INTERTEK’S

ELECTRIC VEHICLE PROPULSION SYSTEMS TESTING

Electric Vehicle testing solutions for automotive manufacturers
CONTENTS

Executive Summary  4

e-Machine dyno test cells  7
27,000 rpm 250 kW e-Machine dyno cell  8
20,000 rpm 500 kW e-Machine dyno cell  10
20,000 rpm 300 kW e-Machine dyno cell  12
18,000 rpm 300 kW e-Machine dyno cell  13
Back-to-Back e-Motor durability testing rig  14
EV motor lubricant test rig  15
eAxle and EDU testing units  16
Transmission testing  18
4,200 Nm 550 kW 2WD EDU cell  19
2,750 Nm 434 kW 2WD EDU cell  19
2WD E-Axle test cell  20
4WD vehicle climatic chamber and powertrain test cell  22
High voltage functional test bed  26
Facility extras  28
Resources and operating model  30

The Intertek Advantage  31
Contact Us  32
Intertek, a leading global Total Quality Assurance provider to industries worldwide, is dedicated to partnering with automotive manufacturers to drive innovation and champion the cutting edge green technologies.

Our UK capabilities
With an existing powertrain testing laboratory in Milton Keynes, which has achieved a number of industry firsts, Intertek is currently developing a new Centre of Excellence for EV Propulsion Systems Testing at a nearby secondary location. This new facility will provide additional capacity and capabilities, significantly enhancing our offering for customers in the automotive sector, placing us at the forefront of the industry for electric vehicle (EV) powertrain testing capabilities.

The new investment, combined with our existing capabilities, will encompass motors, inverters, axle modules, all on-board vehicle electrical systems and complete electric vehicle testing. Our UK facilities will allow our experts to further support the diverse range of customers we are currently partnered with, delivering not only test results but with our enhanced capabilities and world-class facilities, delivering innovative electrification solutions.

Our Milton Keynes facilities will offer automotive manufacturers a one-stop-shop to test their automotive products to the pinnacle of EV testing capabilities.

Electrification driveline technology solutions
One of the challenges with the development of any new technology is the range of expertise required to make it ready for volume production. In a relatively new field such as EV powertrain, some of these requirements may be undefined, required to answer questions revealed by testing but without time in an already hard-pressed programme. The ability to deliver high-quality insights that accurately reflect real world usage is partnered with a focus on accelerating the development process. The new facility is structured for remote set-up so test cells can achieve very fast turnaround, and a high level of automation is specified to allow safe 24/7 operation. Because electrification technology is evolving so quickly, with many questions as yet undefined, there will be a substantial in-house design and build capability so that rigs can be quickly modified, or all new rigs designed and built, to allow new areas of investigation.

Formula E solutions
Intertek’s new European Centre of Excellence provides precision testing of next-generation electric powertrains. The new centre is designed from the ground-up to answer the most challenging questions faced by engineers working at the highest levels of electric motorsport. Experience in Formula E already ranges from delivering component-level insights through to e-Motor and eAxle development testing, providing the high resolution analysis of end-to-end efficiency that allows important but subtle optimisation of hardware, software and race strategy. With the introduction of front axle regeneration, even higher speed MGUs and pitstop recharging, Formula E clients are planning to take full advantage of the next-generation facilities currently being installed.

Our dedication to you
At Intertek, we understand the demand and fast-paced nature of automotive industry. Our dedication to our customers goes beyond our state-of-the-art testing technologies or expert engineers. We provide our customers with 24/7, year-round solutions to ensure you not only meet your project deadlines but are on-hand to adjust test set-up to meet your exact needs and requirements.

Our facilities are also built with our customers in mind. We provide our engineers a dedicated workspace at both our Davy Avenue and Tanners Drive facility to ensure you're able to work closely with the project and have a private area dedicated to your company.
Our UK facilities are the largest independent test centres in the UK, offering in-depth expertise supported by state-of-the-art test equipment. Combined with our 24/7 year-round operation, our teams of in-house engineers deliver flexible testing solutions for our customers. These unique testing facilities provide manufacturers with the latest industry-leading testing technologies for electric vehicles, featuring:

- High-speed capabilities (up to 27,000 rpm direct drive)
- High-power dynos (up to 500 kW)
- In-house rig design capabilities
- High-data quality and minimal downtime
- Rapid set-up and device under test (DUT)/unit under test (UUT) swap-over capabilities

Direct drive, low inertia dynos permit high transient drive-cycle testing of simulated real-world driving. For this reason, direct drive e-machine dynamometers are preferred; a technology that Intertek has been driving forward with its test system suppliers.

