30kW Exportable Power System for Military Tactical Vehicles

SBIR Topic A05-240
Contract # W56HZV-06-C-0590
Phase II
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Wade Carter – Program Manager
30kW Exportable Power System
For Military Tactical Vehicles

AGENDA

● Military Power Needs
● 30 kW System Overview
● System Performance
● Future Vehicle Applications
30kW Exportable Power System
Military Power Needs Addressed

- Increased demand for vehicle systems
- Need for exportable AC and DC power for communications, weapons, medical support and service
- Reduced fuel consumption through higher efficiency power generation
- Updating fleet vehicles with increased power capabilities
30kW Exportable Power System Project Overview

- TARDEC NAC – Phase II SBIR Award to GSE
- GS Engineering (GSE)
  » System Integration, Packaging, Testing and Demonstration
  » System Control, Operator Interface & Wiring
  » Liquid Cooling System
  » Synchronous Belt Drive
- Technology Partners
  » DRS Fermont - 30kW Inverter
  » Magnetic Applications - PMG & Controller
- Vehicle - BAE Systems FMTV 5.0 Ton Cargo
30 kW Exportable Power System
System Key Features

- Vehicle Power at engine idle - 14V/28V @100A/200A
- Exportable AC Power at High Idle
  » 29 kW continuous (3-Phase AC at 120/208)
  » User Selectable Frequency - 50, 60 or 400Hz
- CANbus controlled system
- Operator Interface Panel w/ LCD Display
- Inverter technology available for future design
  » Compact modular design
  » Adaptable to DC or PMG Inputs
  » Selectable output voltage (240/416)
  » Parallel operation
- Retro-fit Kit for Fleet Vehicles
30kW Exportable Power System

System Components

- System Breakers
- Cooling System Heat Exchanger Pack
- Coolant Hoses
- 30kW Inverter
- Operator Control Panel - Inverter
- CAN & System Controller
- Alternator Aux Cooling Fan & Duct
- Modified Shock Tower
- Water Pump
- Coolant Reservoir
- System Wiring
- PM Generator
- Synch Belt Drive System
30kW Exportable Power System Subsystems

- Synchronous belt drive
- Permanent Magnet Generator (PMG) & Unified Controller
- DC-AC Inverter
- System Controller, Operator Interface & Wiring
- Auxiliary Cooling System
30kW Exportable Power System
Synchronous Belt Drive - FEAD

- Synchronous belt system
  - Direct replacement of CAT C7 Serpentine Kit
  - Power transmission - 56 hp & 350 lb-ft of torque
- 4.0:1 DR provides 34kW Power
- Adaptable to other engine/vehicle variants
- Designed for future engine start capability
30kW Exportable Power System
PMG & Unified Controller

- **PM Generator**
  - 4 Independent Windings
  - 3 Separate AC Voltages
  - 88% Efficiency at High Output
  - Air-Cooled

- **Unified Controller**
  - 14VDC 100A at Idle (700 rpm)
  - 28VDC 200A at Idle
  - 56VDC 600A at High Idle (1350 rpm)

- **Over Temp Protection**

- **Temperature Compensation**
30kW Exportable Power System
DC-AC Inverter

- Designed to meet majority of PRECISE Class I AC power quality requirements
- Reduced package
  - 37% lighter than standard 30kW inverters
  - Reduced Package Space fits on side of FMTV
  - 29”L x 16”H x 22” D (13% Reduced Space Claim)
- CAN Controlled
- Broadcasts System Status
- Over Temp Protection
- Liquid Cooled
### 30kW Exportable Power System

**Operator Control / Display**

<table>
<thead>
<tr>
<th>HED CAN Controller &amp; Display</th>
<th>Control Switching</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Vehicle Parameters</td>
<td>• Inverter Power</td>
</tr>
<tr>
<td>• Cooling System</td>
<td>• E-Stop</td>
</tr>
<tr>
<td>• Alternator/Controller (DC System)</td>
<td>• Frequency Select</td>
</tr>
<tr>
<td>• Inverter (Exportable Power)</td>
<td>• Battle Short</td>
</tr>
<tr>
<td></td>
<td>• Contactor Open/Close</td>
</tr>
</tbody>
</table>

![Operator Interface Panel](image-url)

**CAN Controller**

May 7, 2009  
UNCLAS: Dist A. Approved for public release
30kW Exportable Power System
Cooling System

- Closed loop liquid cooling system
- Variable speed pump & fans
  » Monitor & maintain cooling
  » Reduced power consumption
  » Minimized operational noise
  » Increased component life
- Expandable design
30kW Exportable Power System Controller – DC Output

