Torque Feedback for Steer-by-Wire Systems with Rotor Flux Oriented PMSM

K. Scicluna

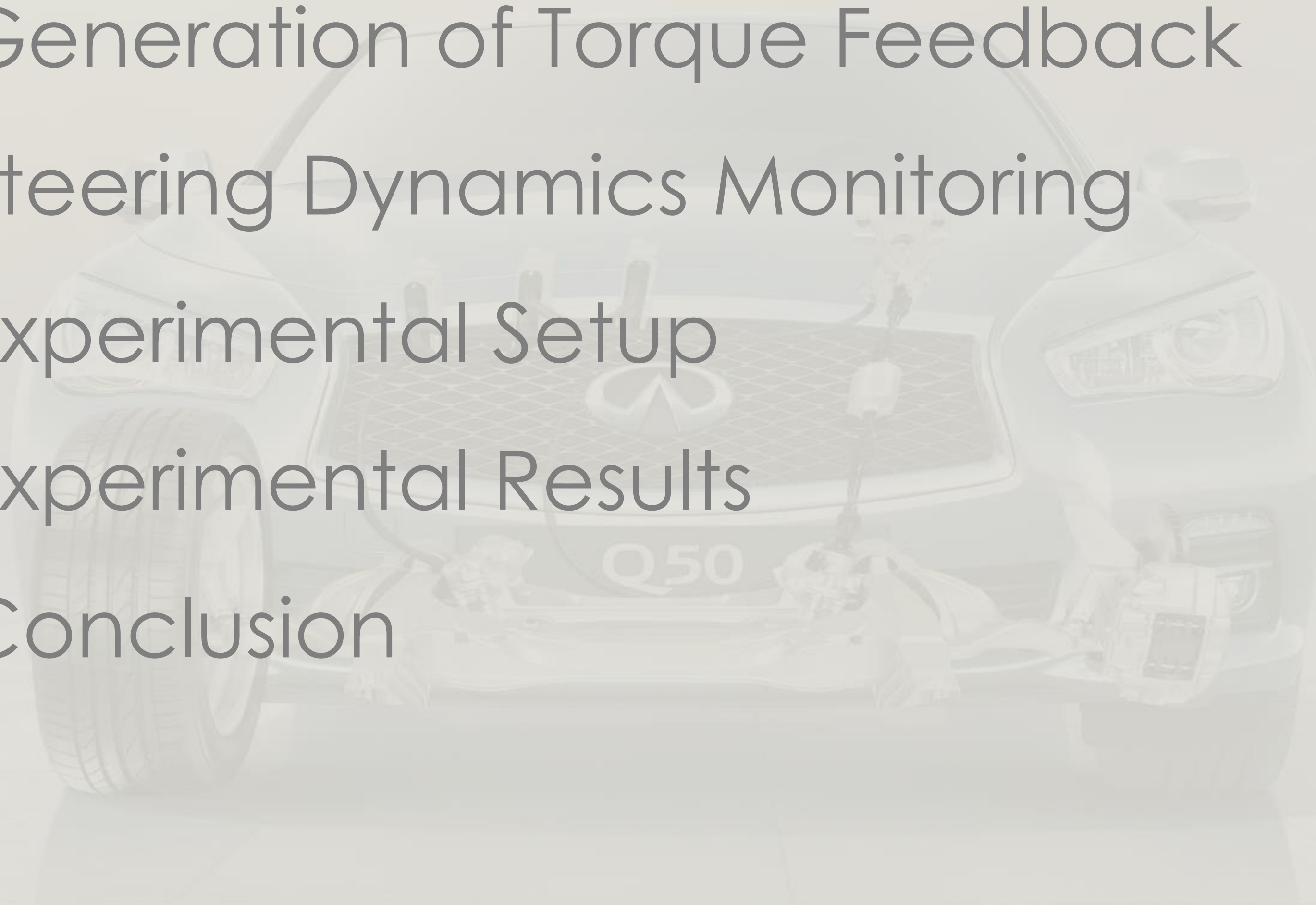
C. Spiteri Staines

R. Raute

MCAST
Malta College of Arts, Science & Technology

Contents

- System Overview
- Generation of Torque Feedback
- Steering Dynamics Monitoring
- Experimental Setup
- Experimental Results
- Conclusion



