TECHNISCHE UNIVERSITÄT CHEMNITZ

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Compact Dynamic Motor Test Bench Integrated in Mobile Steering Test Bench

Rinya Ramesh, M.Sc.

Supervisors: Prof. Dr.-Ing. Olfa Kanoun[1], TU Chemnitz, Dr.-Ing. Abderrahmane[1] Benchirouf, Dipl.-Ing.M.Sc. Christian Guenther[2]

Objectives

MOTIVATION

- Current test bench designs are bulky with complex algorithms
- Inflexible and complex test systems increase development time
- Flexible and fast execution of motor performance test
- Reduce test time due to ECU software revisions
- Compact and rugged and automation of test execution
- Reduce development time caused by bulky inflexible test system

AIM

The aim of this thesis was to develop a compact test bench for steering electric motor drive under various working points and load conditions along with automation of the tests for added flexibility. Over the duration of the thesis, the various possibilities of developing a test bench that can achieve the test standards for the steering power packs under various working points and load conditions using a compact architecture was researched. The key test cases for the power pack were identified, and a flexible application software was designed with the aim of using the same test bench to functionally verify and validate different power pack designs and software versions without modifying the test bench software and the hardware setup.

SCOPE

- Selection of load and load controller
- Analysis of load performance to match system requirements
- Design of control system and system identification
- Flexible Software Application Design
- Integration of prototype
- Integration tests and analysis of tests

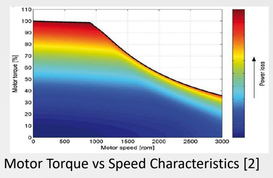
Research &Concept

System Requirements

- DUT specifications
- Motor torque vs Speed curves
- Rack size constraints
- Electrical integration / Control mechanism
- Load control, RPM control
- Cost effectiveness

Motor Specifications[1]

Parameter	Value
Torque	2 – 8 Nm
RPM range	60 – 3000
Power Output	400 – 800W
Operating Temperature	-25 °C – 125 °C

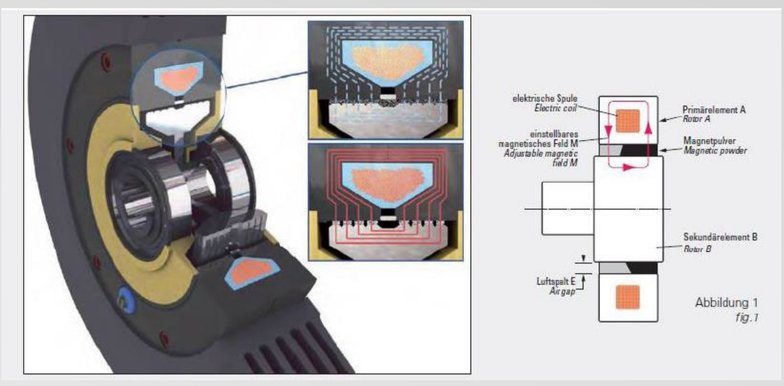


Motor Torque vs Speed Characteristics [2]

Load Comparison

	Pros	Cons
Magnetic Particle Brake	▪ Torque independent of speed ▪ Easy control ▪ Low to Mid RPM range ▪ Easy maintenance ▪ Compact size for operating range	▪ Not for RPM < 40 ▪ High heat dissipation at high RPM ▪ Particle distribution
Hysteresis Brake	▪ Torque independent of speed ▪ Easy Control ▪ Easy maintenance ▪ Compact size for operating range	▪ Torque ripples ▪ Hysteresis effect ▪ Not for high power applications ▪ Torque may change with speed
Permanent Magnet Brake	▪ Quick response ▪ Easy maintenance ▪ Temperature Stability	▪ Low power applications ▪ Constant Current source required
Eddy Current Brake	▪ Easy control ▪ Easy maintenance	▪ Torque dependent on speed ▪ High heat dissipation ▪ Torque speed characteristics do not match
Motor	▪ Can be selected to match operating range	▪ Bulky ▪ Torque ripples ▪ Complex control mechanism ▪ High maintenance

Magnetic Particle Brake



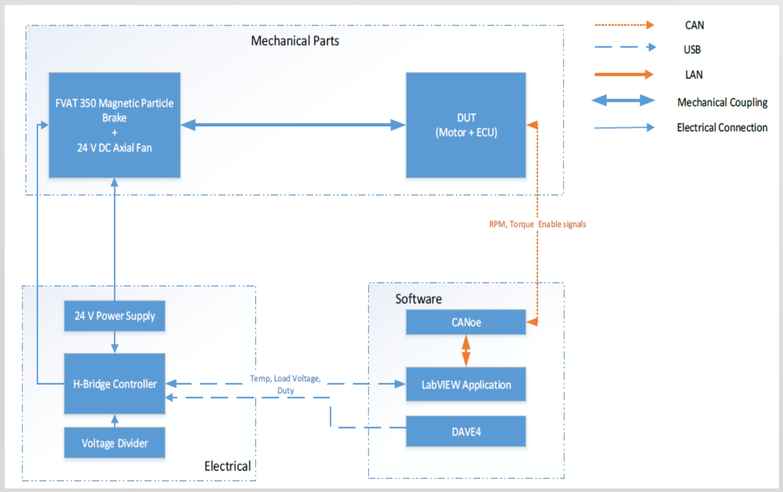
Magnetic Particle Brake [3]

