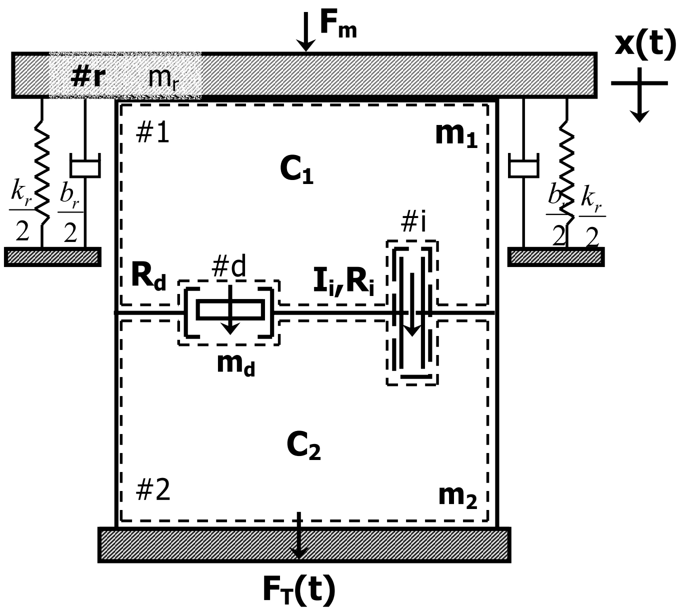
Hydraulic Engine Mount Analysis

HEMA 04.1: *Interactive Design and Simulation Tool*

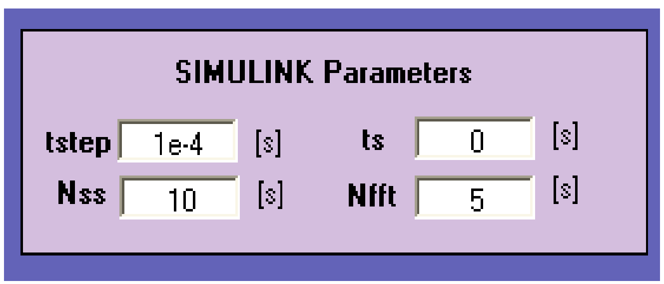
- Time and Frequency Response Simulations
- Linear and Non-Linear Models (Based on First Principals)
- Estimation of Mount Parameters Given Experimental Data
- Parametric Design Studies
  - Mount as a component
  - Mount within a ½ Car Model

