<table>
<thead>
<tr>
<th>Converter Voltage (V)</th>
<th>Converter Power (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>Trolley</td>
</tr>
<tr>
<td>Tram</td>
<td>Metro</td>
</tr>
<tr>
<td>EMU</td>
<td>HST</td>
</tr>
<tr>
<td>Loco</td>
<td></td>
</tr>
</tbody>
</table>

**ONIX Converter range**

- **ONIX 3000**
- **ONIX 1500**
- **ONIX 800**
- **Onix 350**
## High power IGBT drive functions

<table>
<thead>
<tr>
<th>Functionality</th>
<th>Solution</th>
<th>Sub-assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assure a safe switching</td>
<td>Input capacitors</td>
<td>Power electronics</td>
</tr>
<tr>
<td></td>
<td>Laminated bus bars</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decoupling capacitors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>di/dt control</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vce clamping</td>
<td></td>
</tr>
<tr>
<td>Protect the traction drive</td>
<td>IGBT monitoring</td>
<td>Gate drives</td>
</tr>
<tr>
<td></td>
<td>Short circuit detection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vge clamping</td>
<td></td>
</tr>
</tbody>
</table>
Semiconductor evolution

- 1985: 1,7kV-2x800A
- 1990: 3,3kV-1200A
- 1995: 4,5kV-1200A
- 2000: 6,5kV-600A
- 2005: 1,6kV-1200A, 4,5kV-4000A, 1,7kV-2x800A, 3,3kV-1200A, 4,5kV-1200A

IGBT, GTO
Some high power IGBTs

- EUPEC Module 600A-6.5kV
- FUJI PPI 1200A-4.5kV
- EUPEC Module 1200A-3.3kV
- TOSHIBA PPI 1200A-4.5kV
Water cooled power modules for the PRIMA locomotive range and Diesel electric locomotives
PALIX isometric view

Input voltage: up to 2000V
Power: 1200kW
Glycoled water cooling

Decoupling capacitors
Discharge resistors
Laminated bus bar
Water plate
Gate drives
IGBT module
Palix Module

Gate drive compartment

Laminated bus bar
AEM7 locomotive refurbishment
First IGBT series locomotive in the world

- ASEA traction drives
- Service in 1981
- DC motors
- Thyristor rectifiers
- Oil cooling
- Fleet: 53 locomotives

- ALSTOM traction drives
- Service in Feb 2000
- AC motors
- ONIX IGBT inverters
- Water cooling
- Fleet: 30 locomotives

The old one

The new one
AEM7 Main Characteristics

- **Customer:** AMTRAK (US)
- **Order:** 30 locomotives
- **Service:** Feb 2000
  - Boston-Washington
- **Type:** AEM7
- **Contract:** Refurbishment with IGBT AC drives
- **Supply:**
  - 25 kV-60Hz
  - 12.5kV-60Hz
  - 12 kV-25Hz
- **Power:**
  - ~ 6000kW input
  - 5000kW traction
  - 4326kW regeneration
  - 2290kW rheostatic
  - 1375kVA auxiliaries
- **Effort:** 230kN @ 70kmh
- **Max speed:** 125mph (~ 200kmh)
- **Bogie:** BoBo

- **Power scheme:** 4 AC traction drives
  - 4 PMCFs intercaled
  - 4 motor inverters
  - 1 auxiliary inverter
  - 4 rheo choppers
- **Semiconductors:** IGBT 3,3kV-1200A
- **Converter cooling:** Glycoled water
- **Power modules:** χNIX 1500-PALIX
- **Control:** AGATE Control
- **Motor:** 1250 kW
  - 15780 Nm at starting
  - 1985rpm @125mph
- **Transformer:** 7326 KVA
  - 4 x 1050V
  - Tap changer
  - 13,2 T
- **Mass:** 91T
AEM7 Simplified power scheme

12.5 & 25kV-60Hz
12kV - 25Hz

480V-60Hz
1375KVA
AEM7 Amtrak Locomotive
Traction Central Block
Syria Diesel Electric Locomotive

DEL CoCo 3200 HP 120km/h
Syria Diesel Electric Locomotive
Power architecture
Syria Diesel Electric Locomotive
PALIX IGBT Inverters

Inverter
Rheo
Chopper
BB427001 Freight Locomotive
Starting effort: 320kN
Max speed: 140km/h
Tractive power: 4200kW
Braking power: 2600kW
Weight: 90t

Rheostatic or regenerative braking
PRIMA range: 4U power scheme

- DJ(C)
- DJ(M)
- H(O-M)
- PMCF & RH
- PMCF 3kV
- M1
- Inverter
- CVS-AUX

Specifications:
- 25 kV-50Hz
- 15 kV-16Hz 2/3
- 3000 V DC
- 1500 V DC
- 3000 V DC
- 380 V 50Hz
BB427000: motor block for 2 axles
## High power ONIX traction drives

### References

<table>
<thead>
<tr>
<th>DEL/EL</th>
<th>Type</th>
<th>Customer</th>
<th>Power</th>
<th>Supply</th>
<th>Speed</th>
<th>Quantity</th>
<th>Delivery</th>
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</thead>
<tbody>
<tr>
<td>Loc</td>
<td>AD32C</td>
<td>Syria Railways</td>
<td>2370kW</td>
<td>Diesel</td>
<td>120km/h</td>
<td>30</td>
<td>1999</td>
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<tr>
<td>Loc</td>
<td>AEM7</td>
<td>Amtrak U.S</td>
<td>6000kW</td>
<td>12.5 &amp; 25kV-60Hz, 12kV-25Hz</td>
<td>200km/h</td>
<td>30</td>
<td>1999</td>
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<tr>
<td>Loc</td>
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<tr>
<td>Loc</td>
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<td>Iran Railways</td>
<td>2877kW</td>
<td>Diesel</td>
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<td>100</td>
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<td>Fossil fuel</td>
<td>3700kW</td>
<td>Turbine</td>
<td>240km/h</td>
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<td>4200kW</td>
<td>25kV-50Hz, 1500V</td>
<td>140km/h</td>
<td>415</td>
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<tr>
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<td>4200kW</td>
<td>25kV-50Hz, 15kV-16.7Hz, 1500V</td>
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<tr>
<td>Loc</td>
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<td>SNCF</td>
<td>4200kW</td>
<td>25kV-50Hz, 1500 &amp; 3000V</td>
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<td>2003/2008</td>
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<tr>
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<td>New Jersey Transit U.S</td>
<td>2600kW</td>
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<td>160km/h</td>
<td>33</td>
<td>2003</td>
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<tr>
<td>Loc</td>
<td>DEL</td>
<td>Egyptian Railways</td>
<td>700kW</td>
<td>Diesel</td>
<td>80km/h</td>
<td>30</td>
<td>2003</td>
</tr>
</tbody>
</table>
Thank you for your attention