LabVIEW in Research and Education at the Division of Dynamics at Chalmers University of Technology

Viktor Berbyuk*, Thomas Nygårds* Remko Krul** and Carsten Watolla***

**Division of Dynamics*
Chalmers University of Technology
Göteborg, Sweden

*** NI Netherlands B.V.*
**** NI Sweden AB*

NIDays09
World Graphical System Design Conference
10th March 2009, STOCKHOLM

Agenda

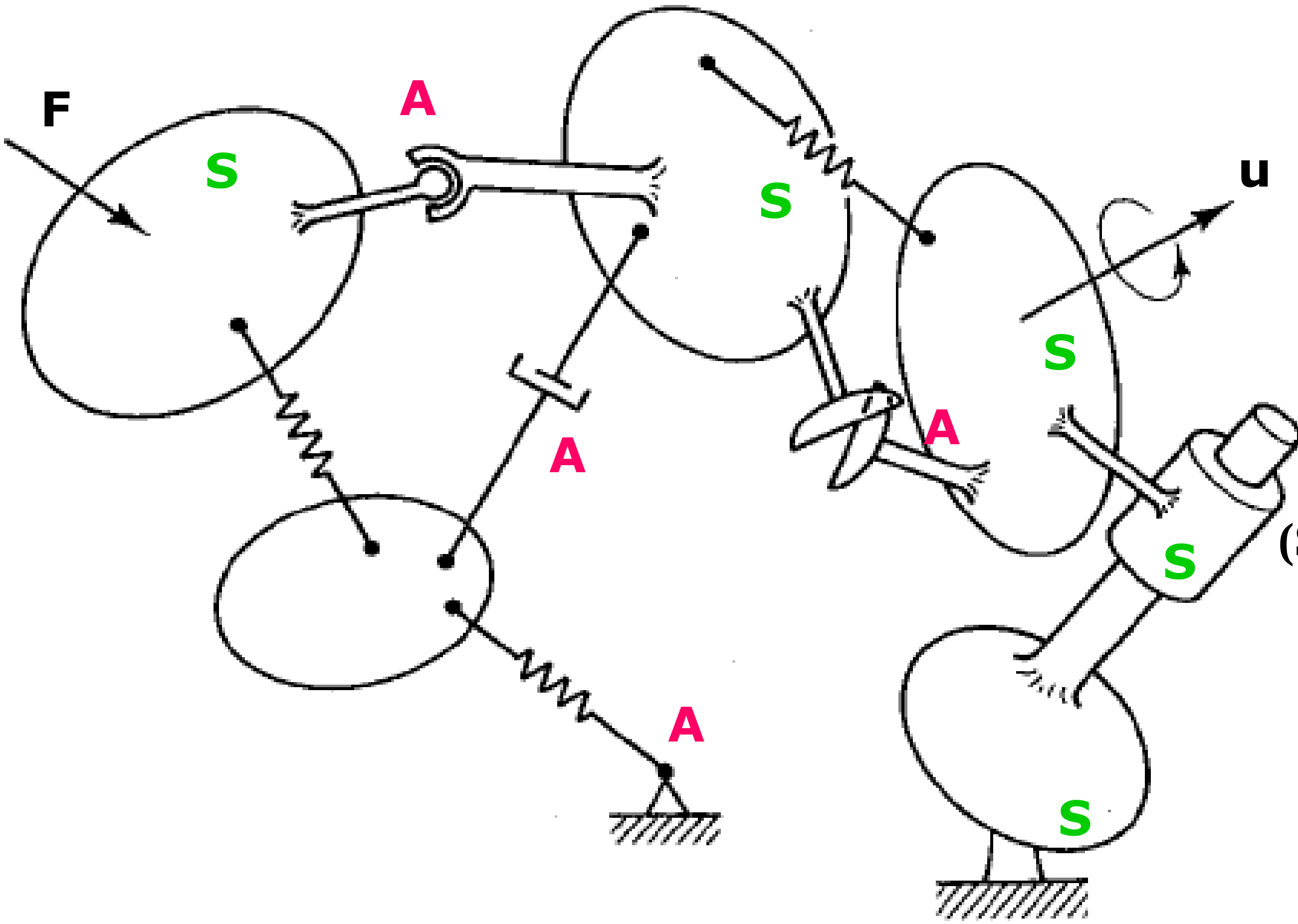
- MecSAS
- Introduction
- Applied Mechanics & MecSAS
- Smart Materials & Mechamatronics
- Vibration Energy-to-Electrical Energy Conversion
- Adaptronic Suspension for Washing Machines
- Adaptronic Engine Mounting Systems
- Adaptronic Bogie for High Speed Train
- Vibration Control Course at CHALMERS
- Conclusions

Research at Mechanical Systems

http://www.am.chalmers.se/~berbyuk/mecsas.pdf

- **Controlled multibody systems dynamics with adaptronics**
  Optimal interaction between dynamics and control in MBS with AFCs
- **Active technology for vibration and noise control**
  Adaptronic approach using smart materials based actuator and sensor technology
- **Semi-active and active mounts and suspensions**
  Commercial vehicles and high speed trains
- **Power Harvesting from Vibrations**
  Smart materials based Vibel technology
- **Running projects**
  Active Engine Mount Systems for Commercial Vehicles
  Advanced Suspension for Washing Machines
  Adaptronics for Bogies and Other Railway Components
  Vibration-to-electrical energy conversion using Terfenol-D

Active Technology and
Mechanical Systems with Active Structure



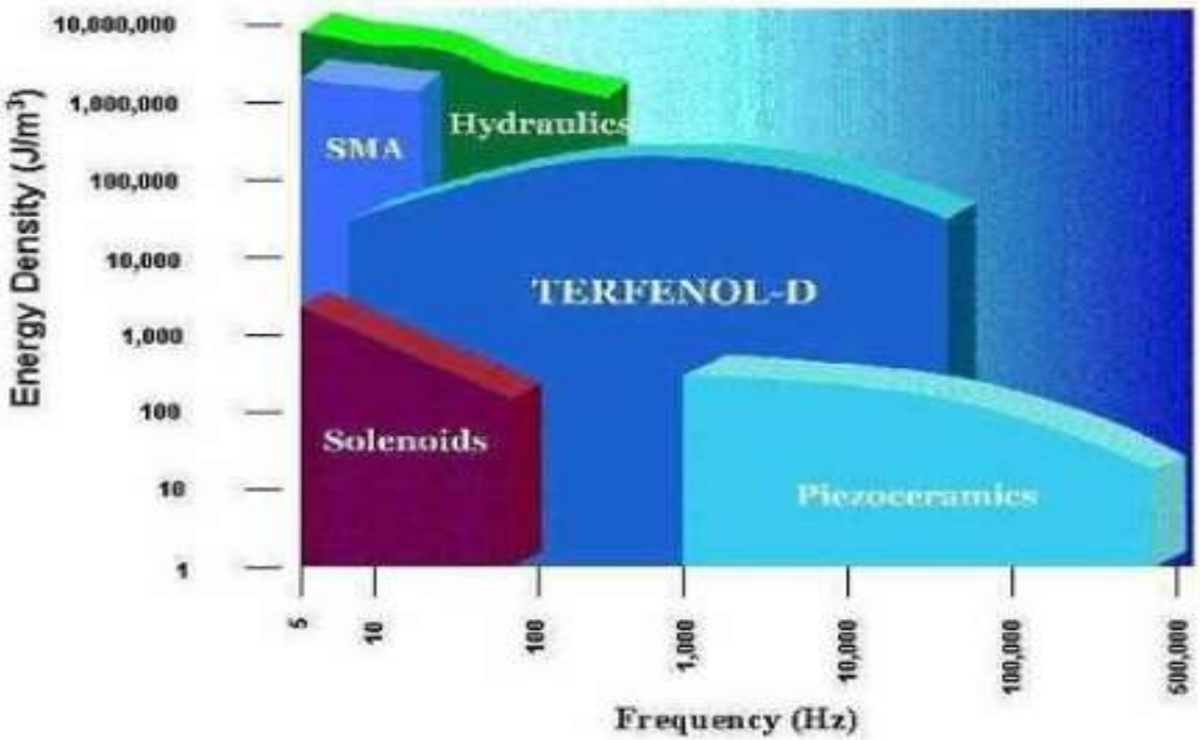
Adaptronic Mechanical System

Mechatronics
(Sensors, actuators, controller)

*Mecha**ma**tronics*
(Smart, multifunctional materials)

Optimality
(Minimal upgrading with maximum efficiency)

