

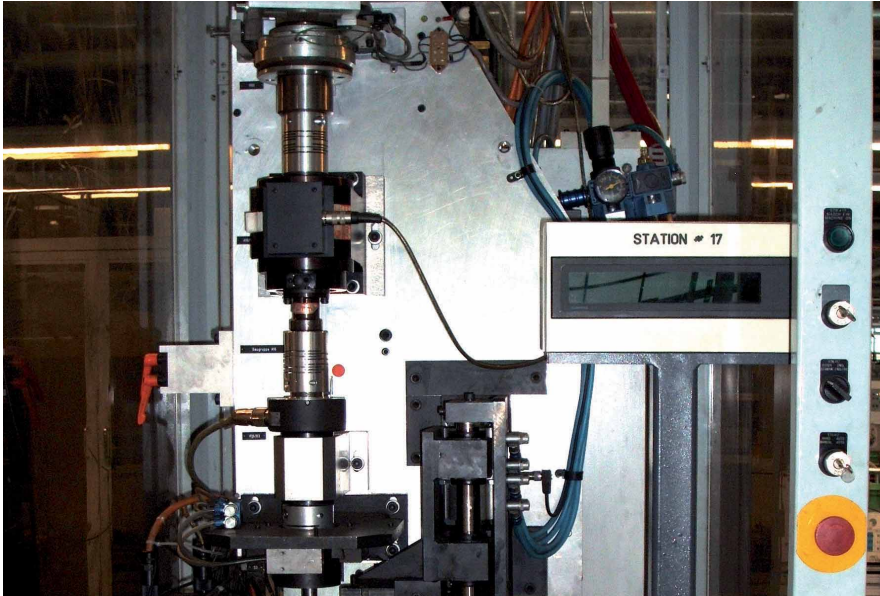
KISTLER

measure. analyze. innovate.

Test Stand Systems

for Electric Motors
and Gearing
at Laboratory (R&D),
Production (EOL)
and Quality Assurance
(QA)

Test stand technology by Kistler

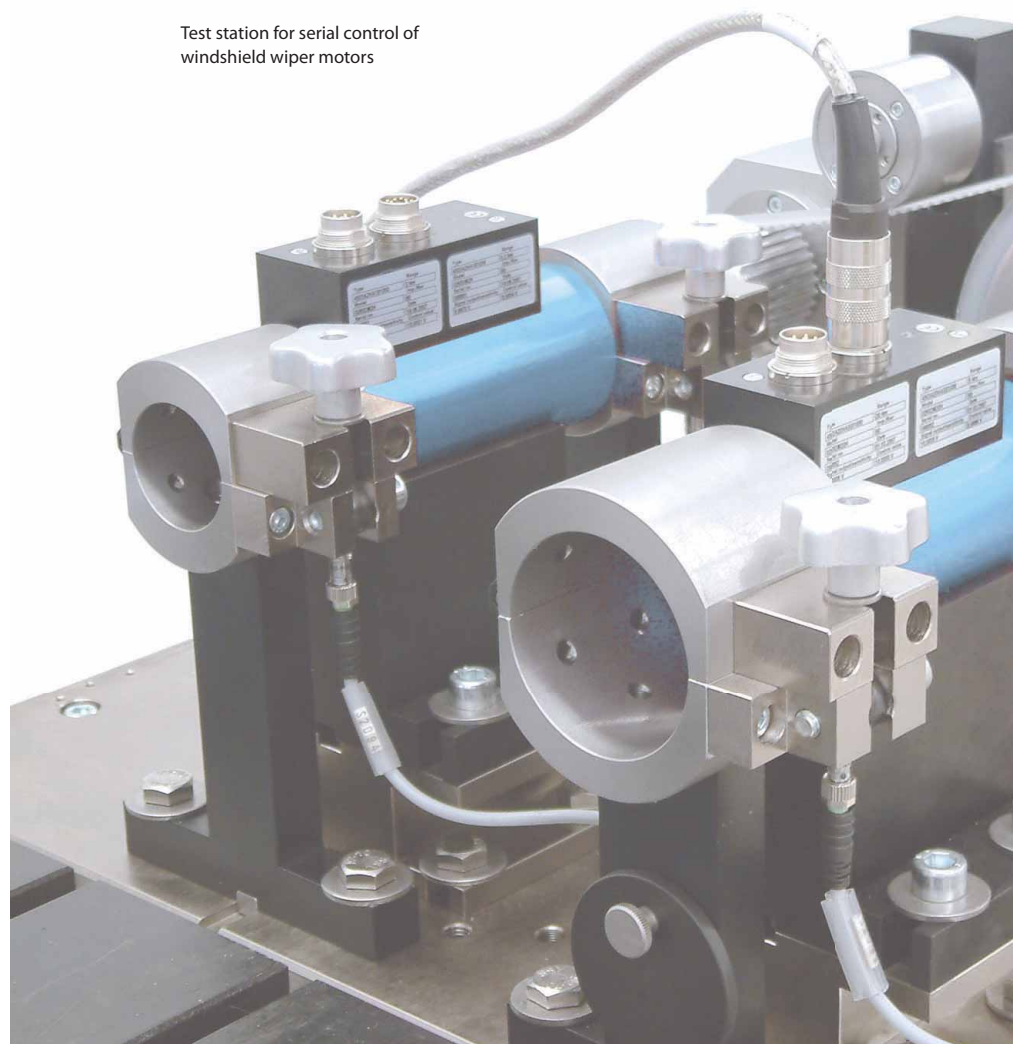


The scope of services comprises mechanical components such as drive test set-ups with torque sensors, small test stands with torque-/speed measurement and manual or external control, as well as computer controlled complete solutions for the analysis and documentation of electrical machinery.

By means of an integrated power analyzer, computer controlled test stands can be realized with up to 8-channel current-/voltage measurement, so that a separate efficiency specification of motor and converter can be effected even for converter fed drive systems.

The analysis of mechanical and electrical features, of the thermal evaluation, overload capacity and technical data of electrical machinery, of which the most important are efficiency and performance factor, today makes heavy demands on safe operability and flexibility of a test stand system.

Test station for serial control of windshield wiper motors



At a glance

Special features of Kistler test stand systems

- Modular design
- Use of active brakes (4-quadrant operation)
- Torque ranges 0,01 ... 25 000 N·m
- Power ranges 2 W ... 500 kW
- Speed ranges up to 120 000 min⁻¹
- High-precision power analyzer for electronic data logging
- Standard- and customized software packages
- Optimal project handling
- Worldwide after-sales service

Configuration

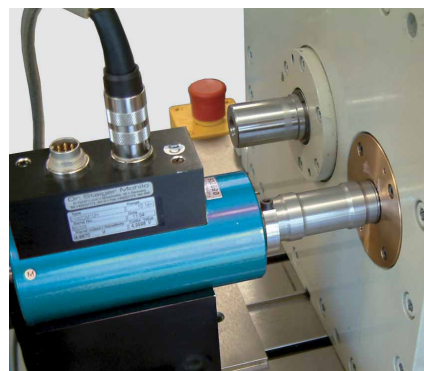
An optimal functioning mainly depends on the selection of mechanical and metrological components. Load is effected by an active brake, which works in 4-quadrant operation.

Only this version allows all the necessary functions especially in the laboratory field.

The modular software not only serves for collecting and presentation of measuring data, but also allows simulating of HIL (hardware-in-the-loop) as well as automation of measurement and test processes.



