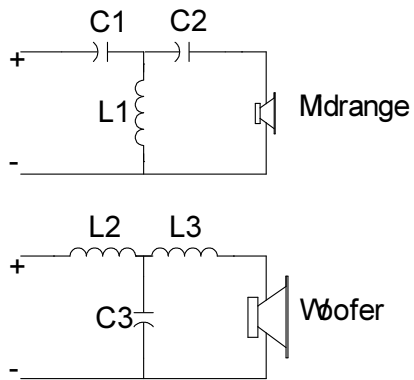
$$C_2 := 270 \cdot \mu\text{F}$$



Crossover Definition - 3rd Order High and Low Pass



Schematic



Theoretical Values

$$C_1 = 65.294 \cdot \mu\text{F}$$

$$L_1 = 3.104 \cdot \text{mH}$$

$$C_2 = 195.883 \cdot \mu\text{F}$$

$$L_2 = 5.610 \cdot \text{mH}$$

$$C_3 = 903.007 \cdot \mu\text{F}$$

$$L_3 = 1.870 \cdot \text{mH}$$

Enter Actual Component Values Below

High Pass

$$C_1 := 80 \cdot \mu\text{F}$$

$$L_1 := 2.5 \cdot \text{mH} \quad R_1 := 0.2 \cdot \Omega$$

$$C_2 := 240 \cdot \mu\text{F}$$

Low Pass

$$L_2 := 13 \cdot \text{mH} \quad R_2 := 0.5 \cdot \Omega$$

$$C_3 := 400 \cdot \mu\text{F}$$

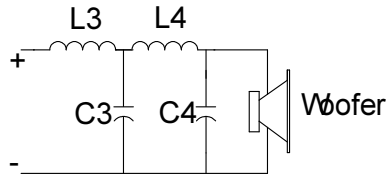
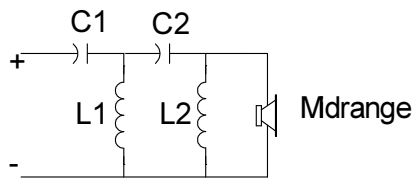
$$L_3 := 4.5 \cdot \text{mH} \quad R_3 := 0.2 \cdot \Omega$$



