STUDY ON ACOUSTIC BEHAVIOR OF LOUDSPEAKER MOUNTED ON BIW FRAME

COMSOL CONFERENCE 2018 BANGALORE

HARMAN VirtualWORKS

Virtual Product Development

HARMAN International. Confidential. Copyright 2015.

INTRODUCTION

Scope:

To develop the Comsol App based on the fully parametric geometry models to study the Acoustic behavior of a Loudspeaker.

The BIW enclosure configurations are divided into 2 types

1. Single Beam enclosure configurations
2. Multi Beam enclosure configurations

Input:

BIW Enclosure and speaker geometry and design parameters.

Deliverables:

I. SPL at 1m on-axis
II. Cone displacement
III. Impedance curve
IV. SPL distribution inside the enclosure
V. Simulation Report

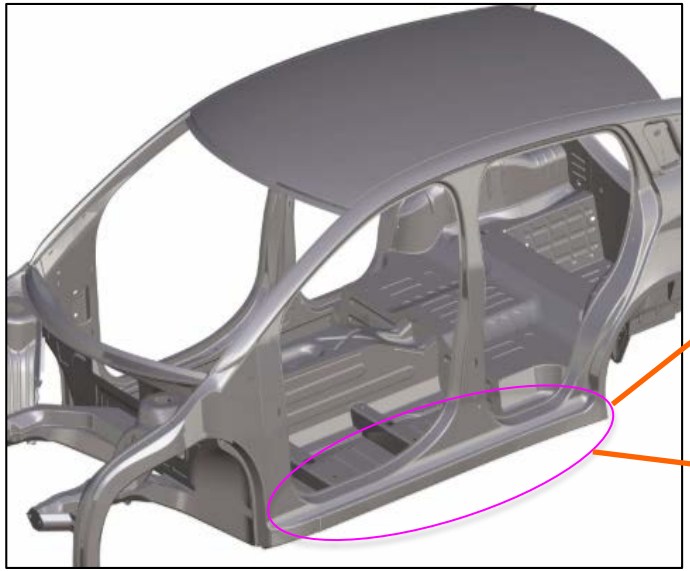
Car subwoofer sample model

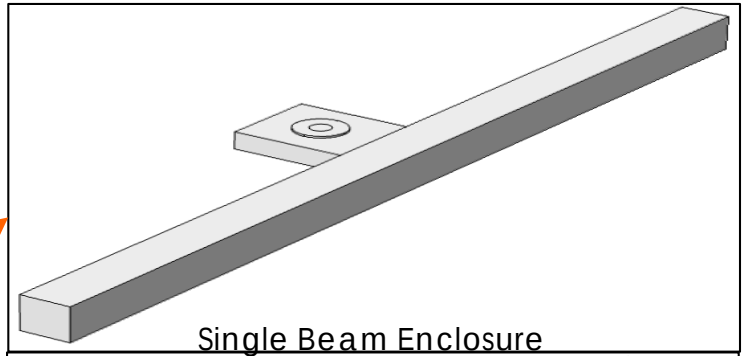

BIW frame

HARMAN International. Confidential. Copyright 2015.

