ML TQWT Design Worksheet - Acoustic and Electrical Response 12/20/03

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Reference : Design and Construction of a Mass Loaded Tapered Quarter Wavelength Tube (ML TQWT)
Using the Fostex FE-164 Full Range Driver
by Martin J. King, 4/21/01

Unit and Constant Definition

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

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

Air Density : $\rho := 1.21 \cdot kg \cdot m^{-3}$

Speed of Sound : $c := 342 \cdot m \cdot sec^{-1}$

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

Driver Thiele / Small Parameters : Fostex FE-164 Properties

$f_d := 45 \cdot Hz$

$V_{ad} := 15.28 \cdot liter$

$R_e := 4.5 \cdot \Omega$

$Q_{ed} := 0.58$

$L_{vc} := 0 \cdot mH$

$Q_{md} := 1.35$

$Bl := 4.0 \cdot \frac{newton}{amp}$

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

$S_d := 78.54 \cdot cm^2$

$Q_{td} = 0.406$

ML TQWT Geometry Definition (see Figure 7, pg 16 of the referenced article)

$L := 56.7 \cdot in$ (Length of the ML TQWT)

$\xi := 0.40$ (Driver Position Ratio)

$S_0 := 0.493 \cdot S_d$ (Area of the small end of the ML TQWT)

$S_L := 6.163 \cdot S_d$ (Area of the large end of the ML TQWT)

$Density := 0.50 \cdot lb \cdot ft^{-3}$ (Stuffing density : $0\ lb/ft^3 < D < 1\ lb/ft^3$)

$r_{port} := 0.9375 \cdot in$ (Radius of the port)

$L_{port} := 2.75 \cdot in$ (Length of the port)

Transmission Line Definition

(0 lb/ft³ < D < 1 lb/ft³)

$n\_closed := 4$ (n_closed > 1)

$n\_open := 4$ (n_open > 1)

Geometry Definition

$TR := \left(S_L - S_0\right) \cdot L^{-1}$ $TR = 0.031\ m$

Closed End of Transmission Line (Driver ---> Closed End)

Section Length	Initial Area	Final Area	Stuffing Density
$L_{c_0} := L \cdot \xi \cdot (n\_closed + 1)^{-1}$	$S_{c_{0,0}} := S_0 + TR \cdot \xi \cdot L$	$S_{c_{0,1}} := S_{c_{0,0}} - TR \cdot L_{c_0}$	$D_{c_0} := 0.0 \cdot lb \cdot ft^{-3}$
$L_{c_1} := L \cdot \xi \cdot (n\_closed + 1)^{-1}$	$S_{c_{1,0}} := S_{c_{0,1}}$	$S_{c_{1,1}} := S_{c_{1,0}} - TR \cdot L_{c_1}$	$D_{c_1} := Density$
$L_{c_2} := L \cdot \xi \cdot (n\_closed + 1)^{-1}$	$S_{c_{2,0}} := S_{c_{1,1}}$	$S_{c_{2,1}} := S_{c_{2,0}} - TR \cdot L_{c_2}$	$D_{c_2} := Density$
$L_{c_3} := L \cdot \xi \cdot (n\_closed + 1)^{-1}$	$S_{c_{3,0}} := S_{c_{2,1}}$	$S_{c_{3,1}} := S_{c_{3,0}} - TR \cdot L_{c_3}$	$D_{c_3} := Density$
$L_{c_4} := L \cdot \xi \cdot (n\_closed + 1)^{-1}$	$S_{c_{4,0}} := S_{c_{3,1}}$	$S_{c_{4,1}} := S_0$	$D_{c_4} := Density$

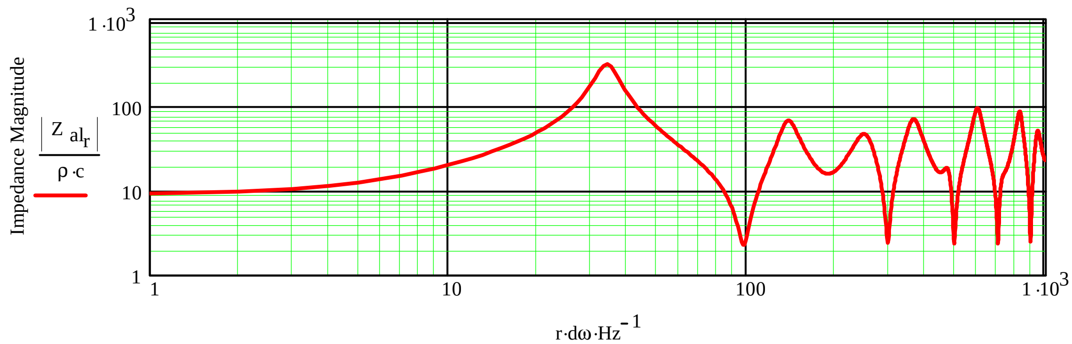
Open End of Transmission Line (Driver ---> Open End)

