30kW Exportable Power System for Military Tactical Vehicles

SBIR Topic A05-240

Contract # W56HZV-06-C-0590

Phase II

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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

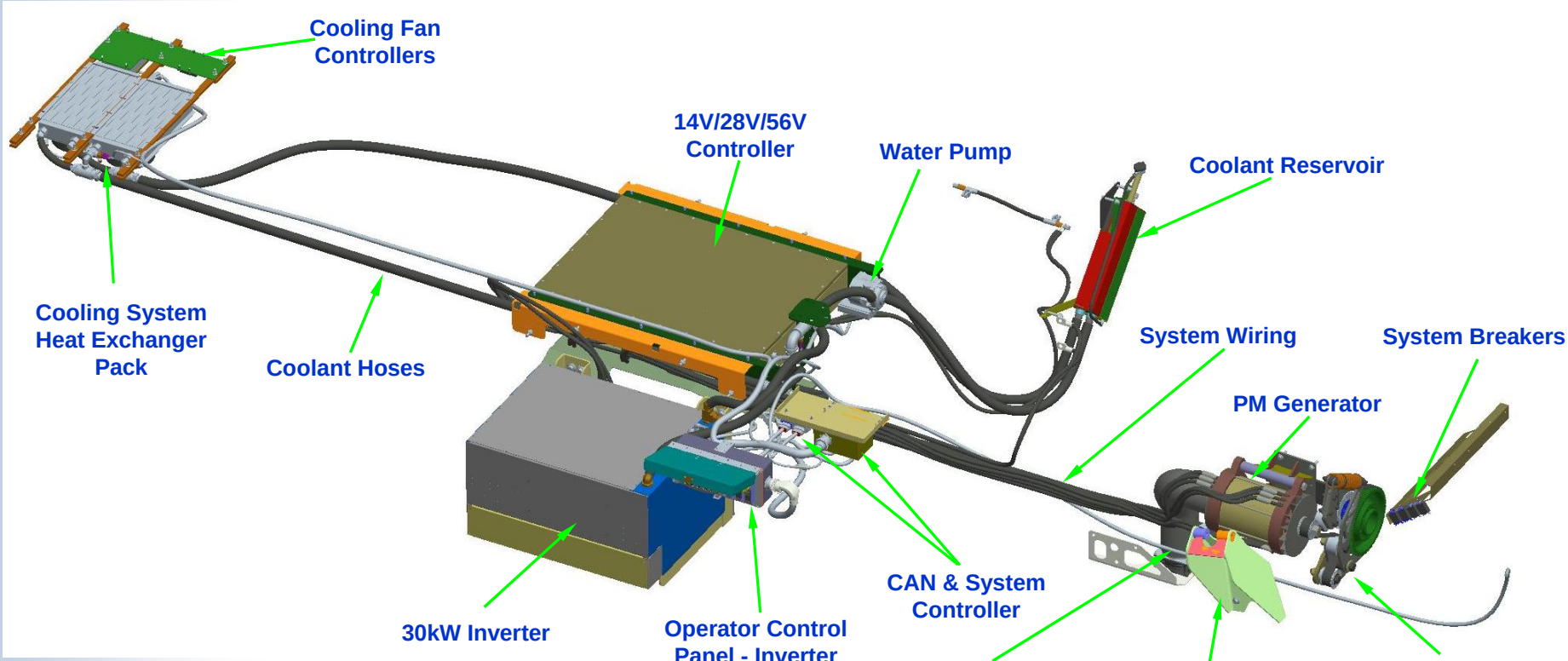
30kW Exportable Power System Project Overview

