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TEST REPORT
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EXRO – 100V EMotor Performance Benchmarking

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1. Introduction

1.1. Background

A series of tests are performed with an E-motor and Coil Drive supplied by EXRO to demonstrate performance at different operation conditions. Following tests are performed based on the request from EXRO:

- Unload test:
  E-motor was spined by applying 5 Nm torque command. The DC voltage is set to 25V, and the DC current is limited to 20A. E-motor was free spinning without any dyno load. This test is performed to show that the coil driver and motor are installed properly.
- Different throttle levels with fixed motor speed:
  25% - 50% - 75% throttle levels are applied to the Coil Driver while dyno was driving at 500rpm. This test is performed to show that the coil driver could switch between series and parallel modes based on different operation conditions.
- Different throttle levels with fixed motor speed values:
  25% - 50% - 75% - 100% throttle levels were applied to the Coil Driver. E-motor is spinning at 100rpm, 300rpm, 500rpm, 700rpm, 900rpm, 1100rpm, 1300rpm, 1500rpm, 2000rpm, 3000rpm, 4000rpm, 5000rpm, and 6000rpm. This test is performed to show the maximum torque capability at each speed level.

1.2. Project Objectives

This report contains:

- Waveforms captured showing switching from parallel-to-series and series-to-parallel.
- Torque vs Speed curves from 0-6000RPM with different throttle levels.

2. Experimental Set-up

2.1. Test Engine Specifications

Following table shows the test cell capability.

Table 2-1 – Test Cell Specifications

Properties	Value	Unit
Maximum Speed	10,000	rpm
Maximum Torque	475	Nm
Maximum DC Voltage	1200	V
Maximum DC Current	1000	A
Maximum DC Power	750	kW

Figure 2-1 Dyno Set-up

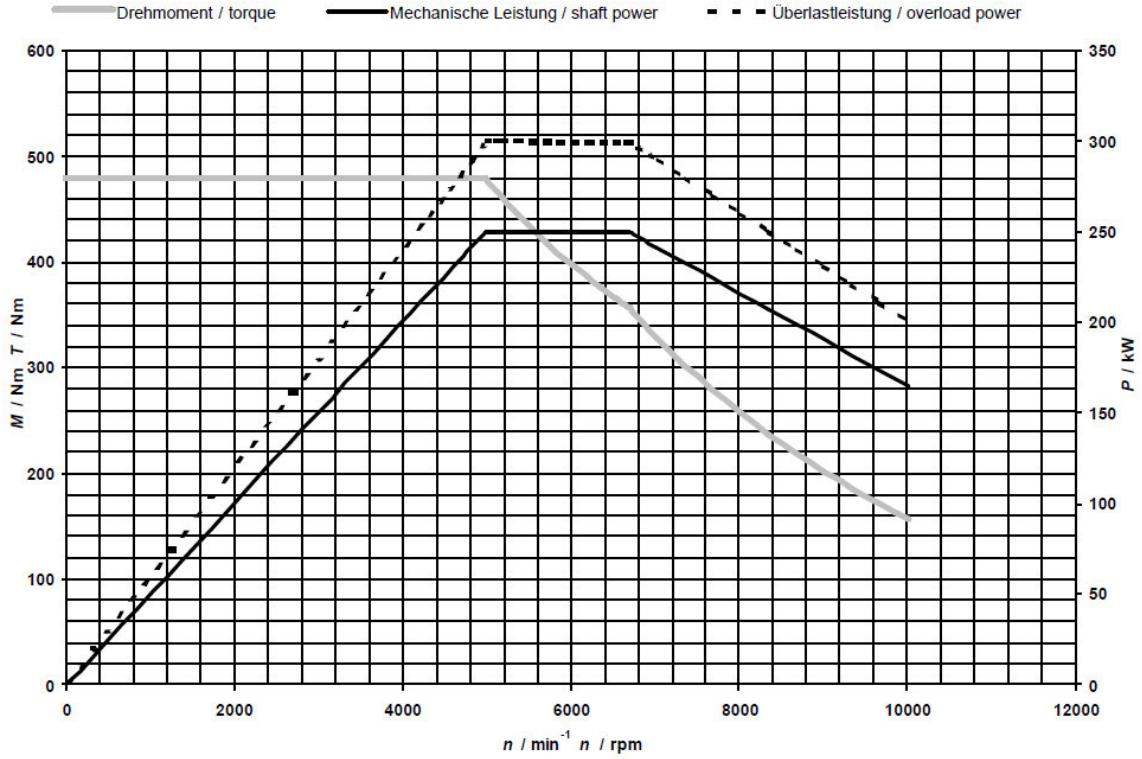

Figure 2-2 Dyno Torque-Speed limits

2.2. Test Procedures

The test is performed based on customer's document "Coil Driver Third-Part Validation Testing Procedure.pdf"

3. Test Results

3.1. Operation Modes Switching

During the test, the DC voltage is set to 100V, and motor spins at 500rpm. Following figure shows that the mode switching happens when throttle level increases from 50% to 75%. When switching happened, the phase to phase voltage becomes 0.