Crossover Definition - 4th Order High and Low Pass



Schematic



Theoretical Values

$$C_1 = 51.938 \cdot \mu\text{F}$$

$$L_1 = 2.600 \cdot \text{mH}$$

$$C_2 = 103.877 \cdot \mu\text{F}$$

$$L_2 = 11.703 \cdot \text{mH}$$

$$L_3 = 7.050 \cdot \text{mH}$$

$$C_3 = 1.078 \times 10^3 \cdot \mu\text{F}$$

$$L_4 = 3.525 \cdot \text{mH}$$

$$C_4 = 239.574 \cdot \mu\text{F}$$

Enter Actual Component Values Below

High Pass

$$C_1 := 70 \cdot \mu\text{F}$$

$$L_1 := 2 \cdot \text{mH} \quad R_1 := 0.1 \cdot \Omega$$

$$C_2 := 120 \cdot \mu\text{F}$$

$$L_2 := 6.5 \cdot \text{mH} \quad R_2 := 0.3 \cdot \Omega$$

Low Pass

$$L_3 := 17 \cdot \text{mH} \quad R_3 := 0.5 \cdot \Omega$$

$$C_3 := 460 \cdot \mu\text{F}$$

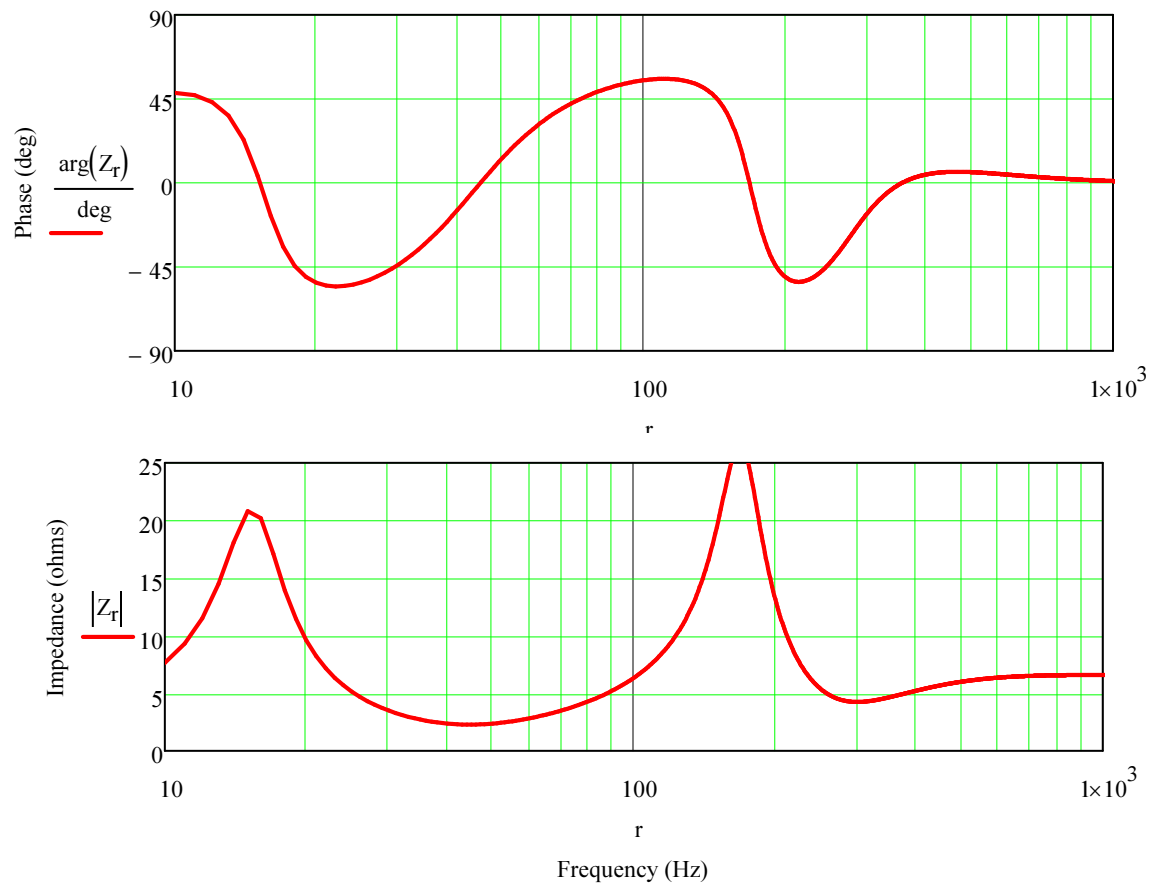
$$L_4 := 8 \cdot \text{mH} \quad R_4 := 0.3 \cdot \Omega$$

$$C_4 := 100 \cdot \mu\text{F}$$



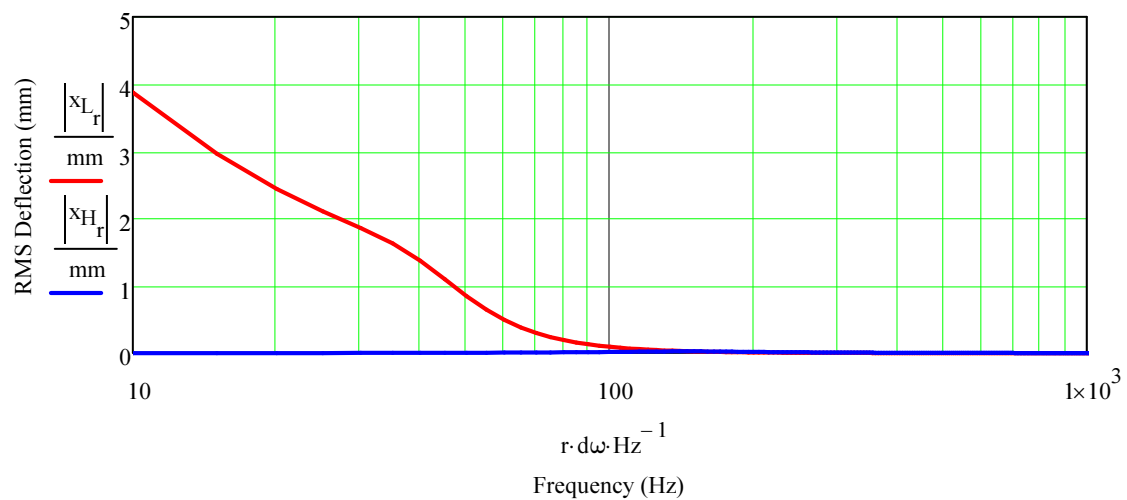


H Frame/OB System Impedance



Driver RMS Displacements

Solid Red is the H Frame Woofer Response
Solid Blue is the OB Driver Response



Part 2 : Detailed SPL Response Calculation

Calculation Includes :

- Position of Front Terminus and Rear Terminus on the Baffle.
- Baffle Step Diffraction for the Front Terminus and the Rear Terminus.
- Room Reflections for the Front Terminus and the Rear Terminus.

Geometry

Coordinate System :

- Origin is the lower left corner of the H Frame
- y = horizontal direction
- z = vertical direction

The variables num_r, n_drv, and n_mth control the number of simple sources used in the calculations. Increasing each will improve accuracy at the expense of longer calculation times. Increase each variable until final plotted SPL stops changing at which point the solution has converged.

