ATTACHMENT 0005
SiC Generator Controller Performance Testing Inspection and Acceptance Criteria

SOW Section #	Performance Description	Type of Test				Preliminary testing	Acceptance testing at TARDEC Labs	Notes
		Inspection	Test (with surogate loads)	Demonstration	Engineering Analysys			
	Section A5-1							
C.2.1.1	The generator controller shall output 600 volts direct current (VDC) in accordance with (IAW) MIL-PRF-GCS600A "Characteristics of 600 Volt DC Electrical Systems for Military Ground Vehicles" (Attachment 002). The generator controller shall be capable of handling a step load of 45kW with a cable length between the controller and the generator of five (5) meters.				X	X		
				X			X	
C.2.1.5	MIL-STD-810G environmental requirements necessary for integration onto combat and tactical vehicles				X	X		
C.2.2.1.1	The generator controller shall be compatible with a 3 phase permanent magnet (PM) machine with and without a position feedback device in both motoring and generating modes		X		X	X		**surogate must be a motor**
				X			X	
C.2.2.1.2	The generator controller shall have inputs and function with all of the following position feedback devices: Resolver, Encoder, Hall Effect sensor				X	X		
				X			X	
C.2.2.2.1	The generator controller shall provide 175 kilowatts (kW) of continuous power output on the 600 volts direct current (VDC) side			X			X	
C.2.2.2.2	The generator controller shall operate an electric machine in torque mode and speed mode to allow for vehicle engine starting and burst acceleration		X			X		**surogate must be a motor**
				X			X	
C.2.2.2.3	Minimum torque capability shall be 700 Newton-meter (N-m) steady-state				X	X		
				X			X	
C.2.2.2.3	Minimum peak (transient) torque capability shall be at least 1500 N-m, 600 Amps Root-Mean-Square (RMS) output				X	X		
				X			X	
C.2.2.2.3	Minimum sustained cranking speed shall be 300 revolutions per minute (RPM),with a capability of at least 300 Amps RMS output, with an objective of 600 Amps RMS output			X			X	
C.2.2.2.4	The generator controller shall have an output direct current (DC) link capacitance no less than 100 micro-Farads (uF) for DC bus stability.			X		X	X	
C.2.2.2.5	The generator controller shall provide 175 kW of continuous power output to the motor				X	X		**surogate must be a motor**
				X			X	
C.2.2.3.1	The generator controller shall not suffer performance degradation or damage following exposure to water jet spraying per the test method described in C.2.2.3.1				X	X		
C.2.2.3.2	The generator controller shall operate without performance degradation during basic shock conditions per the test method described in C.2.2.3.2		X				X	
C.2.2.3.3	The generator controller shall withstand minimum static equivalent loads of 10g vertical, 6g fore and aft, and 6g in the lateral direction for 48 hours.				X	X		
C.2.2.3.4	The generator controller shall operate with no physical damage that affects the performance or functionality at the conditions described in this statement of work			X		X	X	
C.2.2.3.5	The generator controller shall operate without performance degradation during and after exposure to relative humidity up to 100%				X	X		
C.2.2.3.6	The generator controller shall be hardened with nuclear event detection circuitry.				X	X		

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SOW Section #	Performance Description	Type of Test: Inspection	Type of Test: Test (with surogate loads)	Type of Test: Demonstration	Type of Test: Engineering Analysys	Preliminary testing	Acceptance testing at TARDEC Labs	Notes
	The generator controller shall meet its full performance requirements without performance or physical degradation while operating to a minimum ambient air temperature of -60 degrees F				X	X		
C.2.2.3.7	(-51 degrees C)		X				X	
C.2.2.3.8	The generator controller shall comply with the performance requirements defined in ATPD-2404 section 5				X	X		
C.2.2.3.8	ATPD-2404 5.1.8.1 The system, subsystem or equipment shall operate at altitudes from 1300 feet below to 15,000 feet above sea level and atmospheric pressures of 508 millibars to 1080 millibars. Compliance shall be IAW MIL-STD-810G Method 500.5, Procedure II				X	X		
C.2.2.3.8	ATDP-2404 5.2.9 The subsystem or equipment shall deny water entry and operate after immersion to a depth of 1 meter for 2 hours. The subsystem or equipment shall be conditioned to 27 degrees C above water temperature. Subsystems or equipment located on the hull exterior or engine compartment that may be submerged during fording shall deny water entry and operate after immersion to a depth of 2 meters for 2 hours. Compliance shall be IAW MIL-STD-810G Method 512.5 Immersion Procedure I. Connector covers equivalent to Item interconnect harness connectors are permitted. Pressurized air may be used to remove water from the connector pins after immersion.			X		X	X	
