

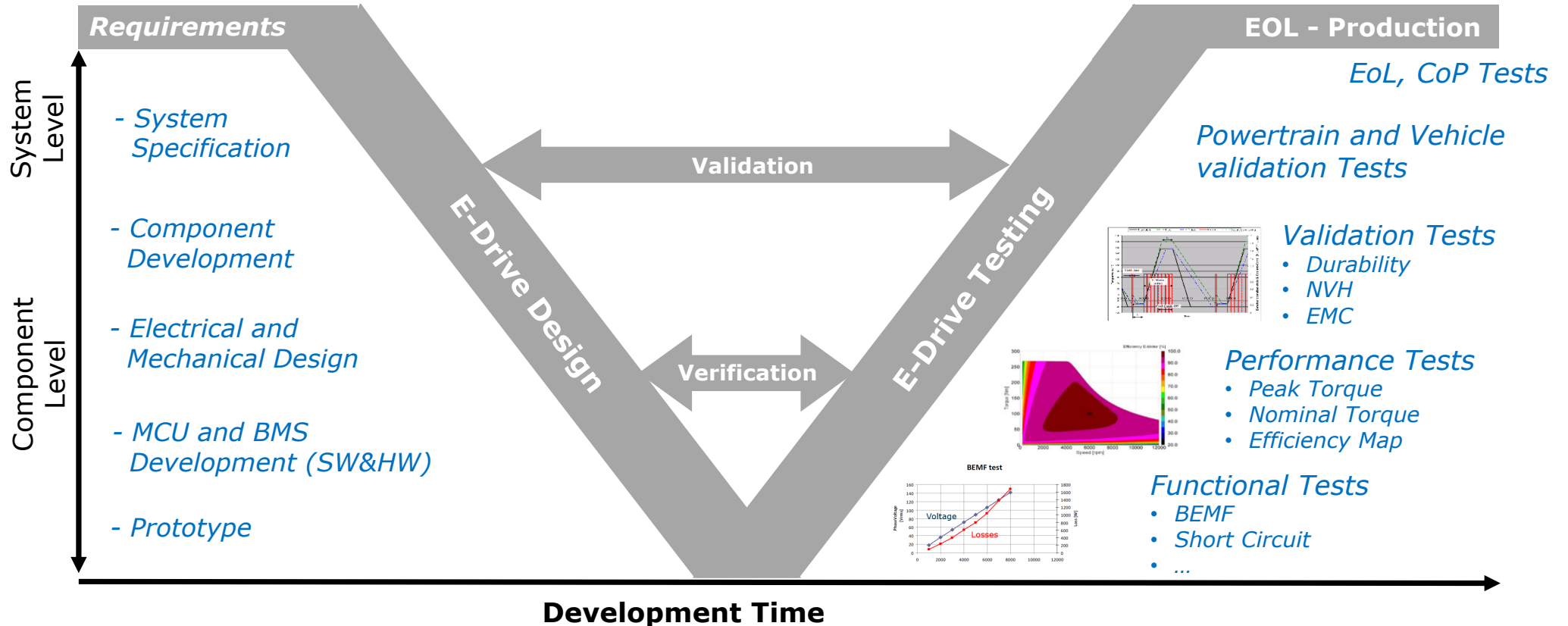


Für einen erfolgreichen DVP - Die besten Testsysteme für Ihre Herausforderungen

Alban Hemery

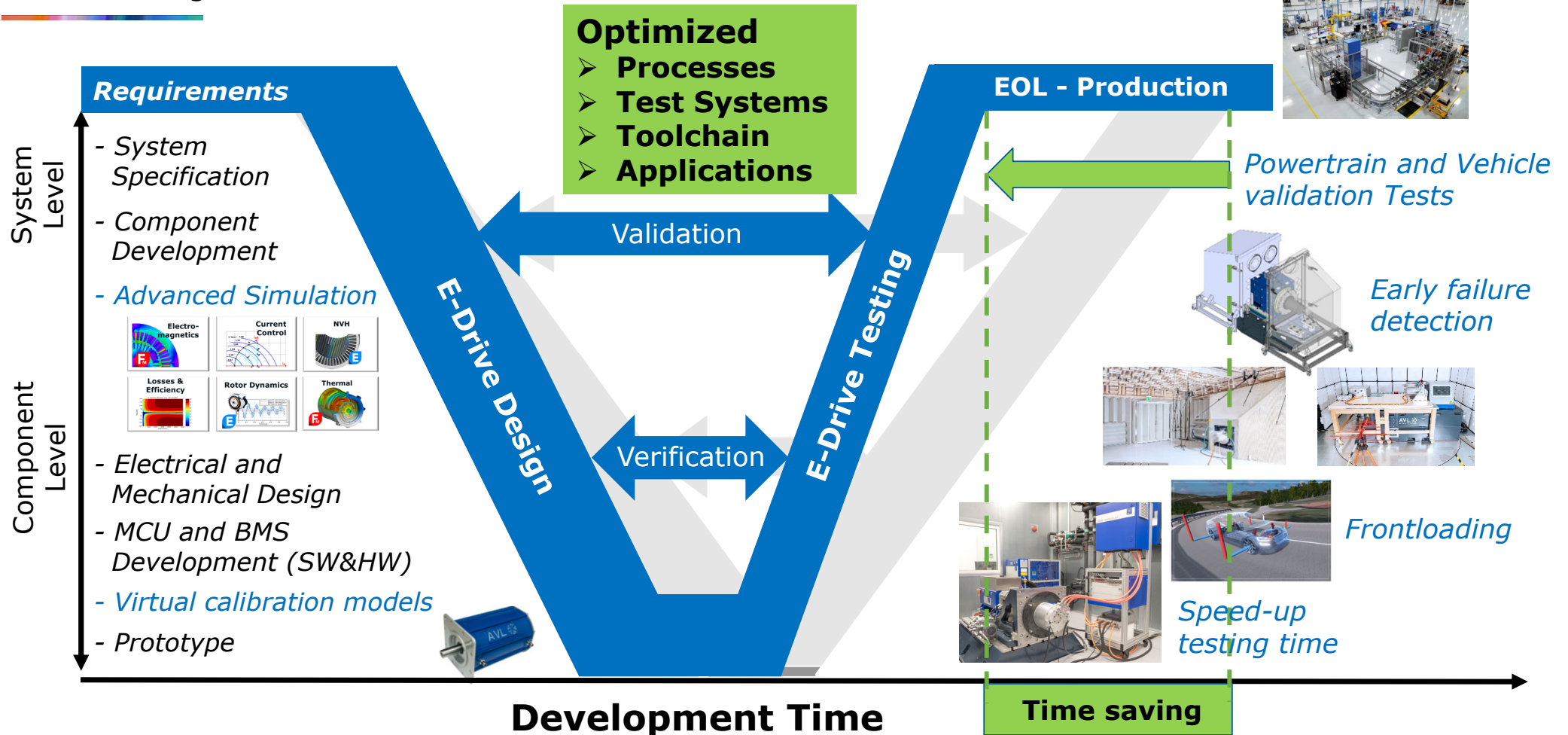
E-Drive Development Process

Tasks at Design and Validation



E-Drive Development Process

Tasks at Design and Validation



Challenges at E-Drive Testing

E-Drive Optimization

- Efficiency, NVH, Torque Ripple...
- Thermal optimization – Derating and Rotor temp. model