Enclosure Geometry Input

- $X_0 := 2.6 \cdot \text{ft}$ (Front Baffle Distance from Rear Wall > Depth of Enclosure)
- $Y_0 := 1.2 \cdot \text{ft}$ (Front Baffle Distance from Side Wall)
- $\theta_0 := 30 \cdot \text{deg}$ (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 := 20 (Number of Points per Unit Length of Baffle Edge)

H Frame Geometry Input

- $H_{\text{width}} := 13 \cdot \text{in}$ (H Frame External Width)
- $H_{\text{height}} := 25 \cdot \text{in}$ (H Frame External Height)
- depth := L + 0.75·in (H Frame External Depth)
- $y_c := 6.5 \cdot \text{in}$ (Terminus Center y Coordinate)
- $z_c := 12.5 \cdot \text{in}$ (Terminus Center z Coordinate)
- $w_{\text{mth}} := 12 \cdot \text{in}$ (Terminus Width)
- n_mth := 10 (Number of Points Across the Width)

Extended Range Driver OB Geometry Input

- $OB_{\text{width}} := 20 \cdot \text{in}$ (OB panel width)
- $OB_{\text{height}} := 20 \cdot \text{in}$ (OB panel height)
- $y_{\text{dc}} := 13 \cdot \text{in}$ (Driver Center y Coordinate w.r.t. lower left corner of OB)
- $z_{\text{dc}} := 12 \cdot \text{in}$ (Driver Center z Coordinate w.r.t. lower left corner of OB)
- $\xi_{\text{ob}} := 0.5$ (Fraction of the Total Depth of the H Frame : $0.001 < \xi < 0.999$)
- n_high := 4 (Number of Points Across Diameter)

Listening Position

$n_listen = 0$ (Listening Position Relative to Speaker)
 $radius := 1 \cdot m$ (Calculation Radius Along Axis of the Extended Range Driver)
 $\theta := 0 \cdot deg$ (0 deg is along the Driver's Axis, $-80 \text{ deg} < \theta < 80 \text{ deg}$)
 $z_p := 33 \cdot in$ (Default Height is Equal to Seated Height)

$n_listen = 1$ (Listening Position Relative to the Room Corner)
 $X_p := 10 \text{ ft}$
 $Y_p := 7 \cdot \text{ft}$
 $Z_p := 33 \cdot in$ (Default Height is Equal to Seated Height)
 $n_listen := 0$ (Method Selection)

Floor Condition

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

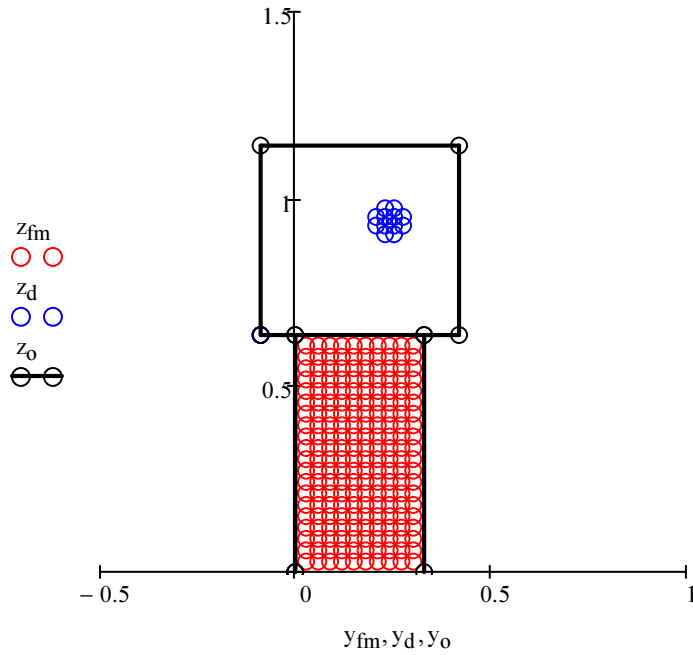
Reflective Surface Selections (if 1 reflective surface is included, if 0 reflective surface is removed)

