



Simulation ITI[®]-SIM Application

Automotive
Engineering

Suspension

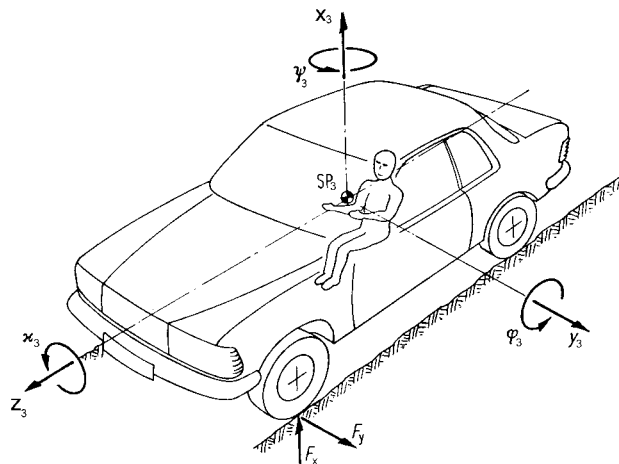
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Vehicle Model for Suspension System Simulations

Apart from the road holding and handling of a vehicle the design of car suspension systems has a further goal – to provide a comfortable ride for the driver and passengers. As many problems in automotive design the interaction of the suspension components, car body, and driver seat is too complex to be solved in an analytical manner and thus provides an ideal application field for simulative analysis and **ITI[®]-SIM**.

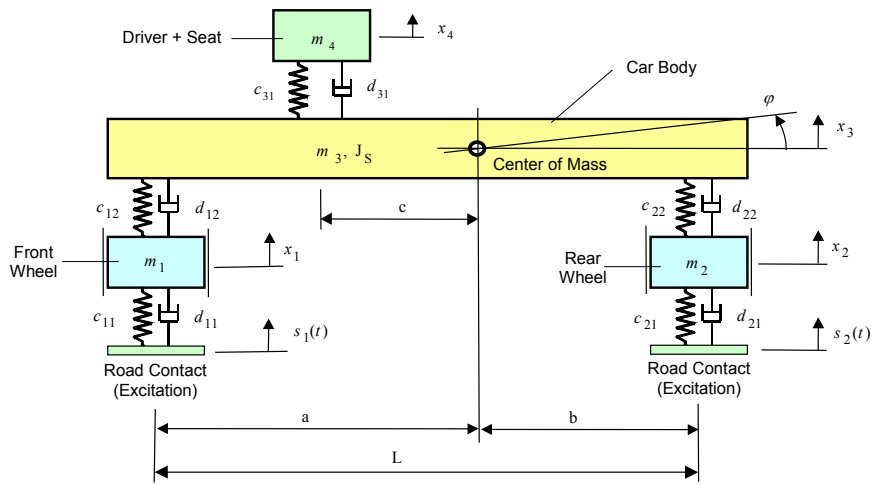
The material presented in this application brief was taken from [1] by courtesy of the authors.