High quality measurements

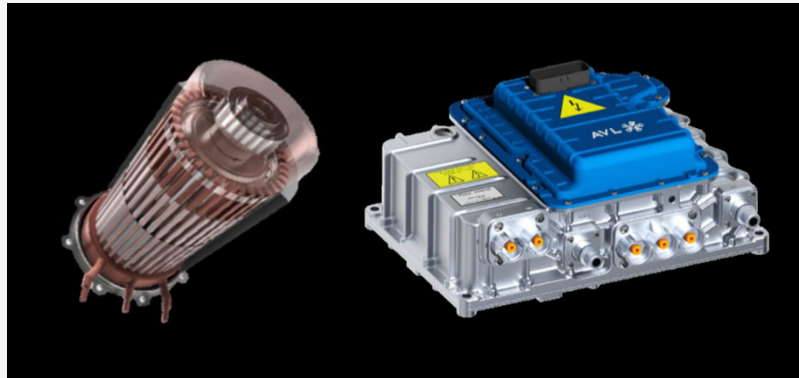
- High standard measurement equipment
- Measurement accuracy
- Known uncertainties of measurements

Data Analysis

- Huge Datafiles and data storage space
- Huge effort to extract the needed information

Big diversity of UUT's

- PMSM, ASM, EESM, SRM
- Different sizes, B-side support, Rotor internal cooling,
- High Speed-, Torque-, Voltage-, Current range



Frontloading

- Drivability – Accel-decel, Curbs, Offroad,
- Thermal behavior, Derating,
- Range estimation
- Safety- active short circuit

Time pressure

- Fast testing process with best quality results

Inverter availability

Safety

- UUT, Testbed, Operator

E-Motor Test System Solutions

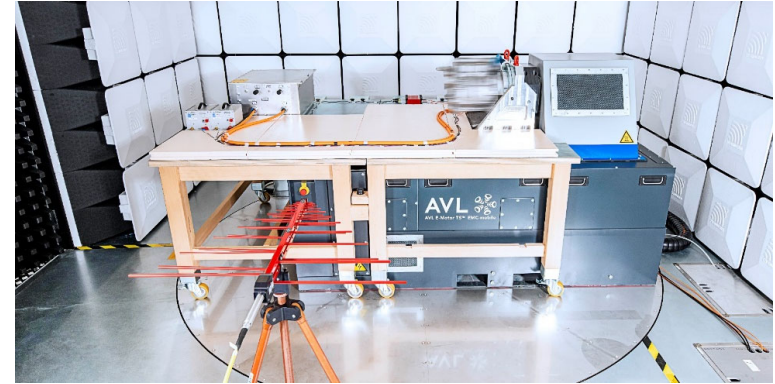
**Performance, Climatic, CoP,
E-Integration → IEC, ISO, GBT**



Durability → PTCE, HTOE, HTHE



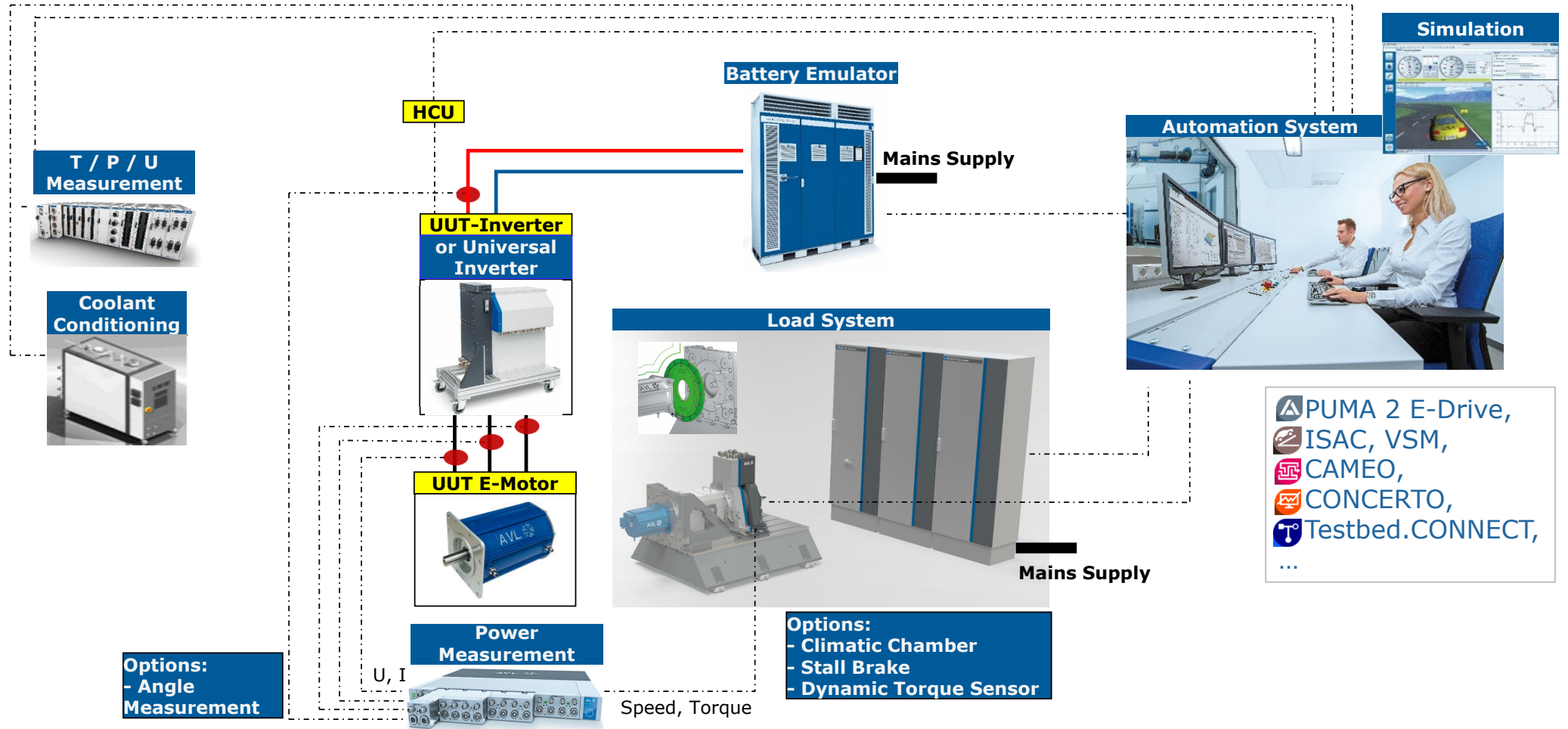
EMC → CISPR25, ISO11452



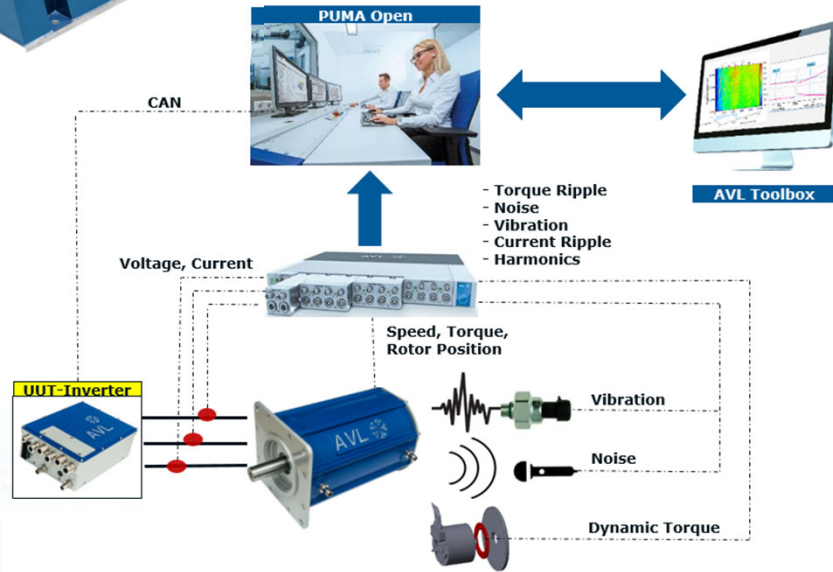
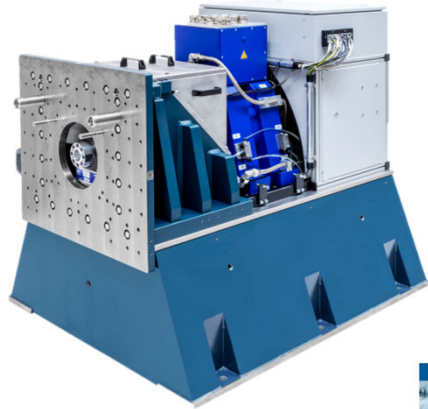
NVH → ISO3745