- **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**

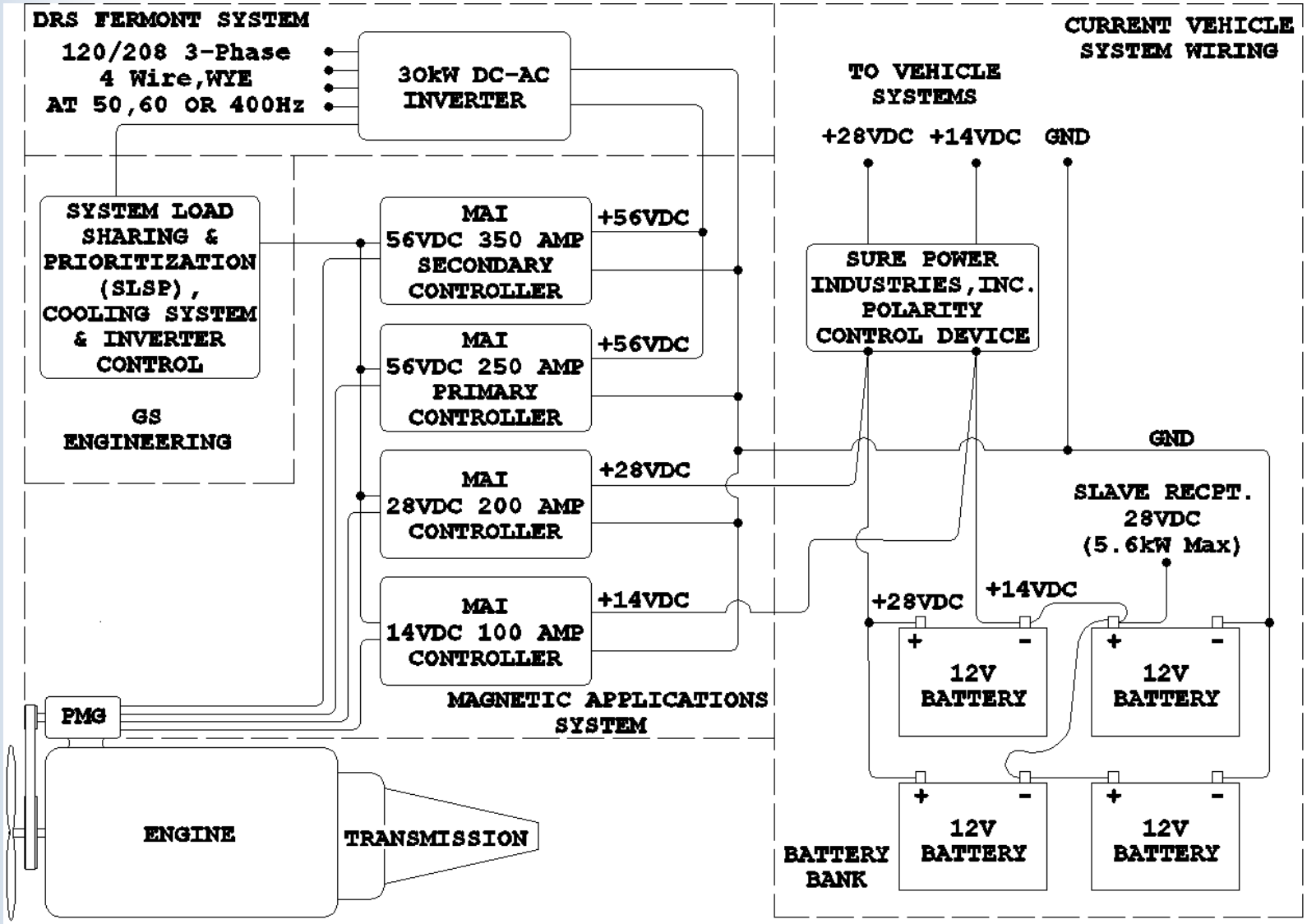
30 kW Exportable Power System System Key Features

- **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



30kW Exportable Power System System Schematic

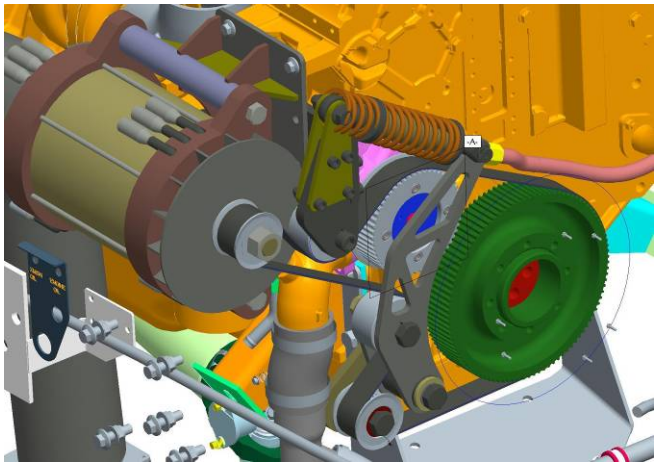


30kW Exportable Power System Subsystems

- 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**

Alternator & Wiring

14/28/56V Controller

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

HED CAN Controller & Display

- Vehicle Parameters
- Cooling System
- Alternator/Controller (DC System)
- Inverter (Exportable Power)