Steer-by-Wire Overview

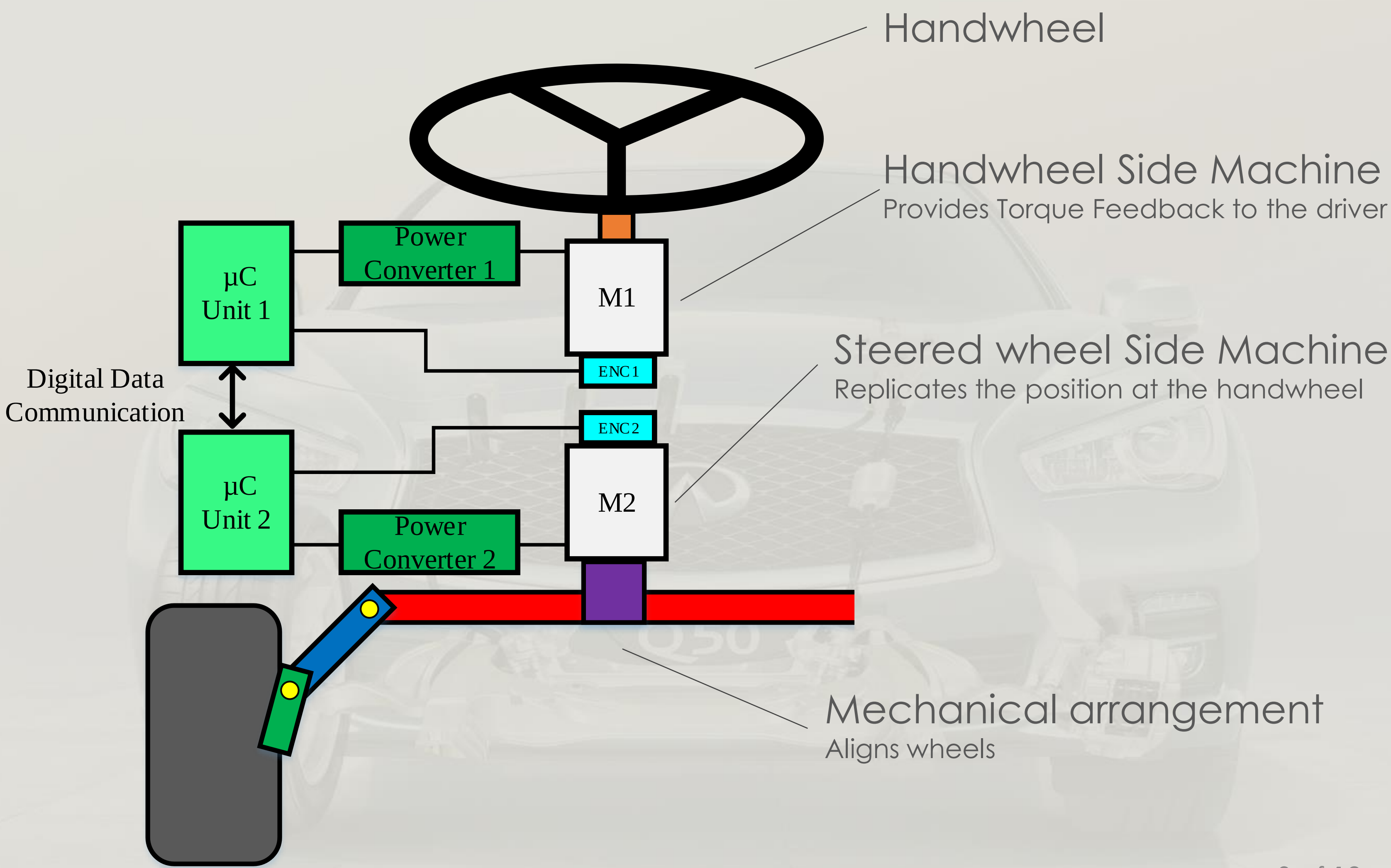


Figure 1: Steer-by-Wire System Diagram

Generation of Torque Feedback

Model-based Methods
Can be easily tuned during real-time
Computationally Intensive

Look-up Table Methods
Computationally not intensive
Requires offline calibration

Torque Sensor at Steered Wheel Side
Accurate torque replication
Sensors are expensive