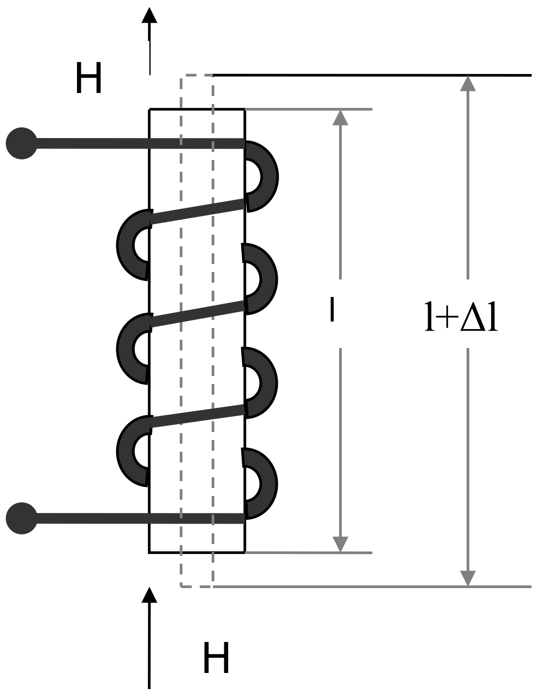
Smart Materials Technology & Mechamatronics

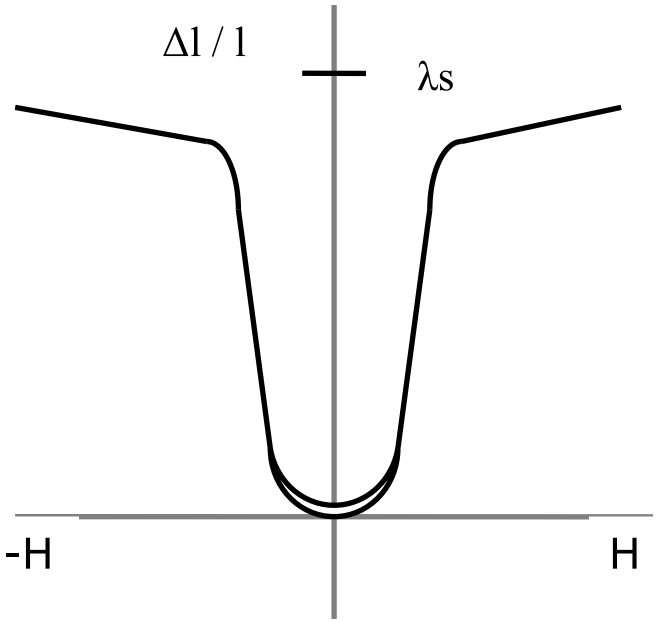


Advantages of Terfenol-D

- **Operation at high temperature Curie T – 380C^0**
- **Low voltage level of operation;**
- **High energy density;**
- **Large strain and force;**
- **Better withstanding mechanical stress;**
- **Fast response time;**
- **Long lifetime.**

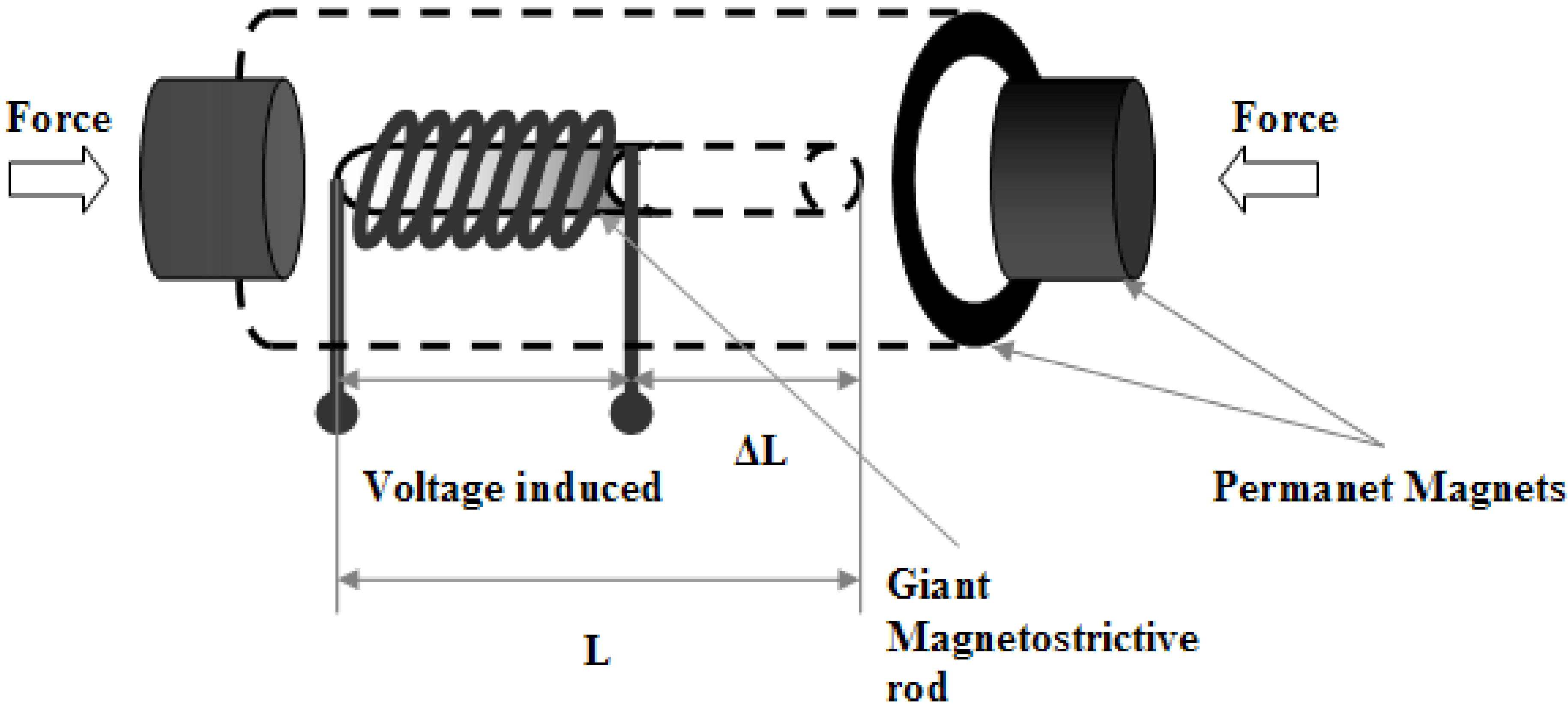
Schematic of Joule Effect



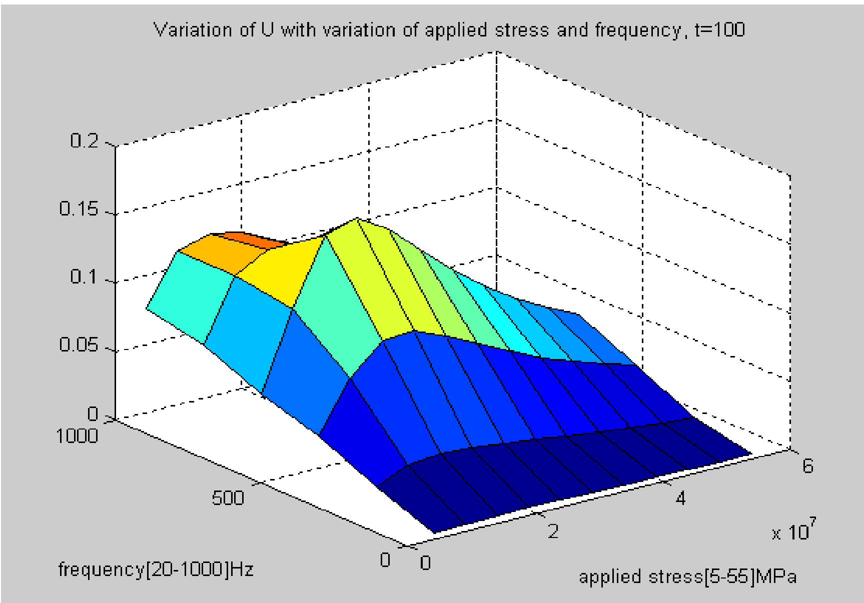


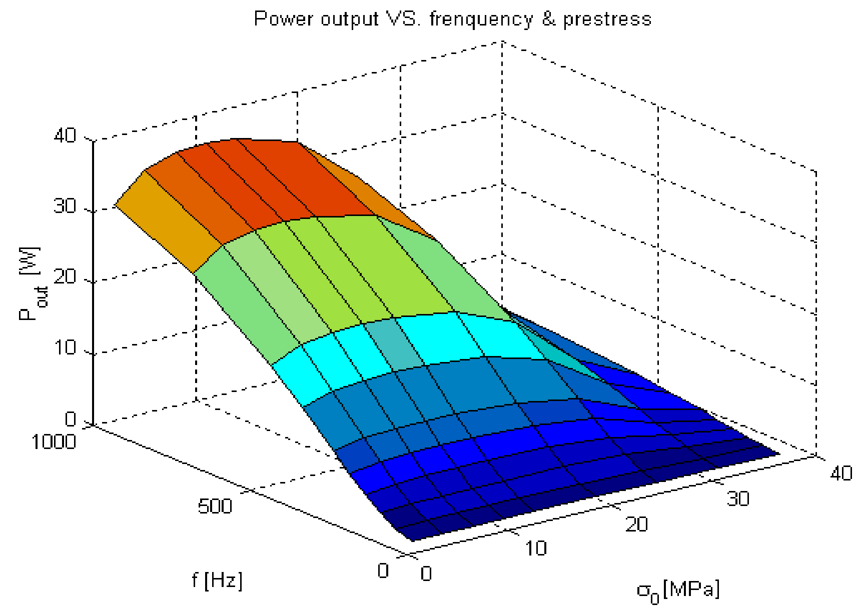
Vibration Energy-to-Electric Energy Conversion