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

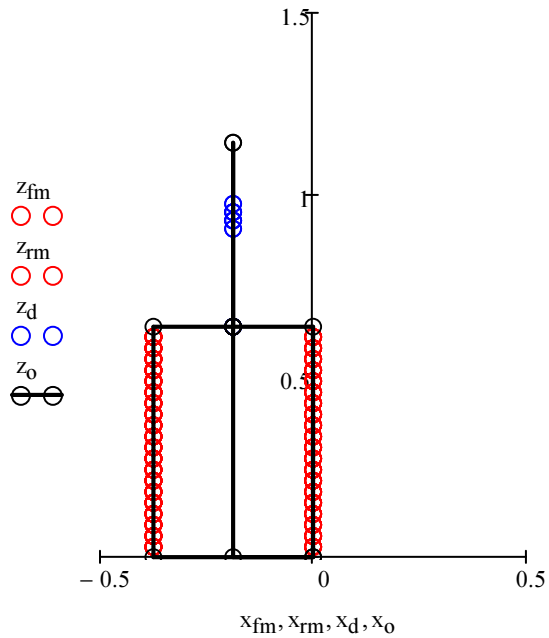


H Frame and Extended Range Driver Simple Source Pattern with Baffle Edge Outline

Front View



Side View



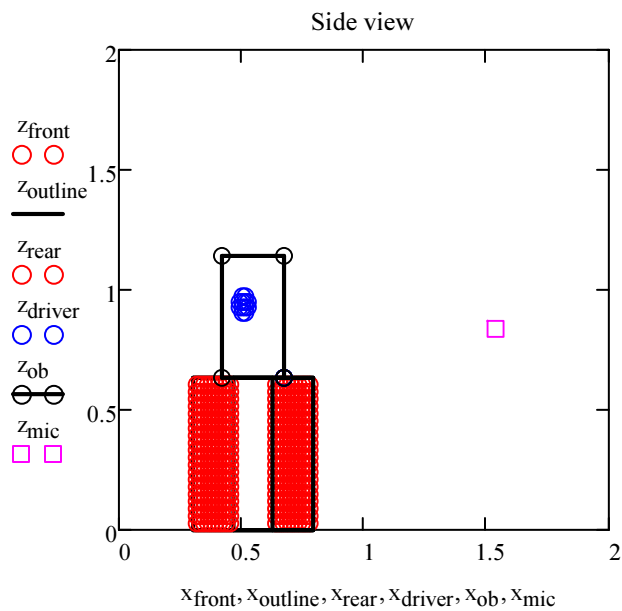
Blue sources represent extended range driver.
Red sources represent front terminus.
Red sources represent the rear terminus.
Black outline represents the baffle edge.
Origin is at the bottom front left corner of the enclosure.