Experimental Steering Dynamics Monitoring

Figure 2 : Kia Sportage 2014 Test Vehicle

Figure 3: System Monitoring through On-Board Diagnostics (OBD)-II port

Vehicle Velocity

Steering Wheel Position

Steering Wheel Torque

Experimental Steering Dynamics Monitoring

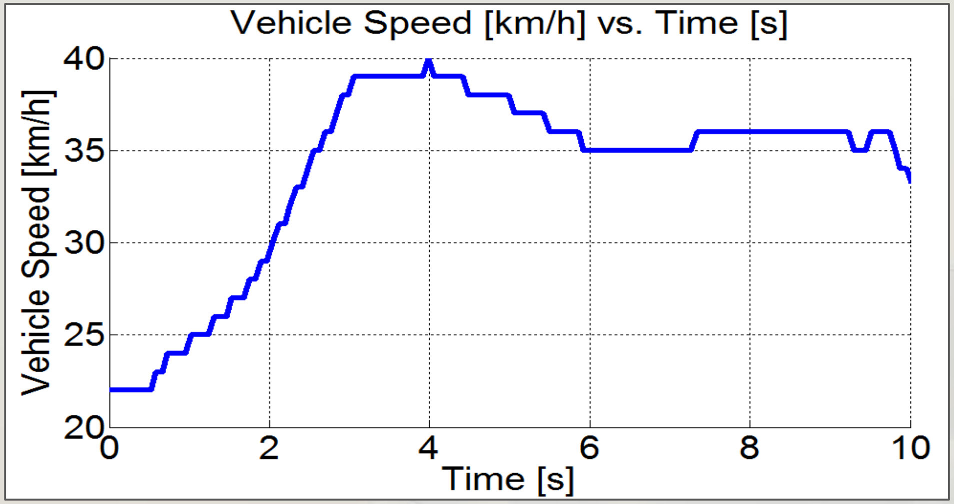


Figure 3: Speed with a speed setpoint of 35 km/h and +/- 30 degree steering changes.

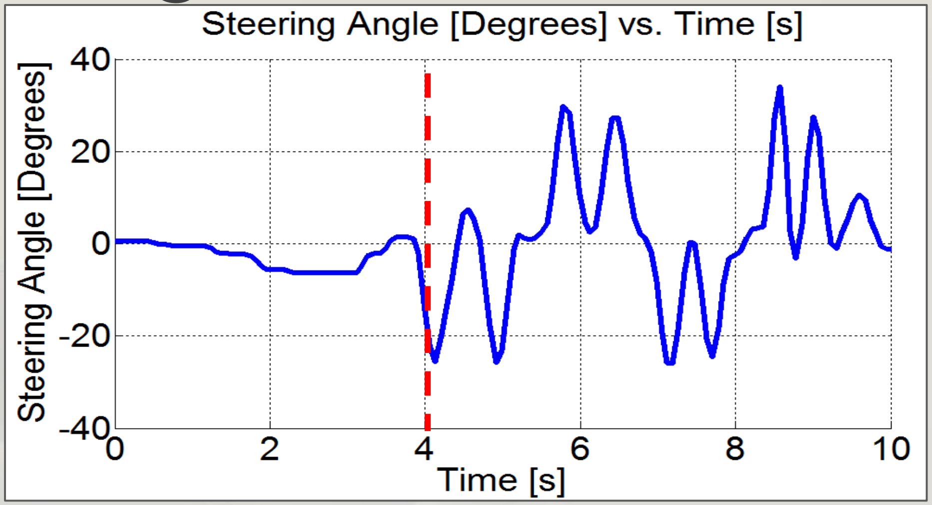


Figure 4: Steering Wheel Angle with a speed setpoint of 35 km/h and +/- 30 degree steering changes.

Torque opposes the direction of steering

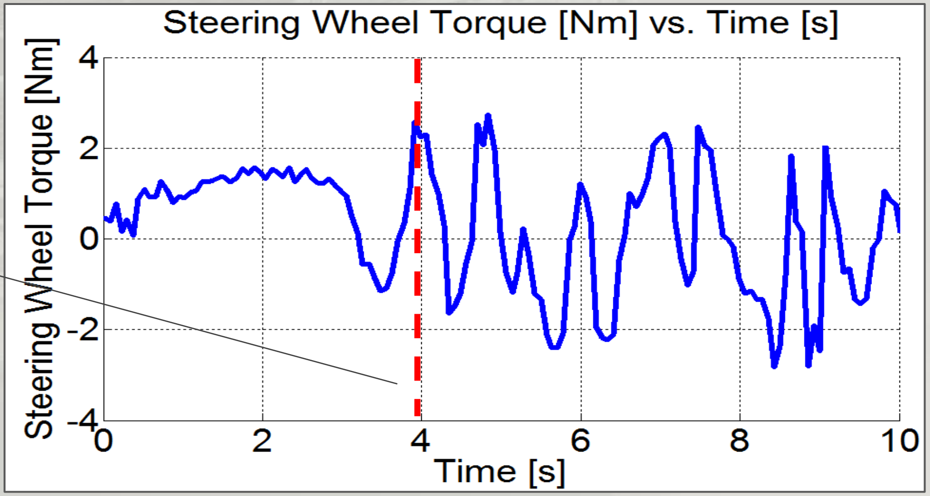


Figure 5: Steering Wheel Torque with a speed setpoint of 35 km/h and +/- 30 degree steering changes.