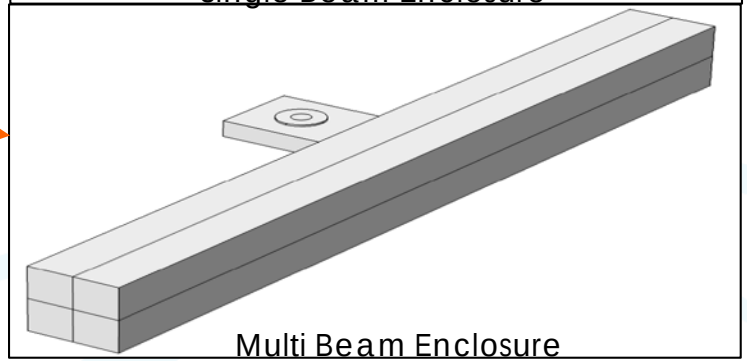
MODEL DETAILS

The location of Single / Multi beam enclosure in BIW frame





Single Beam Enclosure

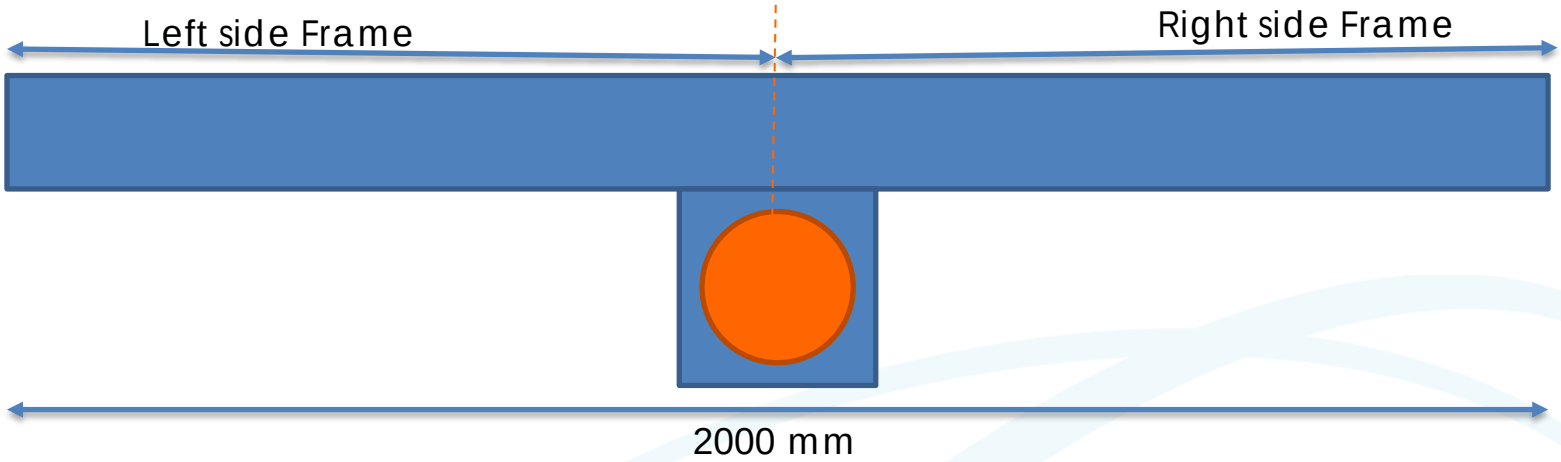


Multi Beam Enclosure

HARMAN International. Confidential. Copyright 2015.

MODEL DETAILS

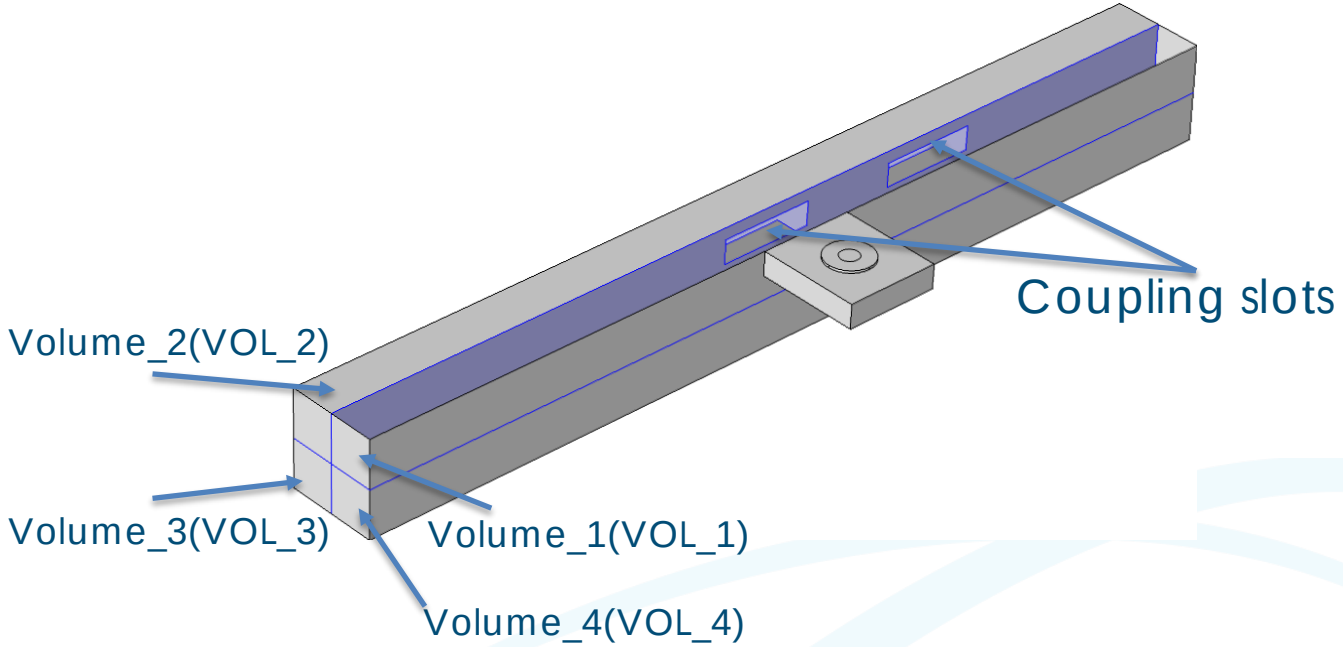
The Single beam enclosure coupled with speaker in the middle