Test cases

- e-Motor performance & EU Reg.85 power certification – up to 27,000 rpm / 500 kW
- e-Motor thermal surveys and de-rating software development
- e-Motor efficiency mapping
- Inverter software development
- Inverter calibration optimisation
- Thermal performance (climatic hood with -40°C to 85°C capability)

As with all automotive test operations, these must be explored across all likely operating conditions, from extreme heat to extreme cold, dust, salt, vibration and driver abuse. A further complication is the range of vibrations to which e-machines are subjected when implemented within a hybrid powertrain. Even within an EV, the location of each system will substantially change the input profiles.

Our environmental testing capability includes:

- Dust tests (up to 3.5 m³)
- EN 60529 – Talcum dust
- ISO 20653 or ISO 16750-4:2010 – Arizona A2 dust
- High-pressure steam
- ISO 20653:2013
- IPX9K
- Mechanical shock (climatic option)
  - Wide selection of shakers available
  - Up to 180g shock
  - Sine Random also available
- Salt spray (ISO 9227)
- ISO 6270-2, ISO 9227, EN 60068-2-11, ISO 6988
- SO\textsubscript{2} testing, Condensation water testing

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- ISO 6270-2, ISO 9227, EN 60068-2-11, ISO 6988
- SO\textsubscript{2} testing, Condensation water testing
27,000 rpm 290 kW e-Machine dyno cell

Cell specification
- Cell size specification (W x D x H):
  - Cell: 3.17 x 7.65 x 2.67 m
  - Control Room: Remote control room
  - Cell Loading Door (W x H): 2.42 x 2.67 m

Fluid conditioning
- Three fluid conditioning circuits are provided in each test cell.
  - Temperature Range: -30 to +150°C
  - Flow Rate: up to 60L/minute
  - Cooling Medium: Water/Glycol or Oil
  - Control: Automation System

Battery emulator power curve
- Nominal Power: 400 kW
- Peak Power: 480 kW
- Voltage: 0 – 1,100 V dc
- Nominal Current: 1,000 A
- Peak Current: 1,200 A
- Current T90 slew rate: > 300 kA/s
- Overload Capability: 120% for 60 seconds every 5 minutes
- Measurement Accuracy: ±0.05% of full scale
- Resolution: 16 Bit

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ELECTRICAL POWER MEASUREMENT

<table>
<thead>
<tr>
<th>Power Source</th>
<th>Measurement Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>3x Phase voltage 1,000 V</td>
<td>500 kHz</td>
</tr>
<tr>
<td>3x Phase current 1,000 A</td>
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- Nominal Power: 400 kW
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**Battery emulator power curve**

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<td>400</td>
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</table>

**Torque meter specification**

- Range: 0 – 1,000 Nm
- Accuracy: ±0.05%

**Power analyser**

- Max Voltage: 1,100 V RMS
- Max Current: 1,200 A RMS
- Up to 6 Phases + DC available
- Fundamental Frequency: 0.1 Hz to 600 kHz
- Max Harmonic Order: Up to 500th Order
- Sample rate = 2 M samples/s

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- Sample rate = 2 M samples/s
20,000 rpm 500 kW e-Machine dyno cell
We have developed specialised e-Machine test rigs capable of testing the latest high-speed machines, supported by high power, high voltage DC supplies. Multiple acquisition channels of high-speed data acquisition can be specified at sample frequencies of up to 2.0 MHz.

Our on-site fabrication and rig build capabilities allow rapid configuration and testing specification changes and updates, as well as bespoke rig or test customisation options. Additionally, our sites can accommodate clients in either communal or private customer offices, allowing them to witness tests and liaise with the project team efficiently.

Cell specification
- Cell size specification (W x D x H)
- Cell: 6.0 x 7.0 x 2.0 m
- Cell loading door (W x H): 1.6 x 2 m

Dyno specification
- Nominal Power: 300 kW
- Nominal Torque: 500 Nm
- Peak Power: 500 kW for > 60 sec. @ 6000 rpm
- Peak Torque: 800 Nm for > 60 sec. up to 6000 rpm
- Max Continuous Speed: 20,000 rpm
- Torque sensor: 1000 Nm range, +/- 1.0 Nm accuracy

18,000 rpm 300 kW e-Machine dyno cell
All of Intertek’s eMobility testing engineers and technicians have been trained to the latest health and safety legislative requirements, allowing them to operate the high voltage test equipment and components. Additionally, all of our test facilities are fully accredited to ISO 9001 and can operate 24/7. ECE Regulation 85 (electric drive trains) certification for e-motors can be conducted in our test cells. Intertek is the first UK test facility to be accredited by the VCA to conduct this testing.