- Tested to MIL-STD 1332 & 1375
- Meets majority of the requirements tested
  - Voltage Regulation
  - Steady-state Stability
  - Dip & Recovery
    - Meets for 14/28V
    - 56V – 32% vs 30% dip
  - Rise & Recovery
    - Meets for 14/28V
    - 56V – 3 sec vs 2 sec recovery
  - Ripple Voltage
  - Voltage Fluctuations
30kW Exportable Power System
DC-AC Inverter Performance

Inverter Specifications

- **Input**
  - 56VDC Nominal (50-62VDC)
  - 640A Nominal
  - +/-20% Voltage < 1sec

- **Output**
  - MIL-STD-1332B Class 2B
  - 120/208VAC (3 Phase, 4 Wire w/ Ground)
  - Power Rating - 30kW
  - Power Factor - 0.8 lag
  - Efficiency ~ 83%
  - 2% Total Harmonic Distortion (THD)

<table>
<thead>
<tr>
<th>Model Number</th>
<th>318-01-01</th>
</tr>
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<tbody>
<tr>
<td><strong>INPUT SPECIFICATIONS</strong></td>
<td></td>
</tr>
<tr>
<td>Voltage</td>
<td>56VDC Nominal (50-62VDC)</td>
</tr>
<tr>
<td>Current</td>
<td>640Amps Nominal</td>
</tr>
<tr>
<td>DC Power Disturbances</td>
<td>+/-20% Voltage for less than 1 sec</td>
</tr>
<tr>
<td><strong>OUTPUT SPECIFICATIONS</strong></td>
<td></td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>MIL-STD-1332B Class 2B</td>
</tr>
<tr>
<td>Configuration</td>
<td>Three Phase, Four Wire plus Ground</td>
</tr>
<tr>
<td>Voltage</td>
<td>120/208VAC, 50</td>
</tr>
<tr>
<td>Rated Power Factor</td>
<td>0.8 lag</td>
</tr>
<tr>
<td>Output Power</td>
<td>30,000 Watts</td>
</tr>
<tr>
<td>Output VA</td>
<td>37,500 VA</td>
</tr>
<tr>
<td>Rated Output Current</td>
<td>1042.3 Amps</td>
</tr>
<tr>
<td>Voltage Regulation</td>
<td>1%</td>
</tr>
<tr>
<td>Frequency</td>
<td>Selectable: 50/60/400 Hz</td>
</tr>
<tr>
<td>Waveform Deviation</td>
<td>5 %</td>
</tr>
<tr>
<td>Efficiency at rated load</td>
<td>Better than 95 %</td>
</tr>
<tr>
<td>Harmonic Distortion</td>
<td>Better than 5 % single harmonic, 2% THD</td>
</tr>
<tr>
<td>Output DC Bias</td>
<td>Better than 0.1V</td>
</tr>
</tbody>
</table>

**ENVIRONMENTAL QUALIFICATIONS**
- Electromagnetic Interference/ Electromagnetic Compatibility (EMI/EMC): MIL-STD-461E Army Ground
- Vibration: MIL-STD-810F, Category 10
- Audible Noise: 70 dBA at 36 inches (0.9 Meters)
- Shock (Transit Drop): MIL-STD-810F, Procedure IV
- Operating Temperature: -50°F to +135°F (-45°C to +63°C)
- Storage Temperature: -60°F to +150°F (-51°C to +66°C)
- Blowing Rain: MIL-STD-810F, 45 degrees, 3 inches per hour (12.7 cm/hr)
- Sand and Dust: MIL-STD-810F, Blowing Dust, Blowing Sand 1400mg/cubic meter
- Relative Humidity: 35% to 95%

**PHYSICAL SPECIFICATIONS**
- Weight: Less than 200 lbs
- Width (Enclosure): 29.0
- Depth (Enclosure): 22.4
- Height (Enclosure): 16.3

**COOLING REQUIREMENTS**
- Cooling Mixture: 50-50 Glycol Water
- Flow Rate: 3 GPM Minimum
- Coolant Temperature: 149°F (65°C) Maximum
- Power Dissipation into Liquid: 4000W
- Power Dissipation into Ambient Air: 1000W
# 30kW Exportable Power System