HARMAN International. Confidential. Copyright 2015.

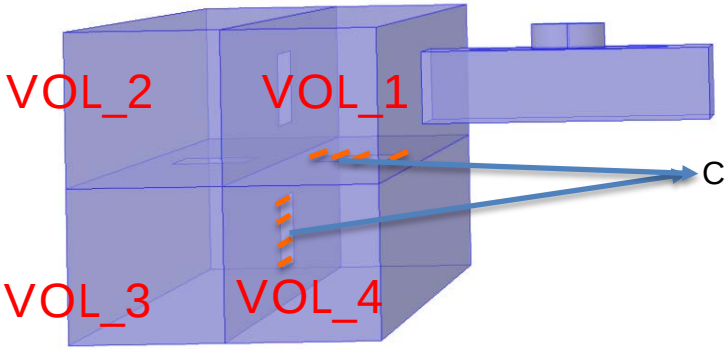
MODEL DETAILS

The Multi beam enclosure coupled with coupling slots (openings) between beams



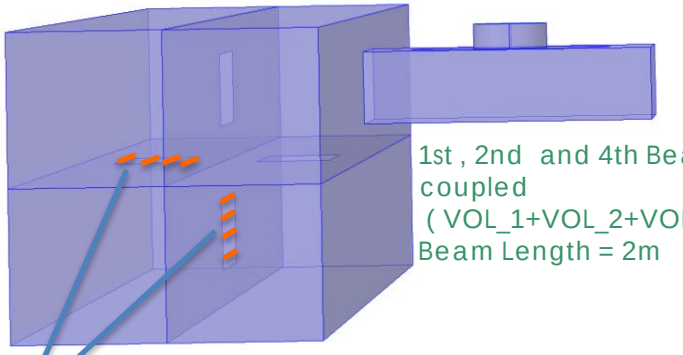
HARMAN International. Confidential. Copyright 2015.

MULTI-BEAM CONFIGURATIONS

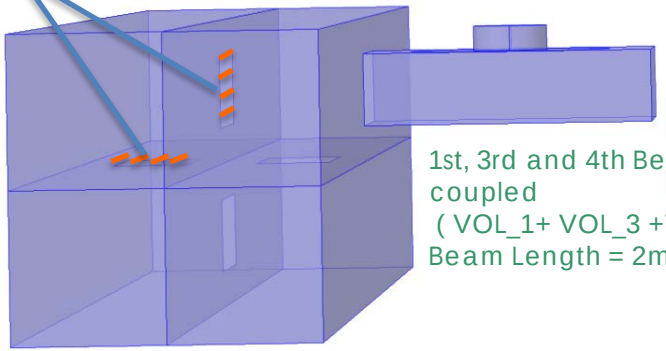


1st , 2nd and 3rd Beam volumes coupled
(VOL_1+VOL_2+VOL_3)
Beam Length = 2m

Closed slot openings



1st , 2nd and 4th Beam volumes coupled
(VOL_1+VOL_2+VOL_4)
Beam Length = 2m



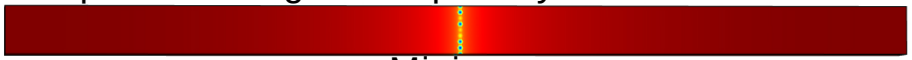
1st, 3rd and 4th Beam volumes coupled
(VOL_1+ VOL_3 +VOL_4)
Beam Length = 2m

HARMAN International. Confidential. Copyright 2015.