Cell specification
- Cell size specification (W x D x H)
- Cell: 5.0 x 7.0 x 2.0 m
- Cell loading door (W x H): 1.6 x 2 m

Dyno specification
- Nominal Power: 250 kW 4300 to 18000 rpm
- Nominal Torque: 550 Nm 300 to 4300 rpm
- Peak Power: 300 kW for > 120 sec. 3750 to 18000 rpm
- Peak Torque: 1,000 Nm for > 120 sec. 300 to 3,750 rpm
- Nominal Speed: 7,000 rpm
- Max Continuous Speed: 18,000 rpm
- Torque sensor: 1,000 Nm range, +/- 1.0 Nm accuracy

### Description

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
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<tbody>
<tr>
<td>Battery emulator limits</td>
<td>Voltage = 1000 Vdc Current = 1000 Adc (peak)</td>
</tr>
<tr>
<td>Oil rig flow limits</td>
<td>Min = 0.05 lpm Max = 10 lpm</td>
</tr>
<tr>
<td>Oil rig max temperature</td>
<td>185°C</td>
</tr>
<tr>
<td>Coolants max limits</td>
<td>Min = -15°C Max = 90°C</td>
</tr>
<tr>
<td>Coolants max flow rate</td>
<td>15 lpm</td>
</tr>
<tr>
<td>Power analyser</td>
<td>6ph + DC Max Voltage - 1,000 V Max Current - 1,000 A Sample rate = 2 M samples/s</td>
</tr>
<tr>
<td>Data acquisition system</td>
<td>Max sampling frequency: 2 Ms/sec Comm: RS485, EtherCAT</td>
</tr>
<tr>
<td>CAN comm data log</td>
<td>Vector box VN7640 flex ray/CAN</td>
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</tr>
<tr>
<td>Oil rig flow limits</td>
<td>Min = 0.05 lpm Max = 6.5 lpm</td>
</tr>
<tr>
<td>Oil rig max temperature</td>
<td>75°C</td>
</tr>
<tr>
<td>Coolants max limits</td>
<td>Min = -5°C Max = 85°C</td>
</tr>
<tr>
<td>Coolants max flow rate</td>
<td>15 lpm</td>
</tr>
<tr>
<td>Power analyser</td>
<td>3ph + DC Max Voltage - 1,000 V Max Current - 1,000 A Sample rate = 2 M samples/s</td>
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**Back-to-back e-Motor durability testing rig**

This testing rig is primarily designed for efficient durability type testing, where the testing of two machines at once harvests twice the running hours. Our back-to-back rigs are capable of fully automated operation, allowing our customers to utilise the test rig for a shorter period of time, whilst still running the full course of their testing requirements. With our wide range of customer requirements, we have designed our back-to-back rig to suit a broad range of product sizes and weights. Our equipment is fitted with customer mounting plates, allowing us to accommodate a large range of customer specific DUT. Our custom mounting plates also include a wide spaced linear rail system, allowing for all types of DUT and driveshaft arrangements. Our DUT carriages allow for pre-rigging and enable rapid deployment of testing. Precision centre bearing furnishes accurate shaft alignment at high speeds and supports high resolution contact-less torque measurement system with custom splined shaft adaptors for DUT coupling including galvanic isolation if required.

**Cell specification**
- Cell size specification (W x D x H):
  - Cell 4.0 x 6.3 x 4.0m
  - Cell loading door (W x H): 1.59 x 2.0 m
- Cell 0.003 kgm² plus customer specific shafts and DUT

**DESCRIPTION**

<table>
<thead>
<tr>
<th>DC source</th>
<th>2x Regatron Lab GSS modules providing up to 64 kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torque sensor</td>
<td>500Nm HBM T40b sensor</td>
</tr>
<tr>
<td>Max. speed</td>
<td>Up to 20,000 rev/min with existing torque sensor</td>
</tr>
<tr>
<td>Control System</td>
<td>National Instruments</td>
</tr>
<tr>
<td>Data channels</td>
<td>24 PRT’s, 1x vibration monitor, Analog/Digital Channels</td>
</tr>
<tr>
<td>Coolant conditioning</td>
<td>1.5 to 90°C at 5 to 20 litres/min</td>
</tr>
<tr>
<td>Pumps</td>
<td>0.003 kgm² plus customer specific shafts and DUT</td>
</tr>
</tbody>
</table>

**Nominal power curve**

**EV motor lubricant test rig**

This testing solution was created to enhance the performance and cooling of e-Motors specifically designed for electric vehicles. Our EV motor lubricant rig enables development of e-Motors lubrication and/or EV lubricants and can conduct tests at a wide range of temperatures and flow velocities. Our rig can help you:
- Reduce e-Motor losses to improve efficiency and vehicle range
- Improve e-Motor cooling to reduce the need for motor de-rating at high load
- Develop improved fluids to better meet the changing needs of the automotive industry

Upon demand, the rig is also ready to provide tilting capabilities and simulate real-world challenges. With the increasing development of electrification technologies in the automotive market, we have designed our EV motor lubricant test rig to suit a broad range of fluid and motor types and designs.

