

SIMPACK User Meeting 2003

Traction Vibrations in Trains with Groups of Asynchronous Motors

Physical Aspects
Method of Analysis
SIMPACK Implications

Siemens Transportation Systems
Business Unit Trains
Kaspar Schroeder

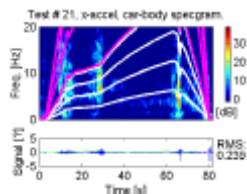
28.03.03 Schroeder
Nr. 2

SIEMENS

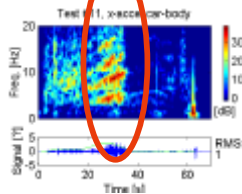
Problem posed

Experimental evidence when running up:

Normal Behaviour



Occasionally ...



Aims:

- Analysis of mechanism
- Find effective changes in design
- Find influences of uncertainties of environment/system
- Yield most reduced model, e.g. for controller layout

Trains

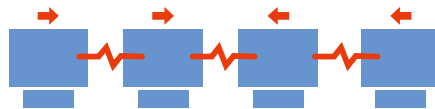
Transportation
Systems

Problem posed

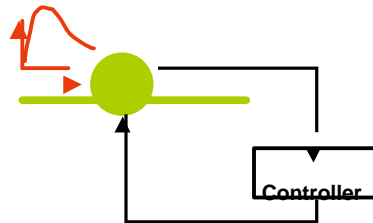


Physical Aspects of the System, 1

Vibration Chain:

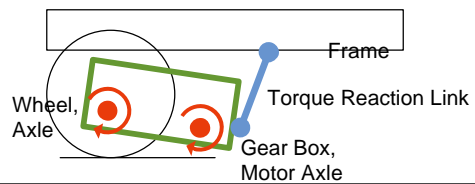


Friction:



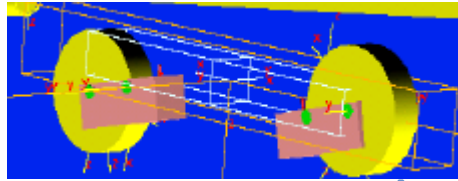
Slip control:

Canon box
(Tatzlager):



Physical Aspects of the System, 2

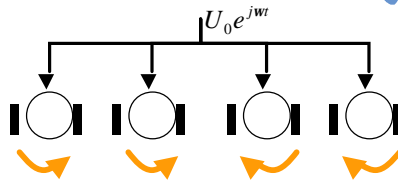
Bogie pitch, wheel unload:



Asynchronous motor:

$$\bar{M}_{i,el} = \frac{2\bar{s}}{s^2 + 1}, \text{ Kloss Formula}$$

Converter group:



Overall system coupled in a very high degree, particularly related to the interaction of electrical, mechanical and controller components.

Implementation of the Model

Train modelled as mass-chain

Planar model of train

Wheel-/Motor-/Gear-Unit as substructure, mirrored

Controller and electric components modelled via SIMPACK-Control

Only linear implementation, no determination of operation point

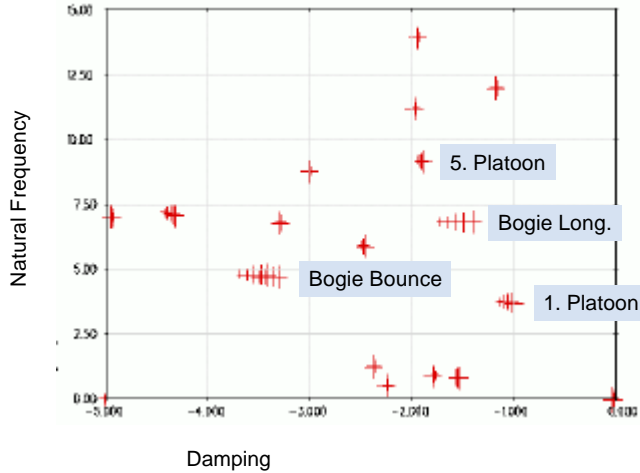
No wheel-rail contact, simple friction law

$$F_R = \mathbf{m}(v) F_N$$

$$\Delta F_R = F_N \partial \mathbf{m} / \partial v \Delta v + \mathbf{m}_0 \Delta F_N \quad \text{linearised}$$