VERIFICATION
MODAL ANALYSIS OF BIW FULL FRAME

Simulation results of Modal analysis of enclosure

SPL plot for1st Eigen Frequency at 85.801 Hz

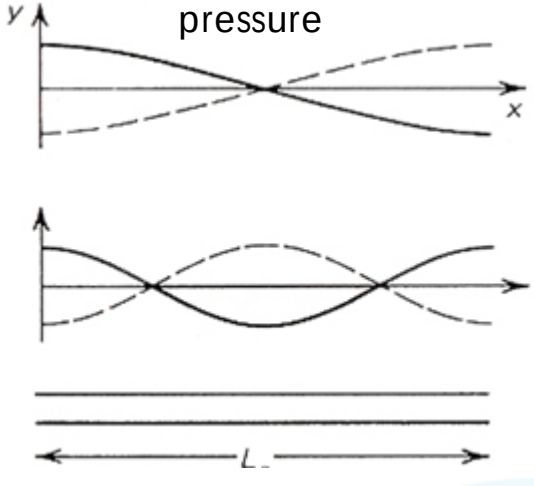


Minimum

SPL plot for 2nd Eigen Frequency at 171.6Hz

Maximum

Standing waves in Closed/Closed end frame



f1= c/2*l
= 344/4 =86.00 Hz
$\boldsymbol{Here}, \lambda = 2l$

f2 = c/l
= 172.0 Hz
$\boldsymbol{Here}, \lambda = l$

Where c= speed of air
=344 m/s
l = length of frame
= 2m

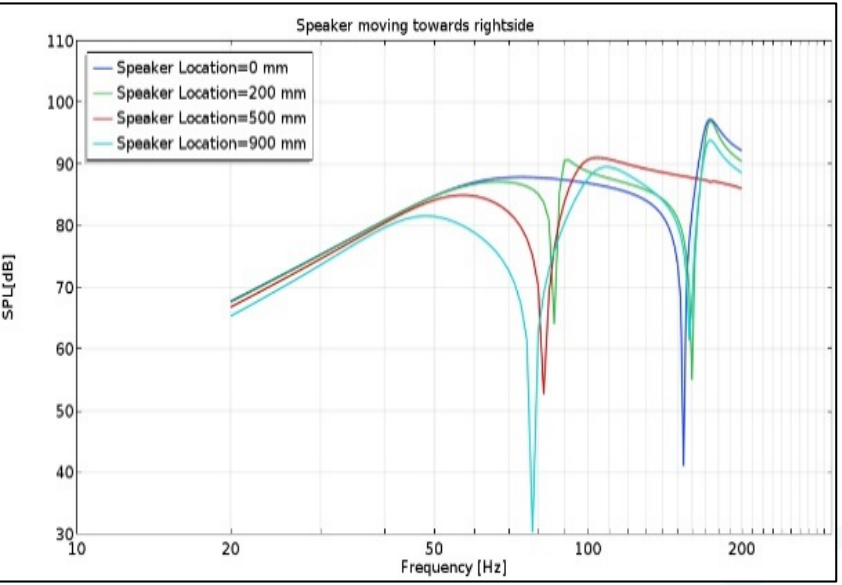
- Considered only the Longitudinal modes because the frame Length is much larger than width/height of frame.
- The first standing wave/mode creates pressure anti-node at the closed ends as shown in the above image.
- When the Speaker is at middle so the first mode will not be excited and second mode only will be excited at 171.6 HZ.