E-Motor TS Performance - Typical Testbed Setup



E-Motor TS Performance – Key Features (1/3)



Up to 550kW (660kW peak) /
650Nm (780Nm peak) / 25krpm
Standard optimised high speed mechanics and
dyno system with long bearing life time.
No derating at high speed and smallest footprint

**Power Measurement System
dedicated to Automotive test**
Measure dynamically, speed, torque, current,
voltage, noise and vibration with one device for
better analysis

High Dynamic Torque Sensor
Measure torque and lateral forces applied on
the UUT which you could never see before

E-Motor TS Performance – Key Features (2/3)



High performance speed control

High dynamic speed control
High precision low speed measurement and control.

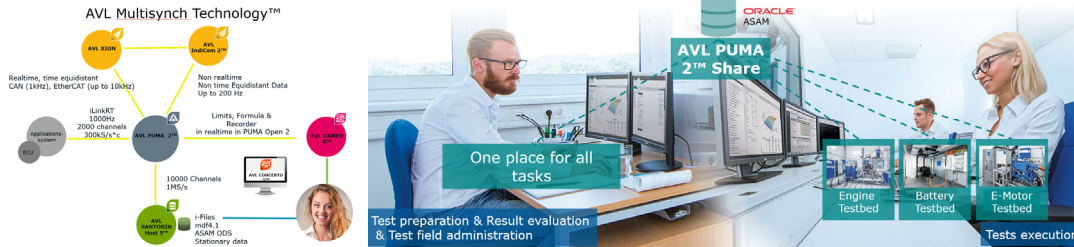
Advanced E-Drive Calibration

Save 80% time in E-Drive calibration and maximise the efficiency and driveability of your E-Drive system

E-Motor Identification Process

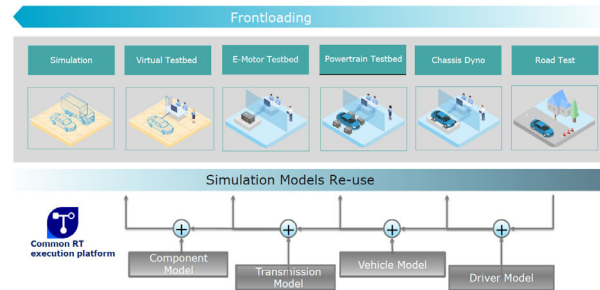
Lean & continuous testing process from AVL E-Drive testbed to AVL Inverter testbed

E-Motor TS Performance – Key Features (3/3)



Synchronised & Central Data Management

High Performant and Optimized Interfaces, Synchronized Data, central management of parameters and result data



Front Loading Toolchain

Real-time BEV simulation, Manoeuvre-based Vehicle & Driver simulation, connect your own real-time (@10kHz) and offline models to the testbed

E-Library – Works out of the box - Customisable

Testing standards



ISO 16750



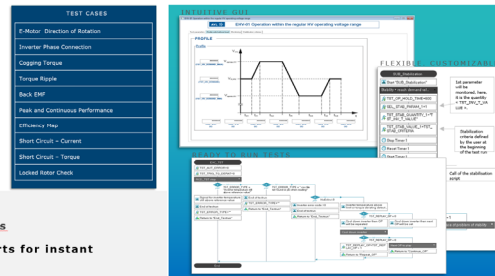
IEC 60349



Chinese National Standard GB/T 18488_2

E-Library

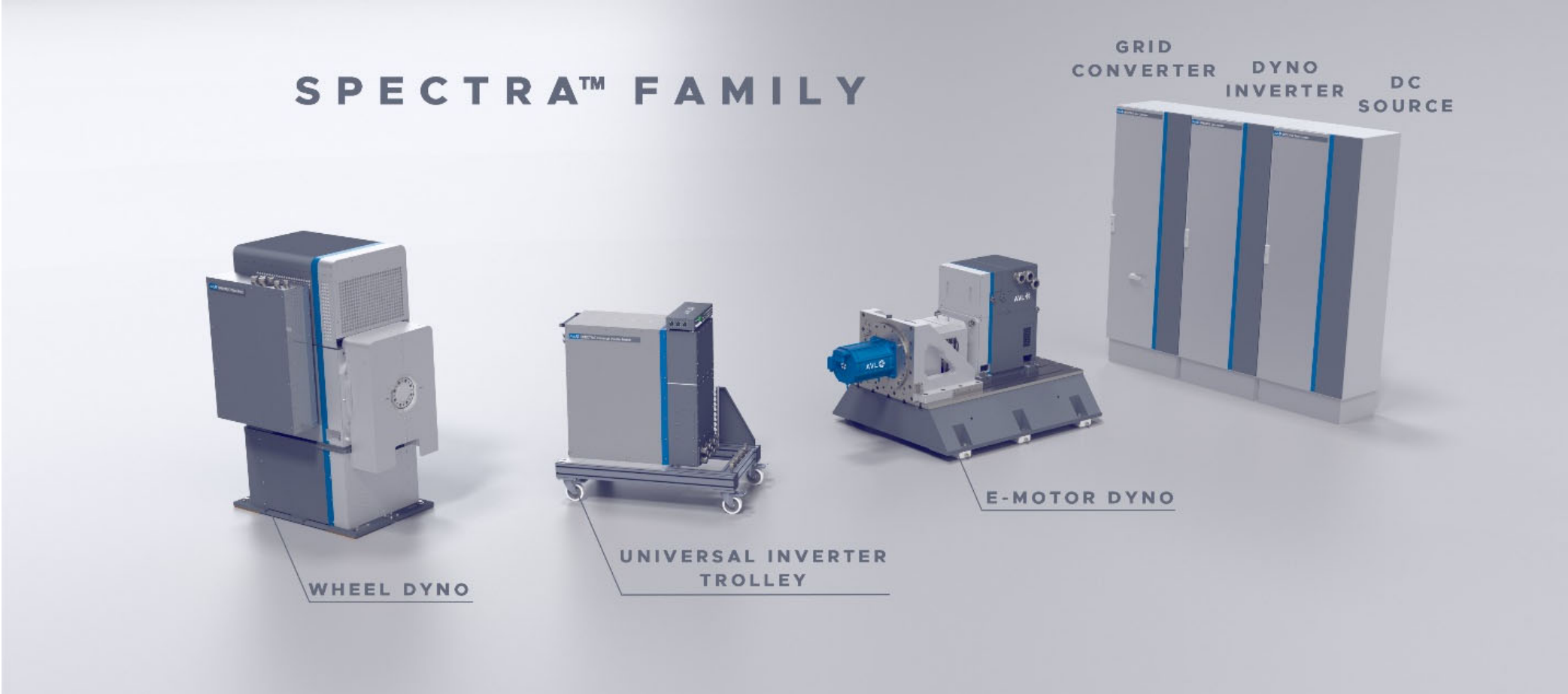
- Ready to use testruns
- Automatic data reports for instant data Analysis