Song He and Prof R. Singh

System Model & Parameters



Fluid Model

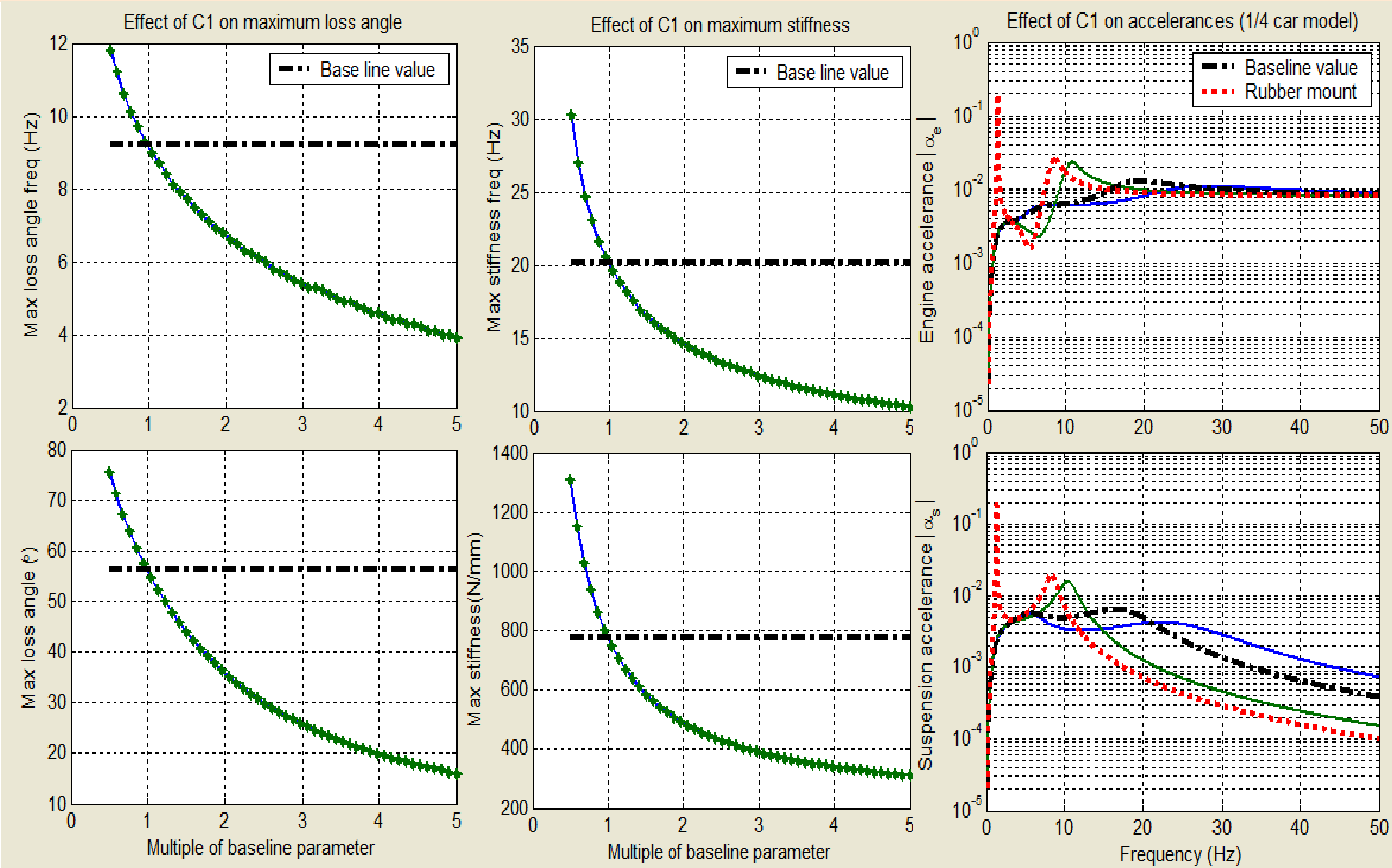


Simulation Parameters

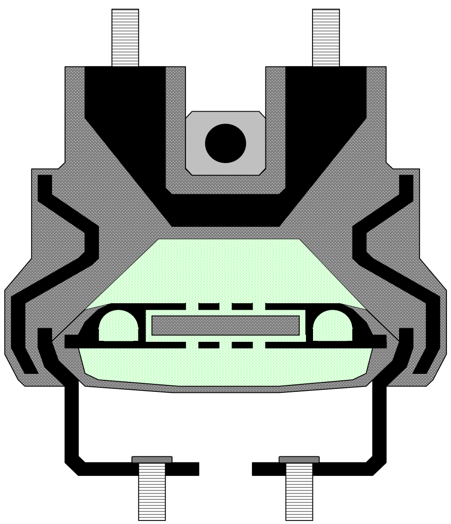
Symbol	Physical meaning	Symbol	Physical meaning
k_r	Rubber dynamic stiffness*	b_r	Rubber viscous damping*
ρ	Fluid density	μ	Fluid viscosity
m_r	Rubber mass	A_r	Piston area
A_i	Inertia track area	A_d	Decoupler area
C_1	Upper chamber compliance	C_2	Lower chamber compliance
R_i	Fluid resistance of inertia track	l_i	Inertia track length
b_{d0}	Equiv. decoupler damping	l_d	Decoupler gap length
m_{d0}	Actual decouper mass		