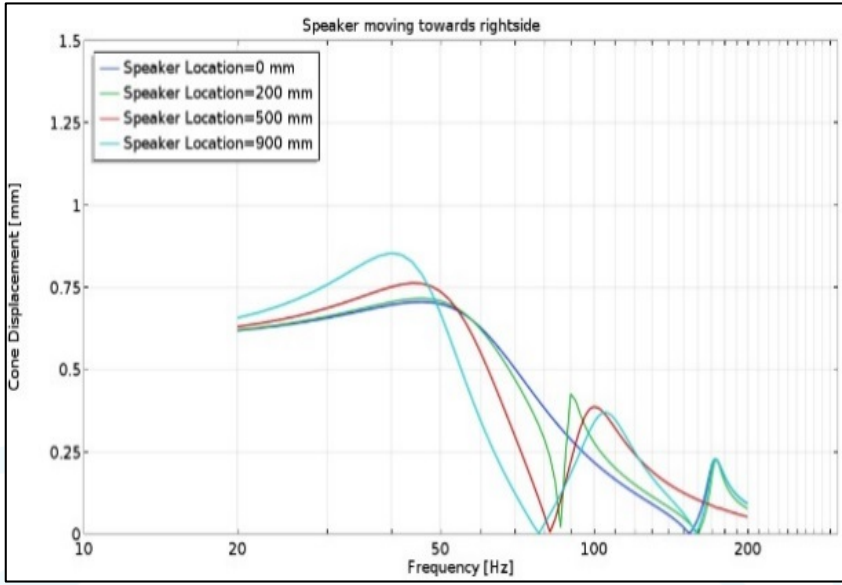
HARMAN International. Confidential. Copyright 2015.

VERIFICATION
SPL AND DISPLACEMENT PLOTS

HARMAN

SPL and Displacement plots of the speaker for Single Beam enclosure with speaker integrated at different locations

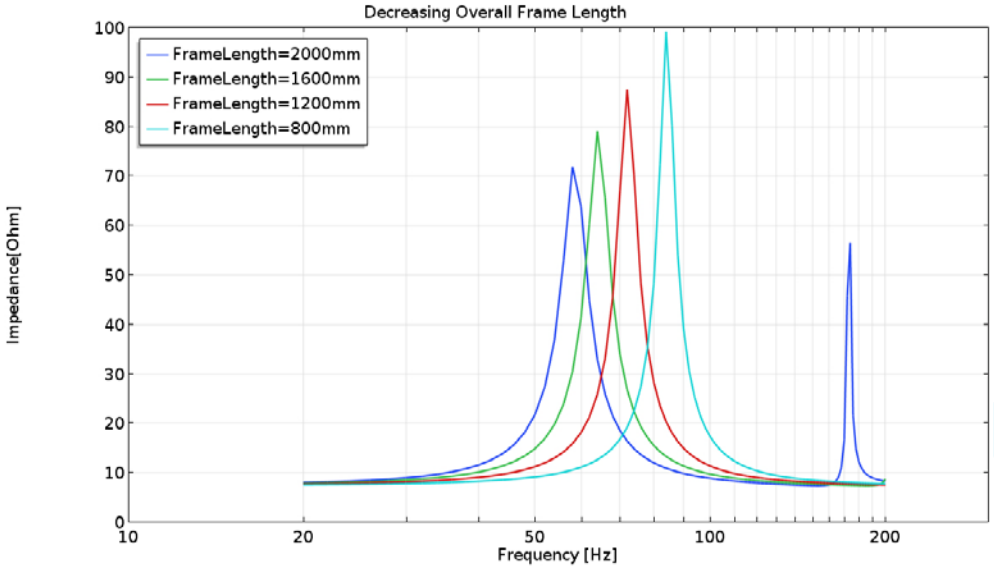




HARMAN International. Confidential. Copyright 2015.