Villari Effect



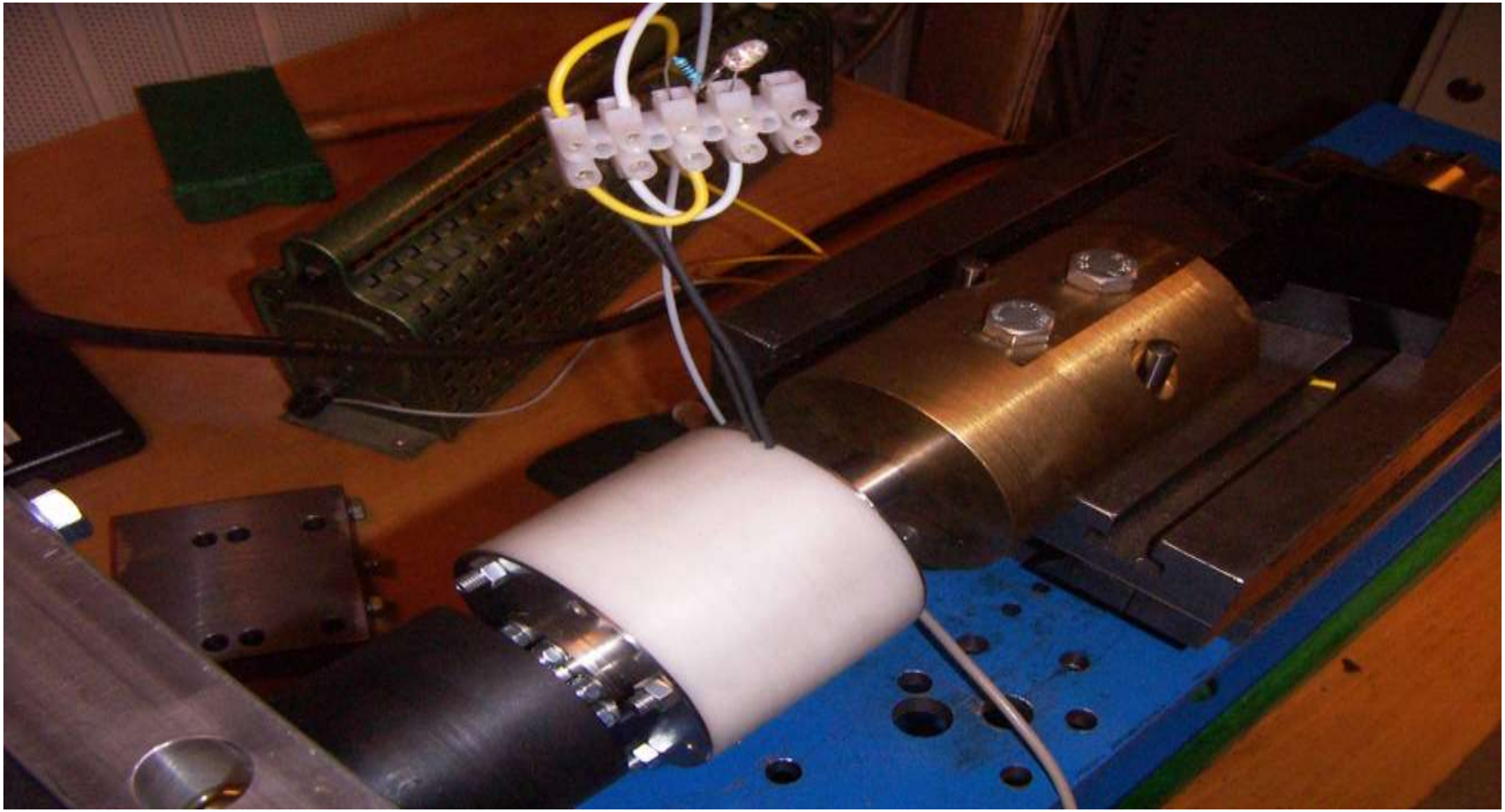
Sensitivity of performance of Terfenol-D based MEG w.r.t. frequency, applied stress and prestress



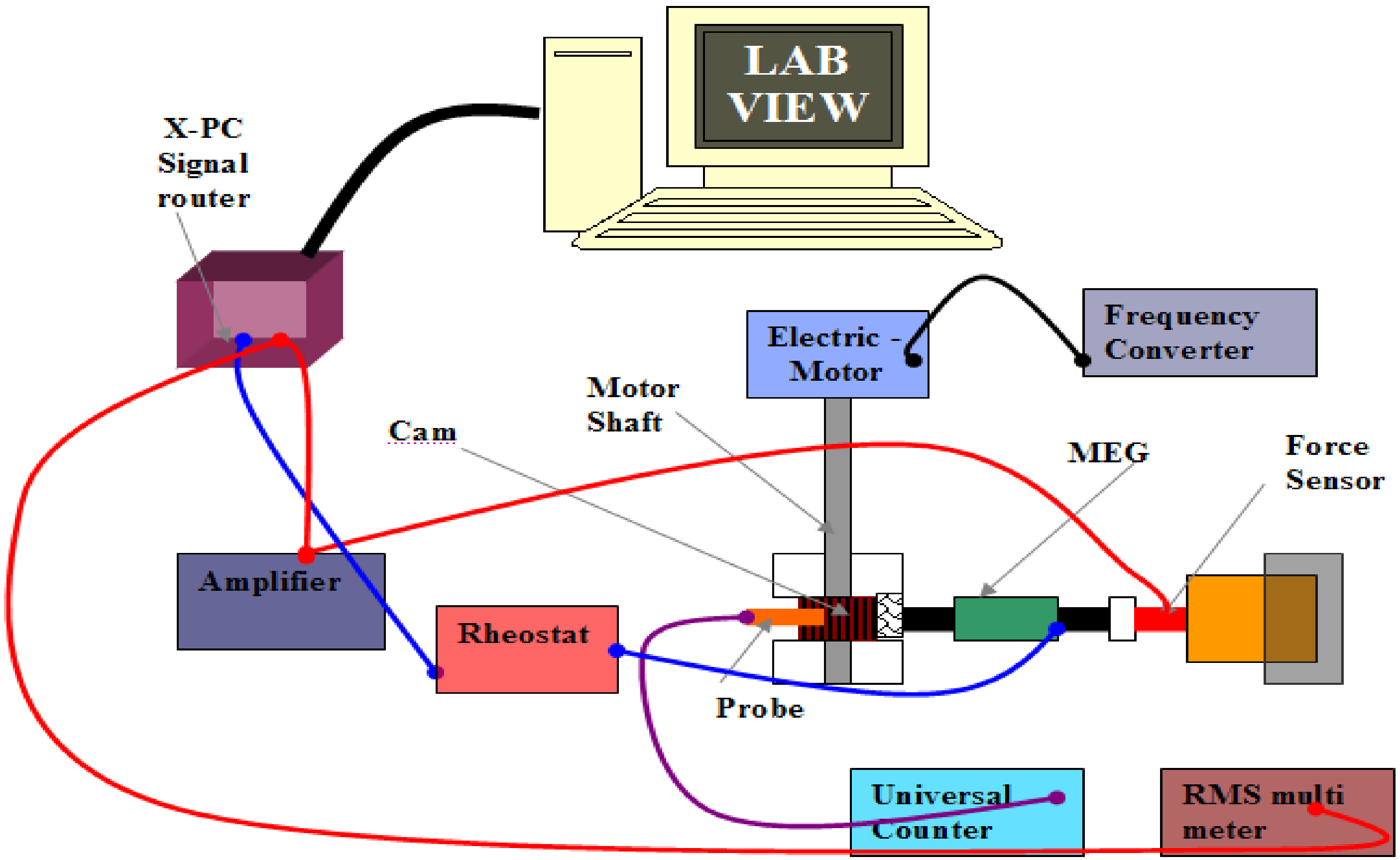


Berbyuk V., "Towards dynamics of controlled multibody systems with magnetostrictive transducers", *J. of Multibody System Dynamics*, Vol. 18, 2007, pp. 203-216, http://dx.doi.org/10.1007/s11044-007-9078-y