E-Library

Ready to use test runs according to testing standards (ISO, IEC, GB/T...), Automatic data reports for instant data Analysis

AVL SPECTRA™ Modular, Compact and High Performance Power Electronics



AVL SPECTRA™ Reduced Cabinet footprint



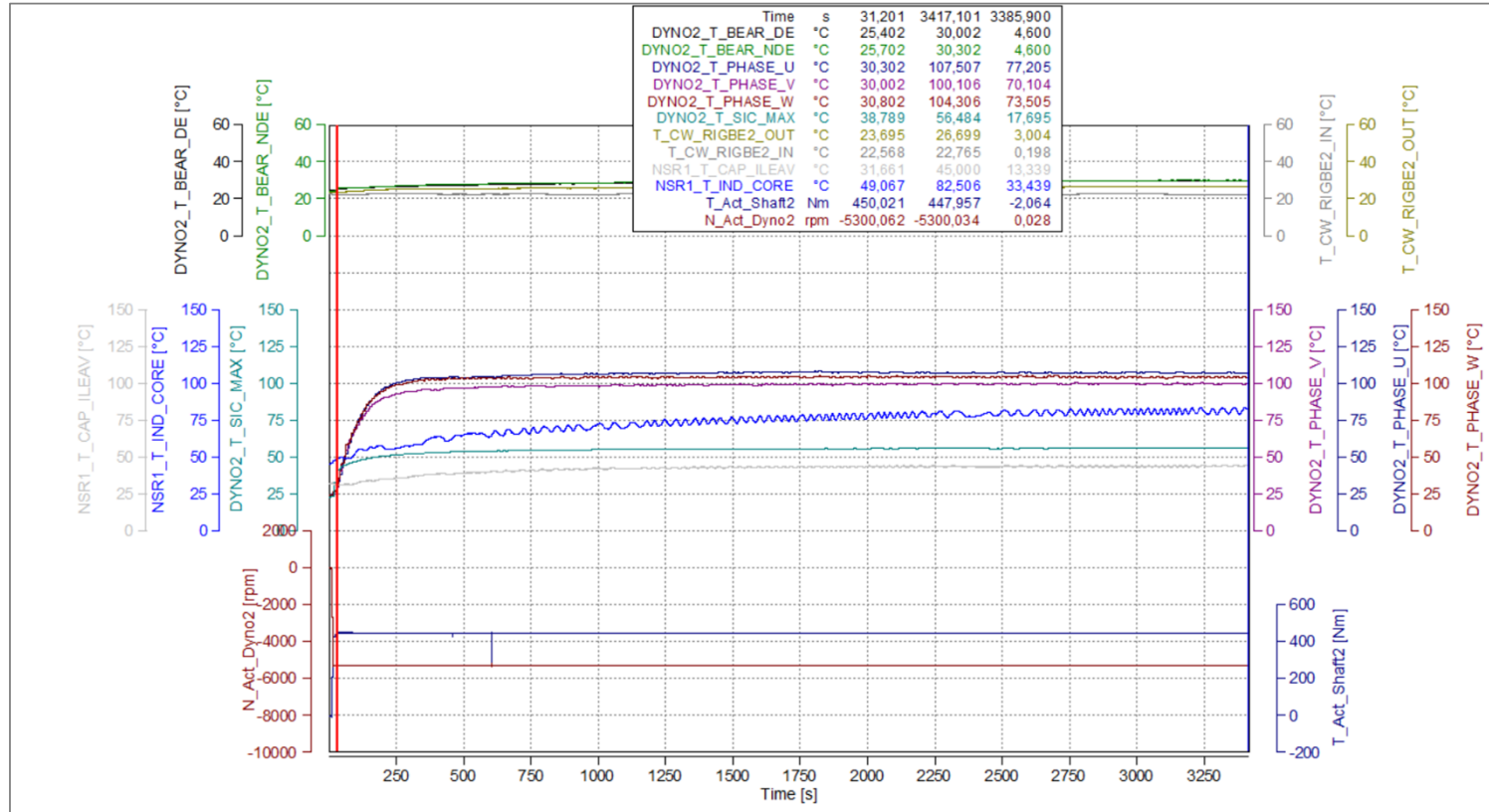
Vs.



