

## **E-Drive End of Line Testing in production**

Dipl.-Ing. Ralph Heckmann<sup>1</sup>

<sup>1</sup> *teamtechnik Maschinen und Anlagen GmbH, Planckstraße 40, 71691 Freiberg / Germany,  
Ralph.Heckmann@teamtechnik.com*

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### **Summary**

E-Drives are a challenge in automated EOL testing. Electrical tests must be performed in addition to the tests on the mechanical functions of the transmission. Electrical measurements need to be recorded and electrical safety tests carried out. High currents and voltages need to be supplied, transmitted and regulated. The integration of additional control hardware and communication software is an additional challenge for the test systems. The integration of rapid and sophisticated measurement technology and diagnostics is required.

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### **1. Introduction**

teamtechnik is a supplier of advanced testing technology for all kinds of DCT and hybrid transmissions based on modular platform. The next logical step is to transfer this platform for the testing of E-Drives. E-Drive projects are currently really taking off on the market. While production may be starting off with smaller batch sizes, all the signs are pointing towards bigger batch sizes.

teamtechnik implements modular test concepts for the EOL testing of the latest generation of E-Drives. The extensive experience of modular transmission EOL testing is now being put at the service of E-Drive testing. A challenge for measurement, drive and safety engineering.

This prompts the following questions:

- What are the current production requirements?
- What are a facility's test requirements for E-Drive?
- How does teamtechnik integrate these requirements into an E-Drive test facility?

The main elements of a successful EOL testing of E-Drives are:

- Flexibility in the layout of the test facility
- Appropriate and customised adaption
- Repeatable test results with powerful and dynamic drive technology
- Flexible test software in terms of parameterization and test sequence

## **2. The E-Drive testing requirements**

What is happening on the market at the moment? The variety and complexity of transmission development is greater than ever before. All automotive manufacturers are rapidly developing electric vehicles and are increasingly integrating E-Drives into the vehicles. After the MT and DCT transmission generations, transmission developed into an active element in the powertrain due to hybridization. The next step in powertrain development is the integration of the internal combustion engine and the transmission on the electric drive axle. This means that automation in E-Drive testing has to ensure that these requirements are comprehensively covered.

### **2.1. Market requirements**

Production is seeing the launch of many projects with short schedules and a large spectrum of planned batch sizes (from small to large series). The test systems suitable for this purpose must be based on proven platforms. The automation must be expandable quickly and economically.

### **2.2. Product requirements**

E-axes extend the interfaces to the test bench through electric power supply and additional sensors in the unit. Further BUS and inverter systems must be supplied and integrated into the control architecture of the test bench. Technologies from the engine and transmission test are combined in the test bench. The special housing design of the axes requires new interfaces for fixing in the test bench and automation transport in the test bench. Different geometrical designs, OEM requirements and technical control architectures need to be reproduced in the test facilities. Flexible production is therefore a major requirement faced by OEMs.

### **2.3. Test technology**

E-Drives are making extra and new demands on test technology. Electrical tests must be performed in addition to the tests on the mechanical functions of the transmission. Electrical measurements need to be recorded and electrical safety tests carried out. High currents and voltages need to be supplied, transmitted and regulated. The integration of additional control hardware and communication software is an additional challenge for the test systems. Extended interfaces to the product include electricity, cooling water and oil.

The integration of rapid and sophisticated measurement technology and diagnostics is required. Fast capture of measurement data and flexible interfaces are essential aspects of test technology that allow current test requirements to be met.

Testing software has become more than just a matter of managing a test procedure. More than 65 % of the source code and sequence encompasses communication diagnostics and requests from the E-Drive. Communication with control units, control technology, peripheral measuring systems, test sequence management, data management and production statistics are components of the test bench control system.

Where a test bench in the past was primarily a means of measuring noise, its main components today for E-Drives are much more complex, such as extensive calibrating and testing functions.

### **2.4. Production**

High availability and high maintainability must be ensured for production systems. Production capacity must be able to grow and the flexibility to encompass new types is essential. Testing equipment has to be integrated in the overall logistics of the E-Drive production. From direct integration of test benches in the assembly line to fully independent testing lines. Testing data must be transferred to central host systems to store this data for later use.