Simplified Torque Generation

Torque opposes Handwheel

Linear Range +/- 20 degrees

Saturation to +/- 2 Nm outside Linear Range

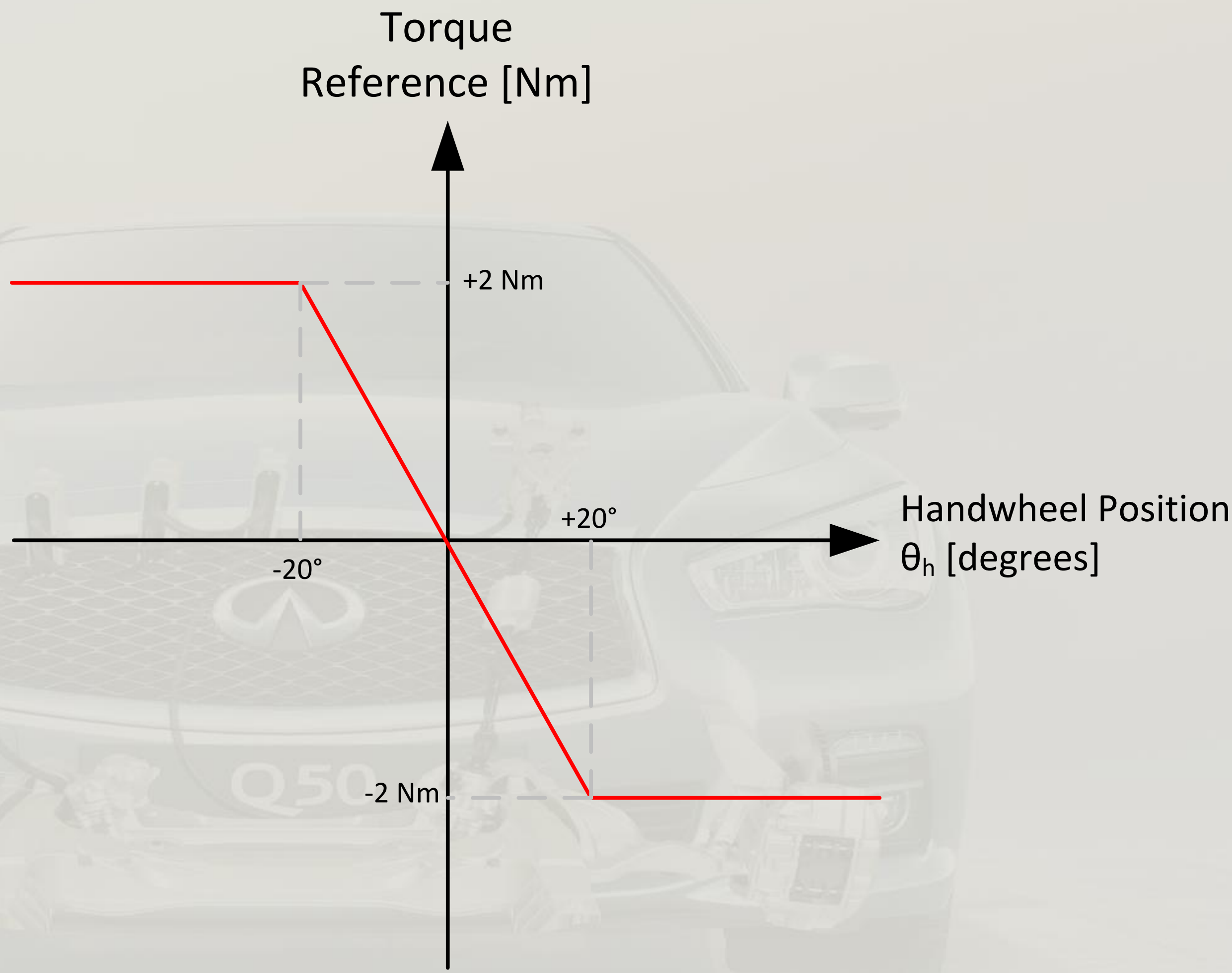


Figure 5: Torque Reference [Nm] vs. Handwheel Position [degrees]