Test stand for electric motors with high-performance gearbox (efficiency >96 %)



Shaft 1 (directly): 70 N-m/8 000 min⁻¹
Shaft 2 (i = 1:7): 10 N-m/50 000 min⁻¹



Validation of electric power tools

Typical components

- Rack with lifting device
- Mounting plate
- Motor brake
- Torque-/speed sensor
- Gear unit for speed and torque adjustment
- Specimen retaining unit
- AC- and/or DC-motor supply
- Terminal box for specimen and temperature sensor
- Optional climatic chamber
- Activation hardware for motor converter (specimen)
- Measuring signal conditioning
- Computer-interface hardware
- Power analyzer
- PC with printer and network interface
- User defined software

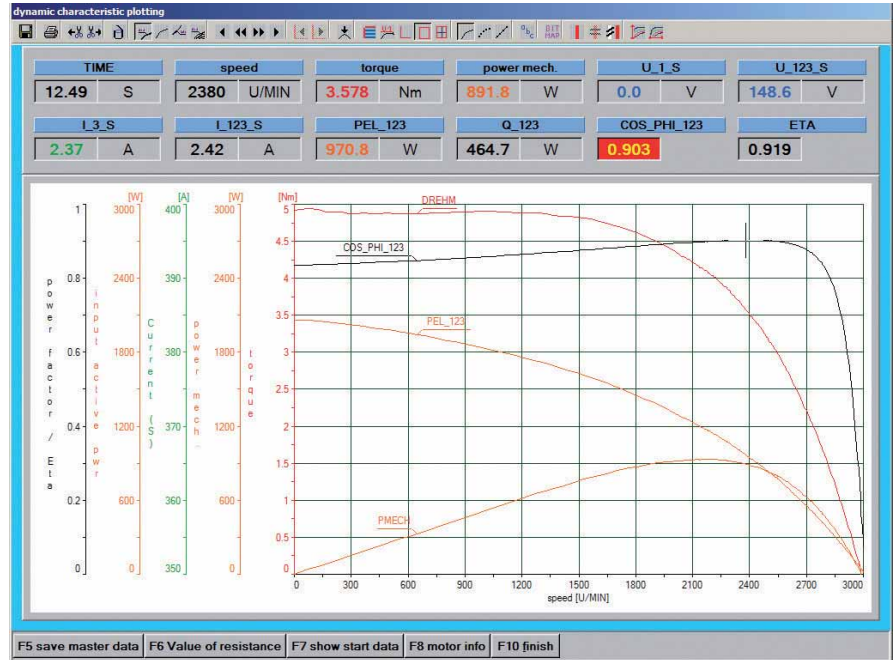
Software

Control

The software serves for parameter assignment of the test stand including the converter for the active brake and the test sequences of the test system, so that an optimum of profitability and precision is achieved.

Control functions

- Diverse test modules
- Manual operation
- Characteristic (dynamic, stepwise)
- Locked motor torque test
- Friction loss measurement
- Warm-up operation
- Static operation
- No load
- Families of characteristics
- Harmonic values
- Load cycles/cyclical load
- Step changes in load with transient data collection
- Load/start-up characteristics
- Recorder
- Customer specific applications
- Laboratory report



Monitoring

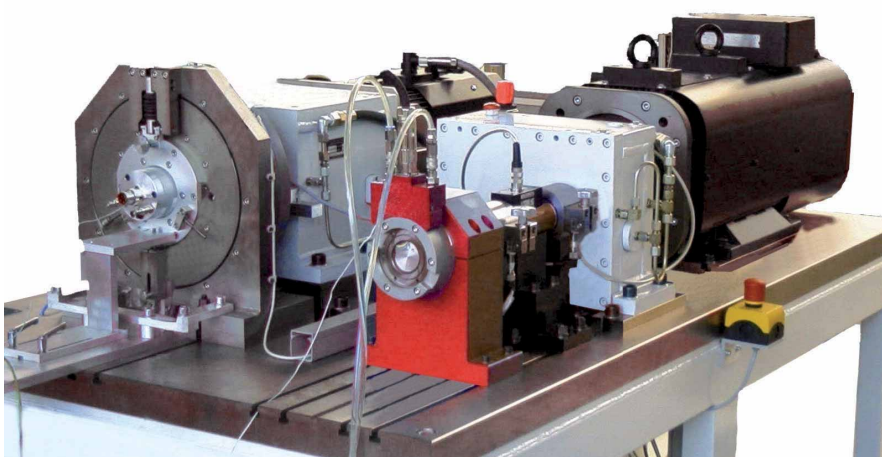
The software is especially useful for simulating loads of the cyclical working conditions of specimen. Additionally, measuring signals with limit values are

monitored to generate in production plants and quality control tasks on a go or no go decision.

Test stand for electric motor spindles
 (Speed 120 000 min⁻¹, 6 kW
 Speed 50 000 min⁻¹, 45 kW)

Monitoring functions

- Menu controlled, multilingual user prompting
- High-speed data collection
- Menu controlled calibration of the torque sensor
- Graphic and numeric display and output (printer) of measured values
- Test parameter management
- Storage of the measuring data
- Processing of stored graphic data (scaling, color, section)
- Curve optimization and adjustment
- Data export/import
- Statistical evaluation



From XS to XXL ...

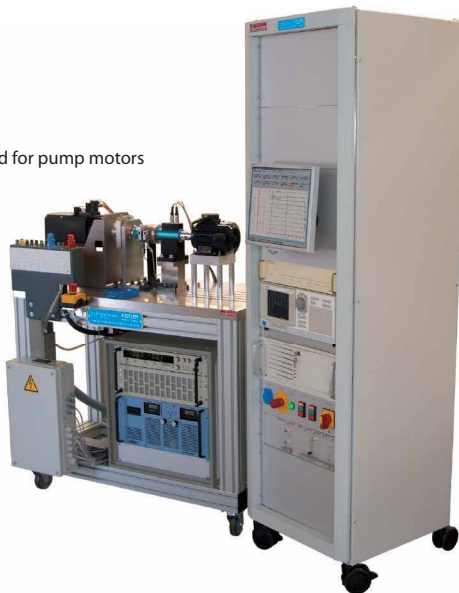
With scalable features such as lifting device, adjustable fastening of specimen, integrated torque calibration device, gear unit for torque and speed adjustment, climatic chamber, noise

insulation and much more, we will design the most suitable test stand solution for your individual requirements.



Loading unit for drives

Test stand for pump motors



Test stand for gearboxes (Vertical measuring alignment)

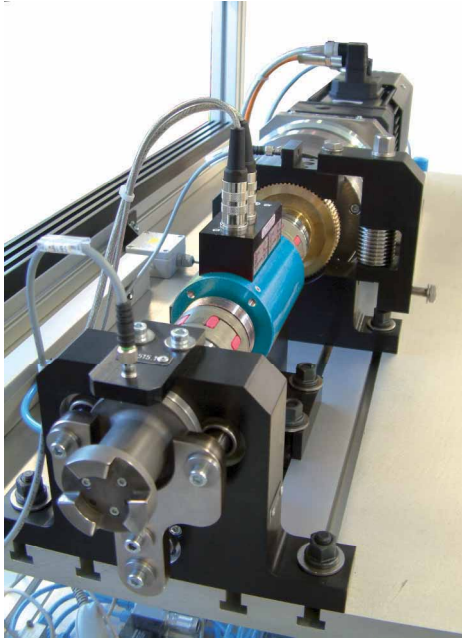


Test stand for blower motors



Electric motor test stand with lifting device and high-performance gearbox

... nothing's impossible!



Test stand for wheelchair drives
(Final inspection)



Controller electronics for compact systems
(Mechanical set-up with noise insulation
and climatic chamber)



Torque measurement

The precise measurement of torques at rotating drives and components is a very important criterion for an effective product designing and a safe quality control in production and assembly.

The universal dual-range torque sensor Type 4503A... therefore offers a variety of flexible application possibilities.



Torque sensor Type 4503A... dual-range sensor
with integrated speed measurement

Test stand systems – for your motors, too ...



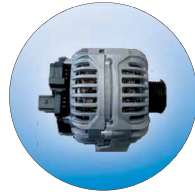
Vacuum cleaner universal motors



DC motors



Electronic motors



Motor vehicle generators



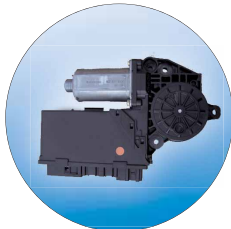
Windshield wiper motors



Drill hammers



Angle grinders



Window lifters



Induction motors



AC motors



and your motor ...




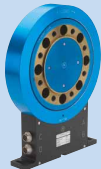
Test stand for window lifters and seat adjustment

Performance portfolio

Type of test stand	Specimen	Range of performance*
Electronic motor test with and without load for development and laboratory	1+3 Ph AC-drives, gear-motors, DC-motors, synchronous motors, converter/controller plus motor	10 W ... 500 kW 0 ... 120 000 min ⁻¹ 0,05 ... 25 000 N·m
Generator test stands for R&D	DC- and AC-generators, starter generators	100 W ... 150 kW 0 ... 50 000 min ⁻¹ 0,05 ... 500 N·m
Continuously operating test stands for electrical drives and generators, optional with climatic chamber	Standard motors, electronic tools, motor vehicle generators	10 W ... 150 kW 0 ... 20 000 min ⁻¹ 0,05 ... 500 N·m -40 ... 180 °C
Measuring and evaluation of friction torque at rotating components	Bearings, switches, ball screws, gear boxes	0 ... 10 000 min ⁻¹ 0,05 ... 1 000 N·m
Test stations for final inspection in manufacturing/assembling	Electric drives, general	10 W ... 150 kW 0 ... 20 000 min ⁻¹ 0,05 ... 500 N·m

^{*)} extra ranges on request

Rotating torque sensors (selection)

Type	Measuring range [N·m] min. - max.	Accuracy class	Mechanical connection	Max. speed [min ⁻¹]
 <p>4503A... Digital dual-range sensor with brushless transmission (data sheet 4503A_000-595)</p>	0,2 ... 5 000	0,1	Shaft	50 000
 <p>4504A... Torque measuring flange – short profile, robust, bearingless, high accuracy (data sheet 4504A_000-598)</p>	50 ... 5 000	0,1	Flange	15 000

www.kistler.com

KISTLER
measure. analyze. innovate.