C.2.2.3.8	ATDP-2404 5.2.9 The system, subsystem or equipment shall not cause ignition of an explosive atmosphere. Compliance shall be IAW MIL-STD-810G Method 511.5 Procedure I		X			X		
	ATDP-2404 5.2.1 The system, subsystems and equipment shall meet their full performance requirements without performance or physical degradation during and after vibrational stresses as outlined in the composite isolated random-on-random vibration Tables I through VI for turret and hull/sponson locations. Compliance shall be by test IAW MIL-STD-810G Method 514.6, Vibration, Procedure I, Category 20, Ground Vehicles				X	X		
C.2.2.3.8			X				X	
C.2.2.4.1	The generator controller shall have protection from short circuit conditions at the high voltage outputs		X			X	X	
C.2.2.4.2	The generator controller shall sense a connection between its power circuitry and the chassis and notify the vehicle (broadcast) via CAN if a Ground Fault is detected at the controller 600 VDC output			X		X	X	
C.2.2.4.3	The generator controller's high voltage (HV) power (600 VDC) and return shall be electrically isolated from the generator controller's primary power (28 VDC) returns by a resistance of 100 Megaohms or greater.			X		X	X	
C.2.2.4.4	The generator controller's HV power (600 VDC) and return shall be electrically isolated from the equipment chassis by a resistance of 100 Megaohms or greater when not connected to the Ground Fault Detector circuitry			X		X	X	
C.2.2.4.5	The generator controller shall be designed and manufactured to comply with High Voltage Corona (HVC) pursuant to the requirements defined in MIL-HDBK-454, Guideline 45 for altitudes up to 15,000 ft (4,572 m)				X	X		
C.2.2.4.6	The generator controller shall have a green light emitting diode (LED) indicator by the HV connector signifying if 600VDC is being outputted through the connection. The LED shall turn red if the safety interlock is open. The LED shall turn blue if the HV safety interlock has been overridden and the connection is outputting 600VDC			X		X	X	
C.2.2.4.7	The generator controller shall incorporate arc flash mitigation to limit incident energy as described in C.2.2.4.7 pursuant to the IEEE-1584 Arc Flash Standard				X	X		
C.2.3.1	The generator controller shall be controllable via J1939 CAN protocol. The generator controller shall provide no network termination			X		X	X	

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		Inspection	Test (with surogate loads)	Demonstration	Engineering Analysys			
C.2.3.2	The generator controller shall make available on the CAN network all monitored data; this includes phase voltages, DC bus voltage, currents, temperatures, fault status, feedback [bus voltage, current quadrature (Iq) component, and current direct (Id) component {higher update rate}, speed, available temperatures] and all other data that the controller monitors.			X		X	X	
C.2.3.3	The generator controller shall make available on the CAN network the following functions: Enable/disable, Torque command, speed command, voltage command, mode selection (torque, speed, voltage)			X		X	X	
C.2.3.4	The generator controller shall be configurable via reprogramming through the CAN network interface			X		X	X	
C.2.3.5	The generator controller CAN messages shall use the messaging format in the CAN message interface control document (ICD) template (Attachment 001)			X		X	X	
C.2.3.6	The generator controller shall monitor and report status of the high voltage interlocks via CAN			X		X	X	
C.2.3.7	The generator controller shall record faults and report them over the CAN network for system diagnosis			X		X	X	
C.2.3.8	The generator controller software shall alert via CAN when regulation pursuant to MIL-PRF-GCS600A (Attachment 002) is not possible due to generator and generator controller limitations (Attachment 002)				X	X		
				X			X	
C.2.3.9	The generator controller options described in C.2.3.9 shall be programmable via CAN and through an additionally provided serial port			X		X	X	
C.2.3.10	The generator controller shall be programmable through the graphical user interface to allow for integration with PM machines of varying designs as described in paragraph C.2.2.1.1			X		X	X	
C.2.3.11	The generator controller shall utilize a 28VDC input for low voltage control power. The 28 VDC bus shall be compatible with MIL-STD-1275E			X		X	X	