## **2.1. Economic requirements**

As well as availability and investment costs, down time resulting from modifications for the integration of new types, to the test procedure or to parameterization have a major impact on both the technical and economic efficiency of a production system. It must be possible to plan for this. Different OEM requirements must fit on an E-Drive testing system.

## **2.2. Conclusion**

What does that mean for the EOL testing of E-Drives?

To achieve technical excellence and economic efficiency, E-Drive automated testing has to be combined with maximum flexibility and high technical competence and the application of a modern EOL testing system. That is why we have escalated the tried and tested modular transmission test bench platform to the E-drive test bench. These technical properties, combined with the flexibility offered by adding an electric application, provide the ideal solution. teamtechnik's response to these requirements: The teamtechnik Modular Automated E-Drive Testing System - Flexibility through modularity.

The basis for successfully implementing the teamtechnik machine platform for E-Drive testing. Synergies between all the transmission types within the test process. Application benefits from a fully-developed solution, worldwide service support and flexible test plan editing.

## **3. The teamtechnik solution: Modular Automated E-Drive Testing System**

### **3.1. Testing technology**

A modular control architecture and very flexible testing software serve as the basis for the integration of electrical testing content. In particular, E-Drives require flexibility in both interfaces and software programming, which is solved by modular machine controls and the teamtechnik software concept.

For functional testing, the E-Axis requires two brakes, which can apply speed- or torque-controlled load profiles to the electric motor. The brake energy can be fed back via an intermediate circuit of the power supply of the electric machine by means of modern converter technology. The alternating voltages are thereby converted into direct current and fed into the direct current source. The efficient energy circuit between the test motor and the braking system requires the grid to only cover the lost energy.

The high performance of measurement technology and data acquisition have to be adapted to electric content and additional complex electrical tests require competence in electric measurements and electric machine design and testing software. Interface to: E-motor / sensors / TCU add on, cooling water, BUS simulation, and additional power supply for hybrid

The motor characteristics are checked for safety and function after final assembly. The test technology is extended to include electrical tests and measurements:

- El. tests e.g.: resistance, high voltage, insulation, short circuit test, temperature sensor check, measuring voltage and current
- Motor tests e.g: test of rotor (resolver) signal, synchronization of resolver angle to el. motor commutator, generator mode test el. characteristic, NVH, boosting, generator test, load testing

This is done using tried and tested measurement technology/sensors and measurement data recording from NI.

The test software must have functionalities and interfaces that allow:

- Flexibility in test sequence control and data management with full parameterization
- Interface to E-Drive control units and sensors and to hybrid applications
- Interface to subsystems

The modular design of the test bench mechanics and controls makes it possible to quickly integrate ambitious measurement technology and hybrid electrical testing devices. As far as testing software is concerned, teamtechnik has successfully developed the test software teamsoft.TEST that meets the demands of modern, flexible and powerful E-drive testing. The components of the test software are a database and a programming system, a runtime system based on National Instruments® LabVIEW® and analysis and visualization modules. The software combines a high performance runtime system with drag&drop editing and safe data handling. Future modifications in the test software application can be handled by this system from parameter changes to the creation of new testing programs for E-Drives, and that without detailed knowledge of LabView.

### **3.2. Automation**

Flexible solutions are created by teamtechnik in order to meet the production batch size requirements quickly and efficiently in production. Expandable and extendable automation is the central component of the teamtechnik automation concept. An extension from the hand-loaded test bench to the fully-concatenated test system is possible thanks to modular extension possibilities.

What processes are necessary for modern E-Drive testing? After assembly, the E-Drive is dry, the converter and TCU are mostly assembled, all design groups are installed and the electric and hydraulic connectors are accessible to allow all the necessary connections.

The processes are:

Loading from assembly line, rigging, weight check, oil filling, TCU flashing, pre-test/setup, EOL-functional test, oil draining, post-flashing TCU, weight check, unrigging, offloading OK and NOK parts.