VERIFICATION
IMPEDANCE PLOTS

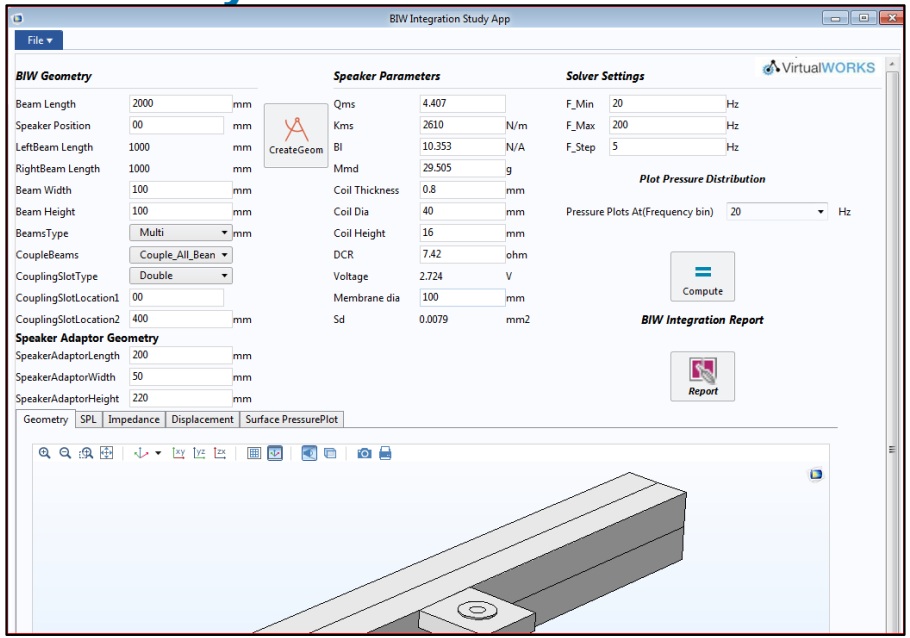
Impedance plots for Single Beam enclosure with different lengths

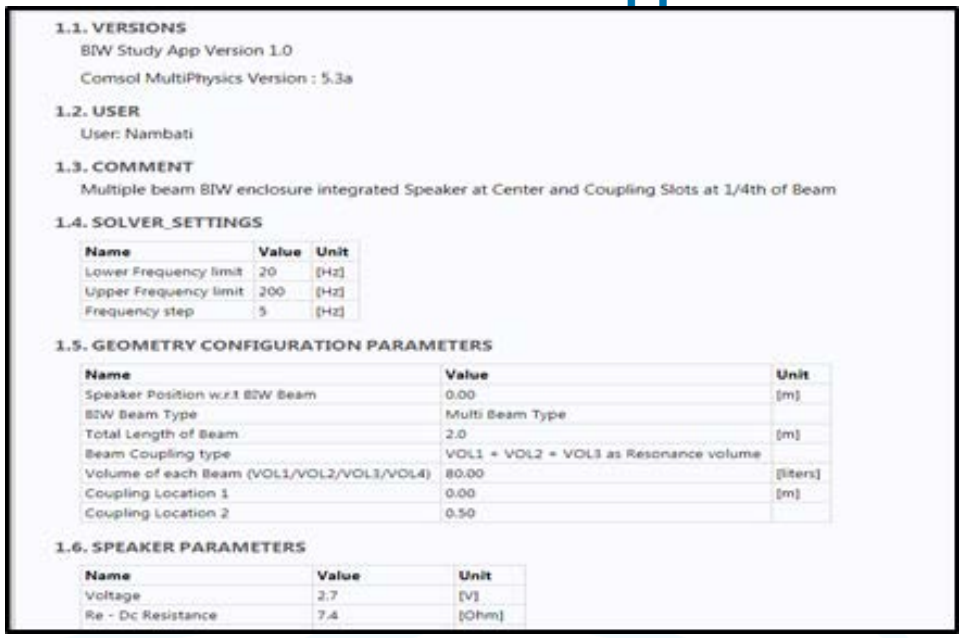


HARMAN International. Confidential. Copyright 2015.

COMSOL APPLICATION GUI

Geometry creation and Pressure acoustic simulation with Comsol App





1.1. VERSIONS

BIW Study App Version 1.0

Comsol MultiPhysics Version : 5.3a

1.2. USER

User: Nambati

1.3. COMMENT

Multiple beam BIW enclosure integrated Speaker at Center and Coupling Slots at 1/4th of Beam

1.4. SOLVER_SETTINGS

Name	Value	Unit
Lower Frequency limit	20	[Hz]
Upper Frequency limit	200	[Hz]
Frequency step	5	[Hz]

1.5. GEOMETRY CONFIGURATION PARAMETERS

Name	Value	Unit
Speaker Position w.r.t BIW Beam	0.00	[m]
BIW Beam Type	Multi Beam Type	
Total Length of Beam	2.0	[m]
Beam Coupling type	VOL1 + VOL2 + VOL3 as Resonance volume	
Volume of each Beam (VOL1/VOL2/VOL3/VOL4)	80.00	[liters]
Coupling Location 1	0.00	[m]
Coupling Location 2	0.50	