Our equipment can be fitted with customer specific mounting plates, allowing us to accommodate a large range of customer e-Motors. Additionally, all our test facilities are fully accredited to ISO 9001 and can operate 24/7, allowing us to accelerate our customers test programmes. Our rig can help you:
- Determine e-Motor losses to improve efficiency and vehicle range
- Improve e-Motor cooling to reduce the need for motor de-rating at high load
- Develop improved fluids to better meet the changing needs of the automotive industry

<table>
<thead>
<tr>
<th><strong>Development tests that can be conducted</strong></th>
</tr>
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<tbody>
<tr>
<td>1. Motor rotational loss (no fluid): Evaluation of rotational loss without incurring on windage effect. Possibility to test different bearing types and models.</td>
</tr>
<tr>
<td>2. Rotor windage loss (no fluid): Possibility to quantify losses due to windage, through comparison of results between this test and Motor Rotational Loss Measurement.</td>
</tr>
<tr>
<td>3. Motor cooling fluid viscous loss: Comparison of drag torques using different fluids at different temperatures, at different flow rates and at different tilt angles</td>
</tr>
</tbody>
</table>

**4. Stator heat transfer to cooling fluid:** Fluid cooling capability can be measured at different speeds, temperatures and flow rates, providing the cooling efficiency profile for each test fluid.

**Our EV motor lubricant rig capabilities**

**Motor mounting and tilt specifications**
- Modular design, flexible mounting options available to suit a wide range of motor units
- Test samples can be tilted in a single axis to ±45°. Multiple axis movement available upon customer demand

**Drive system**
- Drive is provided by a 7.5 kW (10HP) 2 Pole AC Induction Motor
- Drive is supplied by a 7.5 kW (10HP) 2 Pole AC Induction Motor

**Temperature and pressure measurement**
- 14 OFF K Type Temperature Channels
- 10 OFF high precision pressure measurement channels
- All temperature & pressure channels are synchronously recorded by the logging software at 2.1Hz

**Fluid conditioning**
- Fluid Temperature control
- Oil Flow Rate control
- Scavange pump to evacuate oil from motor unit under test

**Additional specifications**
- Temperature Range = Ambient to 120°C
- Max Flow Rate = 15 l/min Measurement resolution 0.05 l/min
Our analysis of the test requirements for whole vehicles, transmissions and drivelines has identified the following areas in which progress in test techniques will help to facilitate progress in system technology:

- Drivecycle analysis including torque pattern characterisation
- Noise, Vibration and Harshness
- System and Subsystem efficiency
- Lubrication and cooling system losses
- Fast integration of prototype control systems and software
- Very high-speed data collection
- Precise analysis of component performance
- Comprehensive understanding of EMC issues

**Test cases**

- System integration development
- System level thermal analysis, endurance and durability
- Range and efficiency studies

Early electric vehicles, without regenerative braking, could be tested on a conventional chassis dyno as the energy flow was one way. Since the introduction of regenerative braking, specialist dynamometers are required to provide fast modulation of positive and negative torque. The high current flows in each direction also add the complication of back EMF and other EMI issues.

The next step, already implemented at Intertek, is the introduction of hub-dynos. The many advantages of this technique include:

- Increased consistency through direct engagement with the driveline, removing variability from tyres (pressure, temperature, wear design), tyre slip and strap tensions
- Precise transient responses, e.g. to measure wheel slip and calibrate torque vectoring
- Ability to measure speed differences across each axle
- Low inertia allowing accurate simulation of highly dynamic drive cycles

A well-designed dyno should also offer two or four-wheel drive capability and the ability to operate E-Machines at different voltages on each axe. They must also be far more robust than their ICE counterparts, as very high transient torque loads place tough demands on equipment reliability and must not be allowed to introduce inaccuracy through unwanted movement in the rig or driveline components.

Multi-speed transmissions will require more traditional durability analysis, but even here the conditions are more extreme, with higher torque, potentially from a ‘cold start’, very fast shifting and fast control systems. As with E-Machines, lubricants have a significant impact on efficiency so should also be studied as small physical changes can significantly reduce energy losses.

eAxle and EDU testing units
Transmission testing

Cell specifications
Intertek offers 3 highly configurable and dedicated transmission test cells, providing our customers with a transient, steady-state, and spin rig cell for calibration and friction loss testing. These cells can be fitted with multiple bespoke simulations to provide testing capabilities for the most complex transmission systems, whether manual, hybrid or full electric.