Control Switching

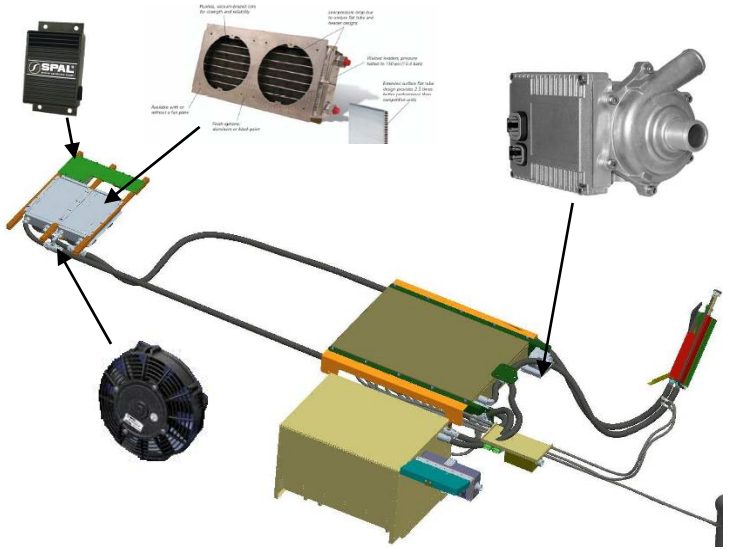
- Inverter Power
- E-Stop
- Frequency Select
- Battle Short
- Contactor Open/Close

Operator Interface Panel

CAN Controller

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)

Model Number	318-01-01
INPUT SPECIFICATIONS	
Voltage	56VDC nominal (50-62VDC)
Current	640Amps Nominal
DC Power Disturbances	+/-20% Voltage for less than 1 sec
OUTPUT SPECIFICATIONS	
Applicable Standards	MIL-STD-1332B Class 2B
Configuration	Three Phase, Four Wire plus Ground
Voltage	120/208VAC, 3Ø
Rated Power Factor	0.8 lag
Output Power	30,000 Watts
Output VA	37,500 VA
Rated Output Current	104.2 Amps
Voltage Regulation	1%
Frequency	Selectable: 50/60/400 Hz
Waveform Deviation	5 %
Efficiency at rated load	Better than 83 %
Harmonic Distortion	Better than 2 % single harmonic, 2% THD
Output DC Bias	Better than 0.1V
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 +138°F (-45°C to +59°C)
Storage Temperature	-60°F to +160°F (-51°C to +71°C)
Blowing Rain	MIL-STD-810F, 45 degrees, 5 inches per hour (12.7 cm/hr)
Sand and Dust	MIL-STD-810F, Blowing Dust, Blowing Sand 1400mg/cubic meter
Relative Humidity	Up to 95%
PHYSICAL SPECIFICATIONS	
Weight	Less than 200 lbs
Width (Enclosure)	29.0"
Depth (Enclosure)	22.1"
Height (Enclosure)	16.1"
COOLING REQUIREMENTS	
Cooling Mixture	50/50 Glycol-Water
Flow Rate	3 GPM Minimum
Coolant Temperature	149F (65C) 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						
CHARACTERISTIC PARAMETER	Precise Class I	Utility			DRS FERMONT 30KW INVERTER	Test Method MIL-STD-705
		Class 2A	Class 2B	Class 2C		
a. Voltage characteristics						
1. Regulation (%)	1%	2%	3%	4%	Precise Class I	608.1
2. Steady-state stability (var./bandwidth %)						
(a.) Short term (30 seconds)	1%	1%	2%	2%	Precise Class I	608.1
(b.) Long term (4 hours)	2%	2%	4%	4%	Precise Class I	608.2
3. Transient performance						
(a.) Application of rated load						
(1) Dip (%)	15%	20%	20%	30%	Precise Class I	619.2
(2) Recovery (seconds)	0.5 sec	3 sec	3 sec	3 sec	Precise Class I	619.2
(b.) Rejection of rated load						
(1) Rise (%)	15%	30%	30%	30%	Precise Class I	619.2
(2) Recovery (seconds)	0.5 sec	3 sec	3 sec	3 sec	Precise Class I	619.2
(c.) Application of sim motor load (200% current) (Note[6])						
(1) Dip (%)	30%	NA	40%	NA	Precise Class I	619.1
(2) Recovery to 95% rated voltage (sec)(Note[1])	0.7 sec	NA	5 sec	NA	Precise Class I	619.1
4. Waveform (Note[2])						
(a.) Maximum deviation factor (%)	5%	5%	5%	6%	Precise Class I	601.1
(b.) Maximum individual harmonics (%)	2%	2%	2%	3%	Precise Class I	601.4
5. Voltage unbalance with unbalanced load (%)(Note[3])	5%	5%	5%	5%	Precise Class I	620.2
6. Phase balance voltage (%)	1%	1%	1%	1%	Precise Class I	508.1
7. Voltage adjustment range (%) (min)(Note[4])	-5% +17	+/-10%	-5% +17 (Note[5])	-5 +5%	Not Adjustable	511.1

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 show 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

30kW Exportable Power System
GSE Contacts

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