CHALMERS Magnetostrictive Electric Generator – MEG



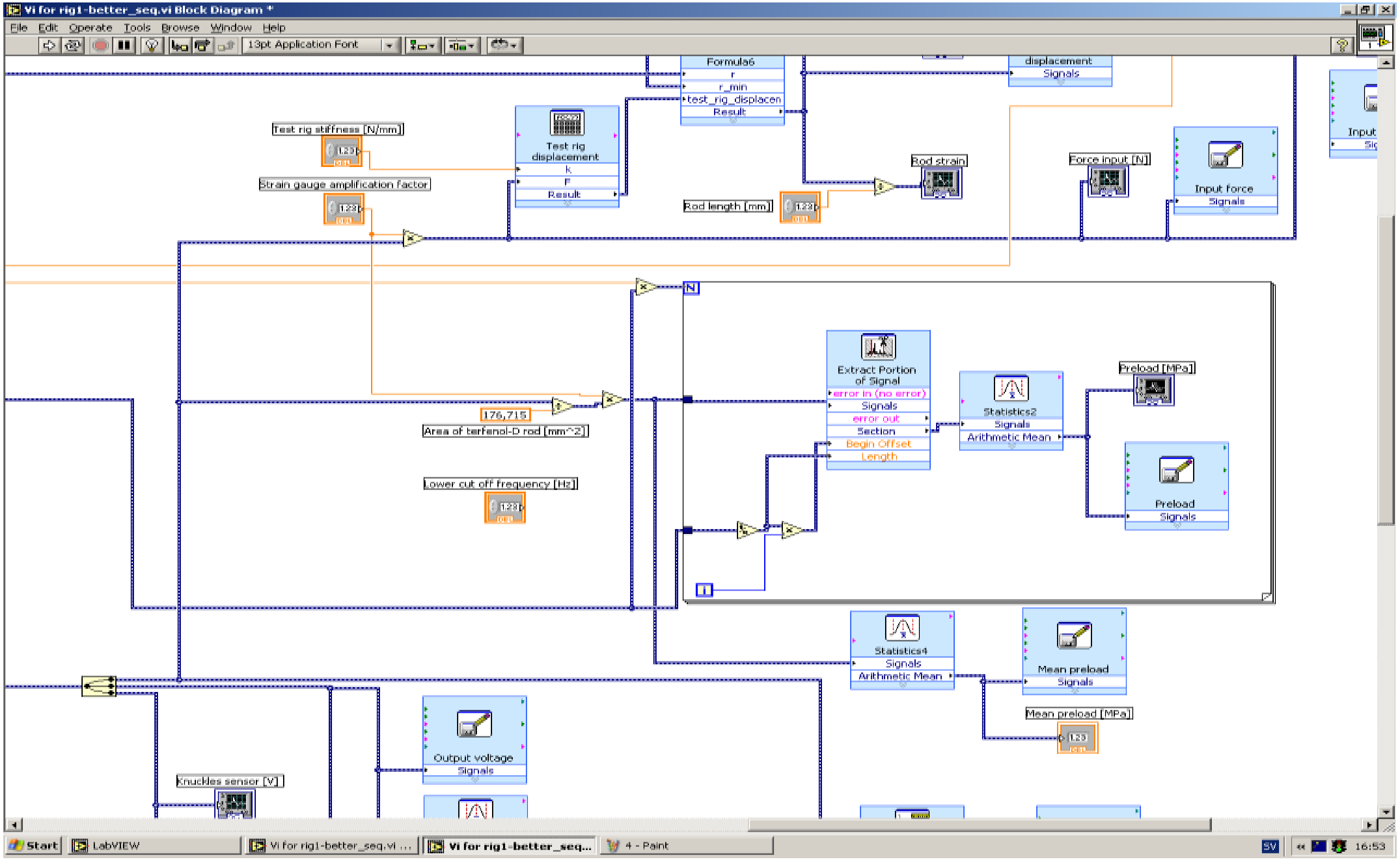
Experimental set up for MEG at MecSAS



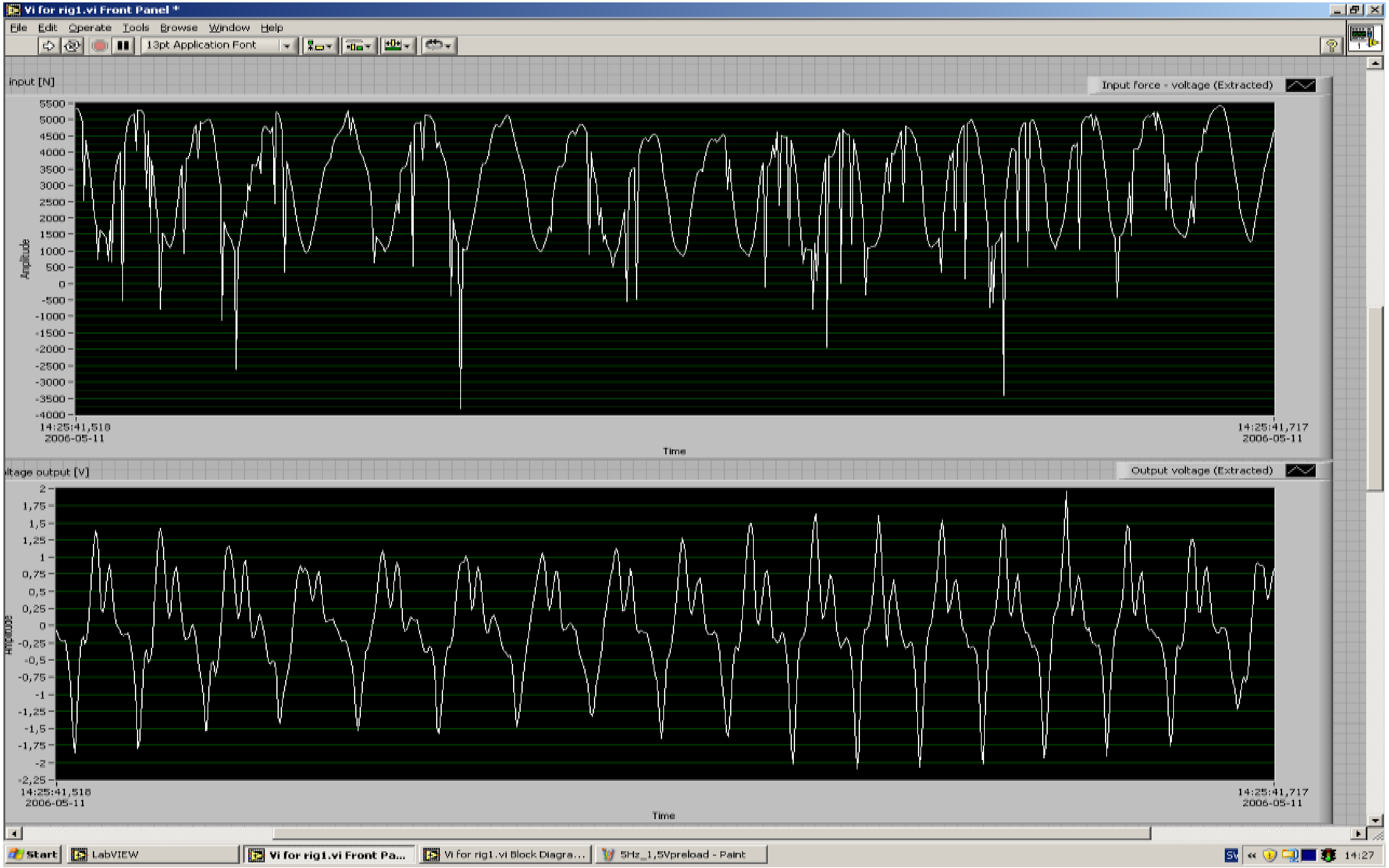
CompactDAQ (LabView)
- 2x NI9215 (Analog in)

Signal conditioning (of strain gauges) in separate hardware to enable the connection of oscilloscope

Data acquisition for MEG test rig



LabVIEW - 5Hz_1,5Vpreload - force & voltage



HFE Test Rig for CHALMERS MEG

Low Frequency Excitations Test Rig

LabVIEW and NI acquisition card which is connected to a PC through a parallel cable

The MEG that includes a 15 mm diameter, 50 mm length Terfenol-D rod, the permanent magnets (packed in 16 tubes containing 20 magnets each) that together with the rod and the Permedyn washers form the magnetic circuit, and the electrical coil from which output electrical energy is picked up

A cam that gives the input mechanical stress to the MEG, an electrical motor that drives the cam through a shaft

The prestress mechanism, force and laser displacement sensors, a frequency controller, an amplifier that amplifies force signal, an oscilloscope (HP, 4 channels, 100 MS/s) which force and output voltage signals are visualized on.