## AC Exportable Power Performance

### MIL-STD-705 AC Waveform Testing Results

<table>
<thead>
<tr>
<th>CHARACTERISTIC PARAMETER</th>
<th>Precise Class I</th>
<th>Utility Class 2A</th>
<th>Utility Class 2B</th>
<th>Utility Class 2C</th>
<th>DRS FERMONTE 30KW INVERTER</th>
<th>Test Method MIL-STD-705</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Voltage characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Regulation (%)</td>
<td>1%</td>
<td>2%</td>
<td>3%</td>
<td>4%</td>
<td>Precise Class I</td>
<td>608.1</td>
</tr>
<tr>
<td>2. Steady-state stability (var./bandwidth %)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a.) Short term (30 seconds)</td>
<td>1%</td>
<td>1%</td>
<td>2%</td>
<td>2%</td>
<td>Precise Class I</td>
<td>608.1</td>
</tr>
<tr>
<td>(b.) Long term (4 hours)</td>
<td>2%</td>
<td>2%</td>
<td>4%</td>
<td>4%</td>
<td>Precise Class I</td>
<td>608.2</td>
</tr>
<tr>
<td>3. Transient performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a.) Application of rated load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) Dip (%)</td>
<td>15%</td>
<td>20%</td>
<td>20%</td>
<td>30%</td>
<td>Precise Class I</td>
<td>619.2</td>
</tr>
<tr>
<td>(2) Recovery (seconds)</td>
<td>0.5 sec</td>
<td>3 sec</td>
<td>3 sec</td>
<td>3 sec</td>
<td>Precise Class I</td>
<td>619.2</td>
</tr>
<tr>
<td>(b.) Rejection of rated load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) Rise (%)</td>
<td>15%</td>
<td>30%</td>
<td>30%</td>
<td>30%</td>
<td>Precise Class I</td>
<td>619.2</td>
</tr>
<tr>
<td>(2) Recovery (seconds)</td>
<td>0.5 sec</td>
<td>3 sec</td>
<td>3 sec</td>
<td>3 sec</td>
<td>Precise Class I</td>
<td>619.2</td>
</tr>
<tr>
<td>(c.) Application of sim motor load (%)(Note 6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) Dip (%)</td>
<td>30%</td>
<td>NA</td>
<td>40%</td>
<td>NA</td>
<td>Precise Class I</td>
<td>619.1</td>
</tr>
<tr>
<td>(2) Recovery to 95% rated voltage (sec)(Note 6)</td>
<td>0.7 sec</td>
<td>NA</td>
<td>5 sec</td>
<td>NA</td>
<td>Precise Class I</td>
<td>619.1</td>
</tr>
<tr>
<td>4. Waveform (Note 4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a.) Maximum deviation factor (%)</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>6%</td>
<td>Precise Class I</td>
<td>601.1</td>
</tr>
<tr>
<td>(b.) Maximum individual harmonics (%)</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>3%</td>
<td>Precise Class I</td>
<td>601.4</td>
</tr>
<tr>
<td>5. Voltage unbalance with unbalanced load (%) (Note 3)</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>Precise Class I</td>
<td>620.2</td>
</tr>
<tr>
<td>6. Phase balance voltage (%)</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
<td>Precise Class I</td>
<td>508.1</td>
</tr>
<tr>
<td>7. Voltage adjustment range (%) (min) (Note 4)</td>
<td>-5% +17</td>
<td>+/-10%</td>
<td>-5% +17</td>
<td>Not Adjustable</td>
<td></td>
<td>511.1</td>
</tr>
</tbody>
</table>

**Notes:**
1. The voltage shall stabilize at or above this voltage (not applicable to all sets rated 5 k or below, or 500kW or larger.
2. Specified values are for three-phase output: for single phase add additional 1%.
3. With generator connected for three-phase output and supplying a single line-to-line, unity power factor, load of 25% of rated current and with no other load on the set. (Not applicable for single-phase connections of sets.)
4. For Mode II sets, upper voltage adjustment is +10% of rated voltage. For Mode I sets operating at 50 Hz, upper voltage adjustment may be limited to the nominal voltages shown in Table IV, Note 4. (Not included here.)
5. Values shown are for sets rated at 15kW and above.
6. Motor load current was 124%. The load was a 5 hp two stage air compressor connected to 208V (L1-L2).
30kW Exportable Power System
TARDEC Demonstration Jan-2009

- Resistive Load – 30kW AC Load Bank
  » Load Steps
  » Continuous Operation
- Inductive Load – Chop Saw, 3 HP Air Compressor
- Capacitive Load – Fluorescent Lighting
- Complex Load - Combination
30kW Exportable Power System
Potential Future Applications

Military Vehicles
- Any tactical vehicle in need of 30kW power
- “Bolt-on” retrofit for fleet vehicles

Government & Commercial Vehicles
- Disaster Relief
- Homeland Security
- Fire Apparatus
- Logging
- Mining
## CONTACT INFO:

<table>
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</tr>
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