Example for a 25.000 rpm / 500 Nm / 350kW Load Unit

AVL SPECTRA™ E-Motor Load Unit

Heat Run: nom. load @ nom. speed // PMM 450/5.3-25

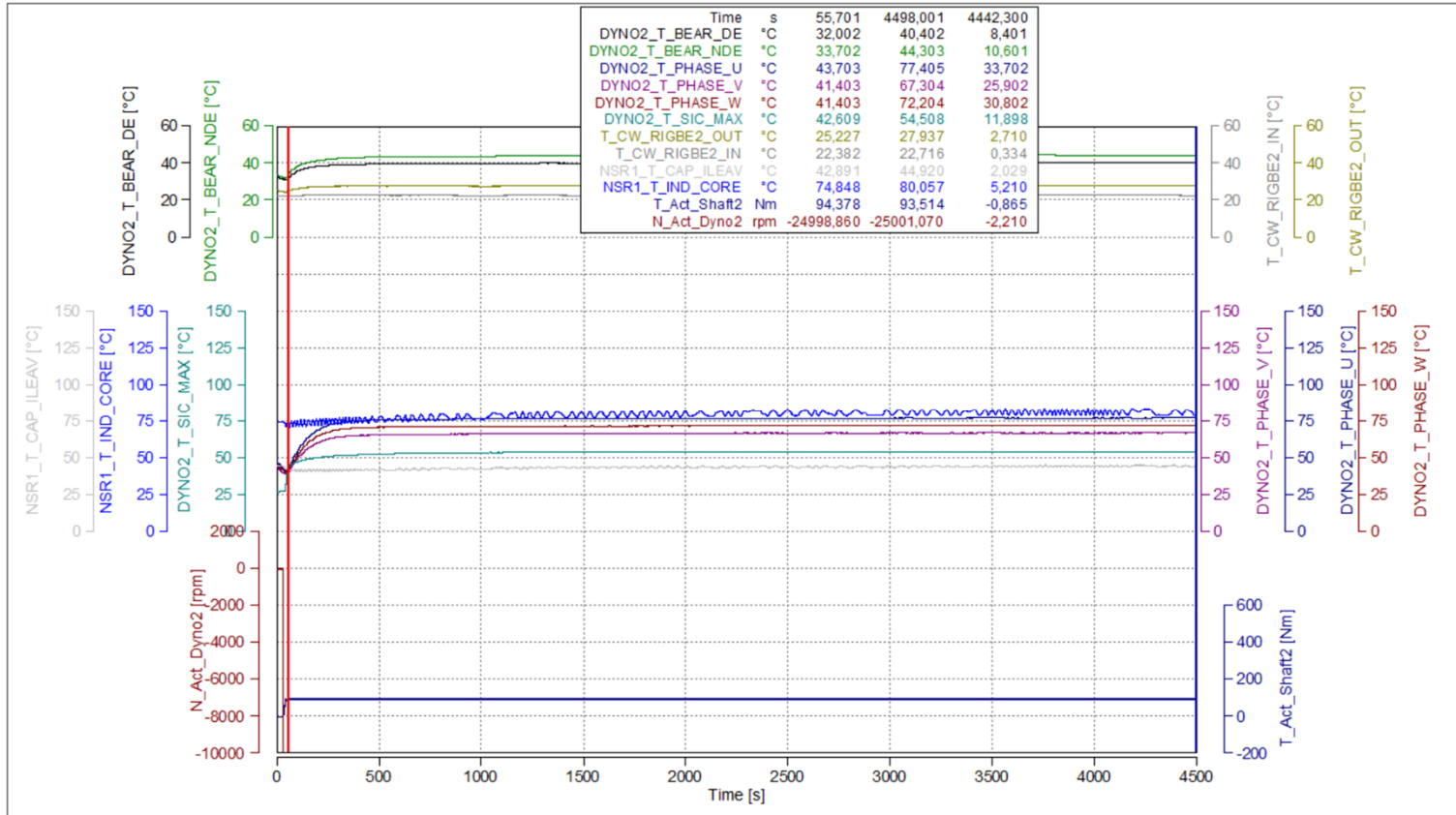


Max. 107 °C
Winding Temperature
@ 450Nm

Max. 25°C
Bearing Temperature
@ 5,300 rpm

AVL SPECTRA™ E-Motor Load Unit

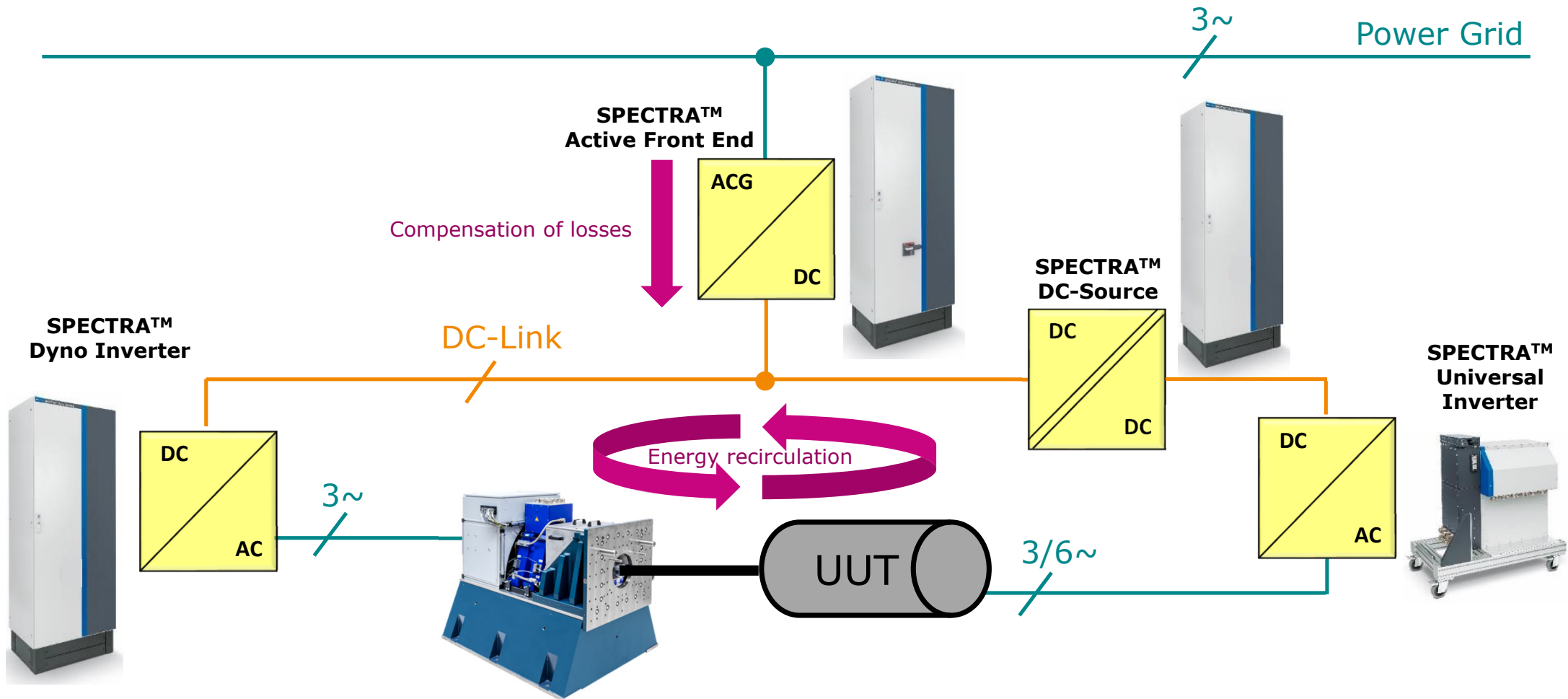
Heat Run: nom. load @ max. speed // PMM 450/5.3-25



Max. 77 °C
Winding Temperature
@ 95 Nm

Max. 45°C
Bearing Temperature
@ 25,000 rpm

Common DC-Link topology with DC || DC-Converter & Full galvanic isolation - Launch Q4 2023



AVL SPECTRA™ 25krpm E-Motor Load Unit

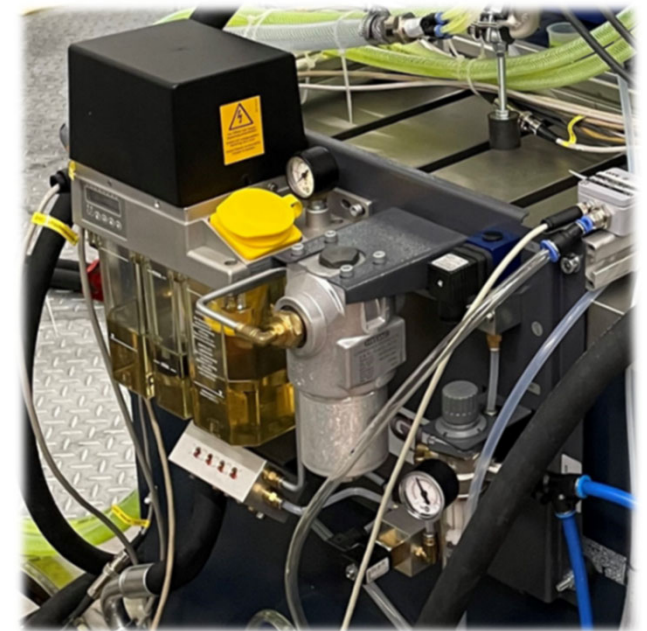
Long Life & Low-noise Bearing technology

- High-speed dynos often utilize lifetime-greased encapsulated bearings
 - Limited bearing lifetime
 - Lifetime decreases even further at higher operating speeds
 - No regreasing possible