Stability Analysis Root Locus, Friction Coefficient

$$\partial m / \partial v = 0 \quad \dots \quad -0.1$$

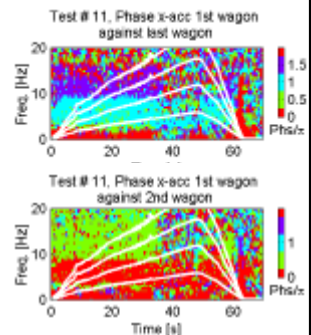
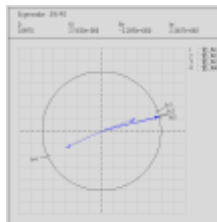
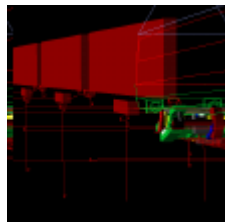


Methods Eigen-Behaviour

Visualisation in SIMPACK
is of strong benefit for analysis

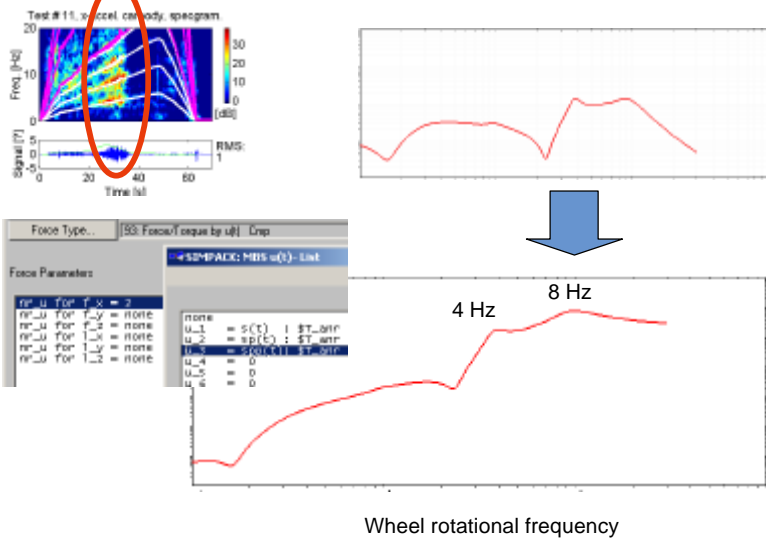
Identification of natural frequencies
via spectral phase analysis of test data

Animation Videos:



Interpretation, Result

Wheel Out-of-Roundness, Transfer Function



Modelling Details

Converter Group and Asynchronous Motors

Quasistatic Model

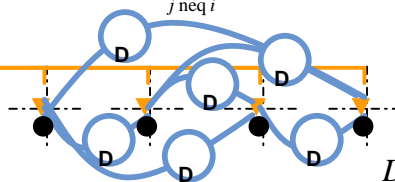
Linearised torque relation:

$$\overline{M}_{i,el} = D_E (\mathbf{w}_{i,L} - \mathbf{w}_{St})$$

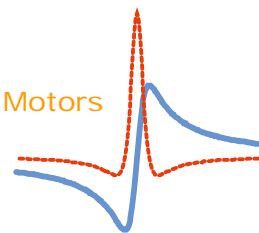
Torque partitioning in converter group:

$$\overline{M}_{i,el} = \frac{1}{4} M_\Sigma + \frac{D_E}{4} \sum_{\substack{j=1 \\ j \neq i}}^4 (\mathbf{w}_j - \mathbf{w}_i)$$

$$\frac{1}{4} M_\Sigma$$



$$D_E = 3 \frac{U_0^2}{w_0^2 R}$$



Messages to INTEC Benefits and "SIMPACK-Wunsch-List"

SIMPACK Benefits:

- No dead end road in modelling thanks to user-routines
- Eigen-Behaviour animation
- Full variety of methods available (for posed problem).

„SIMPACK Wunsch-List“

- Interface to external software not only for **Cosimulation** but also for Linear System Analysis
- **Common equilibrium** by direct method
- **Common linearisation** with parameter variation
- More powerful interface to MATLAB.