Commercial Vehicles Analysis

Nonlinear Frequency Response: Application of a New SIMPACK Feature
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Frequency Response Methods
 Workflow at SIMPACK
 Graphical Output
 1/4-Car Model
 Non-linear Elements:
  Bumper
  Hydraulic Damper
 Results 1/4-Car:
  Degree of Non-linearity
  Transient Step Input
  Excitation Amplitude
 Results Full Vehicle Model
  chassis non-linearity
 Mode shape at
  Low Velocity
  High Velocity
 Results Full Vehicle Model
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 Outlook:
  Tyre Model Extension

Frequency response analysis of non-linear systems

approximate non-linear into linear characteristics of the system

calculate response of non-linear system at harmonic excitation by time integration

calculate frequency response

analyse the result by Fourier series decomposition

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$u(t) = A \sin(\omega t)$

$y(t) = a_0 + \sum_{i=1}^{\infty} a_i \sin(i\omega t + \varphi_i)$

Nonlinear dynamic system

input

output
Nonlinear Frequency Response: Application of a New SIMPACK Feature

Workflow at SIMPACK

Sensor for Signal_2 to n
Sensor for Signal_1

A/D converter

uforce22: Fourier analysis

Graphical output

uforce21: excitation controller

Actuator for moved marker

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SIMPACK-1/4-Car-model

 sprung mass

 spring - damper

unsprung mass

tire elasticity
and road contact

Excitation:
road uneveness
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Nonlinear chassis elements:
- Bumper
- Shock absorber

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Results controversial, additional results desired:
- power of excitation
- accuracy of first order approx.

Transient step input

Results 1/4-Car:
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\[ v = 1 \, \text{[m/s]} \]
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v = 25 [m/s]
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**Time dependency of lateral force:**

- Dependent on side slip angle: linear
- Dependent on vertical load: non-linear: delay for load and unload different

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**SimPACK User Meeting 2003**

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