CONVENTIONAL

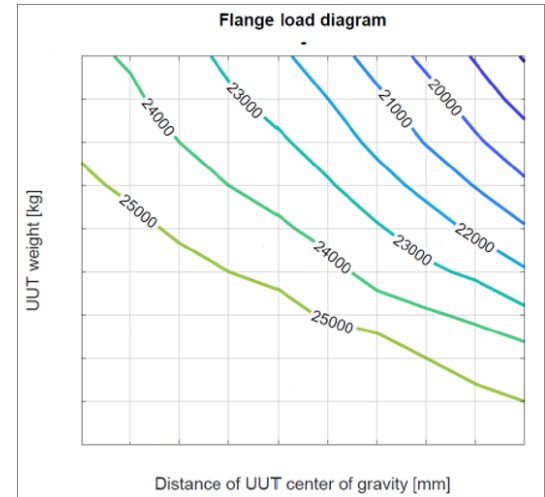
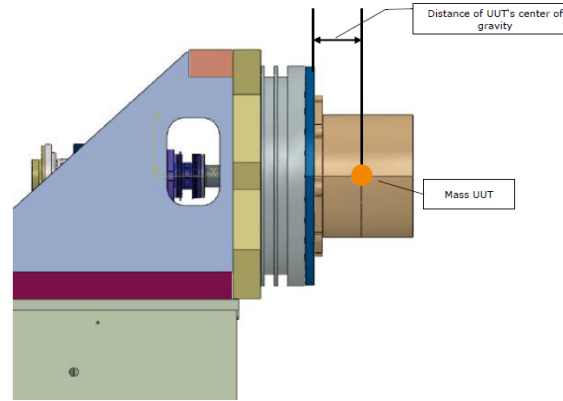
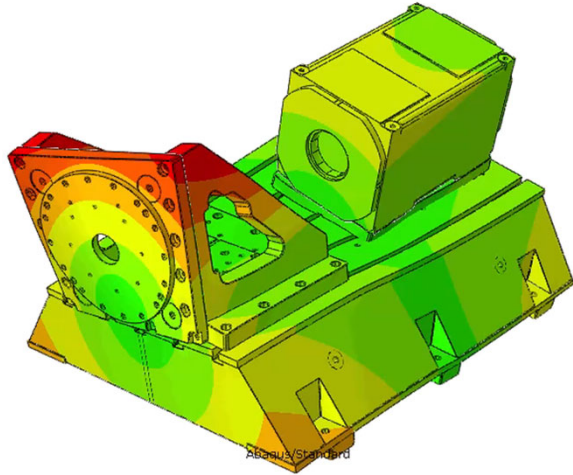
- SPECTRA dynos utilize spindle bearing technology with Oil/air lubrication
 - Lowest vibration levels (<1 mm/s)
 - Optimized bearing lifetime
 - Lifetime >20,000h independent from operating area
- Because of
 - Automatic regreasing unit (fresh oil)
 - Monitoring of main parameters (oil level, air pressure, etc.) necessary

SPECTRA



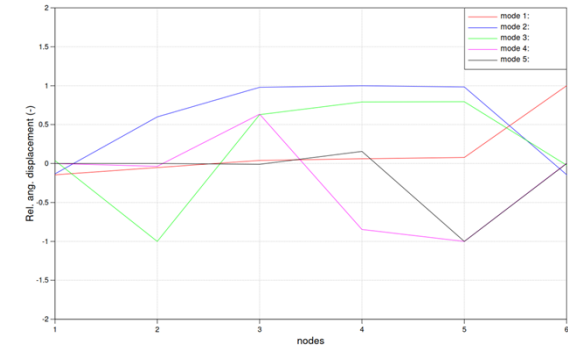
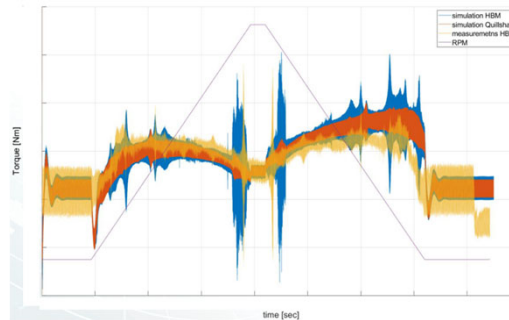
E-Motor TS - High Speed mechanics

Vibration / Structural vibration analysis



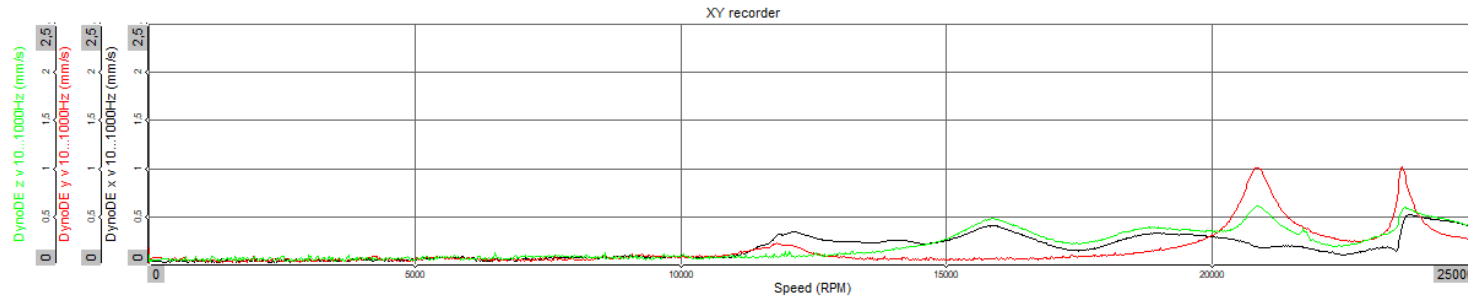
Vibration / Torsional vibration analysis

For torsional analysis, a 1d Model of the shaft system with appropriate boundary conditions is used.

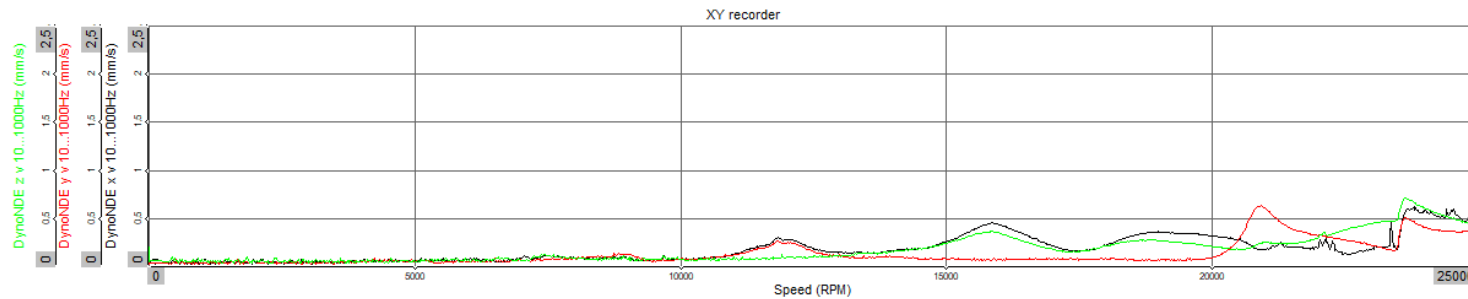


AVL 25krpm Load System - Vibrations measurement on Dyno DE + Dyno NDE + Intermediate Bearing (IBU)

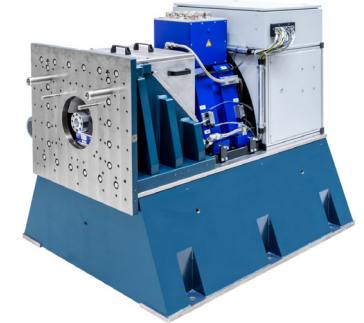
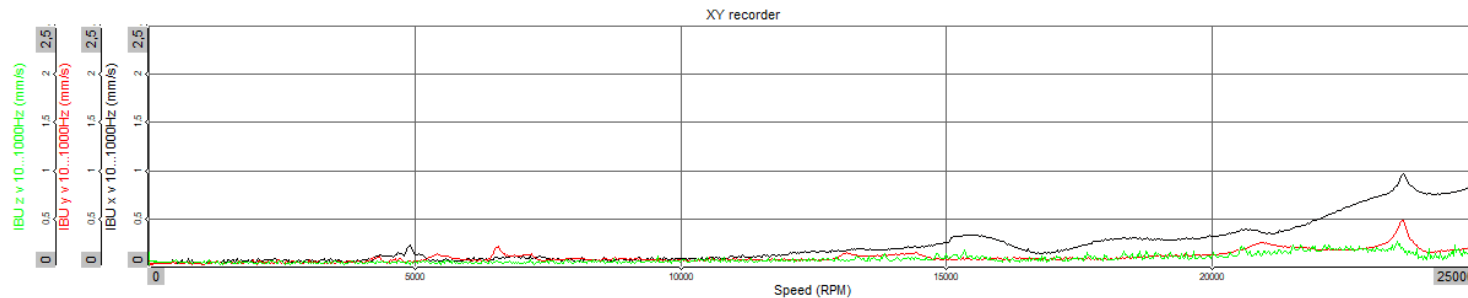
Dyno DE