LFE Test Rig:
Prestress and Sensors

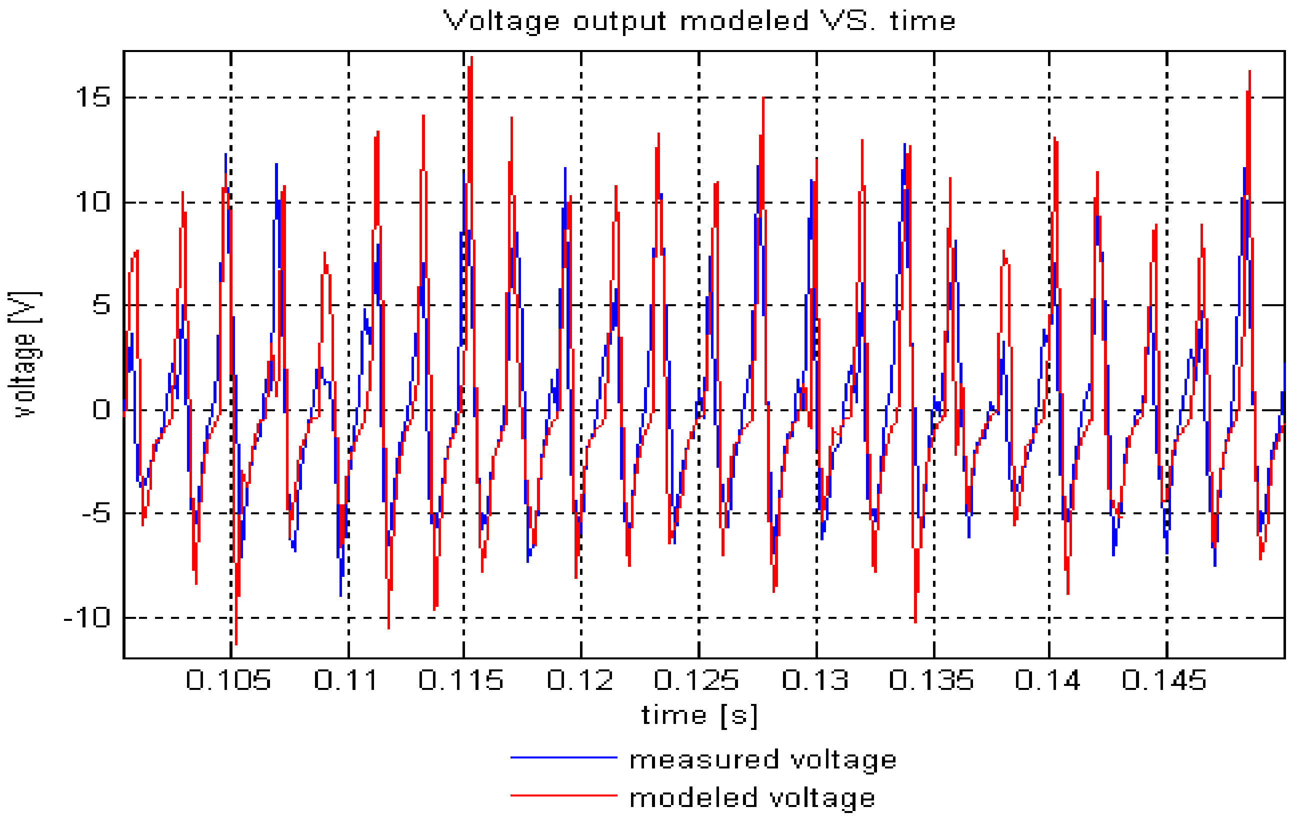
Low Frequency Excitations Test Rig

Experimental Study of MEG

- LabVIEW files
  - input data
  - input frequency
  - force data
  - upper laser data for the upper displacement
  - lower laser data for the lower displacement
  - output voltage
- Force data, upper laser data, lower laser data and output voltage data all filtered before the processing
- All these data are filtered with median filtering
- Upper and lower laser data are also filtered using mean filtering

CHALMERS MEG Model Validation:

Output Voltage - Simulation vs Experiments



Time histories of measured and calculated voltages for f = 500Hz, electrical load = 1 Ohm, and $\sigma_0 = 10{,}18MPa$

Vibration Control in Washing Machines

PhD student Thomas Nygårds

Suspension of Washing Machine

Whole machine test rig

CompactDAQ (LabView)
- NI9233 (ICP)
- NI9237 (Bridge)
- NI9421 (Digital/Tacho)
- NI9215 (Analog in)
- NI9262 (Analog out)

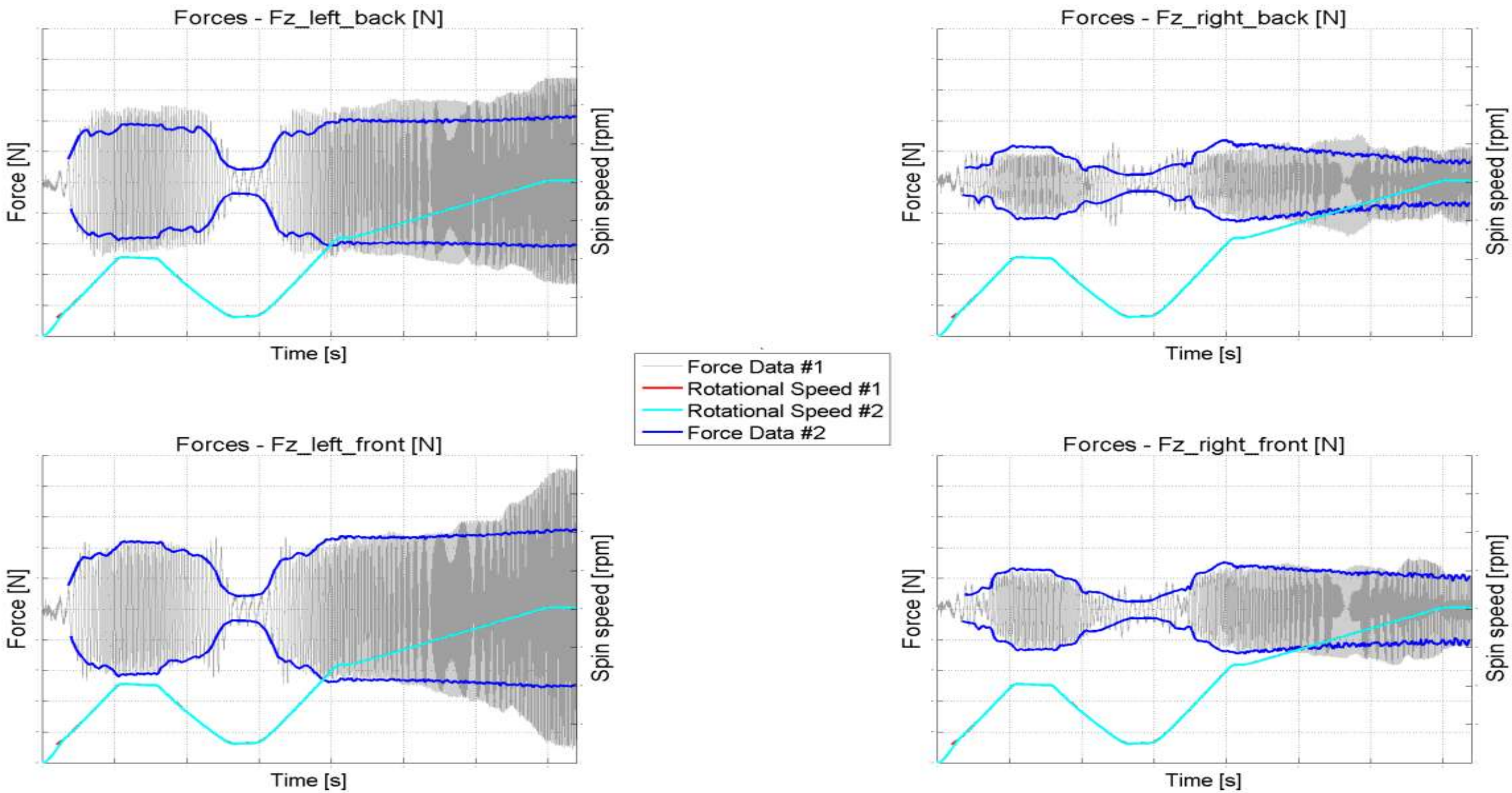
Serial Interface (LabView)
- Displacement sensor