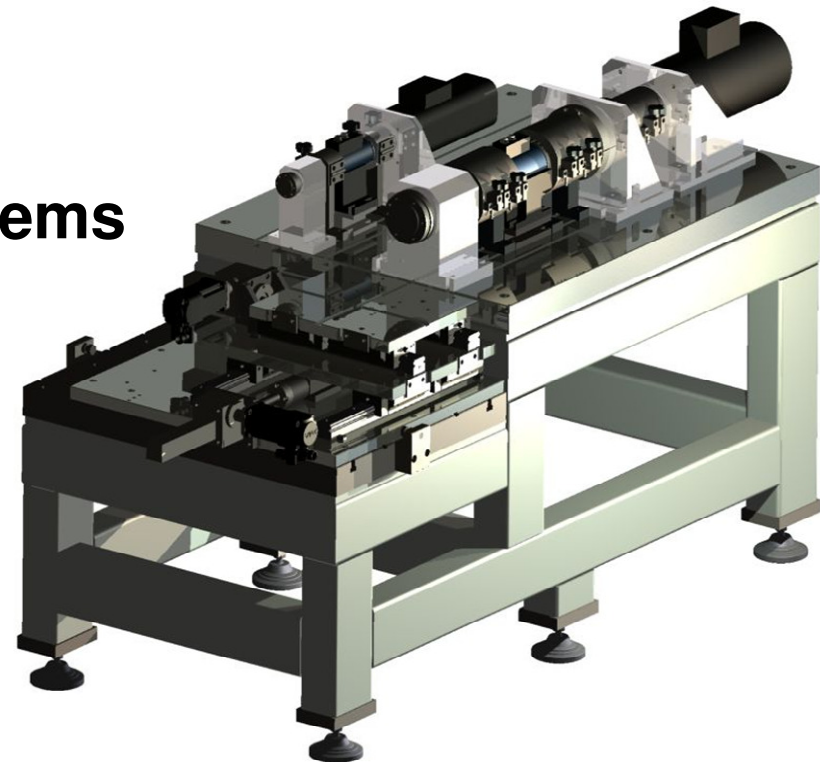
Kistler Group
Eulachstrasse 22
8408 Winterthur
Switzerland
Tel. +41 52 224 11 11
Fax +41 52 224 14 14
info@kistler.com

Dr. Staiger, Mohilo + Co GmbH
A Kistler Group Company
Maierhofstrasse 6, 73547 Lorch
Germany
Tel. +49 71 72 184 0
Fax +49 71 72 184 400
info.staiger@kistler.com

Kistler Lorch GmbH

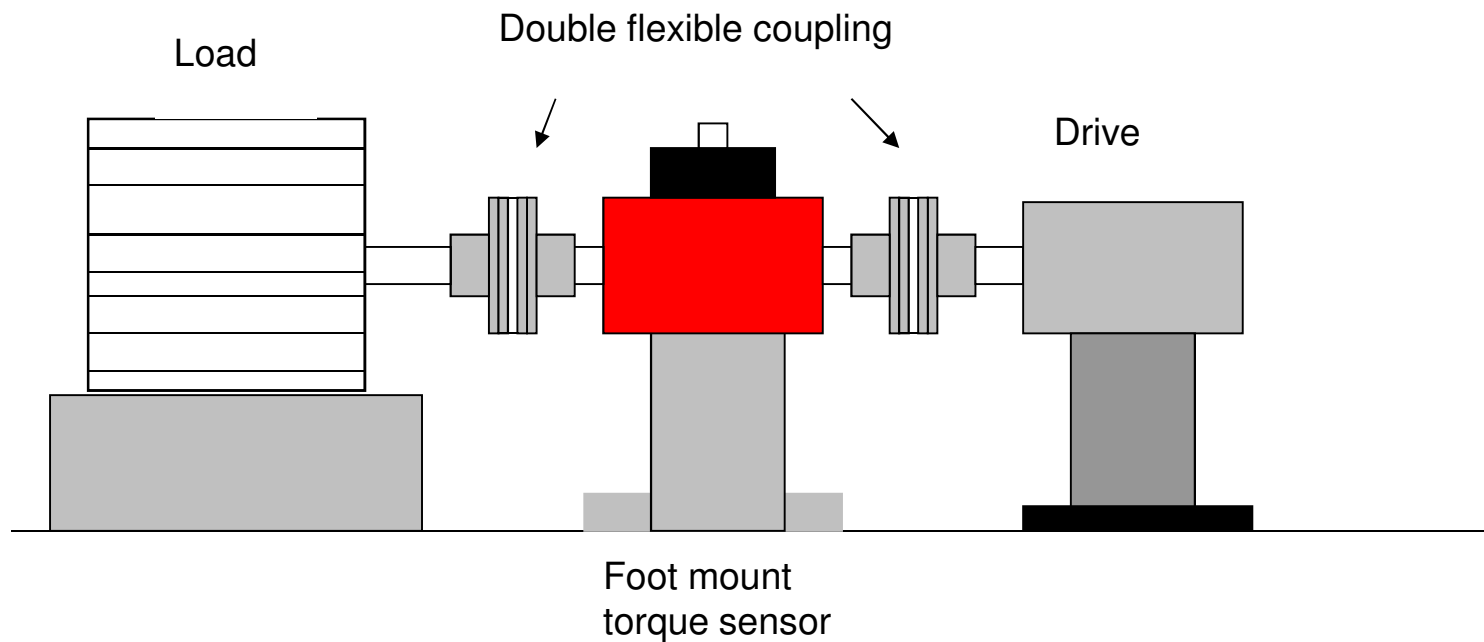
Test Stand Systems for:

- **Electric Motors**
- **Gear boxes**
- **Inverter + motor systems**



APPLICATION SCHEME

Test Stand For Electric Motors



Foot mounted shaft, use double flex coupling to compensate the parallel and angular misalignment.
Good alignment of foot mounted units is still necessary to reduce loads on the bearings.

Generals about high efficient KLR motor test system

The system is applied for testing of electro motors and electric drive systems.

As a load machine a three-phase AC Servo motor is used controlled by a 4-quadrant pulse converter.

During brake operation the energy is fed back to the mains.

The load machine can be driven in 3 different modes:

- Speed constant
- Torque limited
- Torque controlled

The current-, voltage-, and power values (static or dynamic) obtained at the load point are measured by a Power Analyzer.

KLR sensors measure torque & speed.

An automation software for parameterization, control and data management is provided. Measured data are displayed in real time during the automatic or manual test sequences

Limit guarding for all acquired measurements. GUI for numeric & graphic display, flexible scaling and post processing

Data interface for export and import; calculated characteristics can be imported as reference curves.