Experimental Setup

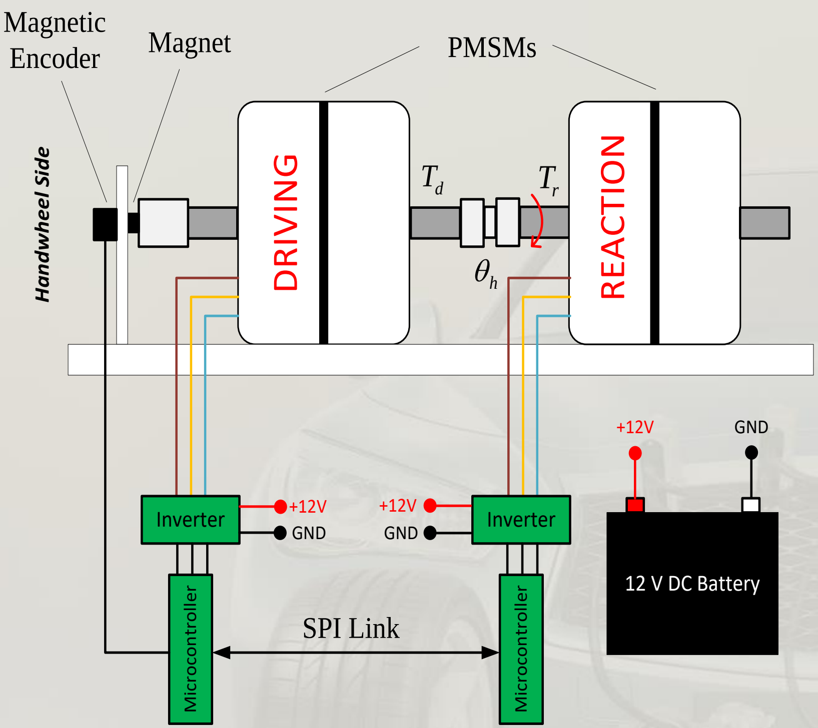


Figure 6: Steer-by-wire handwheel side setup illustration

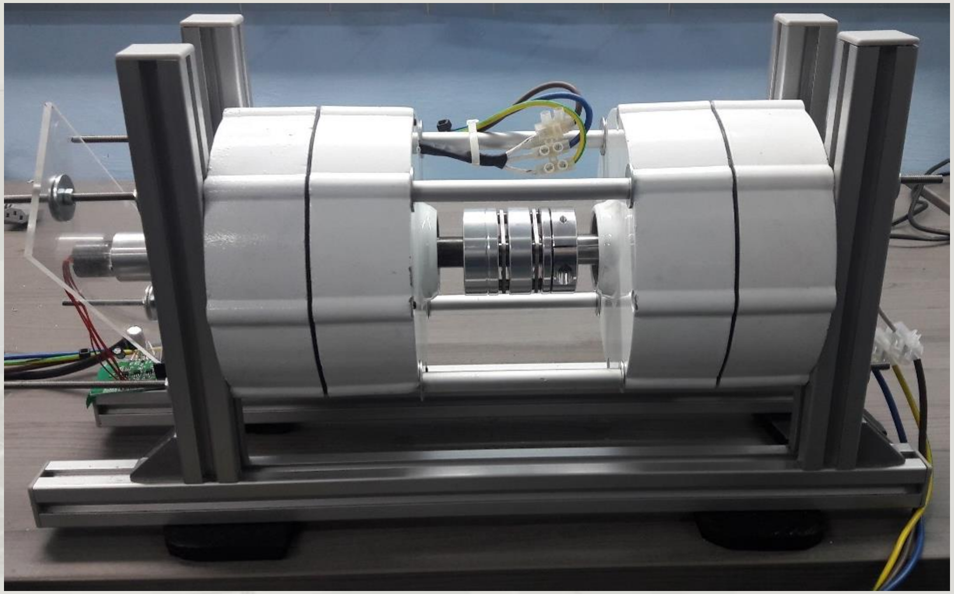


Figure 7: Steer-by-wire handwheel side PMSMs on experimental setup

Experimental Setup

STM32F4 Based Microcontroller