* *Constant value/experimental result interpolation*

Linear Analysis: Effects of Upper Chamber Compliance C1



Nonlinear Analysis I: System Parameters

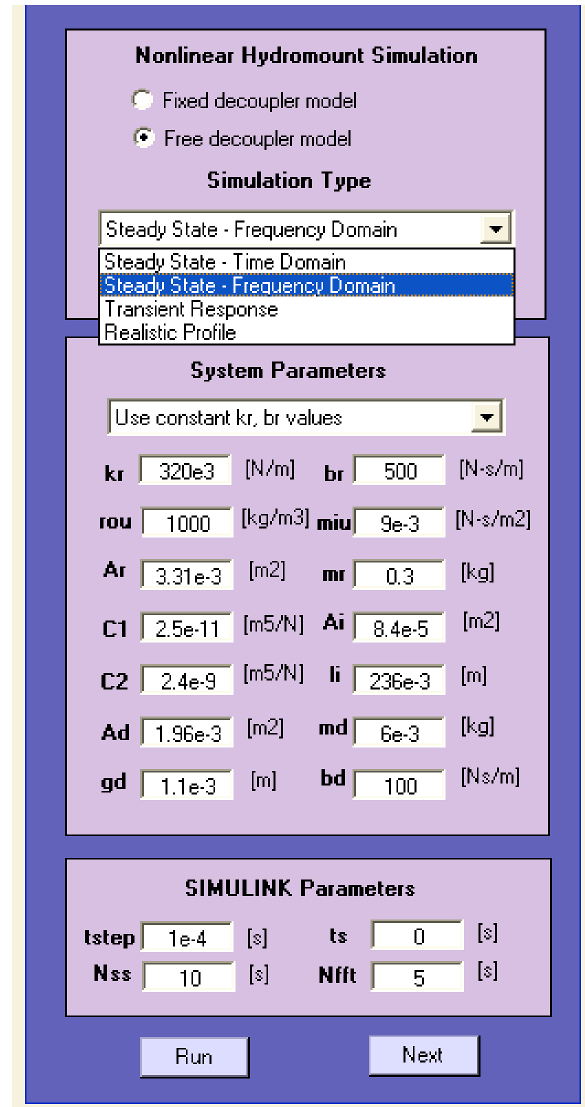


Mount Designs

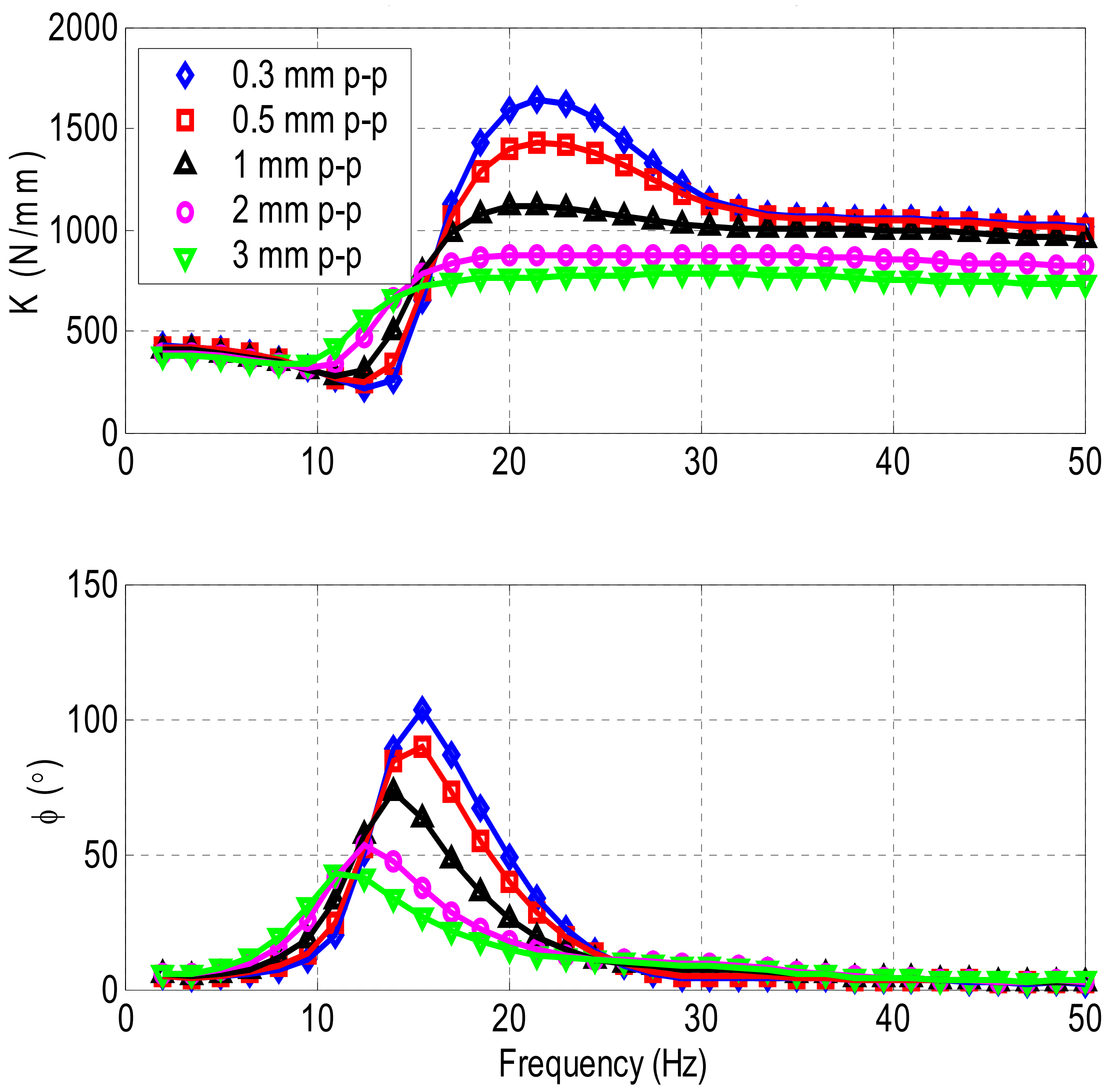
- Fixed decoupler mount
- Free decoupler mount