Transient rig
- 3E Rig
- Input machine matched to engine performance
- Peak figures: 523 kW, 10000 rpm, 10k Nm
- Output machines paired
- Peak figures (each): 552 kW, 3500 rpm, 4.2k Nm
- High precision torque flanges on all machines
- Battery emulator
  - 150 kW continuous capacity
- Fluid handling from -30°C to 130°C , flow rate 15 lpm
- Tri Axis accelerometer capability

Steady-state rig
- 3E Rig
- Input machine matched to engine performance
- Peak figures: 520 kW, 9000 rpm, 1k Nm
- Steady State Absorption output dynamometers
- Peak figures (each): 870 kW, 6500 rpm, 6k Nm
- Battery emulator
  - 150 kW continuous capacity
- Fluid handling from -30°C to 130°C , flow rate 15 lpm
- Tri Axis accelerometer capability

Spin rig
- Single input (1E) 110 kW spin rig
- High precision torque flange
- Fluid handling from -30°C to 130°C , flow rate 15 lpm
- Tri Axis accelerometer capability

Dyno specification
- 2WD EDU - 550 kW per dyno
- ±3,500 rpm
- HBM torque flange – T40B (10,000 Nm)

Battery emulator
- 250 kW
- ± 1000 A continuous

Power analysis
- PMMA (3 phase) or Newtons4th (PPA5510 DC), PPA5520 (3 phase AC)
- Max Voltage - 1,000 V
- Max Current - 1,000 A
- Sample rate = 2.2 M samples/s

Base I/O specification for cell 20
- 60 Thermocouples
- 16 PRTs
- 32 Pressure transducers (including 8 off 0-1 Bar, 1 off Barometric)
- 1 Available CAN Network (extra CAN cards can be provided + ETAS, Vector)

Dyno specification
- 2WD EDU - 434 kW per dyno (640 kW peak)
- ±3,500 rpm
- HBM torque flange – T40B (10,000 Nm)

Battery emulator
- 500 kW
- ± 2000 A continuous

Power analysis
- PMMA (3 phase) or Newtons4th (PPA5510 DC), PPA5520 (3 phase AC)
- Max Voltage - 1,000 V
- Max Current - 1,000 A
- Sample rate = 2.2 M samples/s

Base I/O specification for cell 25
- 60 Thermocouples
- 16 PRTs
- 32 Pressure transducers (including 8 off 0-1 Bar, 1 off Barometric)
- 1 Available CAN Network (extra CAN cards can be provided + ETAS, Vector)
ZwD E-Axle test cell

Cell specification
Each ZwD configuration footprint (W x D x H):
- Cell 1: 8.5 x 4 x 2.6 m
- Cell 1 Control Room: 3.2 x 4.9 x 2.6 m
- Minimum Track Width: 1,450 mm
- Maximum Track Width: 1,750 mm

Dyno specification (each)
Two low inertia transient hub dynos, each with the following specification:
- Nominal Power: 350 kW @ 955 rpm
- Peak Power: 550 kW @ 955 rpm
- Nominal Torque: 3,500 Nm @ 955 rpm
- Peak Torque: 5,500 Nm @ 955 rpm
- Nominal Speed: 955 rpm
- Max speed: 3,500 rpm
- Dyno rotor moment of inertia: 1.1 kgm²
- Acceleration rate to base speed: 30,380 rpm/sec

Acceleration rate to base speed (with overload): 47,740 rpm/sec
Acceleration rate between base speed and 2,700 rpm: 10,745 rpm/sec
Acceleration rate between base speed and 2,700 rpm (with overload): 16,882 rpm/sec
Overload Capability: 157% for 4 seconds every 3 minutes and 130% for 60 seconds every 10 minutes
Noise Level (unloaded): 80 dBA

Torque meter specification
- Range: 0 – 1,000 Nm
- Accuracy: ±0.05%

Battery emulation ZwD
Battery emulation is provided to accommodate 316 kW, 1090A, 1100 V for each ZwD test cell, with a third battery emulator available to be switched to either cell if required.

Single Unit
- Nominal Power: 316 kW
- Peak Power: 410.8 kW
- Voltage: 12 – 1100 Vdc
- Nominal Current: 1090 A
- Peak Current: 1308 A
- Current T90 slew rate: > 300 kA/s
- Overload Capability: 130% for 60 seconds every 5 minutes
- Measurement Accuracy: ±0.05% of full scale
- Resolution: 16 Bit

2 Emulators in Parallel
- Nominal Power: 632 kW
- Peak Power: 821.6 kW
- Voltage: 12 – 1100 Vdc
- Nominal Current: 2180 A
- Peak Current: 2616 A
- Current T90 slew rate: > 300 kA/s
- Overload Capability: 130% for 60 seconds every 5 minutes
- Measurement Accuracy: ±0.05% of full scale
- Resolution: 16 Bit

DUT mounting system
- Dyno centreline height is 850mm above the bedplate.
- An intermediate drive shaft and bearing system provides the interface between the DUT and dyno torque flange. The intermediate driveshaft and bearing supports the weight of the DUT.