Isolated 3 Phase Current Measurement

Isolated 6 channel gate drive board

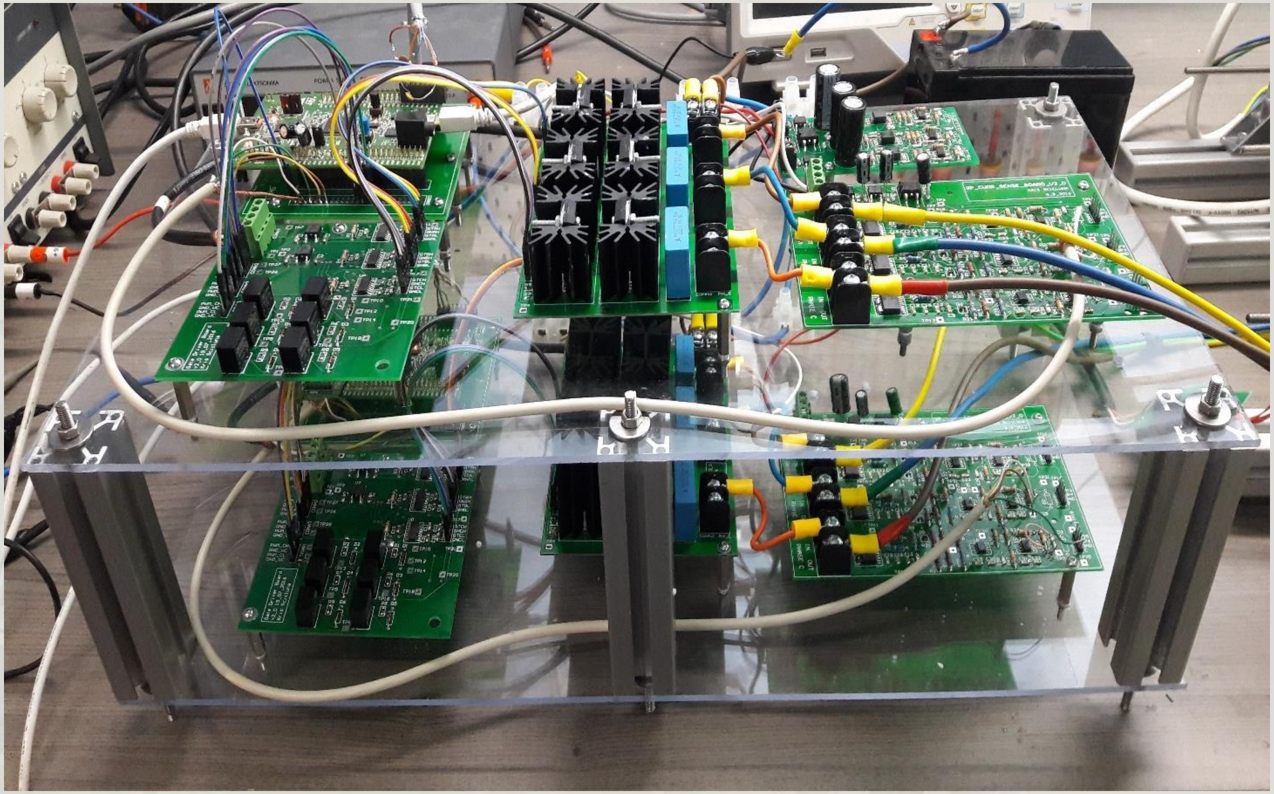


Figure 8: Experimental 12 V 500 W Inverters

Experimental Setup

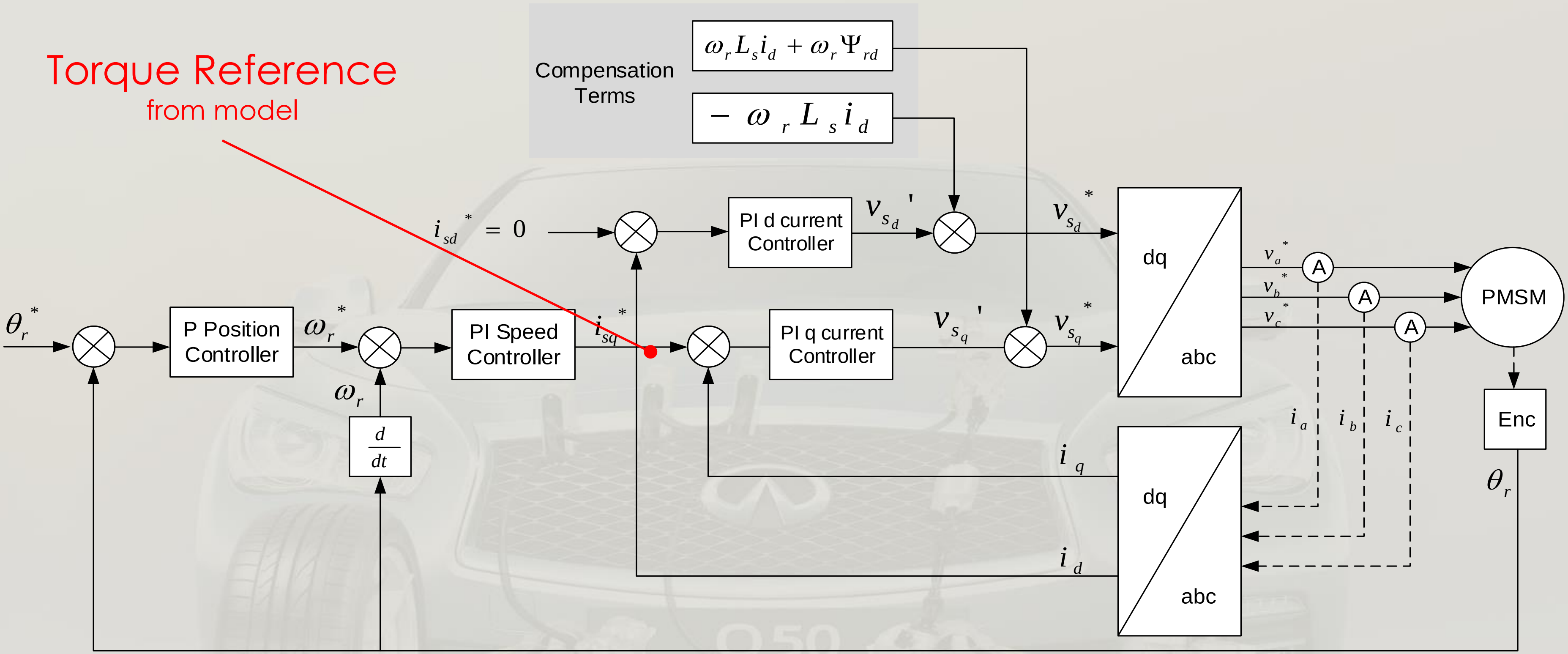


Figure 9: Rotor Flux Oriented Control Topology