Select Response Type

- Steady state response to sinusoidal excitation
- Dynamic stiffness simulation
- Transient responses: Step, Pulse, Saw-tooth, Triangular…
- Realistic profiles response



Nonlinear Analysis II: Dynamic Stiffness Simulation

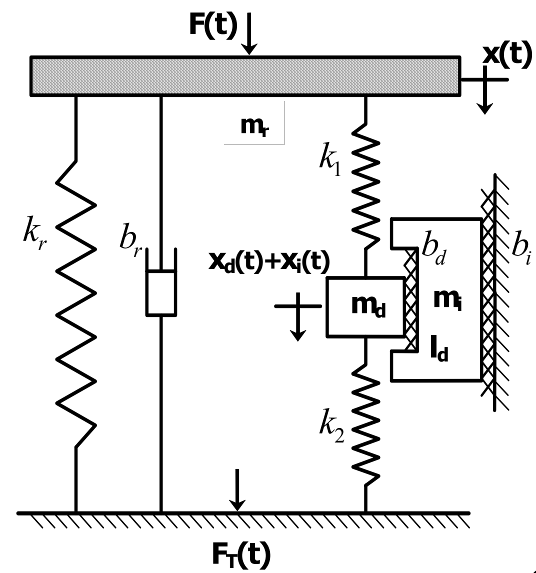


Governing Equations

- Momentum equations
- Continuity equations

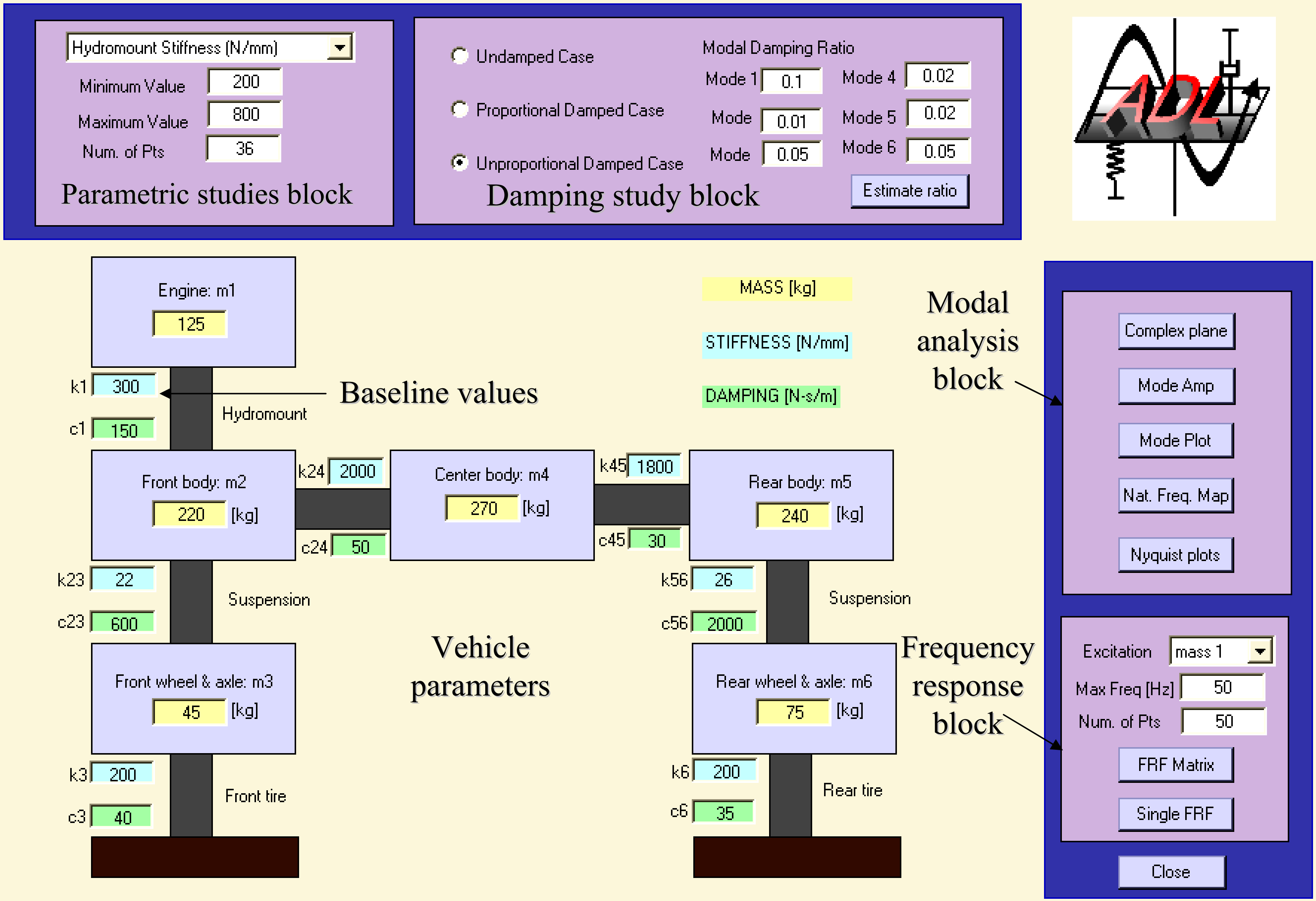
Simulation Algorithm

- Solve differential equations in time domain
- Transform results to frequency domain