Measured parameters:

Mechanical quantities:

- Torque (1 mNm – 25,000Nm)
- Speed (0 – 150,000rpm)

Electrical quantities:

- Current (1 mA – 5000A)
- Voltage (6VDC – 1500VAC)
- Power
- Power factor
- Harmonics (I, U, P)

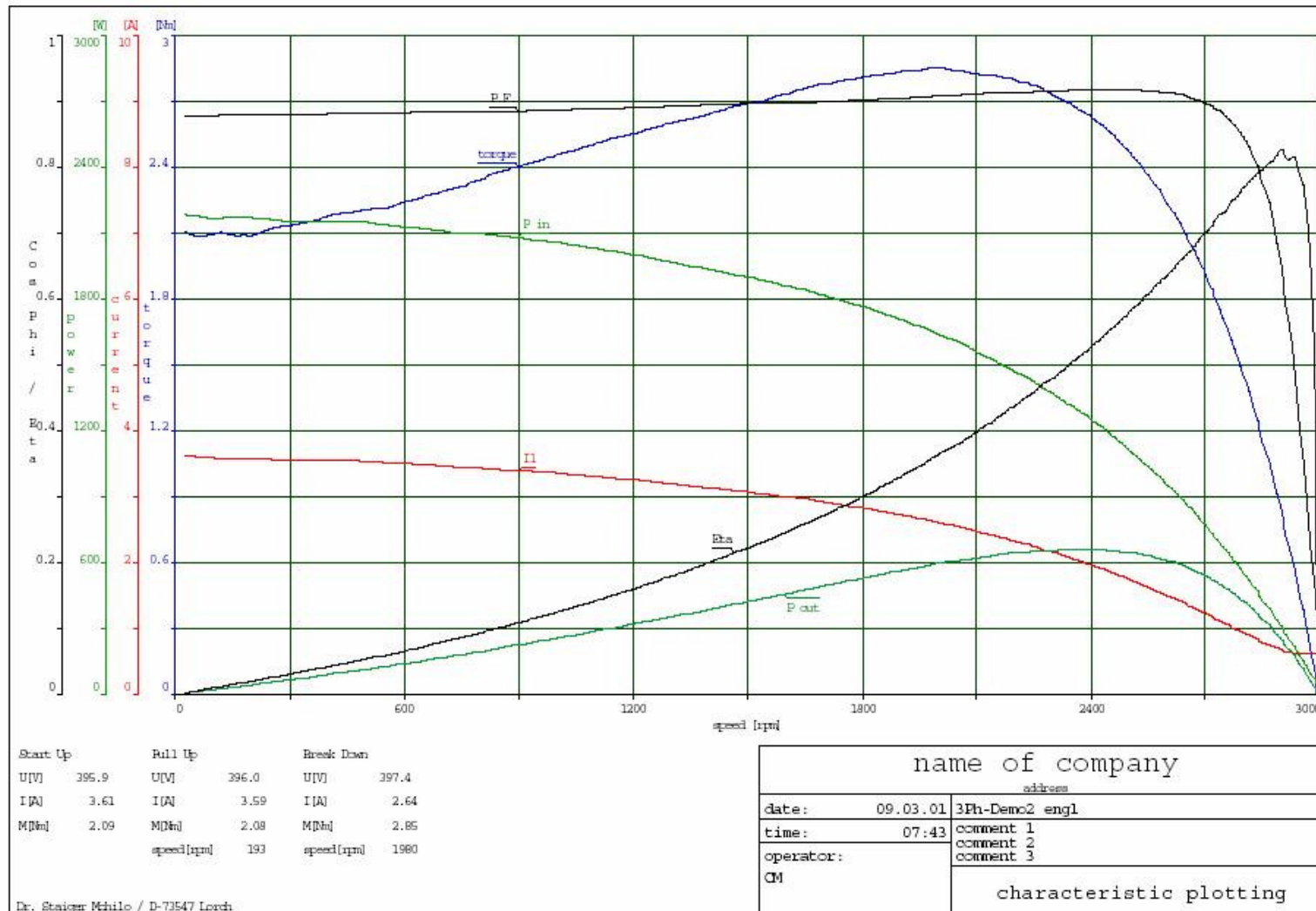
Calculated values:

- Mech. Power
- Efficiency

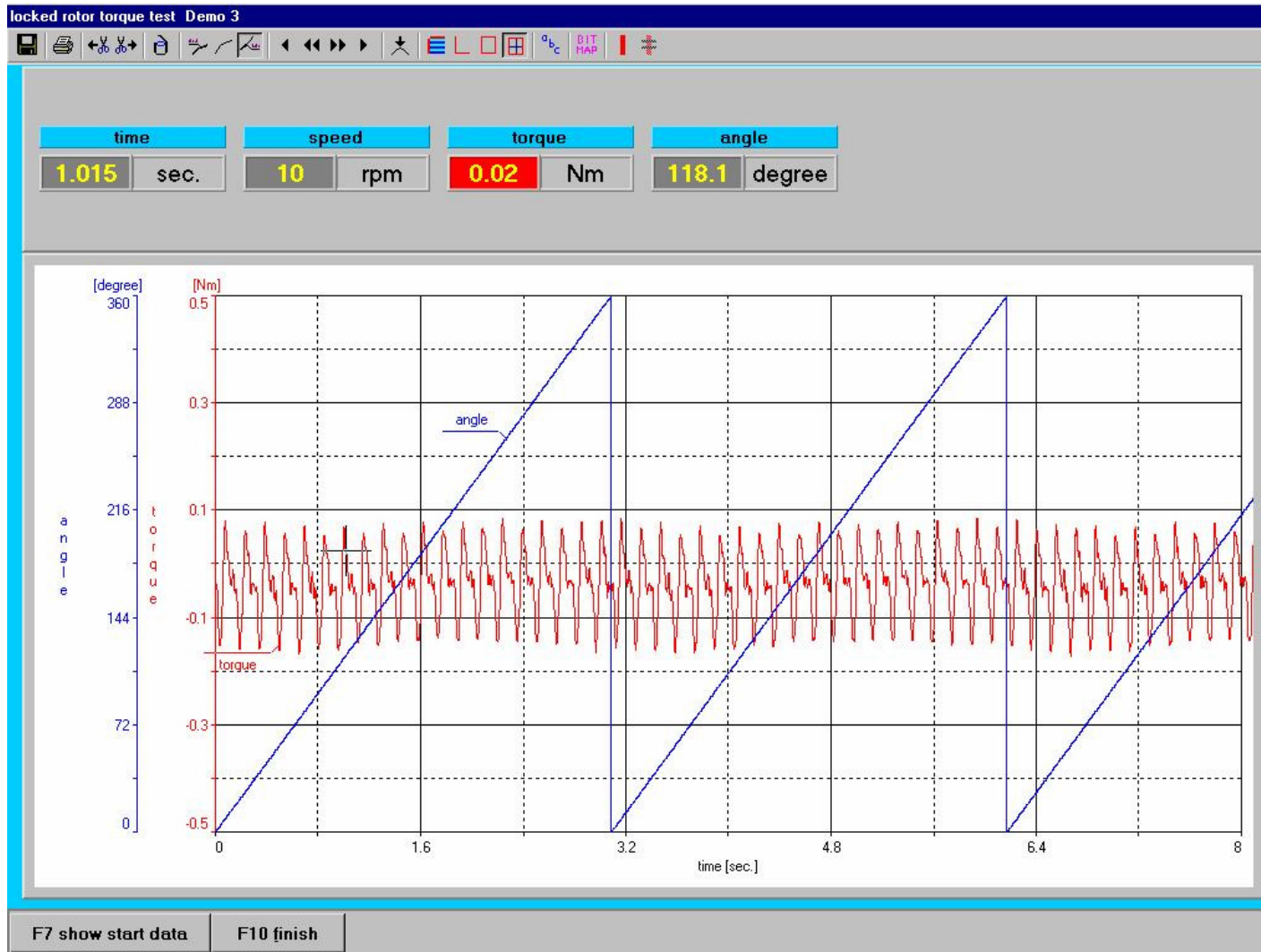
Additional values:

- Temperature
- Cooling (power, flow, pressure)
- Noise, vibration

Typical characteristic of a standard 3 phase AC motor



DC motor: Cogging torque = friction at 1 turn related to the angle position



Typical markets - Test stands

Faurecia-Seat Regulation (DC-Motors)

Motor 1: Rating speed 3000 min⁻¹

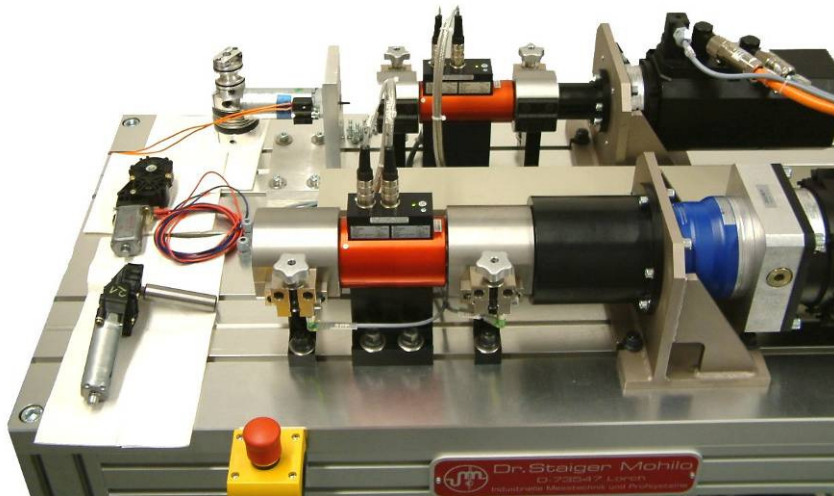
Rating torque 10 Nm

Motor 2: Rating speed 3000 min⁻¹

Rating torque 2,1 Nm

Test modules:

Voltage, electric current, speed, torque,
efficiency (mechanical)



Test stand for wheelchair electronic gears



Test stand for fork lifting motors



3AC motor with ECU

Rated speed 2000 min⁻¹

Rated torque 300 Nm

Test modules :

Voltage, electric current, speed, torque,
temperature, electrical performance,
mechanical performance, efficiency



Motor test system for R & D and validation

Test Stand
Kitech, Korea

Specimen:

- 1 ph UM-AC / UM-DC
- 1 ph + C
- 3 ph
- 3 ph + inverter
- DC
- BLDC



Laboratory layout

Switch cabinet for measurement devices:

- Resistance measurement
- Power Analyzer

Switch cabinet for power electrics:

- ECU for load machines 1+2
- regenerative power feature for brake operation

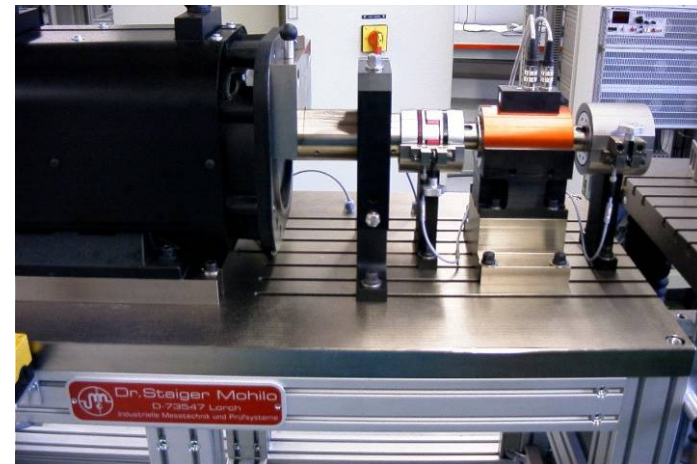
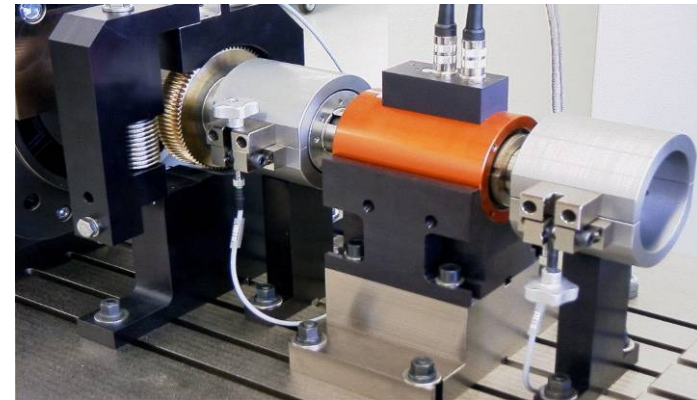
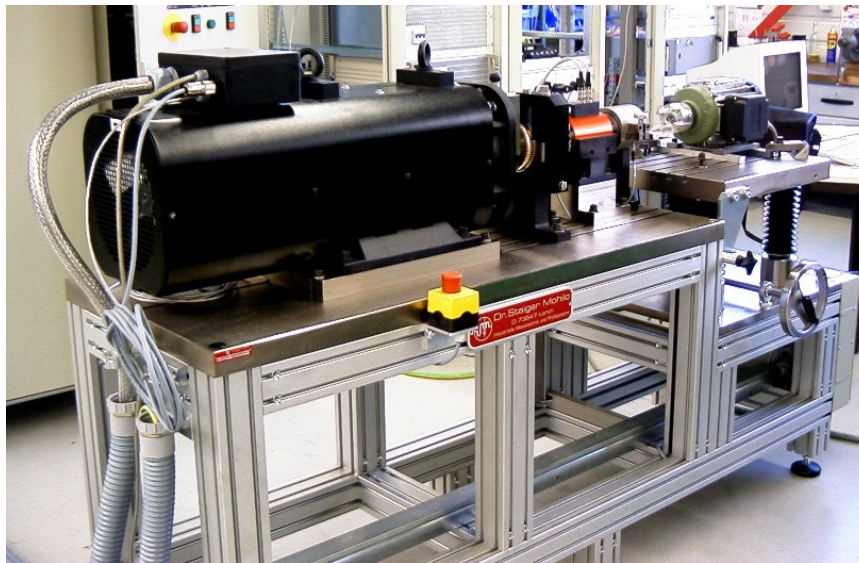


Switch cabinet for test stand operation:

- PC with monitor and keyboard
- Analog and digital control and measurement

**Test Stand
Iskra, Slovenia**

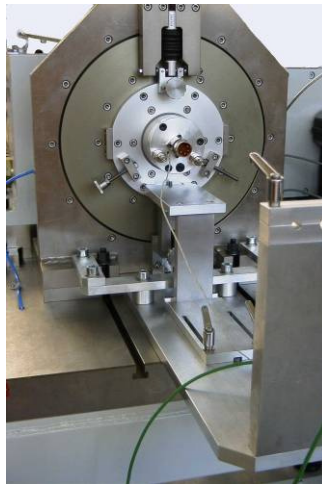
**Specimen:
BLDC**



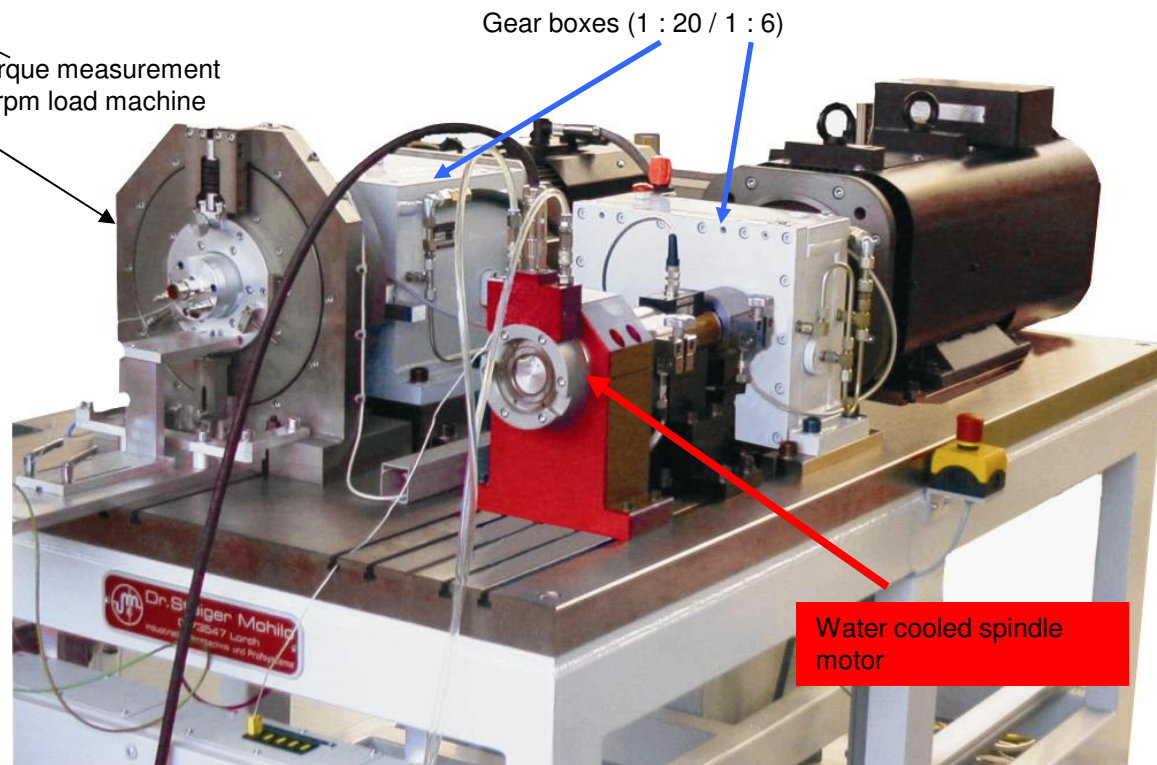
MOTOR TEST SYSTEM FOR HIGH PERFORMANCE SPINDLES

Customer: Jäger, Ober-Mörlen

Prüfling / specimen:	3 Phase - inverter
max. Drehmoment / max. torque:	25 Nm / 2 Nm
max. Geschwindigkeit / max. speed:	50000 / 120000 rpm
max. Leistung / max. power:	45 kW / 7 kW