Cell air climatic control
- Cell air inlet temperature control: +10°C and 40°C with a tolerance of ±3°C.

IO specification
IO Requirements are as follows:

<table>
<thead>
<tr>
<th>IO SPECIFICATIONS (PER 2WD CELL)</th>
<th>LOGGING RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaft Speed D: 3500 rpm/100 rpm</td>
<td>2 kHz</td>
</tr>
<tr>
<td>Torque: ±5500 Nm: 0.05%</td>
<td>2 kHz</td>
</tr>
<tr>
<td>8 x K-type Thermocouples</td>
<td>2 Hz</td>
</tr>
<tr>
<td>8 x PT100°C</td>
<td>200 Hz</td>
</tr>
<tr>
<td>8 x ±10V differential inputs</td>
<td>10 Hz</td>
</tr>
<tr>
<td>8 x Digital Inputs</td>
<td>10 Hz</td>
</tr>
<tr>
<td>8 x Digital Outputs</td>
<td>10 Hz</td>
</tr>
<tr>
<td>2 x ±10V Analogue Outputs</td>
<td>10 Hz</td>
</tr>
<tr>
<td>2 x Flow Meter D: 20 lpm</td>
<td>2 Hz</td>
</tr>
<tr>
<td>2 x CAN busses</td>
<td>1000 Hz</td>
</tr>
<tr>
<td>1 x Flexray Bus</td>
<td>1000 Hz</td>
</tr>
</tbody>
</table>

Power analyser
- Max Voltage: ±1100V RMS
- Max Current: ±1200A RMS
- Up to 6 Phases + DC available
- Fundamental Frequency: 0.1 Hz to 300 kHz
- Max Harmonic Order: Up to 500th Order
- Sample rate = 2 M samples/s
The 4WD cell is dividable in all respects (cell, control room, automation system, data acquisition, battery emulation, etc) to operate as two entirely separate 2WD cells to the specifications given below, whilst maintaining project privacy between the two cells for separate projects and customers but with the flexibility to accommodate a wide range of vehicle platforms including large SUV’s. This set-up allows Intertek to meet the fast moving and demanding requirements of electrified powertrains:

**Cell specification**
- Each 2WD and 4WD configuration footprint (W x D x H):
  - **Cell 1:** 8.5 x 4 x 2.6 m
  - **Cell 1 Control Room:** 3.2 x 4.9 x 2.6 m
  - **Cell 1 Loading Door (W x H):** 3 x 2.23 m
  - **Cell 2:** 8.5 x 5.95 x 2.6 m
  - **Cell 2 Control Room:** 3.2 x 4.9 x 2.6 m
  - **Cell 2 Loading Door (W x H):** 2.8 x 2.45 m
  - **4WD Configuration:** 8.5 x 9.95 x 2.6 m
- **Minimum Track Width:** 1,450 mm
- **Maximum Track Width:** 1,750 mm
- **Minimum Wheelbase:** 2,500 mm
- **Maximum Wheelbase:** 3,200 mm

**Dyno specification (each)**
- Four low inertia transient hub dynos, each with the following specification:
  - **Nominal Power:** 350 kW @ 955 rpm
  - **Peak Power:** 550 kW @ 955 rpm
  - **Nominal Torque:** 3,500 Nm @ 955 rpm
  - **Peak Torque:** 5,500 Nm @ 955 rpm
  - **Nominal Speed:** 955 rpm
  - **Max. speed:** 3,500 rpm
  - **Dyno rotor moment of inertia:** 1.1 kgm²
  - **Acceleration rate to base speed:** 30,380 rpm/sec
  - **Acceleration rate to base speed with overload:** 47,740 rpm/sec
  - **Acceleration rate between base speed and 1,700 rpm:** 10,745 rpm/sec
  - **Acceleration rate between base speed and 2,700 rpm (with overload):** 16,882 rpm/sec
  - **Overload Capability:** 157% for 4s every 3min and 130% for 60s every 10min
  - **Noise Level (unloaded):** 80 dBA

**Power analyser**
- **Max Voltage:** 1,100V RMS
- **Max Current:** 1,200A RMS
- **Up to 6 Phases + DC available**
- **Fundamental Frequency:** 0.1 Hz to 300 kHz
- **Max Harmonic Order:** Up to 500th Order
- **Sample rate:** 2 M samples/s

Our vision is to be able to support our customers’ testing requirements for a full vehicle design verification plan (DVP). This meant it was essential for Intertek to include a full 4WD Vehicle-in-the-Loop test bed. This state-of-the-art test cell is multi-functional to be able to adapt to our customers’ requirements.