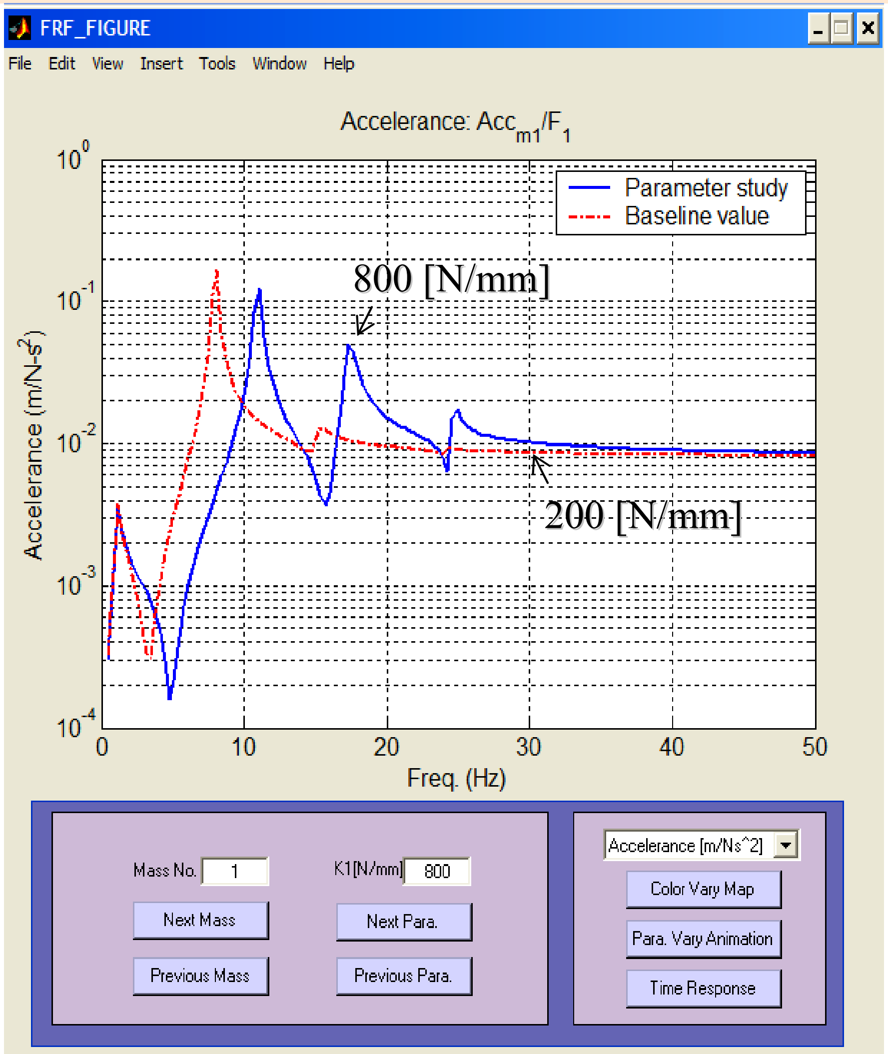


Analogous Mechanical System

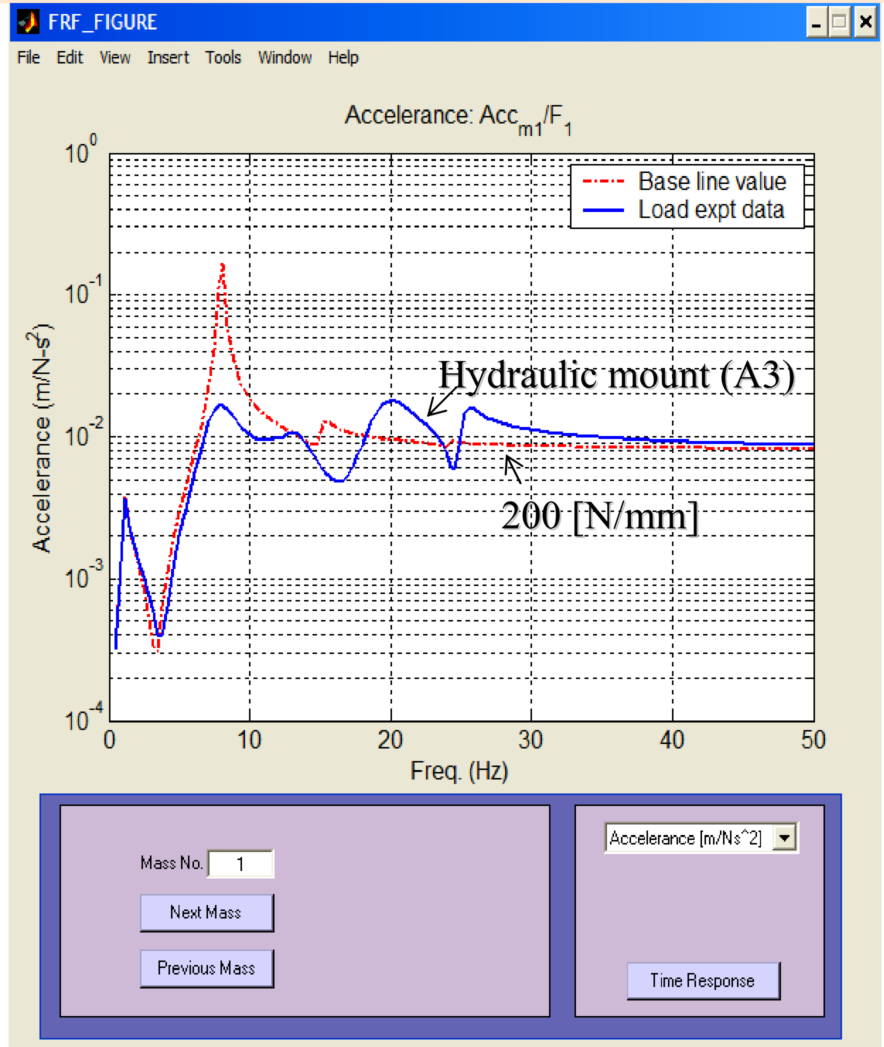
Inclusion of Mount in ½ Car Model



Frequency Response I: Effect of Some Parameters

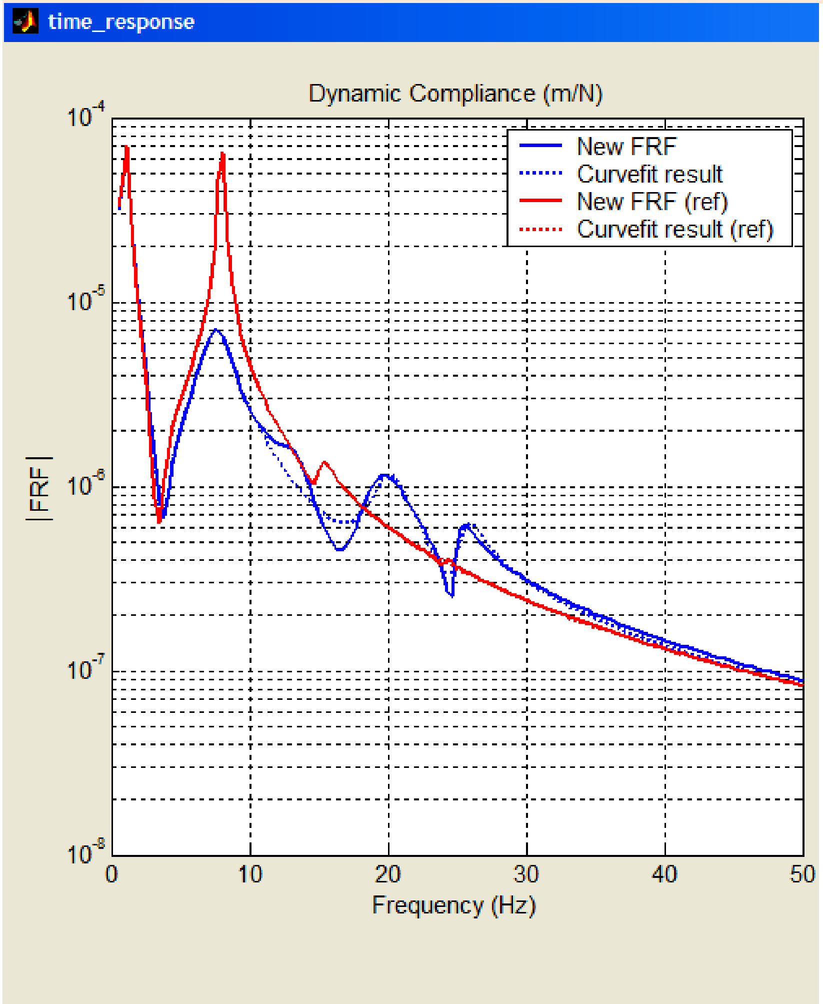


Effect of mount stiffness

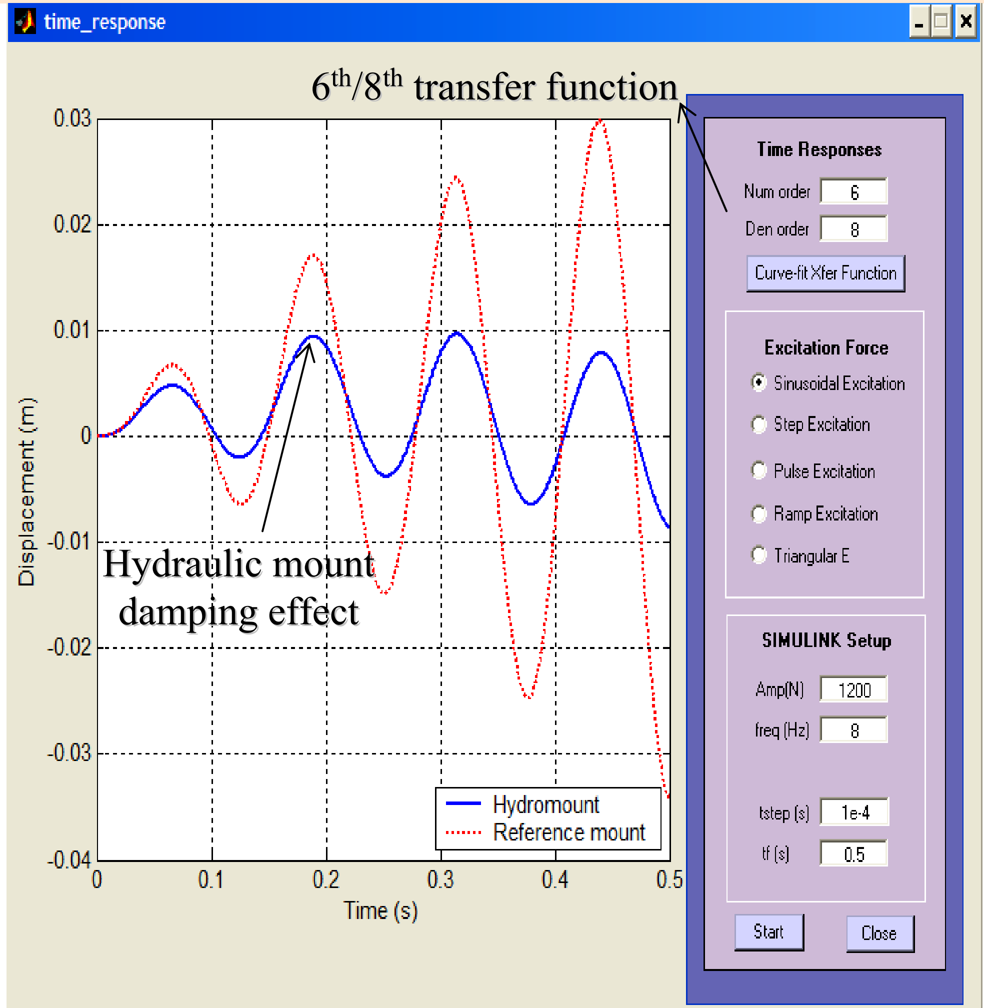


Inclusion of measure stiffness data (A3)

Frequency Response II: Time Domain Responses



Curve-fit transfer function



Displacement response
(given sinusoidal force excitation)

Key References

1. R. SINGH, G. KIM and P. V. PAVINDRA 1992 *Journal of Sound and Vibration* **158**, 219-243. Linear analysis of automotive hydro-mechanical mount with emphasis on decoupler characteristics.

2. G. KIM and R. SINGH 1995 *Journal of Sound and Vibration* **179**, 427-453. Study of passive and adaptive hydraulic engine mount systems with emphasis on nonlinear characteristics.

3. H. ADIGUNA, M. TIWARI and R. SINGH 2003 *Journal of Sound and Vibration* **268**, 217-248. Transient response of a hydraulic engine mount.

4. M. TIWARI, H. ADIGUNA and R. SINGH 2003 *Noise Control Engineering Journal* **51**, 36-49. Experimental characterization of a nonlinear hydraulic engine mount.

5. S. HE 2004 *M.S. thesis, Ohio State University*. Comparative evaluation of linear and nonlinear models of hydraulic engine mounts.

6. A. GEISBERGER, A. KHAJEPOUR and F. GOLNARAGHI 2002 *Journal of Sound and Vibration* **249**, 371-397. Non-linear modeling of hydraulic mounts: theory and experiment.