C.2.3.12	The generator controller application software shall provide access to the parameters listed in c.2.3.12			X		X	X	
C.2.3.13	The generator controller shall cease bus regulation and cease energizing the bus upon external command via messaging from the CAN bus			X		X	X	
C.2.3.14	The generator controller firmware and embedded operating system software shall be upgradable via the serial port described in section C.2.3.9			X		X	X	
C.2.4.1	The generator controller shall operate at full power with 105 degrees Celsius (°C) input coolant and a 150 degrees Celsius ambient temperature. The flow rate shall not exceed 12 liters/minute, at 9 psig (Pounds Per Square Inch Guage) inlet pressure. The maximum outlet steady state temperature shall not exceed 120 degrees Celsius.				X	X		
				X			X	
C.2.4.2	The generator controller components shall be designed to withstand a non-operational peak soak back temperature of 125°C, with an objective of 150 degrees Celsius				X	X	X	
C.2.4.3	The generator controller shall be compatible with an Ethylene Glycol Water (EGW) 50/50 mixture			X	X	X	X	
C.2.4.4	The generator controller shall monitor critical cooling performance data, including at a minimum, inlet and outlet coolant temperatures, and critical heat rejection component temperatures (e.g. power conversion devices). Examples of "Critical components" include the components that will be first to suffer failure due to excessive heat rejection while under load conditions			X		X	X	
C.2.5.1	The generator controller shall have a power density (power/volume) of at least 19.6 kW/liter with an objective of 35 kW/liter.			X	X	X	X	

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SOW Section #	Performance Description	Type of Test				Preliminary testing	Acceptance testing at TARDEC Labs	Notes
		Inspection	Test (with surogate loads)	Demonstration	Engineering Analysys			
C.2.5.2	The generator controller shall have a specific power (power/weight) of at least 10.5 kW/kg and an objective of 25 kW/kg			X	X	X	X	
C.2.5.3	The generator controller shall use SiC modules for the primary switching components inside the controller				X	X		
C.2.5.4	The generator controller shall be designed to be mounted in any physical orientation and operate without degradation			X	X	X	X	
C.2.5.4	The generator controller shall not exceed any of the following dimensions stated in millimeters (mm) (including connectors) 385mm (L) x 130 mm (H) x 280mm (D)				X	X		
C.2.5.5	The generator controller signal connectors shall be commercial off the shelf connectors, of an existing current military standard (e.g. MIL-DTL-38999L w/AMENDMENT 2, series III).	X				X	X	
C.2.5.6	The generator controller shall have three (3) 600VDC output circuits with the following current ratings: (i) 300 amps, (ii) 75 amps, and (iii) 75 amps.	X				X	X	
C.2.5.6	The 600VDC circuits shall utilize solid state circuit breaker that are configured electrically as normally off (the device will not pass current without a gate signal). The circuits shall have a user adjustable current setting that allows for adjustments from 20% to 100% of its maximum current rating. The circuits shall have the ability to be disabled via a message from the CAN bus.			X		X	X	
C.2.6.1	The contractor shall develop a GUI for the SiC generator controllers that functions with both CAN and serial communication interfaces, and that provides data acquisition capability for testing.			X		X	X	
C.2.6.2	The GUI shall allow for the tuning of the generator system parameters in real-time, including hardware controlled and monitored current and voltage limits, control(s) system gain parameters, bus voltage control gains and limits, and any other parameters essential for HV Power production and HV Bus voltage regulation. The GUI shall have data logging and debugging functionality. The GUI shall allow user modification of CAN data frames, packing, bit rate, and all other configurable parameters without modifying source code.			X		X	X	
	Section A5-2							
C.2.1.2	Emission and susceptibility requirements of MIL-STD-461F CE102, CS101, CS114, CS115, CS116, RE102				X	X		
			X				X	
C.2.1.2	Emission and susceptibility requirements of MIL-STD-461F RS103				X	X		
C.2.1.3	Radiated Susceptibility, Transient Electromagnetic Field requirement of MIL-STD-461F RS105				X	X		
C.2.1.4	The generator controller shall meet its operational performance requirements described in this statement of work when exposed to the radio frequency electromagnetic environment (RF EME) described in paragraph 5.3 of MIL-STD-464C, Table 4				X	X		
					X	X		