48V ELECTRIFICATION TESTING SOLUTIONS

Michael Herbel
48V Boardnet Architecture

- 48V High-Power Consumer
- eBooster
- EPS / EHPS
- Roll Stabilization
- PTC Heater
- Electric Pumps
- EI. AC Compressor...
- 48V Battery System
- 48V Generation & Storage
- 48V Starter/Generator
- Classic 12V Boardnet
- DC/DC

48V

12V
### MARKET DRIVER: PRODUCTION COSTS / ROI

<table>
<thead>
<tr>
<th>System Metric ▼</th>
<th>Micro Hybrid</th>
<th>48V Hybrid Concept</th>
<th>Mild Hybrid</th>
<th>Full Hybrid</th>
<th>Plug-In Hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>12V</td>
<td>48V</td>
<td>&gt;100V</td>
<td>200-300V</td>
<td>300-400V</td>
</tr>
<tr>
<td>E-Motor Power</td>
<td>2-3kW</td>
<td>8-12kW</td>
<td>10-15kW</td>
<td>20-40kW</td>
<td>60-70kW</td>
</tr>
<tr>
<td>Regen. Power</td>
<td>0.5-3.0kW</td>
<td>~12kW</td>
<td>~10kW</td>
<td>~20kW</td>
<td>20kW +</td>
</tr>
<tr>
<td>Launch Assist</td>
<td>0</td>
<td>-12kW</td>
<td>&lt;15kW</td>
<td>&gt;20kW</td>
<td>&gt;60kW</td>
</tr>
<tr>
<td>E-Drive range</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>~3km</td>
<td>30-60km</td>
</tr>
<tr>
<td>OEM on-cost estimate</td>
<td>€150-€500</td>
<td>€1000-€1500*</td>
<td>€1600-€3000*</td>
<td>€3000-€5000*</td>
<td>€6000-€9000</td>
</tr>
<tr>
<td>CO₂ Benefit %</td>
<td>4 - 7%</td>
<td>10 - 15%</td>
<td>15 - 20%</td>
<td>20 - 25%</td>
<td>30% +</td>
</tr>
<tr>
<td>OEM Cost / Benefit estimate</td>
<td>€35 – 85 / 1%</td>
<td>€65 – 100 / 1%</td>
<td>€80 – 200 / 1%</td>
<td>€150 – 250 / 1%</td>
<td>€200 – 300 / 1%</td>
</tr>
</tbody>
</table>

Source: AVL PTE, January 2014
AVL BATTERY TEST SYSTEMS
TYPICAL TEST BED SETUP

Safety systems (optional):
- Safety PLC
- Gas and fire - detection
- Fire supression System
- Over-pressure flap
- Inertisation

Climatic Chamber (optional)

Coolant Conditioning (optional)

BCU (BMS)

T / P / U Measurement

UUT - 48V Battery

UUT - 12V Battery

Battery Testers

Mains Supply

Automation Simulation

LYNX

Concerto

Option: AVL InMotion™

Power supply 12V

Thermal camera (optional)

Safety systems
- Safety PLC
- Gas and fire - detection
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Power supply 12V

Thermal camera (optional)
AVL e-STORAGE SYSTEM FOR MICRO-MILD HYBRID TESTING (48V)

<table>
<thead>
<tr>
<th>Power (nominal)</th>
<th>Current (nominal)</th>
<th>DC Voltage range</th>
</tr>
</thead>
<tbody>
<tr>
<td>20kW</td>
<td>+/- 350A</td>
<td>4-65V</td>
</tr>
<tr>
<td>32kW</td>
<td>+/- 600A</td>
<td>4-65V</td>
</tr>
</tbody>
</table>

- Battery Emulator (BE) / Battery Tester (BT) functionality
- Galvanic isolation from mains
- Earth fault detection
- BE safety compliant with ISO 13849-1 PL e
- 0.1% FS voltage and current measurement accuracy with 16bit resolution
- CAN 1kHz and Hybrid interface (U, I, P control modes)
- Very compact dimensions, with wheels
AVL E-MOTOR TEST SYSTEMS
TYPICAL 48V TEST BED SETUP