Model Derivation



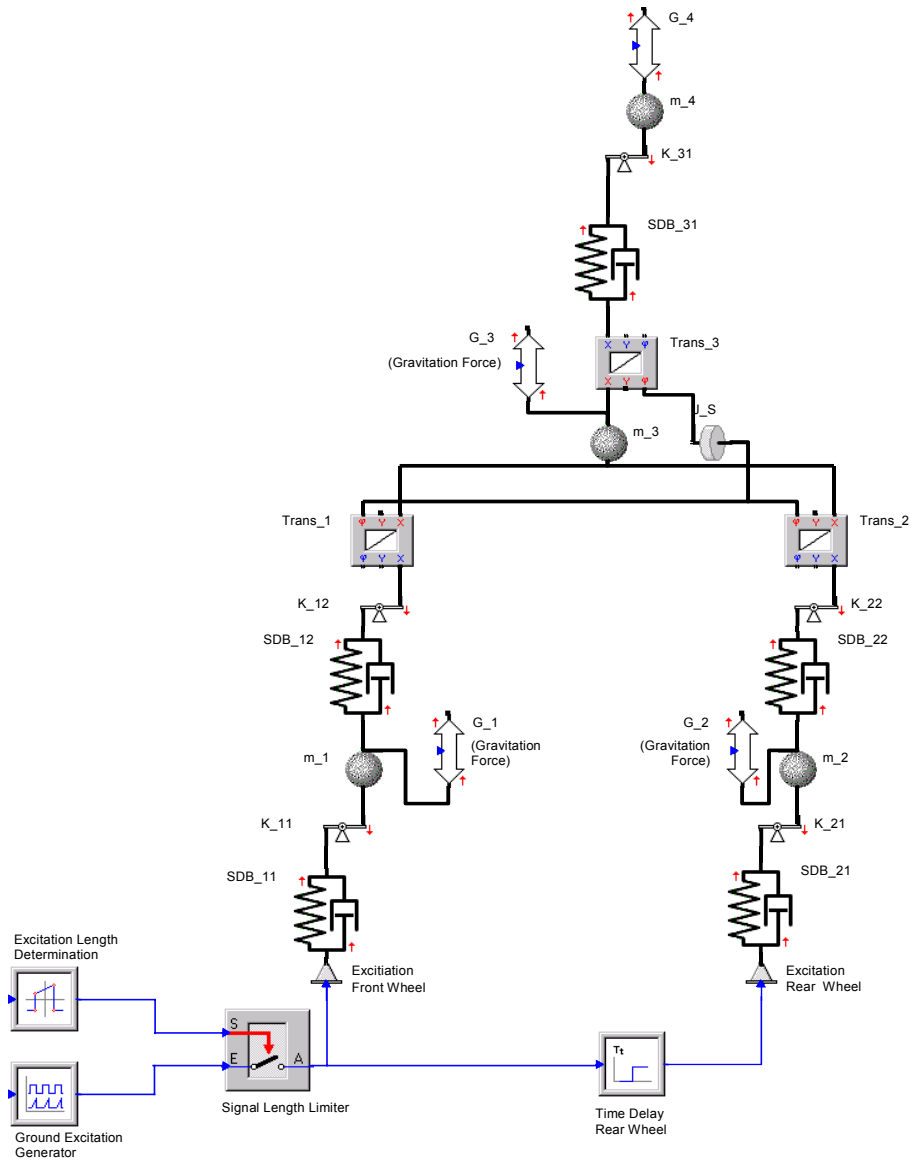
In its simplest form a car model possesses 3 translatory and 3 rotatory degrees of freedom. The more parts are considered, the more degrees of freedom have to be taken into account. In order to limit the model complexity, the neglectance of less relevant degrees of freedom is necessary. In the suspension analysis the movements in x and φ direction are of particular importance. The vehicle movements in y and z direction as well as rotations in χ and ψ direction are neglectable. Further, the car is assumed to be symmetrically loaded (driver and one passenger).

New degrees of freedom are introduced by a more detailed modeling. In this example this concerns the unsprung mass of the wheels, and the mass of driver and seat (both in addition to the already considered body mass movements). All masses are coupled by spring-damper elements. The modeling leads to the half-car model given below:



ITI[®]-SIM Model of Car, Suspension, and Driver's Seat

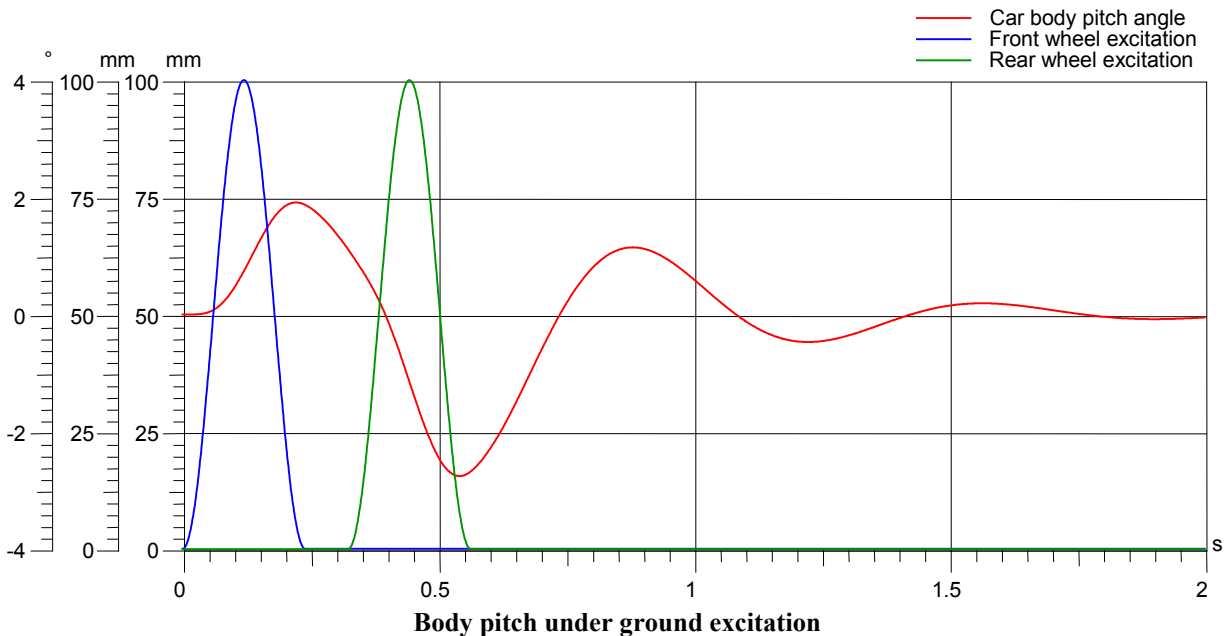
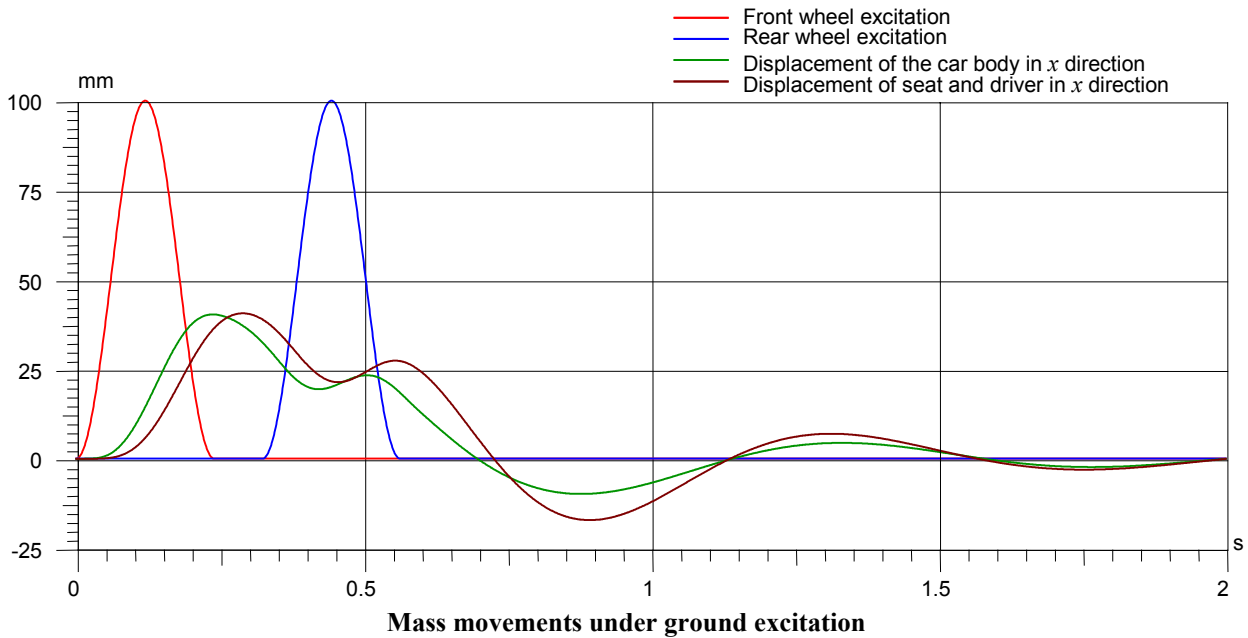
In ITI[®]-SIM above model is mapped one to one to a simulation model:



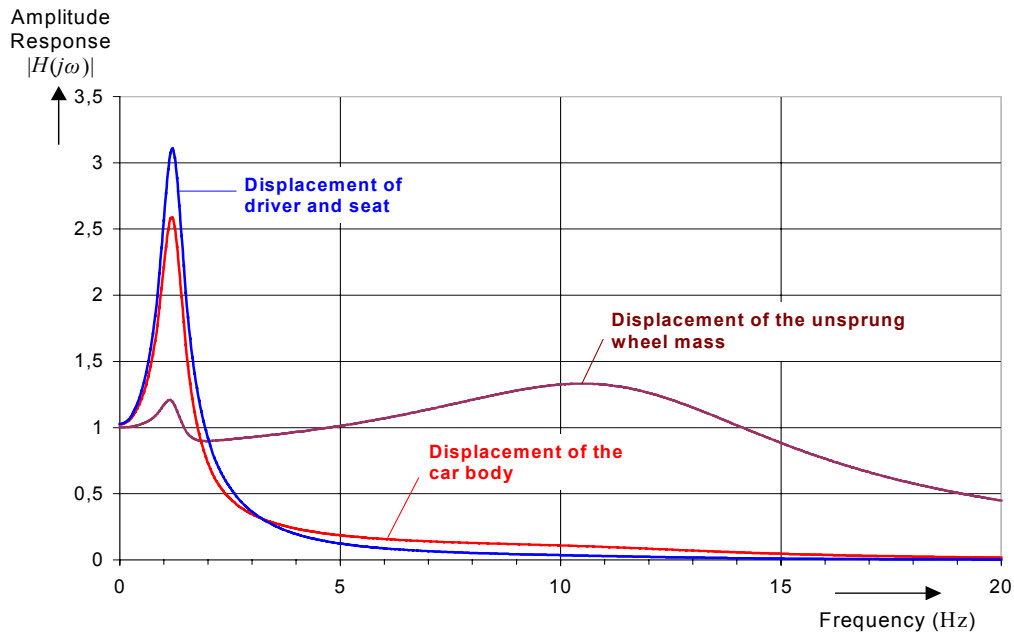
The levers contained in the structure compensate the influence of the gravitational load of the springs on the initial conditions of the system. The transformers couple the translatory and rotary DOF in the model.

Simulation Results

The model allows a comfort-oriented tuning of the suspension components based on the time series and spectral analysis of the vehicle under prescribed excitation conditions. As an example the reaction on a sine-shaped ground excitation is shown in the following diagrams:



In order to analyze the damping behavior of the whole setup, the magnitude transfer functions (amplitude responses) of the body components are studied:



Amplitude responses of the vehicle components under ground excitation

Clearly, frequencies above 2-3 Hz, including the main resonance of the unsprung wheel masses at 10-11 Hz, are well isolated from the driver's seat in this example.

The Benefits of Using ITI[®]-SIM

The modeling in ITI[®]-SIM leads to a clearly structured and comprehensible model, which maps the vertical dynamics and body pitch movements. It allows to solve a variety of design and analysis tasks:

- Interactive simulation and parameter optimization for an efficient and time-saving system design
- Analysis of arbitrary road conditions – ramps, ground waves, uneven road surfaces (stochastic excitations) – and their influence on vehicle and driver
- Parameter variations for studies of the system response with different spring-damper setups and under different load conditions, as well as comparisons between different vehicles.

- Clearly structured system model
- Mapping of the relevant DOF
- Efficient interactive system tuning
- Vehicle simulation under arbitrary road conditions
- Analysis of varying load conditions
- Comparative studies of different vehicles

References

- [1] A. Schmitt, R. Kuhlmann: *Simulationsmodell eines Fahrzeuges. Auszug aus der Diplomarbeit von R. Colusso*. FH Lippe, FB Maschinenbau.