Reaction torque measurement at 120.000 rpm load machine



Cabinets for power electric and measurement not shown

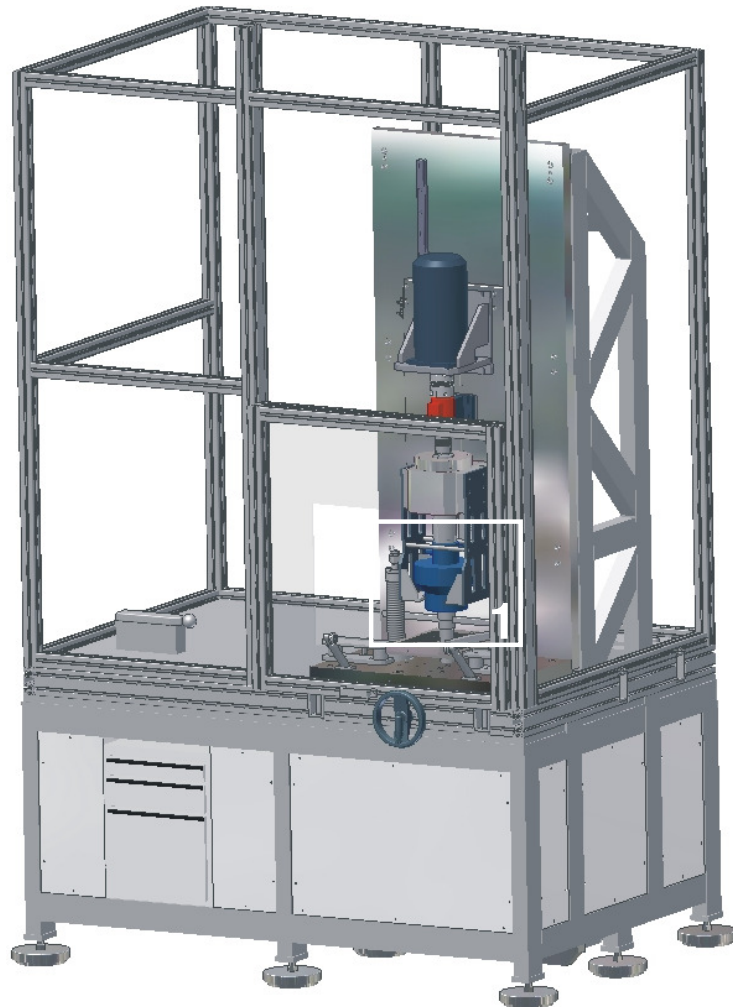
MOTOR TEST SYSTEM

Customer: N.N.

Prüfling / specimen:	BLDC, el. Hybridmotor
max. Drehmoment / max. torque:	500 Nm
max. Geschwindigkeit / max. speed:	10.000 rpm
max. Leistung / max. power:	115 kW



Customer: Wittenstein AG



Gear box EOL test stand:

- Noise: 40 .. 90 dB (A)
- No load torque
- Start up torque
- Axial deviation
- Radial deviation
- Angular deviation: $1 \times 10^{-5} \text{ }^\circ$



An automated test system for induction motor efficiency measurement to IEEE and IEC standards

KERI

KERI Motor Test Lab



Emmanuel Agamloh

Advanced Energy
Raleigh, NC, USA

Daewon Kim

Korea Electrotechnology Research
Institute
Changwon, Korea

Background

■ MEPS in Korea

- ▶ MEPS (minimum Energy Performance System) was effective since 2008 in Korea
- ▶ Test method is based on the IEC Standards
- ▶ A state-of-the art automated test lab was built at KERI to support the MEPS in Korea from 2008 to 2010
 - Test system can perform the efficiency tests meeting the IEC and IEEE standards
 - The lab is also accredited by NVLAP

■ Efficiency measurement to IEEE 112B and IEC 60034-2-1

- ▶ The IEC 60034-2-1 standard is loss segregation method that is practically equivalent to the IEEE 112 B as well as CSA 390
- ▶ Although practically equivalent, there are minor differences in the test standards
 - The way test is performed and how results are calculated

Description of the Test Facilities

KERI

TS-1



TS-2 & 3



TS-4



TS-5



- KERI Motor Test Lab consists of a set of five dynamometers
- Active load machines with 4-quadrant operation and precise torque and speed control by torque feedback
- Test system is capable of manual operation, partially automated operation or full automated
- The test stands can be operated independently
 - ▶ Integrate control software and PC terminal

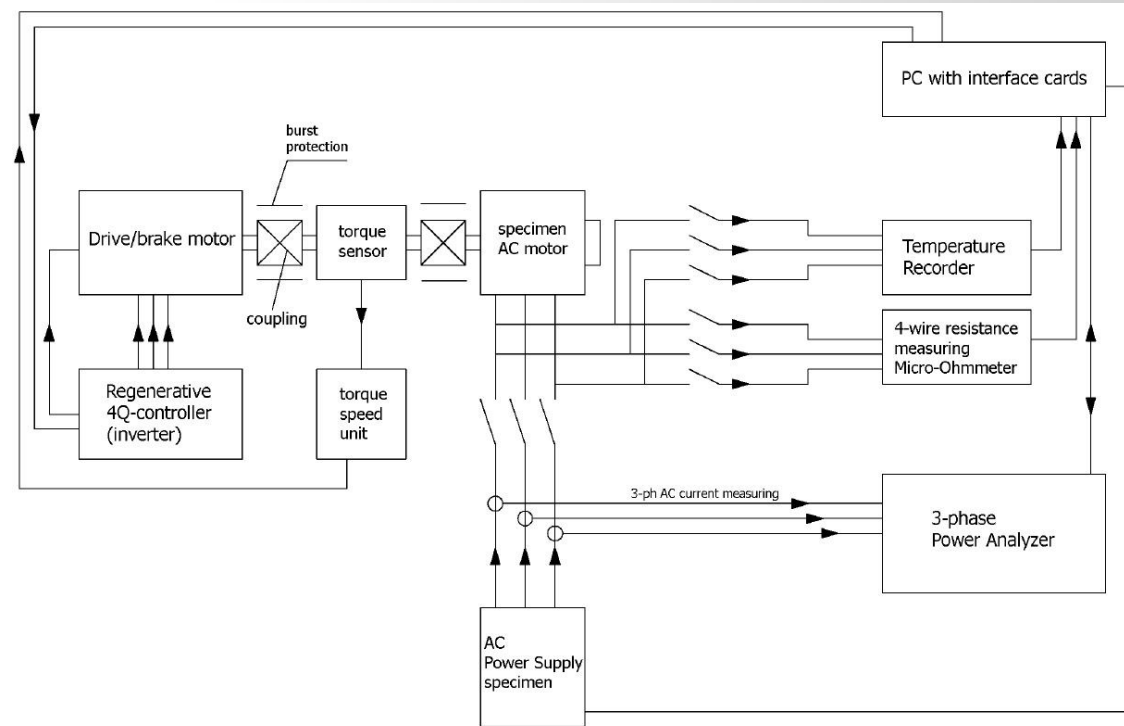
Ratings of each test equipments

Test Stand	Load Motor & drive	Torque sensor	Power Supply System		Current transducer ¹⁾
TS-1	340, 265	2500, 1000	0-600V, 50/60Hz	520A	700A
TS-2	89	350		200A	280A
TS-3	29	100		200A	280A
TS-4	12	30		30A	45A
TS-5	4.3	10		15A	Direct

- The aims of designing of test system is to guarantee the high accuracy both of control and measurement to cover the entire spectrum of motors covered in MEPS in Korea
- The MEPS currently covers the range of motors as followings:
 - from 0.75kW to 200kW
 - 2, 4, 6, 8 poles
- The most considerable points during design of test system were:
 - Selection of torque transducer
 - Sizing the load machine
 - Selection of power supply system and current transducers for electrical power measurement

General Test System Design

KERI



- Test motor and load motors are coupled through burst protection coupling with a flange torque transducer
- Each test stand is equipped with a measurement, instrumentation and data acquisition panel
 - Modern power analyzers for electric power measurements equipped with precise current transducers
 - Multi-channel thermocouples
 - Micro-ohmmeter for resistance measurement
 - PC terminal and integrated operating software
- Torque sensors are intelligent sensors with in-built amplifier and signal conditioning through an RS 232 interface