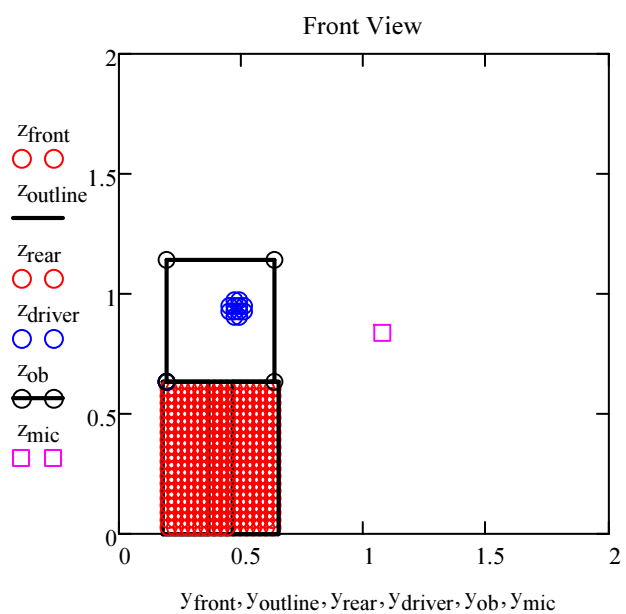
Three Dimensional View

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

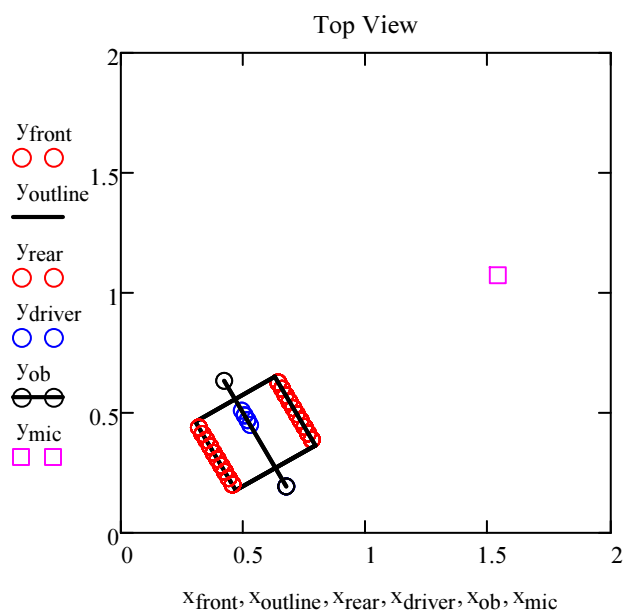
Room Corner is the Origin



Side View - looking out from side wall



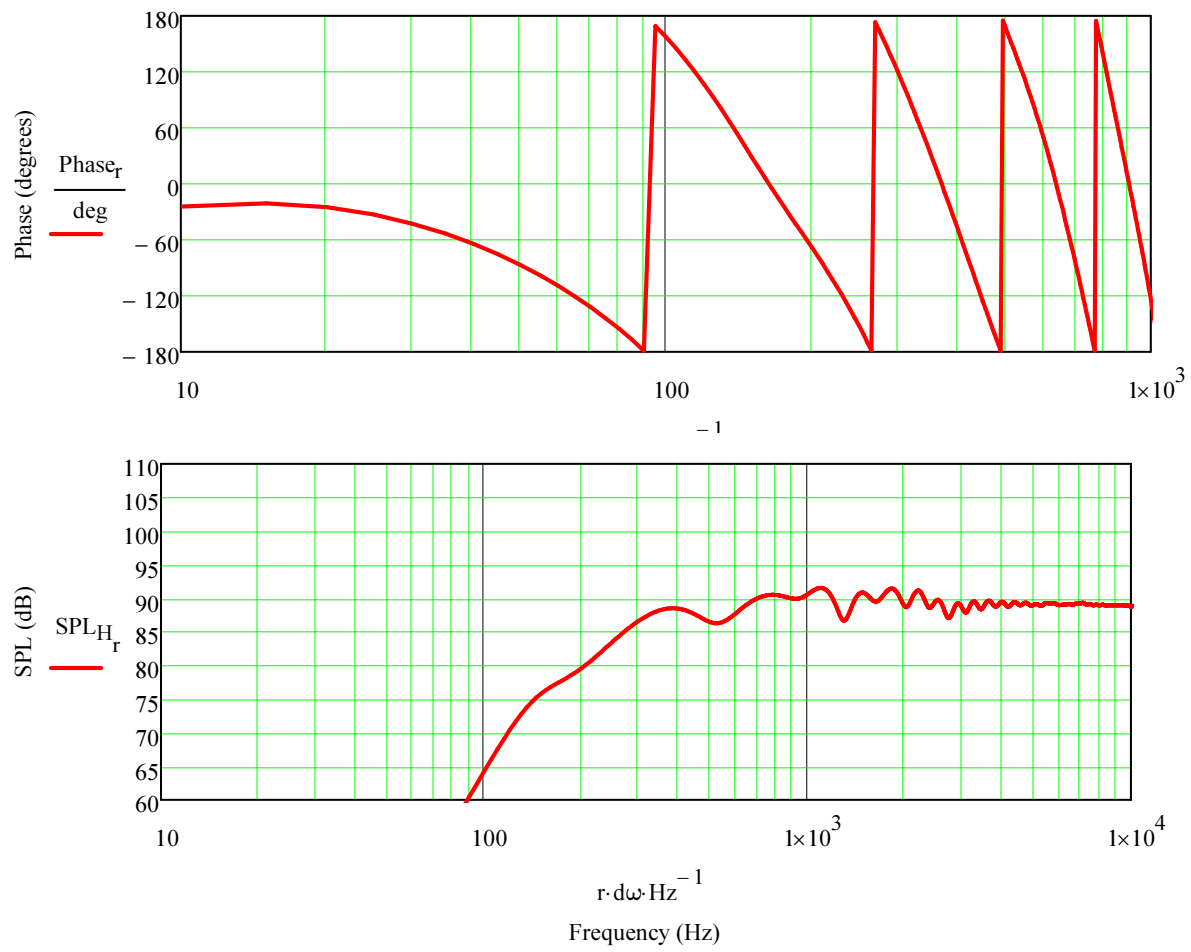