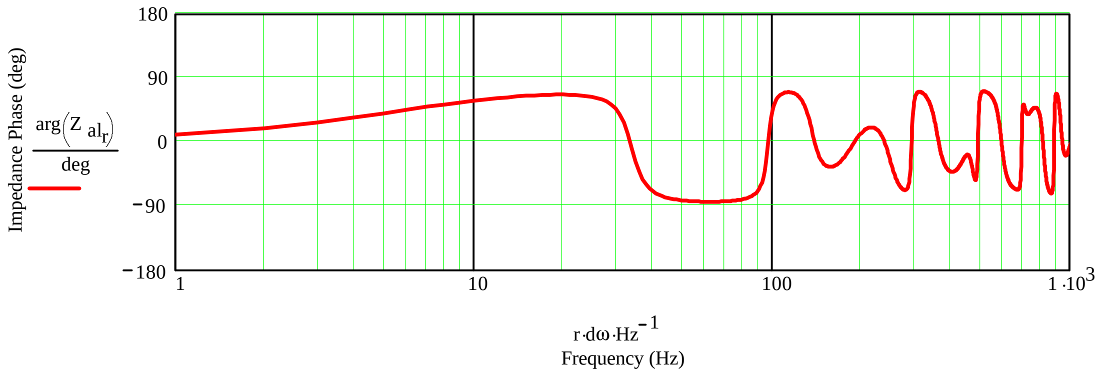
Section Length	Initial Area	Final Area	Stuffing Density
$L_{o_0} := L \cdot (1 - \xi) \cdot (n\_open)^{-1}$	$S_{o_{0,0}} := S_{c_{0,0}}$	$S_{o_{0,1}} := S_{o_{0,0}} + TR \cdot L_{o_0}$	$D_{o_0} := 0.0 \cdot lb \cdot ft^{-3}$
$L_{o_1} := L \cdot (1 - \xi) \cdot (n\_open)^{-1}$	$S_{o_{1,0}} := S_{o_{0,1}}$	$S_{o_{1,1}} := S_{o_{1,0}} + TR \cdot L_{o_1}$	$D_{o_1} := 0.0 \cdot lb \cdot ft^{-3}$
$L_{o_2} := L \cdot (1 - \xi) \cdot (n\_open)^{-1}$	$S_{o_{2,0}} := S_{o_{1,1}}$	$S_{o_{2,1}} := S_{o_{2,0}} + TR \cdot L_{o_2}$	$D_{o_2} := 0.0 \cdot lb \cdot ft^{-3}$
$L_{o_3} := L \cdot (1 - \xi) \cdot (n\_open)^{-1}$	$S_{o_{3,0}} := S_{o_{2,1}}$	$S_{o_{3,1}} := S_{o_{3,0}} + TR \cdot L_{o_3}$	$D_{o_3} := 0.0 \cdot lb \cdot ft^{-3}$
$L_{o_4} := L_{port} + 0.6 \cdot r_{port}$	$S_{o_{4,0}} := \pi \cdot r_{port}^2$	$S_{o_{4,1}} := \pi \cdot r_{port}^2$	$D_{o_4} := 0.0 \cdot lb \cdot ft^{-3}$

Total Length of the Transmission Line

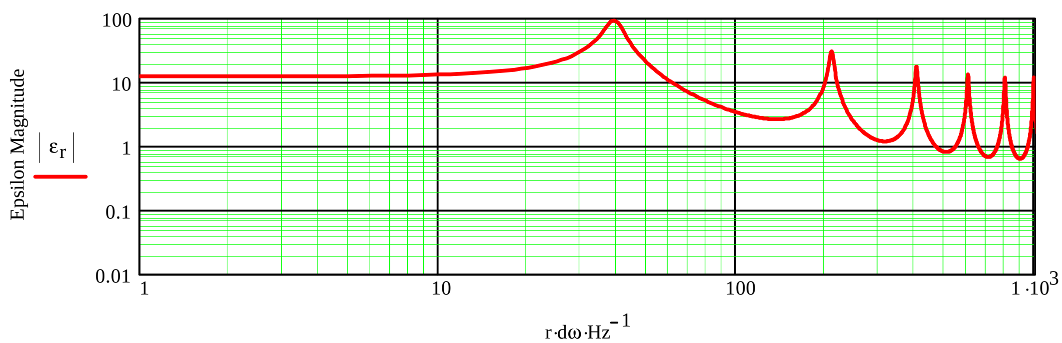
$$\sum_{i=0}^{n\_closed} L_{c_i} + \sum_{i=0}^{n\_open} L_{o_i} = 60.013 \cdot in$$