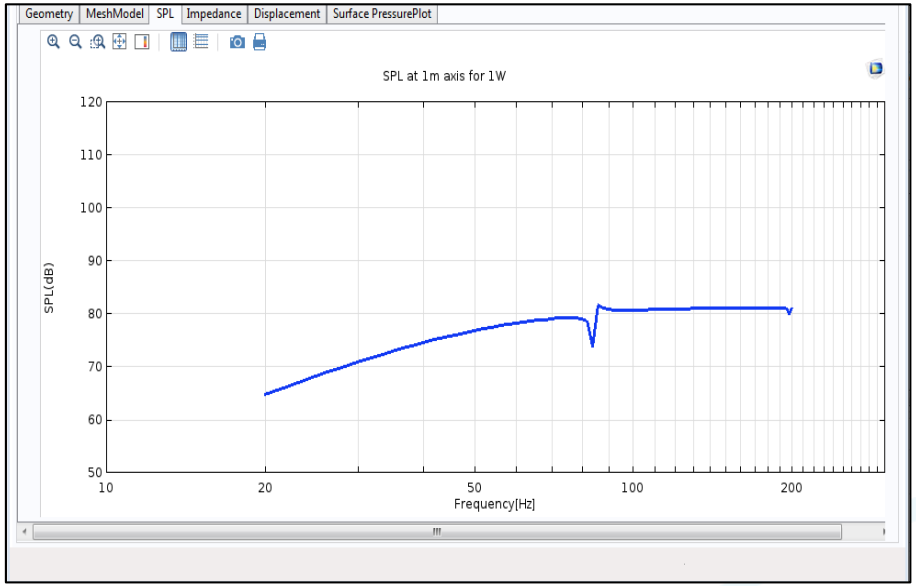
1.6. SPEAKER PARAMETERS

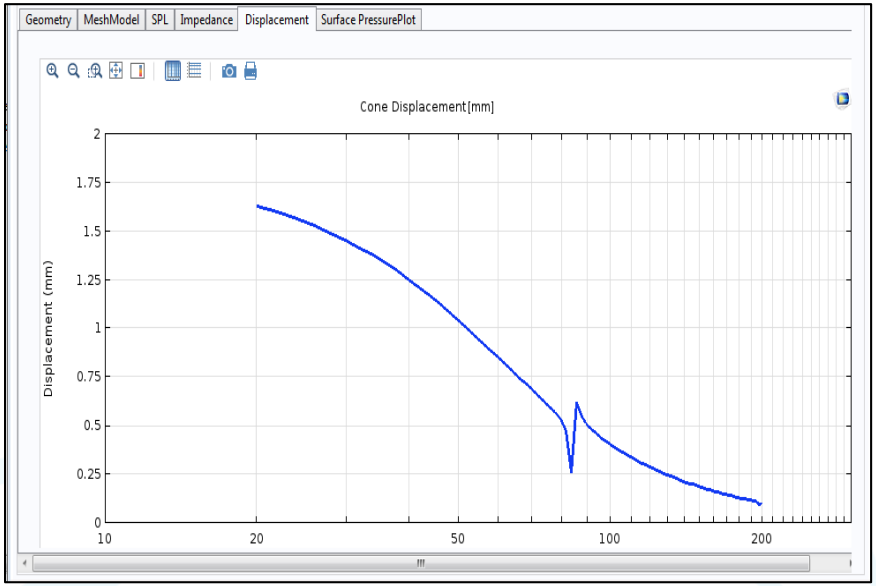
Name	Value	Unit
Voltage	2.7	[V]
Re - Dc Resistance	7.4	[Ohm]

* Total solution time(including simulation report generation) = 2-3mins

HARMAN International. Confidential. Copyright 2015.