Experimental Results

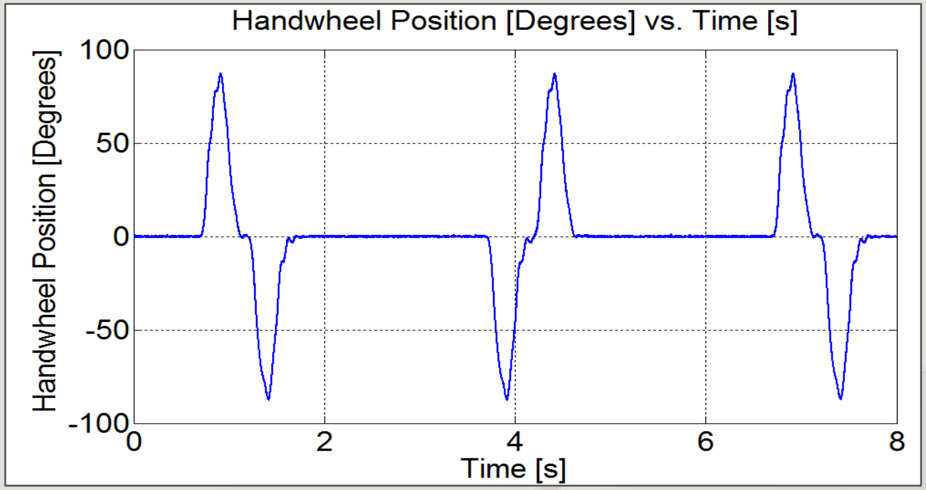


Figure 10: Handwheel Shaft Position set by position controlled driving machine.

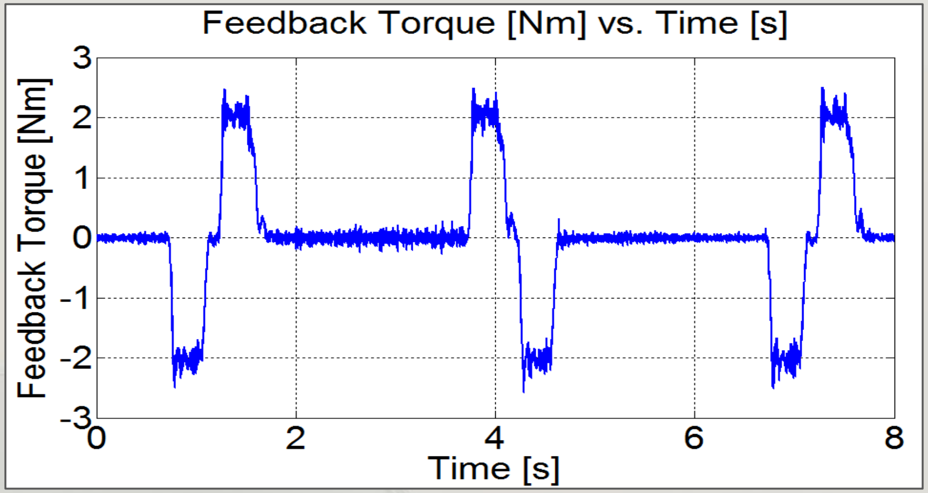


Figure 11: Feedback Torque generated by the reaction current controlled machine.