**Set-up options**
- 4WD vehicle-in-the-Loop
- 4WD powertrain-in-the-loop
- 2 x 2WD E-Axle
- Option to split the 4WD system in two, with complete separation between the two test cells allowing independent customers to access each cell with complete confidentiality.
- The cell air is also split to each cell to allow each cell to run independent ambient air cycles (20°C to 40°C).
- Enables high transient full 4WD powertrain testing, including torque split and wheel slip simulation for chassis dynamics development.
- Future investment will add the capability to allow the real to battery to be used with the addition of a fully climatic environmental chamber (-40°C to +120°C).
- This will allow customers to perform range tests across a wide range of climatic conditions.
- It will also give the capability to perform benchmark tests against other models and allow validation of battery models that have been used in the development of the powertrain.

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  - Four low inertia transient hub dynos, each with the following specification:
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    - **Nominal Speed:** 955 rpm
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    - **Noise Level (unloaded):** 80 dBA

- **Power analyser**
  - **Max Voltage:** 1,100V RMS
  - **Max Current:** 1,200A RMS
  - **Up to 6 Phases + DC available**
  - **Fundamental Frequency:** 0.1 Hz to 300 kHz
  - **Max Harmonic Order:** Up to 500th Order
  - **Sample rate:** 2 M samples/s

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- **Up to 6 Phases + DC available**
- **Fundamental Frequency:** 0.1 Hz to 300 kHz
- **Max Harmonic Order:** Up to 500th Order
- **Sample rate:** 2 M samples/s
Torque meter specification
- Range: 0 – 1,000 Nm
- Accuracy <±0.03%

Battery emulation 4WD
Battery emulation is provided to accommodate 948 kW, 3,270 A, 1,100 V for the 4WD test cell.
- Nominal Power: 948 kW
- Peak Power: 1,232.4 kW
- Voltage: 12 – 1,100 Vdc
- Nominal Current: 3,270 A
- Peak Current: 3,924 A
- Current T90 slew rate: > 300 kA/s
- Overload Capability: 130% for 60 seconds every 5 minutes
- Measurement Accuracy: ±0.05% of full scale
- Resolution: 16 Bit

DUT mounting system
- Dyno centreline heights is 850 mm above the bed plate.
- An intermediate drive shaft and bearing system provides the interface between the DUT and dyno torque flange. The intermediate driveshaft and bearing supports the weight of the DUT.

Cell air climatic control
- Cell air inlet temperature control: +10°C and 40°C with a tolerance of +/- 3°C.
- Cooling capacity: up to 200 kW of heat rejection capacity

Air flow
- 150 km/hr air flow capability to be supplied to a vehicle under test.

IO specification
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High voltage functional test bed

Our background
Our Transportation Technologies team at Milton Keynes, UK, has designed and developed a unique High Voltage Functional test bench (HV-FTB) to expand its eMobility test and validation capabilities outside of the direct sphere of rotating machinery. This custom test bench enables integrated, automated, and transparent development of the necessary High Voltage support systems found in a modern EV or Hybrid vehicle, including HV junction boxes, battery management systems, DC/DC converters, AC and DC charging interfaces, and other HV systems that are now routinely powered from a traction battery.

The modular, expandable HV-FTB
The HV-FTB is modular, expandable and evolves a single point testing architecture into an arena that previously has required many, individual support systems each with their own test agenda. To streamline the optimisation or validation of functional hardware, simultaneous near real time generation of all Primary Vehicle and EVSE Power-buses is supported. In conjunction, the HV-FTB allows the validation of control code, which is often new, unproven and unique to the DUT and can be multi-dimensional in scope, especially where networked communication buses such as FlexRay or GreenPHY are involved.