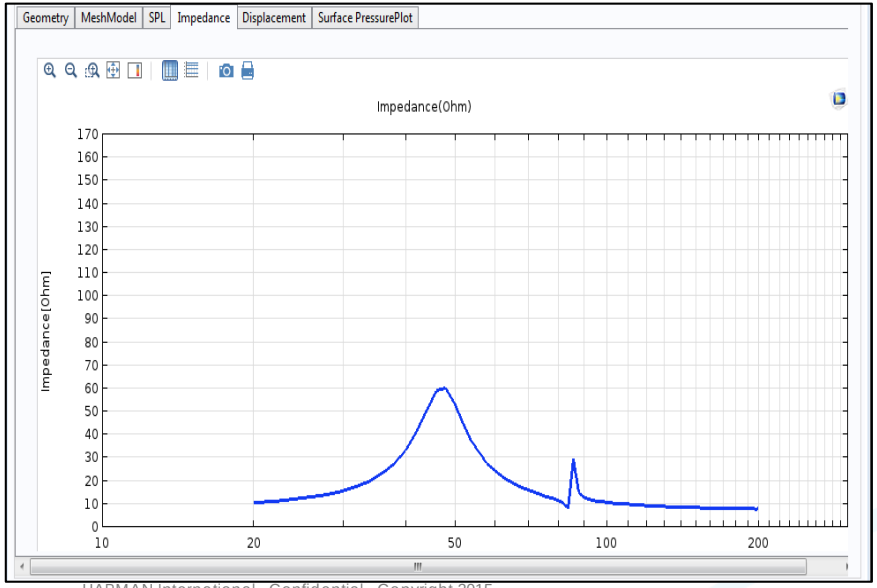
SPL and Displacement plots for Multi Beam enclosure



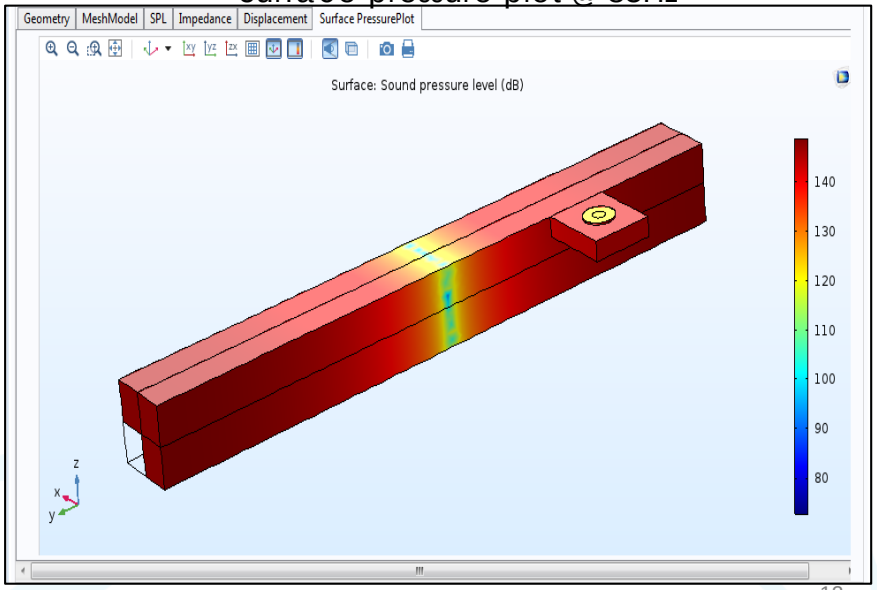


HARMAN International. Confidential. Copyright 2015.

Impedance plots for Multi Beam enclosure



Surface pressure plot @ 85Hz



HARMAN International. Confidential. Copyright 2015.

SUMMARY

1. The BIW Comsol App predicted the acoustic behavior of loudspeaker for all configurations as expected.
2. This App is used to perform the preliminary study on the placement of speaker.
3. More detailed Pressure acoustic simulation would be performed for final optimum configuration which would be derived from the BIW Comsol App.

HARMAN International. Confidential. Copyright 2015.

THANK YOU

FEA Disclaimer

Do not accept or reject a design based solely on the data presented in this report. Every effort is undertaken to ensure the analysis represents the real life scenario as much as possible. Certain factors cannot be accounted for such as temperature, casting / moulding anomalies, polymer fibre orientation and metal drawing inconsistencies. Evaluate designs by considering this information in conjunction with experimental test data and the practical experience of the Design Engineers. A quality approach to engineering design usually mandates final testing as the means of validating the structural integrity of any product

HARMAN International. Confidential. Copyright 2015.