Front View - looking towards rear wall



Top View - looking down from ceiling

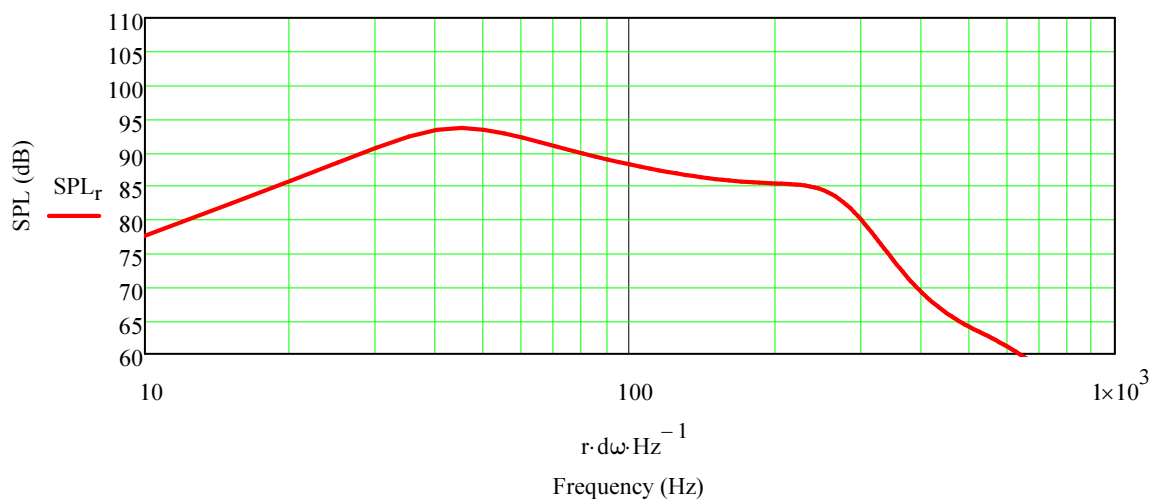
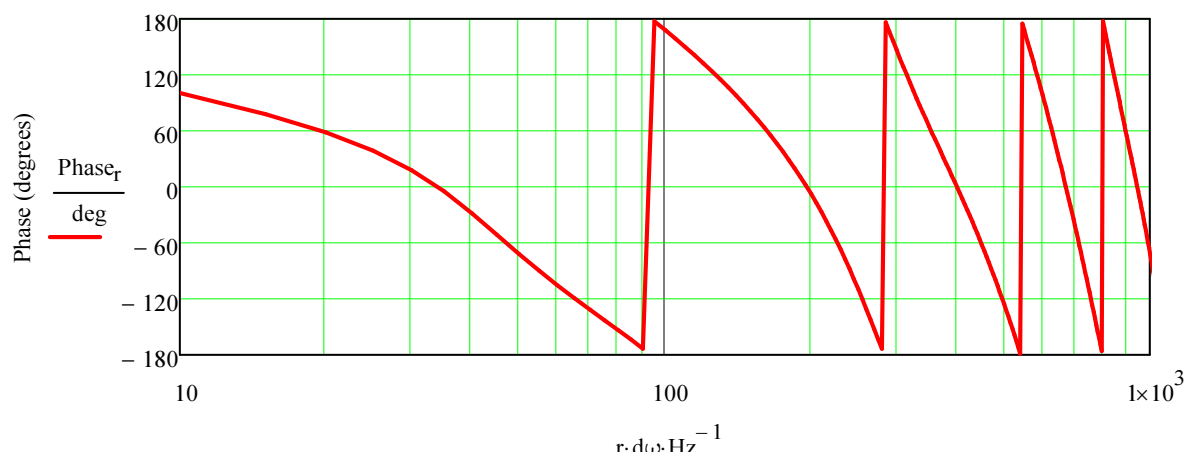


Plotted Response for the Extended Range Driver

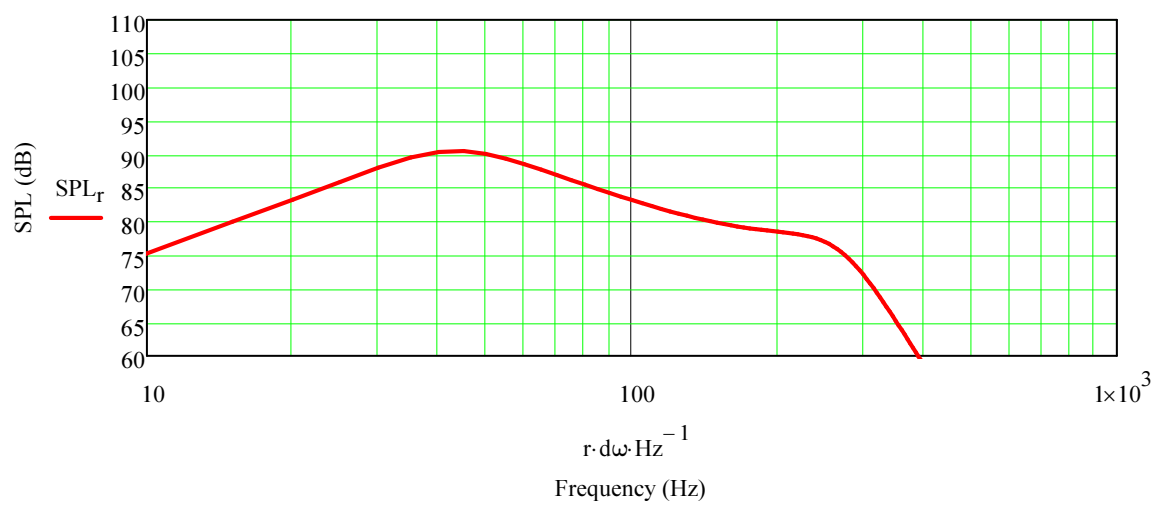
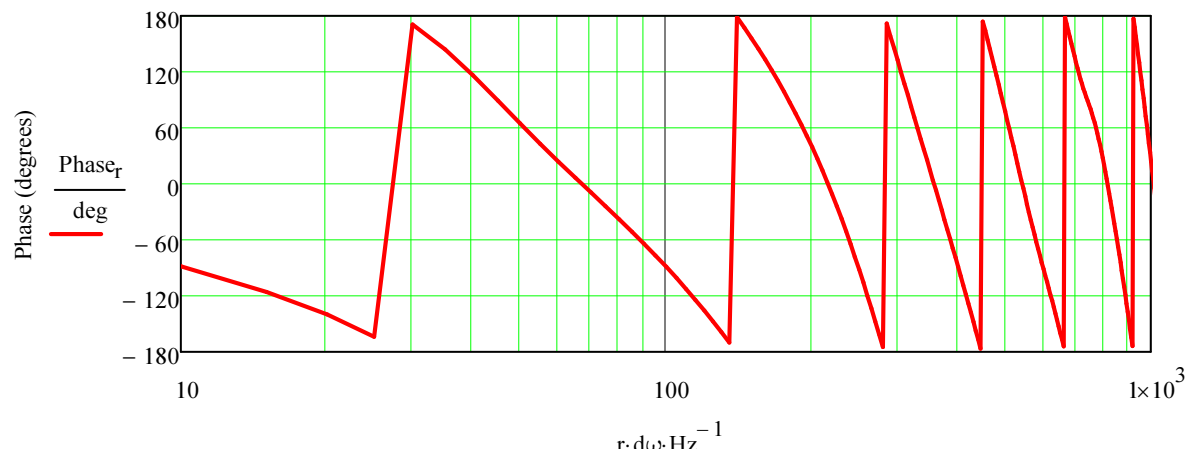