Serial Interface (Stand-alone exe)
- Motor speed control

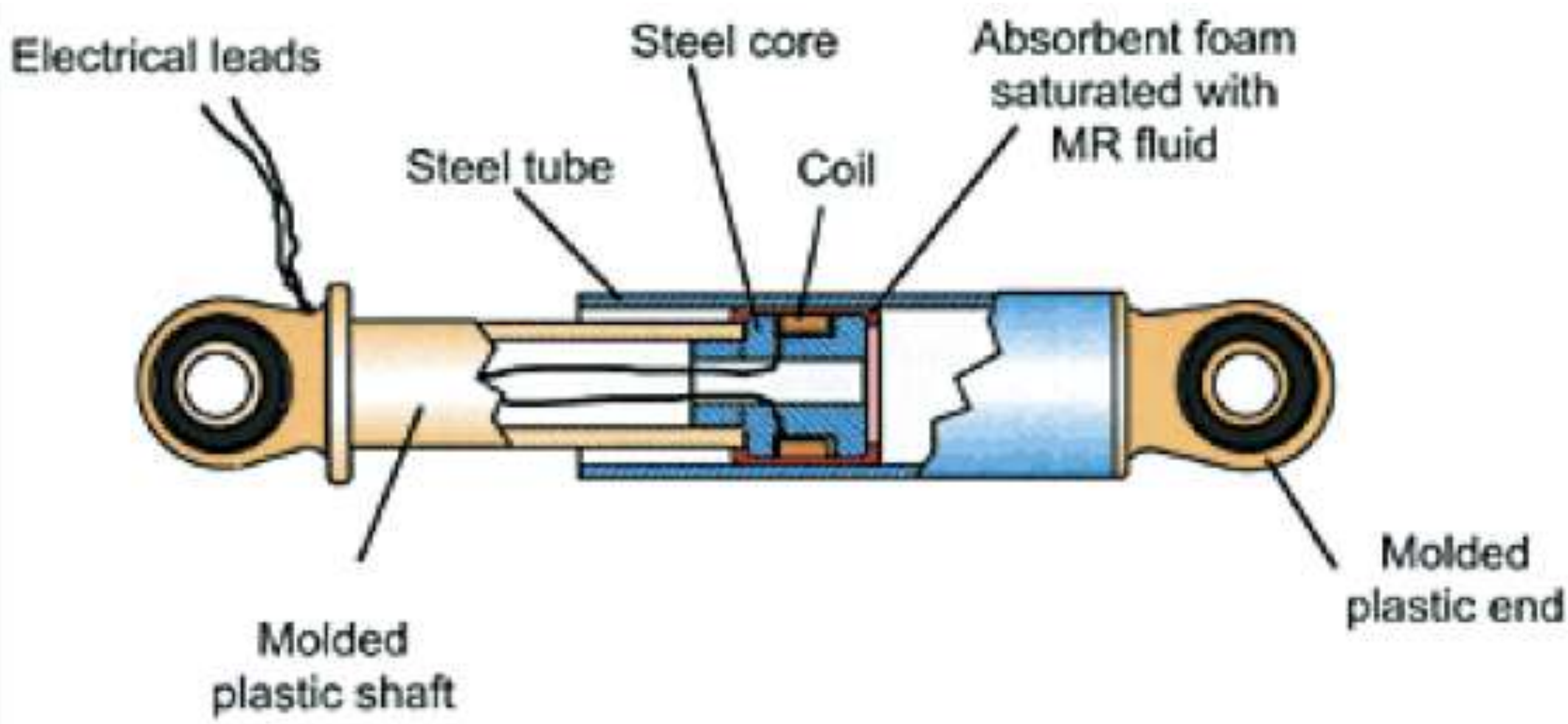
Output

- Vertical output force (4 load cell)
- Spin speed/Tacho (Inductive sensor)
- Position of tub (3D Hall-effect)
- Accelerations (3 ICP)
- Damper Contol Current (Analog)