Dyno NDE



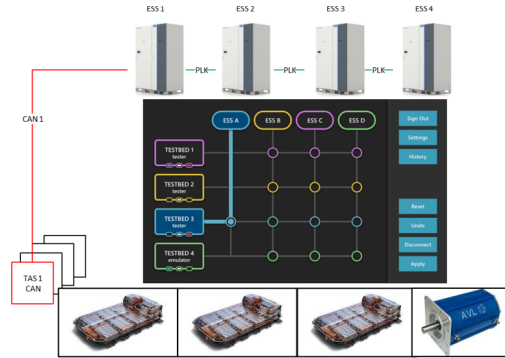
IBU



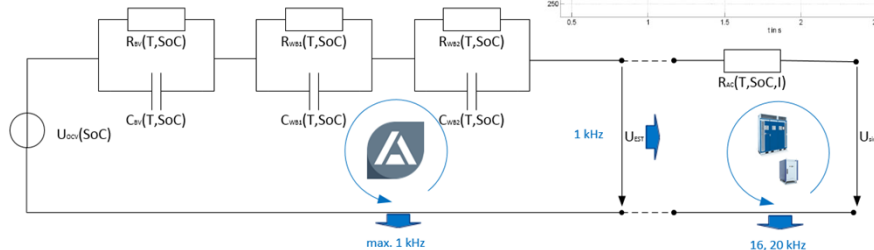
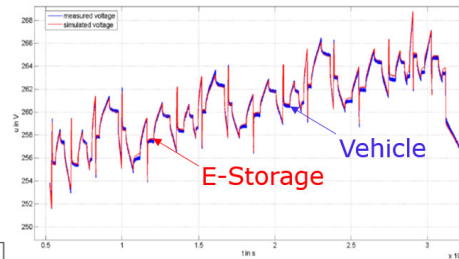
Max. 1 mm/s !
0 – 25 krpm in 125s

X Axial
Y Horizontal
Z Vertical

E-Storage SiC Battery Emulator



Voltage simulation on NEDC cycle



- **Very Small Footprint**
 - 1,4m width for 275kW 1,000A 1,200V
- **High Performance**
 - 1,200V max. voltage
 - 1,000A per channel with 1 or 2 channels
 - 275kW, 550kW power variants, 20% overload capability
 - 0.01% FS voltage and current measurement and control accuracy
 - 10-90% current rise time <1ms
 - Ripple Emulator extension up to 200kHz
- **Advanced Battery Models**
 - Realistic and proven: AVL Battery Models mobaT
 - Easy parameterization: define cell chemistry and number of cells in series and parallel
- **High flexibility**
 - Share devices with simplified and safe automated switching between different testbeds and different applications
 - Possibility to integrate your own MATLAB®/Simulink® models with AVL Testbed.CONNECT™

SPECTRA™ Universal Inverter / Inverter Emulator



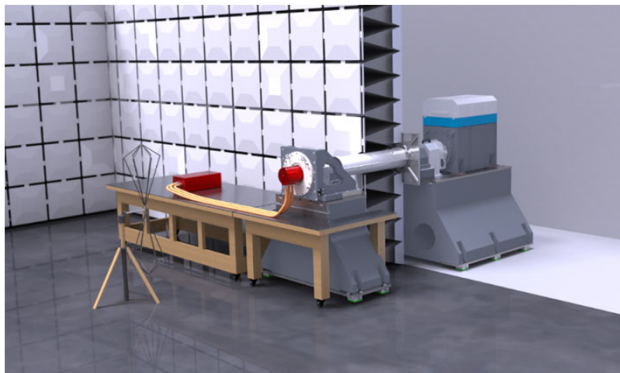
- **Mobile Solution**
 - Close to UUT for most realistic operation
 - Ensure maximum flexibility
- **Automated identification of E-Motor**
 - Simplicity and time saving
- **High Performance**
 - 40-1000V
 - 3 or 6 phases
 - 2-level and 3-level operation
 - Up to 880kVA, Up to 1250A rms
 - up to 20% overload for 10 seconds within 60 sec
 - Up to 96kHz switching frequency
 - Support for PMSM, ASM, EESM
- **Open Control platform**
 - Implement your own SimuLink models
 - Additional SW capabilities in development

E-Motor TS EMC

20krpm Fixed Solution



15krpm Mobile Solution

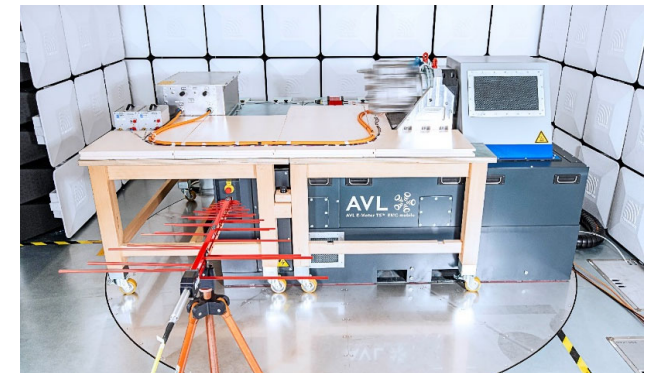


Radiated Emission

- CISPR 25 Ed.4 fully compliant (10dB better than class 5)

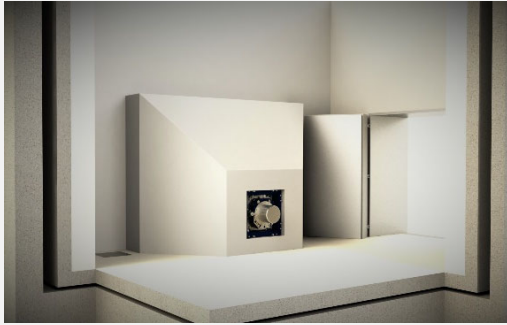
Radiated Immunity

- ISO11452-2, SAEJ551-11, ISO11452-11
- 400V/m with 80% Amplitude Modulation @1kHz



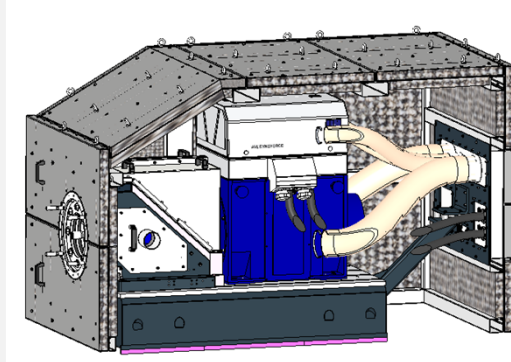
E-Motor TS NVH

PREMIUM Line



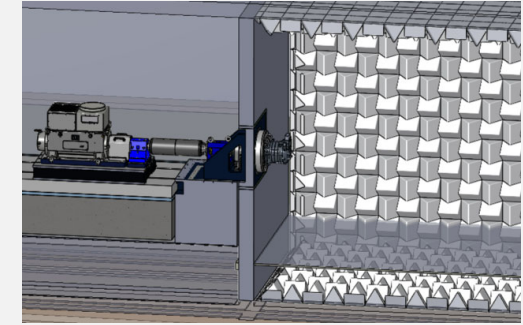
- Class 1 (ISO 3745) NVH chamber
- Ultra low noise level of <math>< 50 \text{ dBA}</math> @20.000rpm
- Wide free field condition around UUT
- Full vibration decoupling
- High speed range 20.000rpm