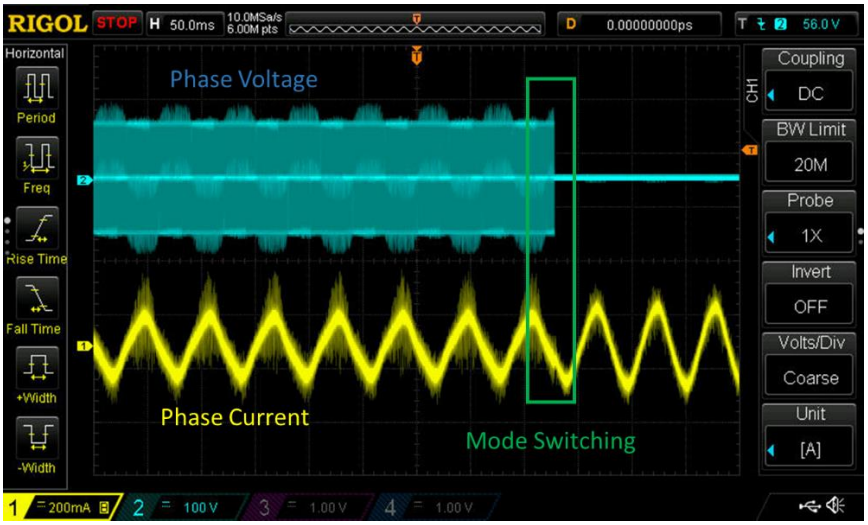

Figure 3-1 Switching from Parallel to Series

Following figure shows that the mode switching happens when throttle level decreases from 75% to 25%. When switching happened, the phase to phase voltage becomes non-zero.

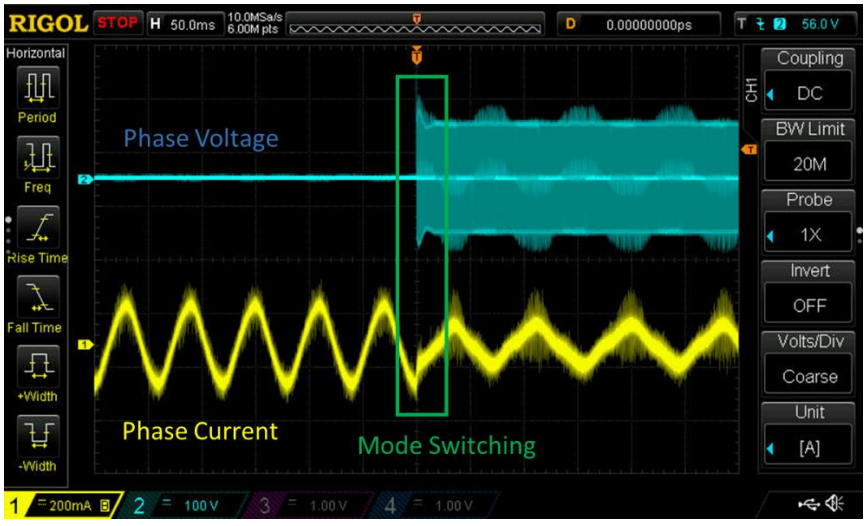

Figure 3-2 Switching from Series to Parallel

3.2. Torque/Speed Curve with Fixed Motor Speed Values

During the test, DC voltage is set to 100V, and motor is controlled at 100rpm, 300rpm, 500rpm, 700rpm, 900rpm, 1100rpm, 1300rpm, 1500rpm, 2000rpm, 3000rpm, 4000rpm, 5000rpm, and 6000rpm. The torque and speed values are sampled by AVL setup, and the data sampling rate is 1000Hz. Speed value represents dyno motor speed. The torque transducer is placed between dyno motor and customer's motor. Following figure shows the max achieved torque at each speed values.

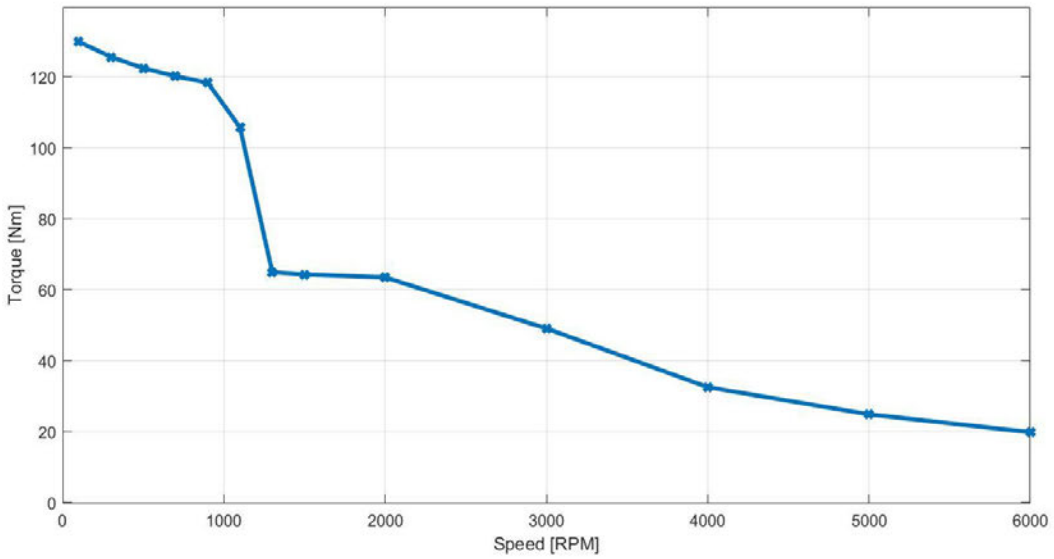

Figure 3-3 Max Achieved Torque at Each Speed Values

4. AVL Recommendations for future testing

It is recommended to perform the test with more operation points at different voltage levels to demonstrate system's capability at various conditions.

5. Conclusions

Based on the tests, it can be observed that motor generates significantly more torque due to the switching between parallel and series mode operations. It is also observed that the switching between different modes is seamless. Overall, this coil switching technology seems to provide torque output improvement across the speed range. It could be a good solution for automotive or any other applications that are looking for high torque density, and cost reduction.