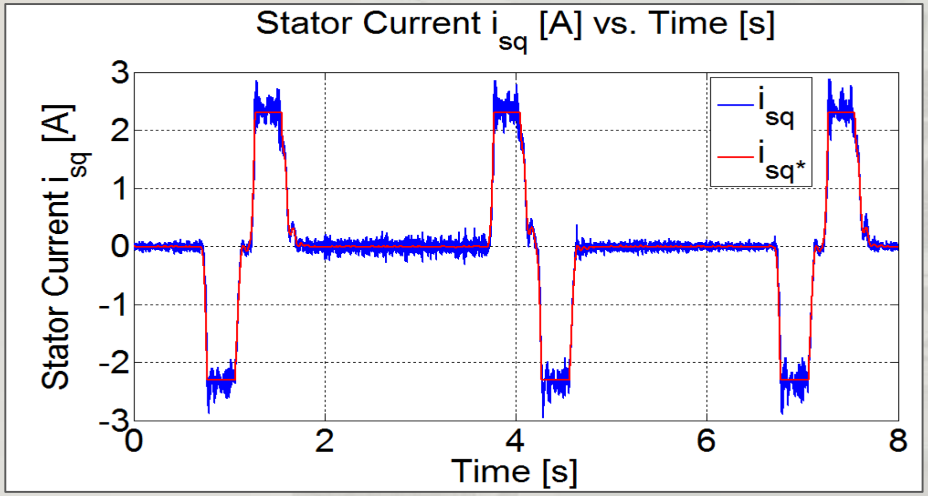


Figure 12: Synchronous frame Stator q axis currents of the Reaction current controlled machine.

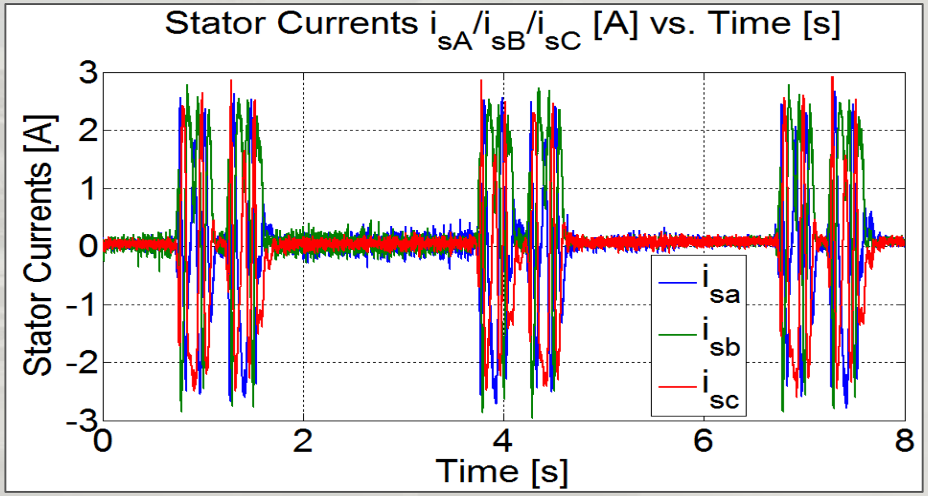


Figure 13: Three phase stator currents of the reaction current controlled machine.

Conclusions

Similar torque reaction profile as commercial vehicle with EPAS

Proposed system can react to transient 1.5 times than maximum rate observed on EPAS

Power on demand for improved efficiency

Discussion

Authors

Kris Scicluna

PhD Research Student,
Department of Industrial Electrical Power Conversion,
University of Malta.
Lecturer, Institute of Engineering and Transport,
Malta College for Arts, Science and Technology
Email: Kris.Scicluna@mcast.edu.mt

Cyril Spiteri Staines

Professor,
Department of Industrial Electrical Power Conversion,
University of Malta.
Email: cyril.spiteri-staines@um.edu.mt

Reiko Raute

Lecturer,
Department of Industrial Electrical Power Conversion,
University of Malta.
Email: reiko.raute@um.edu.mt

About the Department of Industrial Electrical Power Conversion - The Department of Industrial Electrical Power Conversion, IEPC, forms part of the Faculty of Engineering at the University of Malta. IEPC has been at the forefront of research and lecturing in the following areas of electrical engineering: Power Electronics and Distributed Generation; Power Systems and Grid Integration of Renewable Energy Sources (RES); Electrical Machines and Drives; and Electrical Services. **Website: https://www.um.edu.mt/eng/epc**