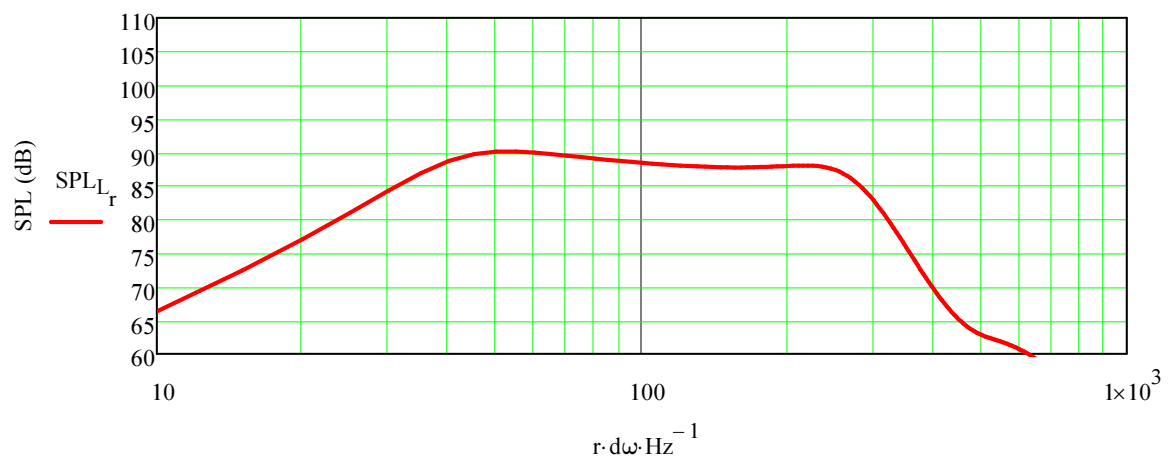
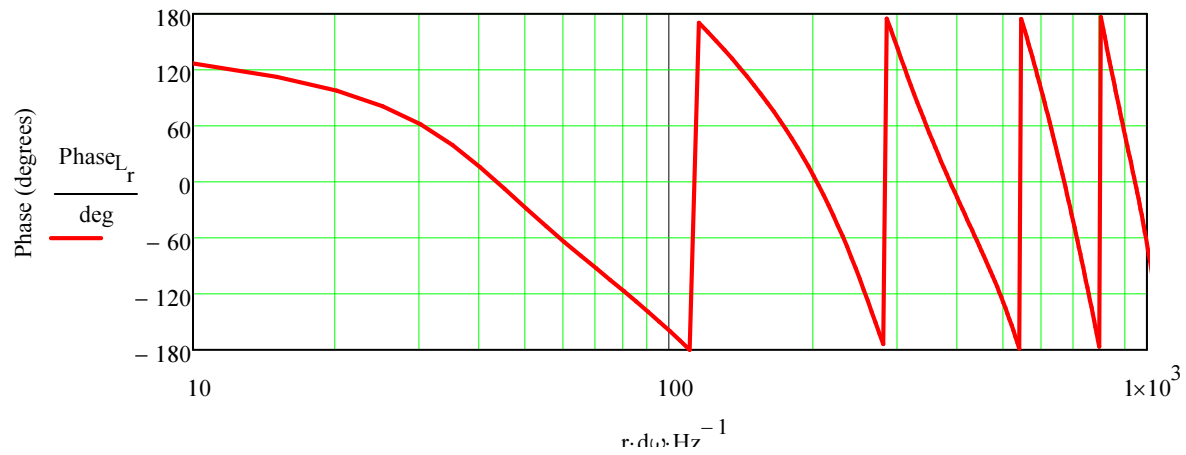
Plotted Baffle Step and Reflection SPL Response for the Front Terminus