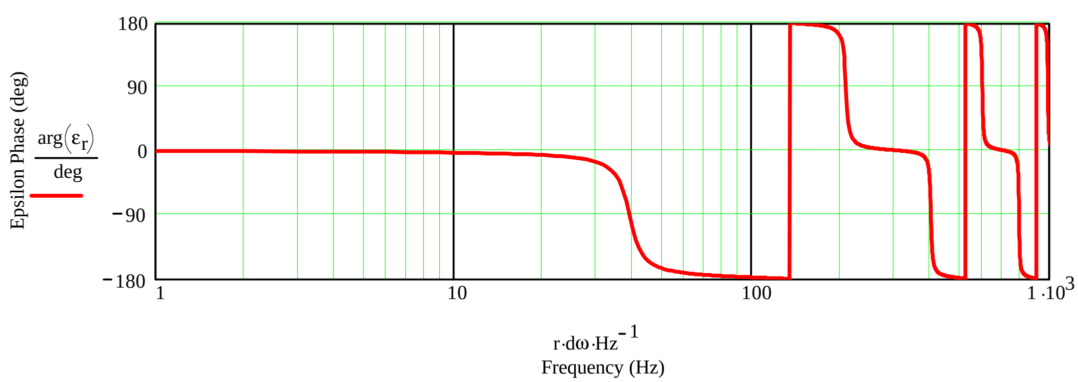
Resulting Acoustic Impedance for the Transmission Line



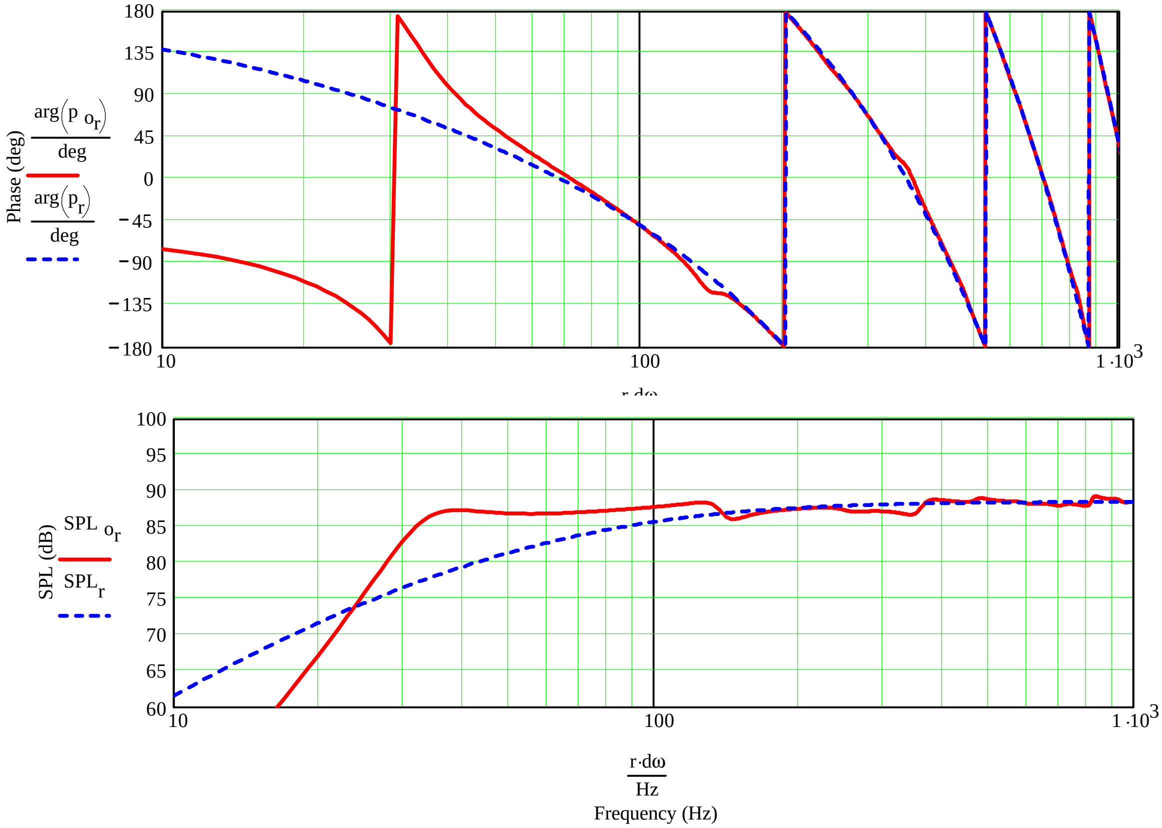


Velocity at the Terminus of the Transmission Line for a 1 m/sec Driver Excitation