Software Test Requirements

- Constant torque case- The torque is kept constant for a certain duration to analyze the power outputs. This test is important to analyze the motor efficiency.
- Test sequence case- This test involves the execution of user defined sequence. This test plays an important role in analyzing the temperature behavior of the motor.

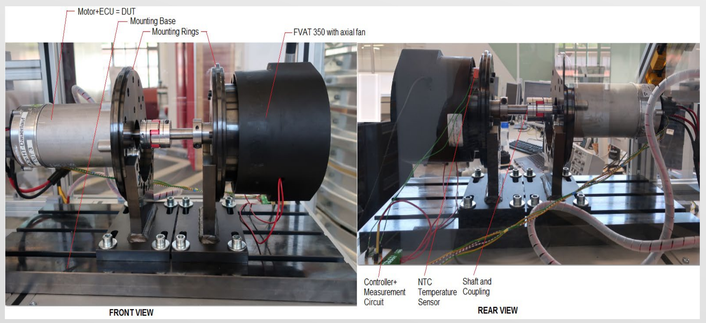
Prototype Development

System Block Diagram



System Block Diagram

Prototype



Prototype of Compact Test Bench integrated in the "Lenkungswagen"

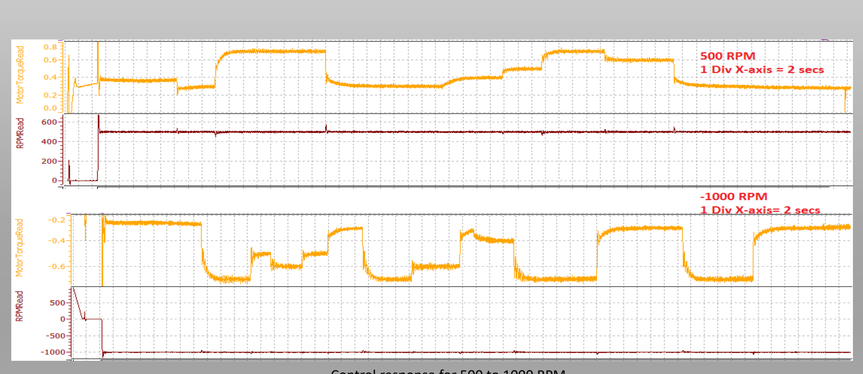
Application Software

Software flow of operations

Configure | Start Test | Log File | View File

Acquisition panel with a running test

Result



Control response for 500 to 1000 RPM

Controller response observations:

- The rise time of 1 to 2 seconds
- The controller gains are constant up to 1000 RPM.
- Brake response time slower than motor acceleration time

Brake response observations:

- The rise time slower for higher RPM
- Max torque for duty cycle not consistent for different RPM
- Brake response inconsistent
- Motor torque drop time inconsistent 20 ~ 120 seconds

Scope of Enhancement

Prototype Enhancements

- Additional power supply→ reduce voltage fluctuations, improve repeatability
- Additional torque sensor for brake torque measurements
- Current measurement circuit

Software Enhancements

- Inclusion of additional Tests
- Option to import MATLAB models for PID simulations
- Additional offline data analysis functionalities
- Programmatically modify latency if possible

[1] Robert Bosch Automotive Steering GmbH, „Servolectric® Electromechanical steering system for dynamic driving experience and highly automated functions," Schwäbisch Gmünd, 2015.
[2] Dr.-Ing. Wolfgang Runge, Dipl.-Ing. Alexander Gaedke, Dipl.-Ing. Markus Heger, Dipl.-Ing. Alexander Vähning, Prof. Dr.-Ing. Hans-Christian Reuss (2009, Oct.). "Electric steering Necessary improvements in vehicles top segment" Electric steering. [online]. 111(10), pp.14-20. Available: https://www.springerprofessional.de/en/ [Jul. 03, 2018].
[3] Merobel.com. (n.d.). "MEROBEL Product Catalogue". [online] Available at: http://www.merobel.com/en/site- Merobel-produit-12-24-magnetic-particle-brakes.html [Accessed 3 Jul. 2018].

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https://www.tu-chemnitz.de/gleichstellung/index.html

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