General Test System Design

KERI

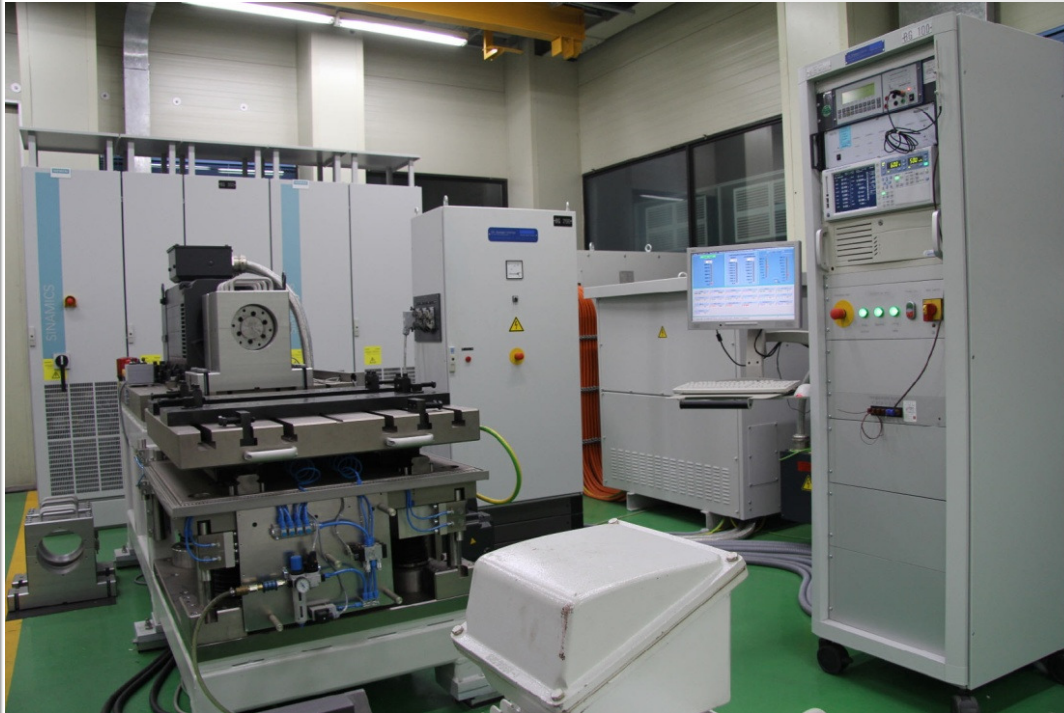


View of test stand#1 : largest dynamometer

- **Test bench** with lifting table motorized
 - A servo motor for vertical height adjustments up to 150mm
 - pneumatic device for horizontal adjustments and for locking the table
 - burst protection
- **Load machine and drive**
 - 340kW & 265kW
 - 2500Nm & 1000Nm
- **Power supply** system
- **Measurement and control** system
 - Current transducer in power cabinet
 - Measurement cabinet
 - PC and system software
- Test stand controlled from control room only with monitor, keyboard and mouse

Power Supply and pneumatic table

KERI



Pneumatic table and Power supply system

Power supply system

- Power supply system consists of:
 - Sinamics inverter module
 - Sine wave filter
 - Fixed and adjustable transformers
- 0-600V, 50Hz or 60Hz
- Voltage control
 - Transformer system - initial coarse control for the wide range
 - Sinamic inverter module to fine tune the voltage to the specified level

Pneumatic table

- Servo motor for height movement
 - Minimum step : 1/100mm
 - Maximum adjustment : 150mm
- Pneumatic devices
 - 6 bar
 - Horizontal adjustment and locking

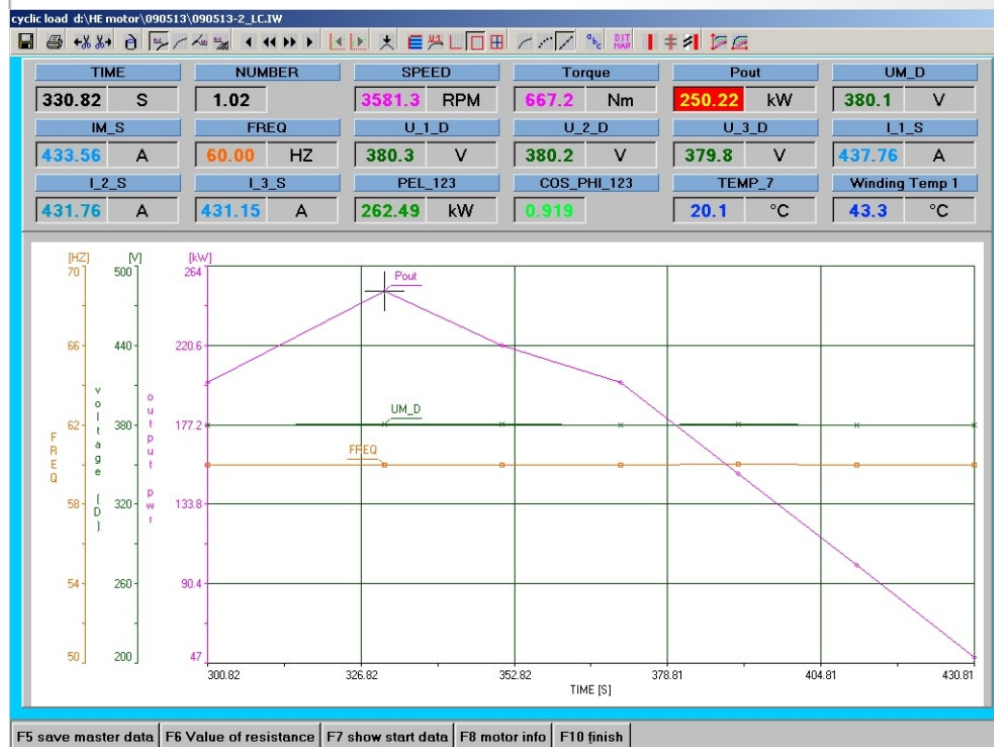
Measurement and Instrumentation

KERI

- **Measurement system consists of:**
 - Sensors, measurement cabinet & Interface car and System software
- **Sensors**
 - High precision Current transducers with power supply
 - Modern flange-type torque sensor : 0.05% of full scale
- **Measurement cabinet**
 - Precision and modern power analyzer : 0.02 % of full scale
 - Micro-ohmmeter : 0.03%
 - Temperature measuring modules : 0.2%
 - PC
- **Interface card**
 - Analog interface with 8 analog input (ADC 16-bit resolution) and 4 analog outputs(DAC 14-bit resolution)
 - Digital interface with 32 digital inputs and 32 opto-decoupled digital outputs
 - GPIB interface for controlling of WT3000 power analyzer
 - RS232 interface for controlling of MGR 10 Micro-ohmmeter
 - Profibus and Watchdog interfaces
- **System software**
 - Automatic test program to IEC and IEEE standard,
 - Manual, semi-automatic, fully-automatic operation

Automation of measurements

KERI



GUI of automatic test software : load tests

- **Loss segregation techniques**
 - Step 1) cold resistance measurements
 - Step 2) rated load temperature rise tests (heat run)
 - Step 3) Load test at six load points
 - Step 4) no-load tests with motor uncoupled
- **Operation mode**
 - Manually, semi-automatically and automatically
 - System settings all in master data file before tests
 - GUI is provided to monitor the statue of tests
- **Hot resistance measurement**
 - Criteria for stability, number of measurements, time period all set in master data
 - The resistance values extrapolated to time $t=0$
 - Test data exported into excel
- **Data saving and automatic calculation of efficiency using excel workbook**
 - Automatic calculation of efficiency according to IEC and IEEE standards

Reasons for measuring Efficiency to IEC and IEEE requirements

KERI

■ MEPS in effect in Korea since 2008

- General purpose three-phase induction motors from 0.75kW to 200kW, 2, 4, 6, 8 pole
- Test method : KS C IEC 61972 method 1 equivalent to IEC 60034-2-1 residual loss method

■ Competence and credibility in efficiency testing

- KERI motor test lab has NVLAP accreditation operated by the US federal agency, NIST
- IEEE 112 B for NVLAP

■ Automated test system developed to simultaneous meet both standards

- Measurement and computation of efficiency according to IEEE 112B and IEC 60034-2-1