EFFICIENCY Line



- Free field NVH behaviour in accordance with ISO 3744
- Flexible testbed configuration including multi-configuration
- High speed range 20.000rpm
- Dyno noise encapsulation for low noise measurement <math>< 65 \text{ dB(A)}</math> @20,000rpm

PRECISION Line

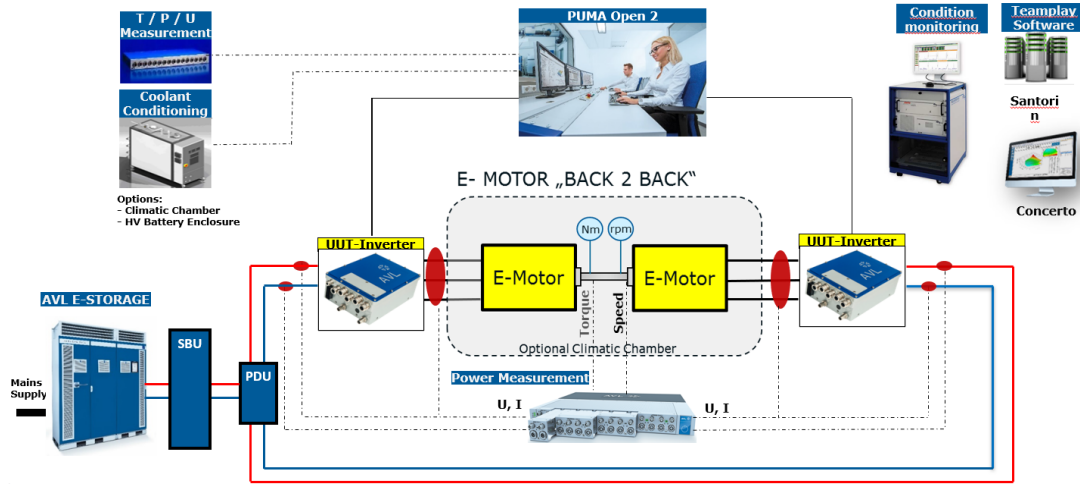


- Class 1 (ISO 3745) semi anechoic chamber with minimal disturbance of free-field area
- Full half-sphere measurement according to ISO3745
- Low operational noise level <math>< 60 \text{ dB(A)}</math> @20,000rpm
- Full vibration decoupling concept

E-Motor TS NVH

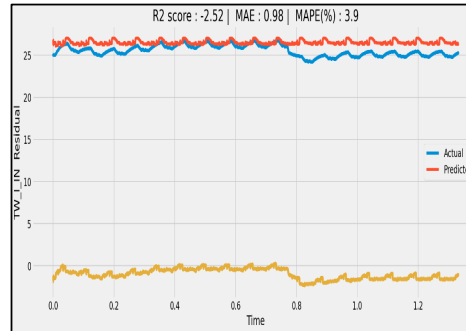
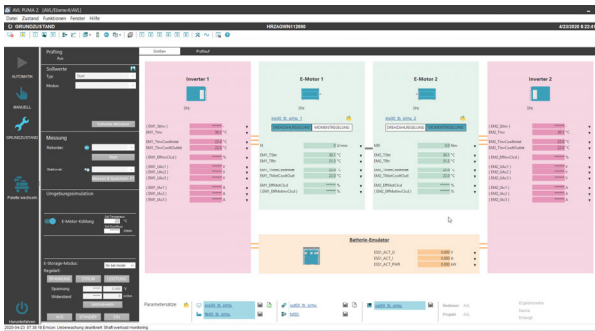


E-Motor TS Durability – Key Features (1/2)



Easy and Modular Automation
Dedicated n/T and T/n controllers with Feed-Forward

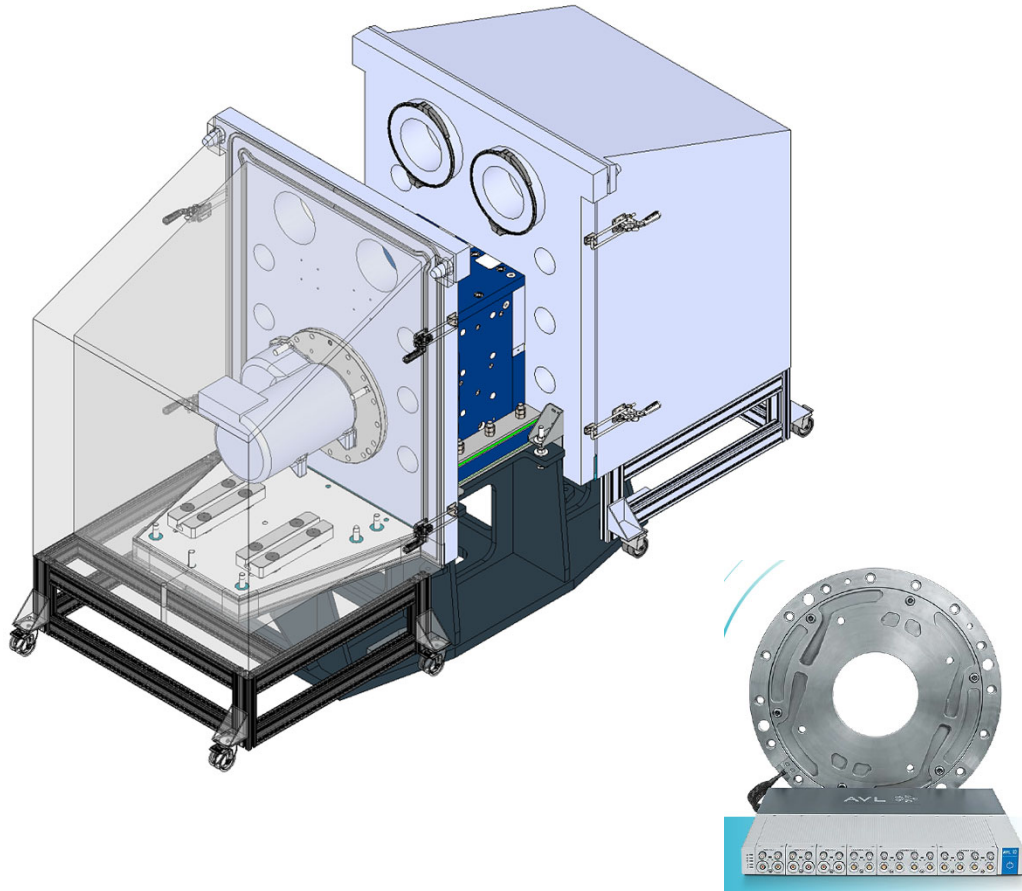
Power Measurement System
dedicated to Automotive test
Measure dynamically, speed, torque, current, voltage, noise and vibration with one device for better analysis



Machine learning

Online diagnostic with easy & quick model generation and root cause analysis

E-Motor TS Durability B2B – Key Features (2/2)



25krpm mechanics with high flange load mounting

Ready for today and future E-Motors

Easy & Fast DUT Handling

Best access to the DUT for mounting / dismounting

High Dynamic Torque Sensor

Measure torque and lateral forces applied on the UUT which you could never see before

Thank you



www.avl.com