Comparison of vertical output forces

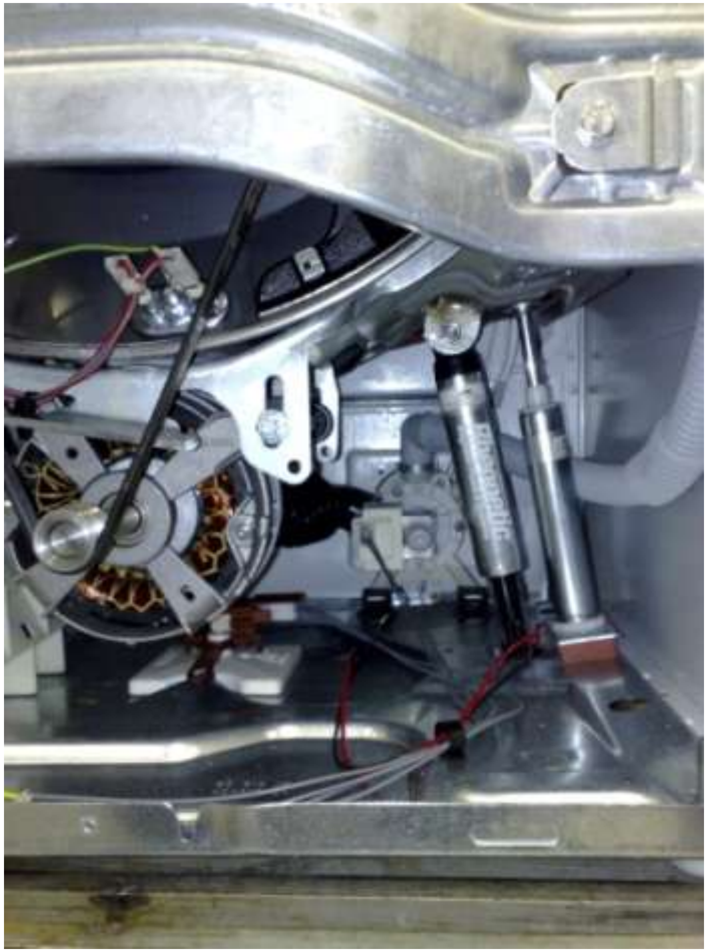


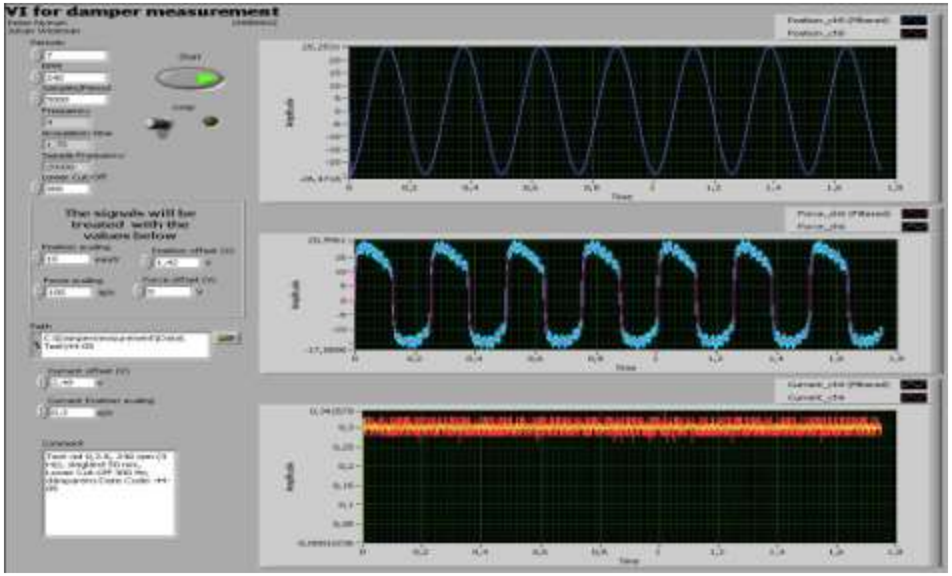
Friction MR damper

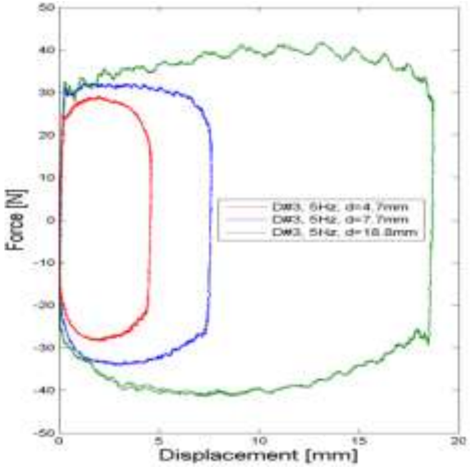


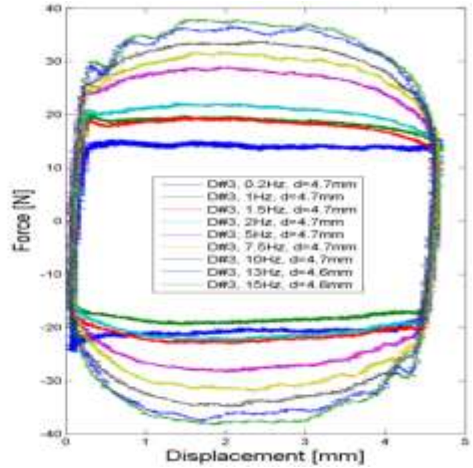
Damper Test Rig: ASKO-Chalmers

Washing Machine with MR Damper





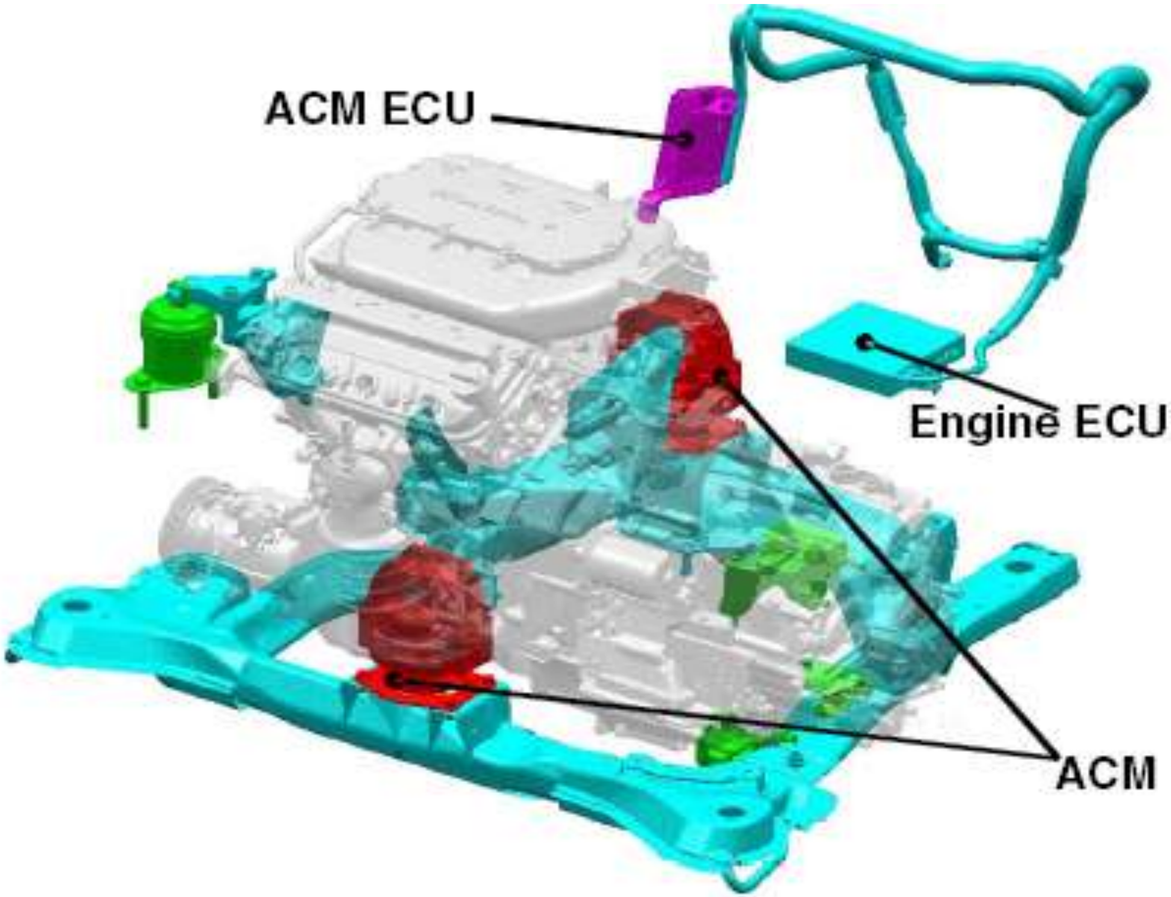




VOLVO Truck with Active Engine Mounts

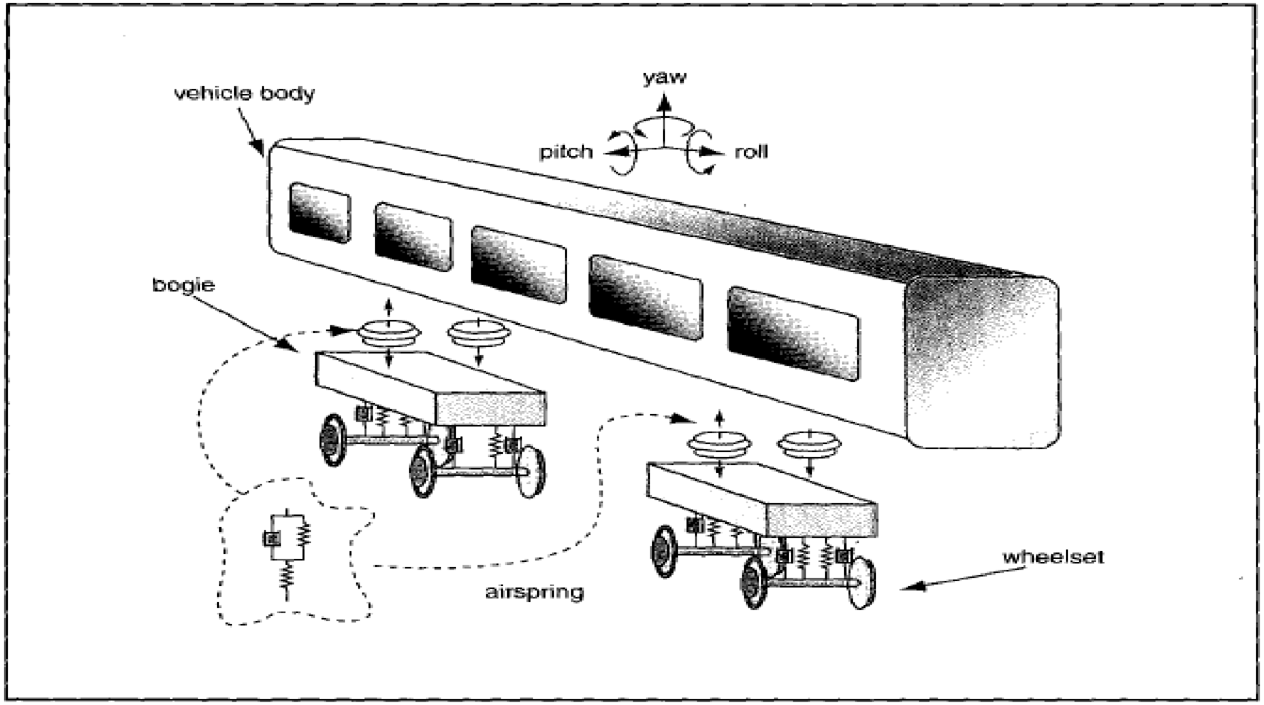
PhD student Hoda Yarmohamadi

Adaptronic Engine Mounting System



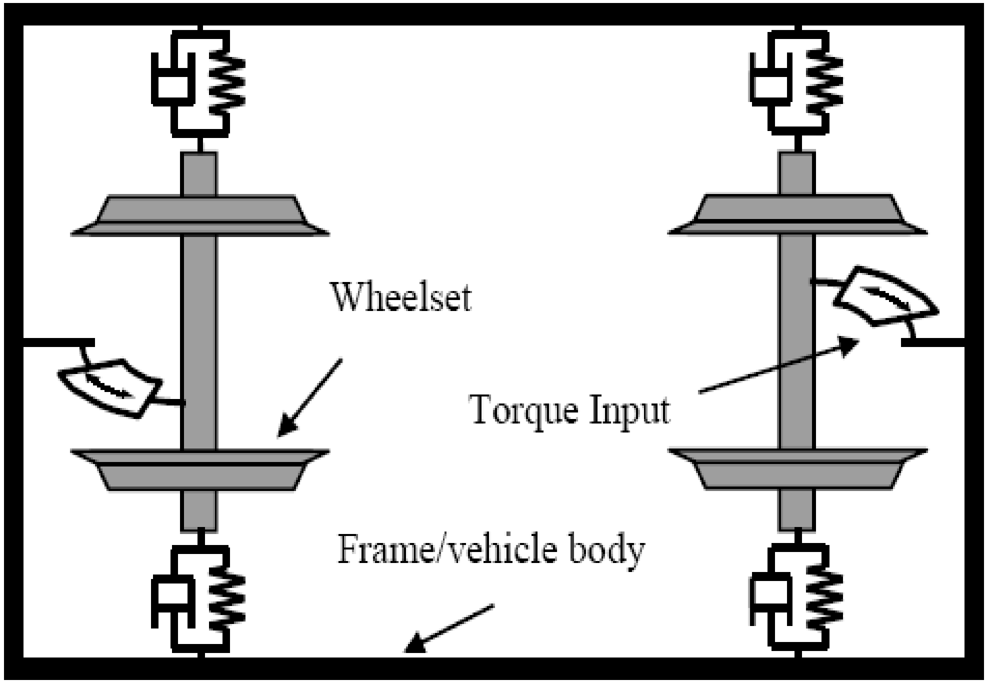
Adaptronics for Bogies and other Railway Components

PhD student Albin Johnsson

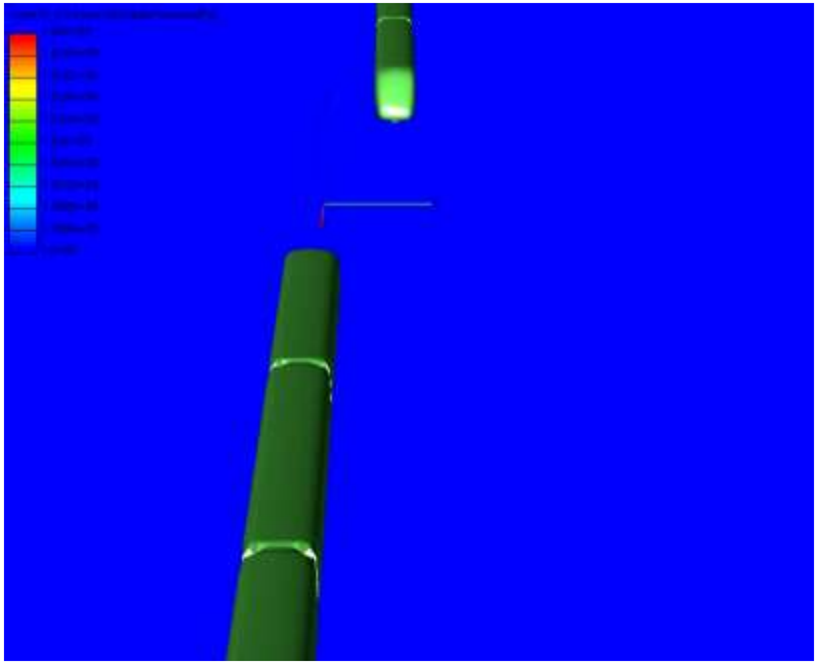


Railway vehicle – mechanical arrangemet

Adaptronics for Bogies and other Railway Components



Plan View of a 2-Axle Vehicle



Aerodynamic excitations

Tt24_p.mpg

Vibration Control Course at CHALMERS

Master of Science Programmes

- **Solid and Fluid Mechanics**
- **Automotive Engineering**
- **Systems, Control and Mechatronics**

Aims

The course aims at providing knowledge on **modern methods and concepts** of passive, semi-active and active vibration control.

To cross the bridge between the **structural dynamics and control engineering**, while providing an overview of the potential of **smart materials,** (magnetorheological fluids, magnetostrictive materials, and piezoceramics), for sensing and actuating purposes in active vibration control.

The **experimental validation** of practical methods, i.e., methods that were found to actually work efficiently for passive and/or active vibration control.

The course prepares students to use **industry-leading data acquisition hardware and software tools** for measurement, signal processing and vibration control, (CompactDAQ, CompactRIO, LabVIEW from National Instruments Corporation, others).

Course Organization