Key features
• High Voltage DC generation – 0 to 1000 Vdc in two 32 kW bi-directional (sink-source) units. Units can be connected in series or parallel, and can operate and transition seamlessly between either load quadrant. This functionality is to simulate the vehicle’s main traction battery and also EVSE DC charging, and can run in various modes (CVCC, Batsim etc)
• High Voltage AC Generation – 0 to 580 Vac, 12 kW, 1 or 3-ph variable VF supply. Providing power to support the test and integration of EVSE AC charging systems, and able to simulate grid disturbances (fundamental frequency shift, harmonic content, voltage glitches etc)
• High Voltage AC/DC Passive Configurable Load Bank – A water cooled 5 kW resistive load bank arranged in a ladder type arrangement gives the ability to simulate AC or DC systems with variable loading. It also enables rapid (<1 mS) step-wise load changes, designed to test the output stability and damping of DC/DC converters
• High Voltage DC Linear Load Bank – 5 kW 600 V highly dynamic DC load. Providing a high fidelity, low noise sink for DC/DC converter testing or other DC loading tests
• EVSE DC Fast Charger – 50 kW – Supporting industry standard DC fast chargers, and enabling validation of High Voltage Junction Box type devices, as well as functional test on charging system interface controllers
• All units are housed in standard sized, custom racking that enables the FTB to be easily shrunk or expanded. This brings simple hardware integration for additional future capability.
All units within the HV-FTB are networked, allowing a single, central test automation system to manage both the DUT and the HV-FTB resources themselves. Further integration of networked data acquisition and analysis devices (oscilloscopes, power analyzers, temperature sensing etc) is also both possible and expected to leverage the highest level of single point, integrated testing.
Facility extras

Climatic hoods
The three e-Motor test cells share a single common climatic hood which can be quickly mounted in any of the three test cells. Thanks to a common interface design each of the three test cells has a permanently installed climatic wall which the e-Motor interfaces through. If climatic testing is required the hood is simply wheeled into the test cell and positioned up to the fixed climatic wall and fastened together:

- Temperature control down to -40°C to +85°C
- Is mobile to be used between the three different dyno cells as required by customer projects
- Provides DAQ/control capability via the test cell automation system
- Accommodates a DUT up to approx. 650 mm diameter and 800 mm length including 400 mm allowance for mounting hardware

Quick change loading pallet
Across our new facility our three e-Machine test cells are equipped with our quick change loading pallet system. This innovative and unique capability allows our engineers to rapidly reduce the time required to set up customer’s motors in the test cells. Our quick change loading pallet reduces the set up time from one week to approximately one hour. This equipment not only increases test efficiency across our facility but also allows the customer to make amends to the test set up and change the motor without increasing test costs and impacting project deadlines.

Development testing of Formula E powertrain technologies
Over the years, electric vehicle technologies and components have seen drastic enhancements and radical leaps in technology design and capability. Many of these innovative steps are realised in the electrification of racing. As Formula E and other electric motorsports have continued to rise in popularity, so has the capabilities of the cars manufactured. In our white paper, we delve into the generational progression of Formula E, and how new and enhanced powertrain testing capabilities can allow engineers to develop and fine-tune their powertrains that can define a generation of racing.

For your free copy of our white paper, click here to download it or contact our team at TT-UKinfo@intertek.com.
Intertek partners with customers at the forefront of the next generation of automotive development, supporting them to develop the best electric vehicles for the future.

As the largest independent automotive EV powertrain testing facility in the UK and with over 30 years’ industry experience, we have been testing high voltage EV and HEV systems since 2011. Our powertrain testing expertise includes the testing and optimisation of eMobility driveline systems, including full electric and hybrid-electric powertrains.

We understand the requirements for EV testing to deliver high-quality insights that accurately reflect real world usage, partnered with a focus on accelerating the development process. Our facilities are built to achieve highly accurate test results with very fast turnaround, and a high level of automation allows safe 24/7 operation. Because of the rapid evolution of electrification technologies, our engineers provide substantial in-house design and build capabilities so that rigs can be quickly modified, or all new rigs designed and built, to allow new areas of investigation without the delays that can be introduced by dependence on third party suppliers.

Designed from the ground-up to offer manufacturers world-class solutions for all EV vehicles and components, combined with our teams of in-house experts with years of combined expertise, Intertek is the partner of choice for both commercial and electric motorsport test programmes.

About Intertek
Intertek is a leading Total Quality Assurance provider to industries worldwide. Our network of more than 1,000 laboratories and offices in more than 100 countries, delivers innovative and bespoke Assurance, Testing, Inspection and Certification solutions for our customers’ operations and supply chains. Intertek Total Quality Assurance expertise, delivered consistently with precision, pace and passion, enabling our customers to power ahead safely.

All of Intertek’s eMobility testing engineers and technicians have been trained to the latest health and safety legislative requirements, allowing them to operate the high voltage test equipment and components. Additionally, all of our test facilities are fully accredited to ISO 9001 and can operate 24/7. Intertek’s facilities are supported by comprehensive in-house instrumentation and facilities maintenance, ensuring minimum down-time with maximum data quality.

Initially the new facility will run on a 2-shift model allowing for 1.5 hours a day of manned testing (80 hours per week). The automation systems are fully capable of running un-manned to allow 24 hours testing to be completed (120 hours per week). weekend operation is available if required.

Resources and operating model

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