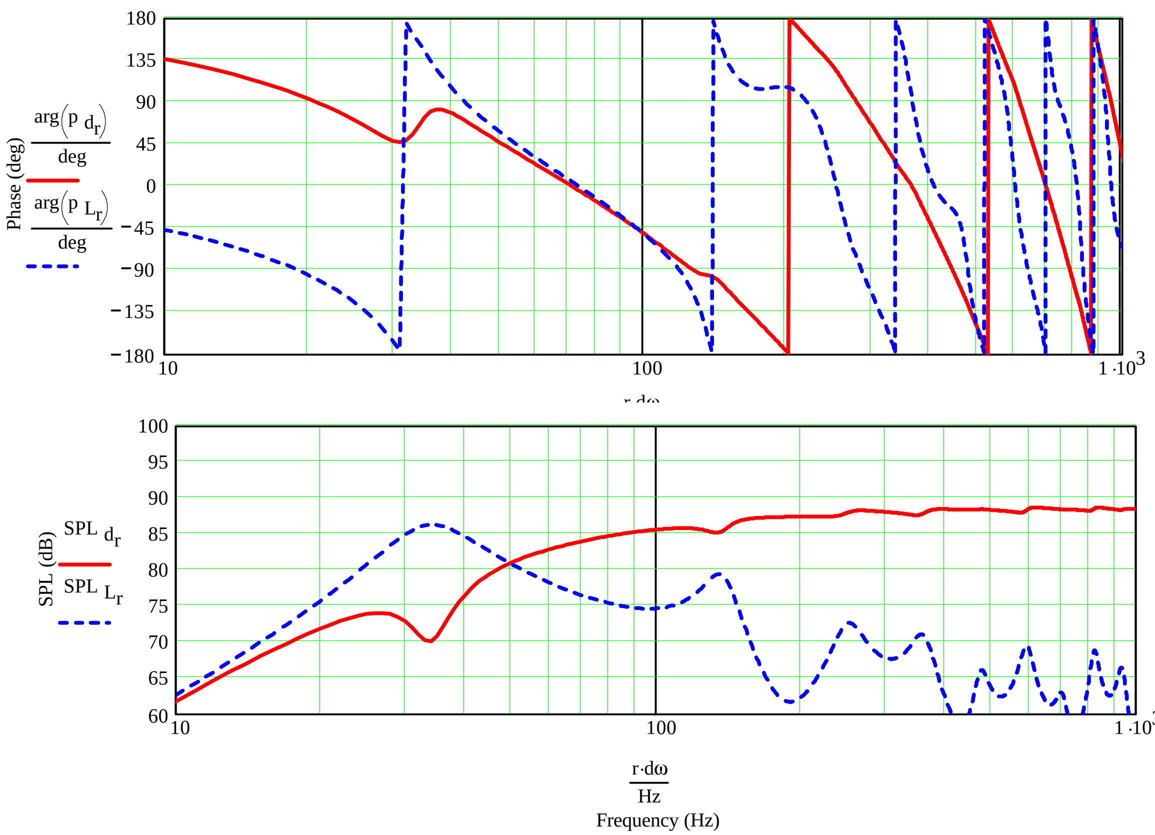




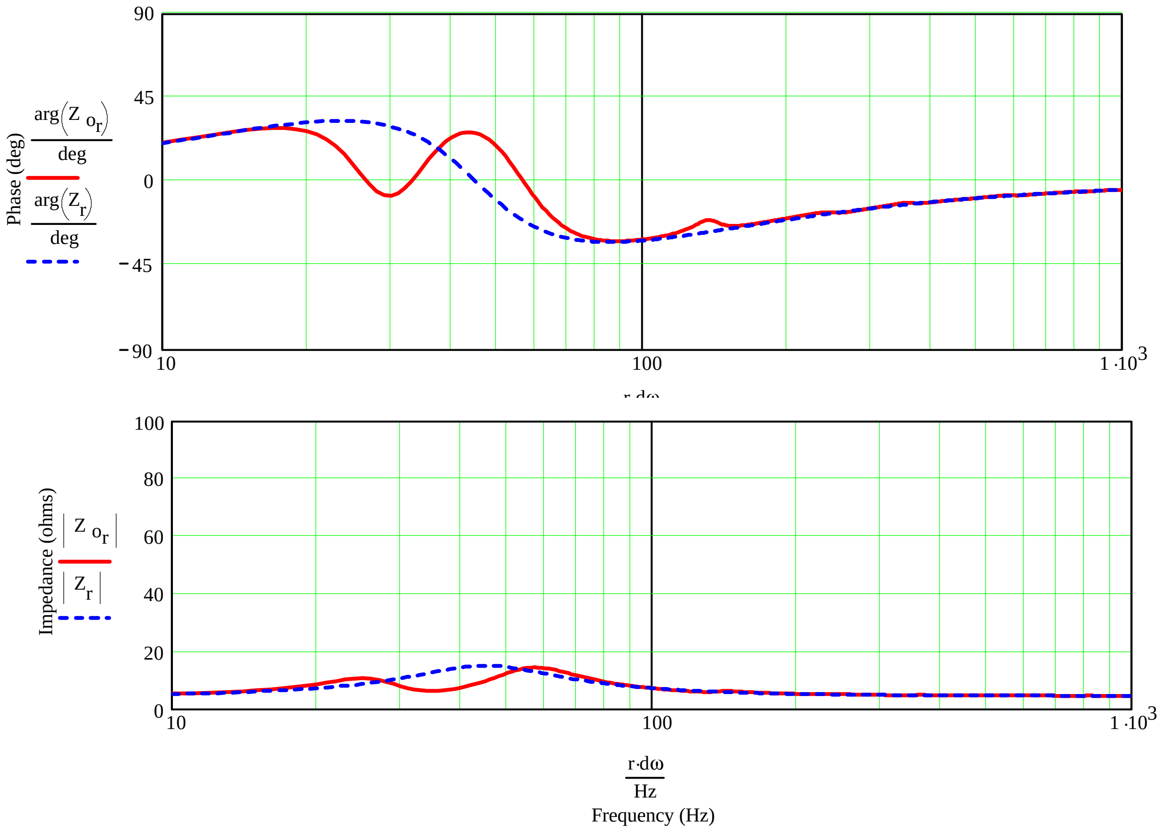
Far Field Transmission Line System and Infinite Baffle Sound Pressure Level Responses



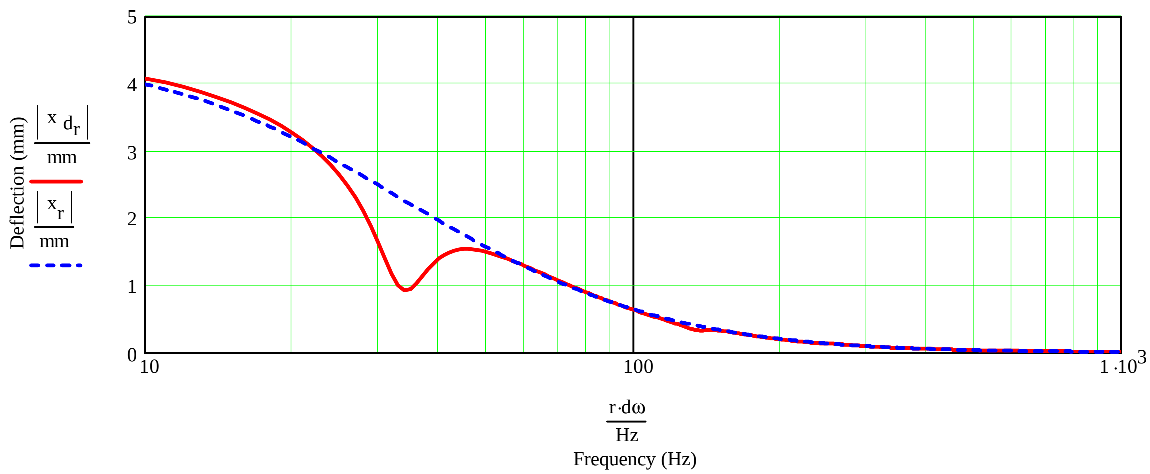
Woofer and Terminus Far Field Sound Pressure Level Responses



Transmission Line System and Infinite Baffle Impedance



Woofer Displacement



System Time Response for an Impulse Input