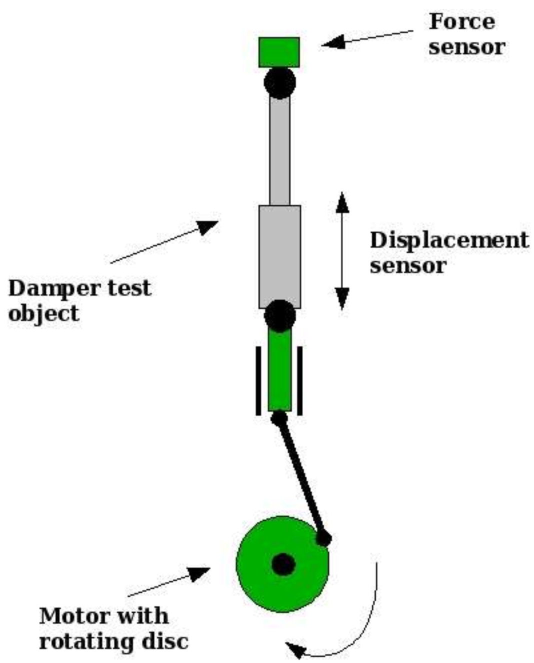
The course will be organized in a way to implement an integrated teaching approach consisting of **Theory, Virtual Instrumentation and Graphical System Design, and Experiment,** supporting high outcome of learning of vibration control theory and practices and industry-leading software and hardware for designing, measurement and testing.

Lectures; Exercises; Computer assignments (LabVIEW);

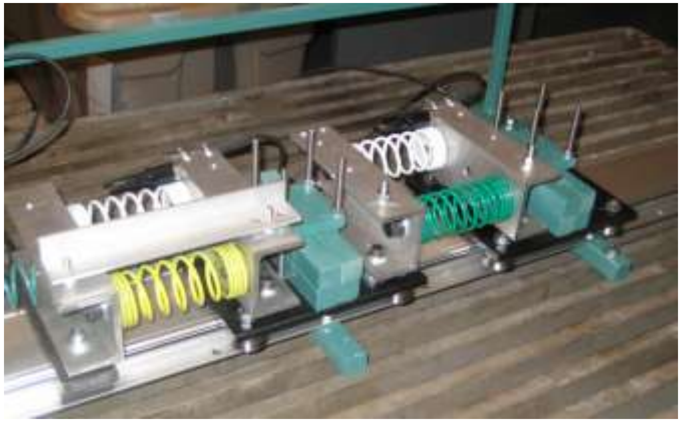
Labprojects on experimental validation of vibration control methods (LabVIEW, CompactDAQ, CompactRIO).

Integrated Teaching Approach:

Theory, Virtual Instrumentation and Graphical System Design, and Experiment



Lab 1

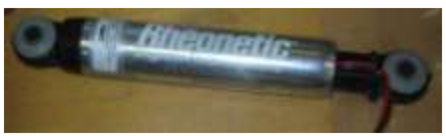


- **Parameter identification for stiffness & damping**
- **Design of passive vibration absorber**

- **Vibration analysis of carts using LabVIEW 8.6 VI**
- **The measurement system CompactDAQ**
  3 accelerometer channels module NI9233
- **Manual speed control**
- **Change of masses and springs is done easily**

Lab 2

- **Study and work with Real-time controller**
- **Analyze performance of semi- active damper**
- **Compare different vibration control algorithms.**



- CompactRIO
  Vibration control of carts using LabVIEW 8.6 VI at RT-processor level
- 2 accelerometers channel module NI9233
- 1 ch. Voltage output for motor speed module 9215
- 1 ch. Voltage output for damper current

Vibration Control Test Rig: Chalmers-NI

MecSAS Partnership

Acknowledgments

Contact

Viktor BERBYUK

Professor

Mechanical Systems with Active Structure

Division of Dynamics

Department of Applied Mechanics

Chalmers University of Technology

SE-412 96, Gothenburg, SWEDEN

Phone: +46-31-772 1516; Fax: +46-31-772 3827

E-mail: viktor.berbyuk@chalmers.se

http://www.chalmers.se

http://www.am.chalmers.se/~berbyuk