The preparation effort and the sheer volume of the testing content mean that many test benches that perform E-Drive testing are sometimes not economical.

The alternative is to build up sequential process steps for the whole testing procedure. Integrating the preparation processes in separate stations. Splitting the testing content into tests with load and without load. Using the EOL-functional test bench only for the EOL testing process that needs a load on the E-Drive. This separation of sequences is to be adapted to the level of automation. The teamtechnik E-Drive automation system is designed as a sequence of stations and processes that integrate the complex preparation processes and allow the separation of testing processes. E.g. stations for oil filling, rigging, TCU flashing, pre-testing, draining, final assembly. The number of stations will be adapted according to the **required** level of automation, by duplication of stations and bypass automation.

Generally the test line will be fully integrated into the production flow of the assembly line, beginning by integrating single test benches into the assembly line transportation system up to the fully automated test lines.

This includes all data acquisition and data transfer:

- Host PC functionality and integration in factory networks
- Remote maintenance and worldwide applications

### **3.3. Flexibility**

From an automation point of view, the following items have an influence on the testing system regarding E-Drive type variance:

Mechanical-, hydraulic-, electrical- and software- interfaces to the E-Drive as well as testing parameters and testing content. A full automation of all interfaces to the E-Drive makes flexibility extremely cost-intensive and carries high risks in terms of design and change over and functionality. Therefore low-key automation is the future solution for E-Drive testing. teamtechnik's general concept is to make all interface items flexible. This means: Flexible pallet design, flexible test benches, flexible testing software.

The flexible adaptation of the test items with an interface to the workpiece carrier provides flexibility in the event of type variability.

#### **3.3.1. Test benches**

The biggest challenges for the E- Drive test benches are:

- The clamping device due to the complex design of the E-Drives
- The additional adaptation in mechanical, electrical and hydraulic terms
- The sometimes high reference torques due to very powerful electric motors
- Implementation of an efficient energy circuit from the brake machines to the test item
- The highly-dynamic control of the speeds via BUS systems

Flexibility in the test bench is achieved by a common interface from test bench to the pallet and by very flexible and modular controls and software design.

Teamtechnik uses proven and tried-and-tested solutions for fixing units in the test bench. The high reference torques are made possible thanks to the solid mechanical design of the test bench frames and drive elements. A powerful and fast control technology enables the implementation of the dynamic requirements.

To expand the testing system with new types, the E-Drive product design has to consider the interfaces to the test system and the testing system itself has to be as flexible as possible at the interfaces between the E-Drive and the test equipment: This type flexibility allows the application of different OEM types in a testing system.

### **3.4. Efficiency**

Economical aspects are fulfilled by having a solution that allows flexible investment by scaling the test system from start up to high speed.

The layout structure and integration of stations and test benches allows good maintainability and high availability by using "open layout" integration and bypass strategies and modular and flexible control architecture. Data safety end testing flexibility is ensured by having a data base and communication module as an integrated part of the testing software.

### **3.5. Simultaneous engineering and partnership**

Simultaneous engineering and partnership between the customer and supplier is another important prospect. This boosts the potential by keeping the same interfaces. Design agreements can be concluded between the customer and the test line supplier. In particular, synergies can be found in the geometrical interface for the E-Drive, by agreeing on common loading points on the pallet, indexing and clamping points on the E-Drive, the same position of connectors and drain plug and universal electric and software interfaces.

As a supplier, teamtechnik offers a global presence in engineering, training and service as a worldwide partner in E-Drive testing.

## References

[1] <http://www.teamtechnik.com>, accessed on Feb. 2<sup>nd</sup>, 2017

## Authors



Studies: Mechanic Engineering TU-Darmstadt

Emphasis: Tooling Machines, Hydraulic Machines and Systems, Fluid Dynamics

1993: Project engineer for Testing of Electric Motors

1996: Start at teamtechnik Maschinen und Anlagen GmbH

2000: Head of product group Transmission Test Systems

2005: Section Manager Test Systems

2008: Division Manager Planning, Technology, Project management

2014: Head of Technical Sales / Worldwide Sales

2016: Vice President Sales Automotive