Option: 48V DC Load

Battery Emulator

T / P / U Measurement

Coolant Conditioning

Test System Mechanics

E-Motor + inverter

Power Measurement

U, I

Speed, Torque

Drive Shaft

Option: 48V DC Load

HCU

Dyno Inverter

Load Unit

Options:
- Stall Brake
- Angle Measurement

Options:
- Climatic Chamber

Automation / Simulation

Battery Emulator

Emulator

Mains Supply

Automation / Simulation

PUMA Open EMCON

Option: AVL InMotion™
48V Boardnet Architecture

48V High-Power Consumer

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- ... PTC Heater
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  El. AC Compressor ...

48V Generation & Storage

- 48V Starter/Generator

Classic 12V Boardnet

- 48V Battery System

DC/DC

12V
AVL POWER ELECTRONICS TEST SYSTEMS
TYPICAL TEST BED SETUP

Baseline Measurement

Coolant Conditioning

UUT chamber

Options:
- Climatic Chamber
- Climatic coolant cond.

2Q DC/DC Converter

Mains Supply

Battery Emulators

Automation / Simulation

PUMA Open EMCON

UUT 48V-Inverter

Power supply 12V

Mains Supply

Speed & angle position signals

e-Motor Emulator

Option: AVL InMotion™

Power Measurement

Option: Switch rack (failure insertion)

Battery Emulators

Mains Supply

UUT 48V-Inverter

Power supply 12V

Mains Supply

UUT 48V-Inverter

Power supply 12V

Mains Supply

2Q DC/DC Converter

Mains Supply

Battery Emulators

Automation / Simulation

PUMA Open EMCON

UUT chamber

Options:
- Climatic Chamber
- Climatic coolant cond.

Power Measurement

Option: Switch rack (failure insertion)
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48V High-Power Consumer

48V Generation & Storage

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- 12V

AVL UK EXPO 2014    Michael Herbel
AVL INTEGRATION TEST SYSTEMS

TYPICAL TEST BED SETUP

- **T / P / U Measurement**
- **Coolant Conditioning**
- **Test System Mechanics**
  - Options: Climatic Chamber

**UUT 48V-Inverter**

**Dyno Inverter**

**E-Motor**

**Load Unit**

Options:
- Stall Brake
- Angle Measurement

**Drive Shaft**

**Mains Supply**

**Power Measurement**

**DC/DC converter**

**48V Battery with BMS**

**12V Battery**

**Option: 48V DC Load**

**Option: 12V DC Load**

**Option: AVL InMotion™**

**HCU**
AVL ELECTRIFICATION TESTING SOLUTIONS
OVERVIEW OF PRODUCT AND SOLUTIONS

Virtual Vehicle + Environment Platform
AVL InMotionTM (optional)

Battery Test Bed
E-Motor Test Bed
Power Electronics Test Bed
Engine Test Bed
Transm. Test Bed
Powertrain Test Bed
Vehicle Test Bed

AVL e-Storage (DC Power Unit / Emulator / Tester)

Common AVL Automation Platform & Host
AVL ELECTRIFICATION UPGRADE ON ENGINE, POWERTRAIN AND VEHICLE TB
AVL ELECTRIFICATION TESTING SOLUTIONS
OVERVIEW OF PRODUCT AND SOLUTIONS

Virtual Vehicle + Environment Platform
AVL InMotionTM (optional)

Battery Test Bed
E-Motor Test Bed
Power Electronics Test Bed
Engine Test Bed
Transm. Test Bed
Powertrain Test Bed
Vehicle Test Bed

AVL e-Storage (DC Power Unit / Emulator / Tester)

Common AVL Automation Platform & Host
For more information, please visit: [www.avl.com](http://www.avl.com)

iPhone and iPad: [AVL Powertrain App](http://www.avl.com)