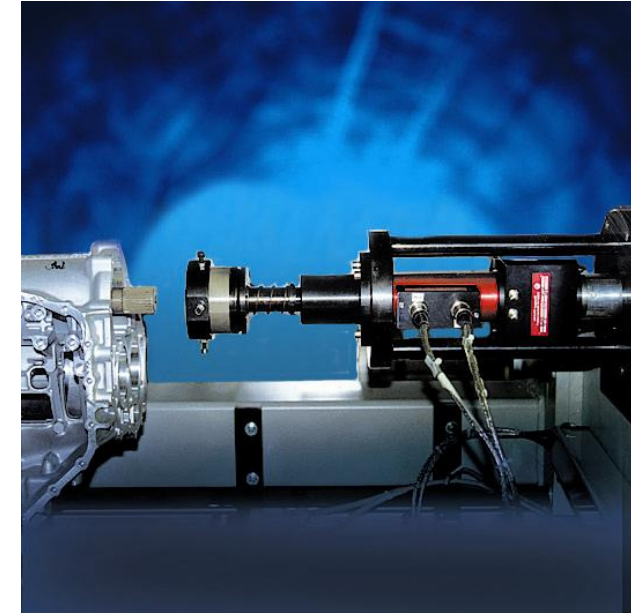
TEST SYSTEMS FOR ELECTRICAL MOTORS

Performance Portfolio

Type of test stand	Specimen (examples)	Performance range (extra ranges on request)
Testing of electric motors (+inverter) for R&D	1 + 3 Ph AC – drives gear motor, DC-motor Synchronous motor Inverter/controller + motor El. Hybrid motor	10W..... ~ 500 kW 0..... ~ 120000 rpm 0.001..... ~ 25000 Nm
Generator test stands for R&D	DC- and AC-generators Starter-generators	100W..... ~ 120 kW 0..... ~ 50000 rpm 0.05..... ~ 1000 Nm
Continuously operating test stands for electrical drives and generators optional with climatic chamber	Standard motors Electronic tools Motor vehicle generators	10W..... ~ 80 kW 0..... ~ 20000 rpm 0.05..... ~ 500 Nm -40 °C..... +180 °C
Measuring and evaluation of friction torque at rotating components	Bearings Ball screws Gear boxes	0..... ~ 10000 rpm 0.05..... ~ 1000 Nm
Test stations for final inspection in manufacturing / assembling	Electric drives, general	10W..... ~ 100 kW 0..... ~ 20000 rpm 0.05..... ~ 500 Nm

APPLICATION FOR MOTOR TEST STANDS

- Wheelchair electronic gears**
- Drive and brake machine for motor saw**
- Wiper window screen motors**
- Window-lift motors**
- CNC spindle motors**
- Starter motors**
- Alternators**
- Fork lifting motors AC/DC**
- Drilling machines**
- Power tools**
- stepper motors**
- Testing pumps for aircraft**
- Testing ball screw spindle**
- Test stand for viscous clutch**
- Differential gear**
- Compressor motors (fridge)**
- Automobile, automatic and control gear**
- Test DC, AC motor with / without inverter**
- Hybrid-electric power train**
- Actuator for aircraft controller**

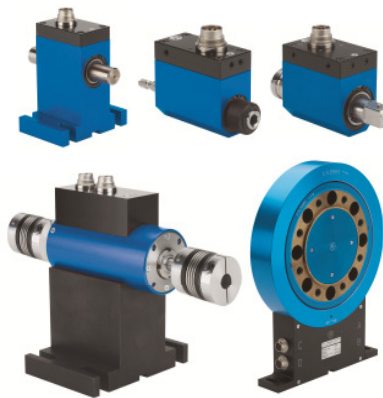


User for Torque Sensors and Test Stand Systems



Fastener Control, Miscellaneous:

STÖGER
BLUM
BLM
DANFOSS
KODAK
GROHE



Elektronik:

ROBERT BOSCH
HILTI
FEIN
SCINTILLA



Automobile & Automotive:

DAIMLER CHRYSLER
AUDI
BMW
VW
RENAULT
GKN WALTERSCHEID
BEHR
DAAF
AMG
ZF LENKSYSTEME
BOSCH REXROTH
SIEMENS
TRW
GETRAG
LENZE



Technical College:

Koblenz, Augsburg,
Frankfurt, Heilbronn,
Hannover, Osnabrück,
Kaiserslautern, Konstanz,
Heidelberg usw.

University:

Stuttgart, München,
Dortmund, usw.

Aviation:

LIEBHERR
AEROSPACE
WITTENSTEIN



WITTENSTEIN AG

Racing:

FERRARI, Formel 1
TOYOTA, Formel 1



Engineering:

HEIDELB.
DRUCKMASCHINEN
LSW
GROB



Mercedes-Benz Test Stand Systems



User for Test Stand Systems

HEIDELBERG

LIEBHERR

DAIMLERCHRYSLER

ZF Lenksysteme

TOYOTA

Rexroth
Bosch Group

BOSCH

WITTENSTEIN AG

Scintilla AG

SIEMENS

SAMSUNG

Danfoss

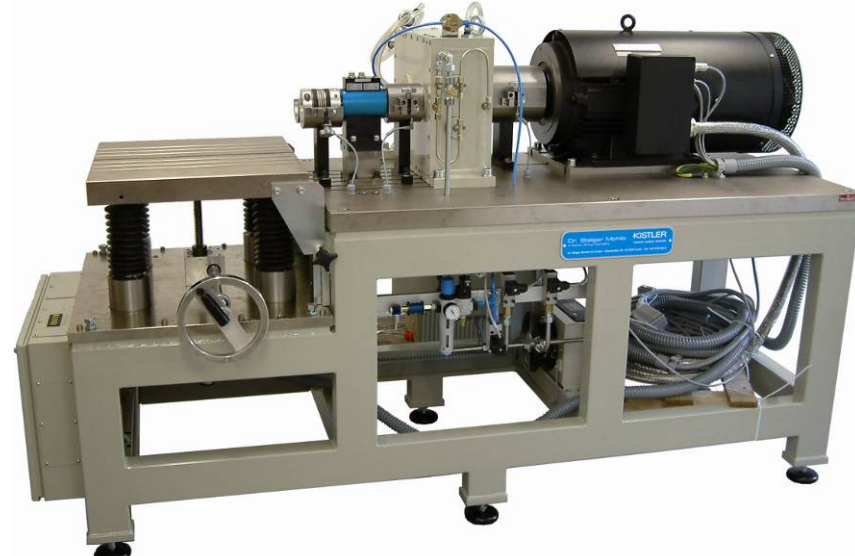
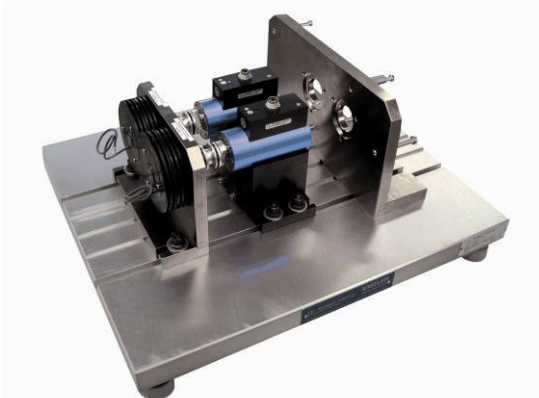
WABCO

KÄRCHER

faurecia

arçelik

HEIDELB. DRUCKMASCHINEN
FRAUNHOFER INSTUTUT
LIEBHERR AEROSPACE
DAIMLER CHRYSLER
ZF LENKSYSTEME
TOYOTA, Formel 1
BOSCH REXROTH
ROBERT BOSCH
WITTENSTEIN
SCINTILLA
SIEMENS
SAMSUNG
ARCELIK
FAURECIA
PIERBURG
THOMSON
DANFOSS
WABCO
KÄRCHER
WOLF MT



LENZE
TEVES
HELLA
HILTI
FEIN
ISKRA
DAAF
JÄGER
ELERO
GETRAG
STÖGER
METABO
ASPERA
RENAULT
BAUER
KODAK
GROHE
FESTO
GAMAK
GYRAX
PMDM

FEV
VDE
VW
LSW
AMG
BLM
API
TRW
IMS
IBL
TEE
ATS
ABS
AUDI
BMW
FORD
BLUM
BEHR
WILO
STILL



GYEONGNAM
TECHNOPARK

Ate

PIERBURG
Motor-Komponenten
VDE

Jäger
High Performance Spindles

ICTC
GAMAK

elero

Iskra
BLM

GETRAG
metabo

TRW
WILO

STÖGER
AUTOMATION