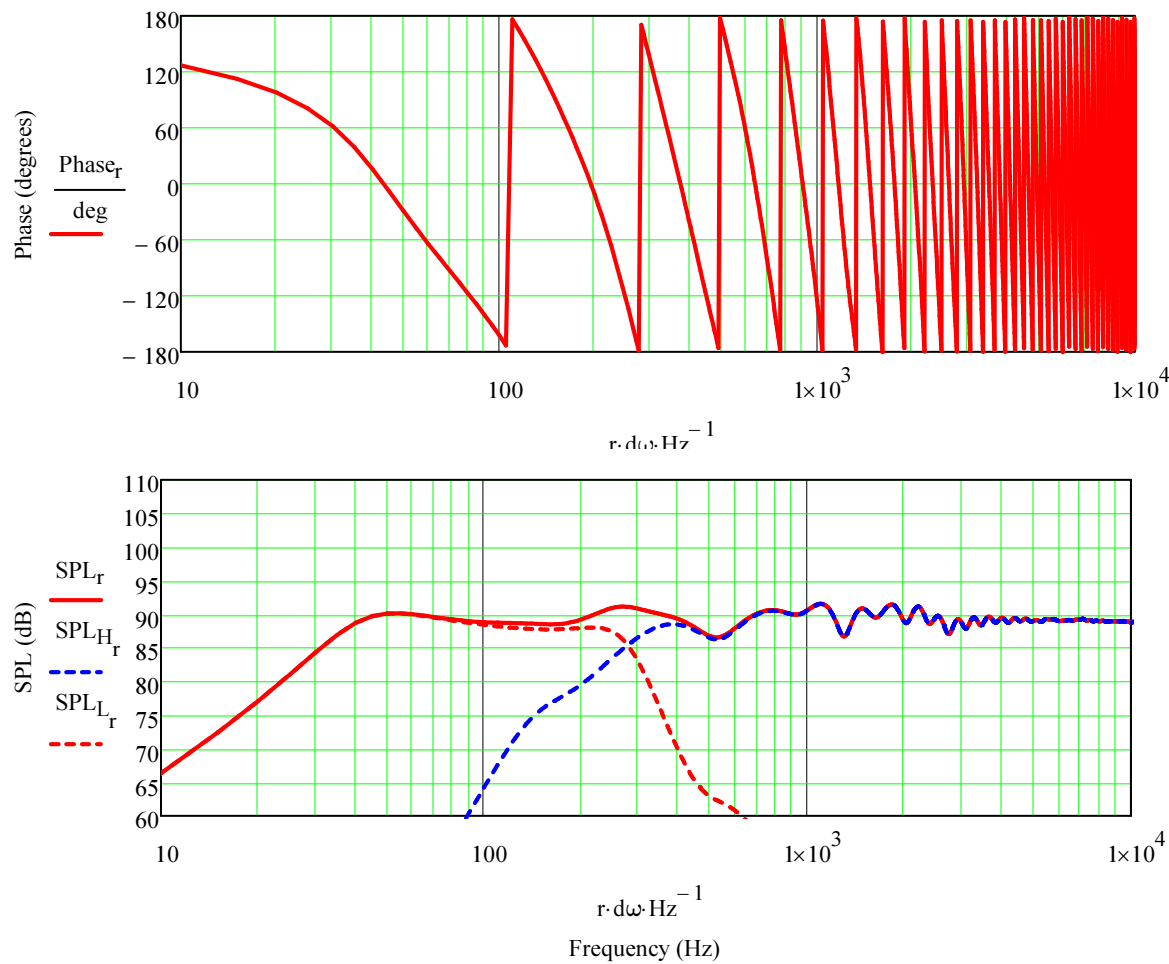
Plotted Baffle Step and Reflection SPL Response for the Rear Terminus



Plotted SPL Response for the H Frame



Plotted SPL Response for the System



System Time Response for an Impulse Input

