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CHARACTERISTICS OF 600 VOLT DC ELECTRICAL SYSTEMS FOR MILITARY GROUND VEHICLES



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This specification is approved for use by the Department of the Army and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Purpose. The purpose of this specification is to provide a system of requirements for the electrical characteristics and safety of high voltage power distribution subsystems. This includes requirements for power sources, power distribution equipment, and power utilization equipment. Rather than an ideal condition (i.e. nominal voltage), this specification defines the extreme limits for normal operations and damage thresholds in steady-state and dynamic conditions. The resulting system of requirements will provide compatibility of source and load behavior for equipment within a single vehicle system, as well as provide an opportunity for commonality of power utilization equipment and power distribution equipment among a family of military ground combat vehicles with different power generation equipment.

1.2 Scope. The scope of this electrical power characteristics specification is focused on high voltage (i.e. 600VDC) electrical power characteristics in a manner similar to MIL-STD-1275 and MIL-STD-704. Electrical performance is characterized through specification of nominal voltage, steady state voltage range, maximum allowed transients and other parameters. The performance is specified under all operating conditions including normal operating mode, fault clearing modes, and other modes resulting from the most common failure mode effects of ground vehicle power systems. The scope extends into safety requirements necessary to specify a common functional approach to high voltage safety system designs and schema to the extent that commonality is encouraged during the design process.

1.3 Applicability. This specification is applicable to high voltage power distribution systems for existing and emerging Army ground vehicles.

1.4 Reference Architecture. Architectural similarities have been identified through analysis of applicable systems. This initial specification focuses on a reference architecture that draws upon the following common attributes: (1) 600 volt power generation, voltage regulation and ground isolation fault monitoring; (2) power conversion from 600VDC to 28VDC; (3) a low voltage battery and low voltage engine starter motor to crank the propulsion engine; (4) absence of a high voltage battery pack to assist in engine starting or to support engine off vehicle operations; and (5) power distribution equipment.

1.5 Resistive Grounding High Voltage Power Distribution. The resistive grounding concept employs a two rail balanced power distribution system created by chassis isolation (in the utilization equipment) and a resistive ground as defined by Section 3.4. The high voltage concept would typically deliver (in the absence of ground fault) +300 VDC and -300 VDC with respect to vehicle chassis. For the majority of the document the DC voltage level will be referred to by its nominal line-to-line value of 600 VDC. The resistive grounding scheme enables ground isolation fault detection.

1.6 Power Quality Modes. Given a disturbance to steady state, voltage regulation will be categorized according to “Normal”, “Fault Clearing” and “Failure” modes with respect to time as shown in Figure 2.

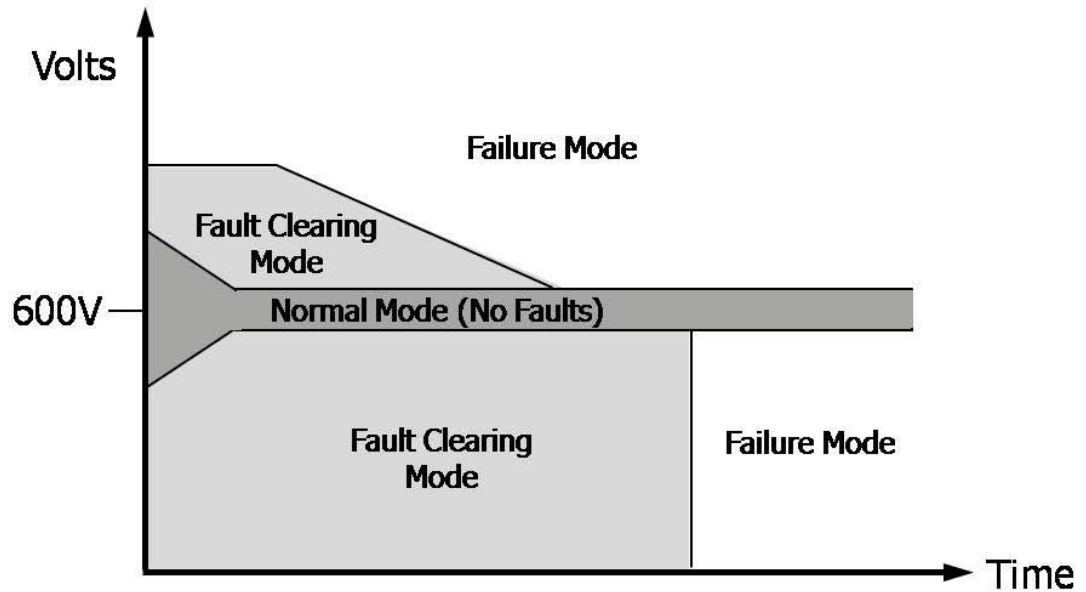


FIGURE 2: POWER QUALITY MODES

2. APPLICABLE DOCUMENTS

18440	General Performance Specification for the Common Modular Power System (v 0.10)
MIL-STD-461F	Electromagnetic Interference Characteristics for Electrical and Electronic Equipment
MIL-STD-704F	Aircraft Electric Power Characteristics
MIL-HDBK-454B	General Guidelines for Electronic Equipment
NFPA 70e	National Fire Protection Agency Standards for Electrical Safety in the Workplace

3. REQUIREMENTS

3.1 Normal Mode. Normal mode is defined as the operating mode of the power system when all parts are operating as intended in the absence of faults.

3.1.1 Definitions

3.1.1.1 Nominal Voltage. Nominal voltage is defined as the voltage value referenced in the title of the power system specification. It is not necessarily the power supply output voltage. High voltage power systems developed in accordance with this specification can be referred to as a “600V” DC power system.

3.1.1.2 Steady State Voltage. The steady-state voltage characteristic is defined as the range from lowest required operating voltage to the highest required operating voltage which exists in the power system during steady state conditions. Steady-state conditions may vary slowly with temperature, engine RPM, and load profile but are defined by the absence of step changes in the load profile from the normal activation and deactivation of system loads.

3.1.1.3 Normal Transient. A normal transient is defined as the largest allowable voltage excursion for a short duration that may be generated by the power generation and distribution system as a result of step load changes. In case of transient upset, the normal transient limits are used to judge assign corrective action.

3.1.1.4 Power Sources. Power sources are defined as source of power generation and voltage regulation for delivery to the power distribution system.

3.1.1.5 Power Distribution. Power distribution is defined by two functions: (1) delivery of power from the source to the load, and (2) protection from faults in the load or in the power distribution system. This second function requires fuses and/or circuit breakers. Power distribution equipment includes power cables, main and secondary power distribution units or boxes, and electronics such as digital communications busses and a processing resource to control the system. The power control system performs the power up and power down of the system, controls the normal on/off switching as needed, monitors the circuit protection devices and resets trips if needed, and collects diagnostics status for the power system.

3.1.1.6 Utilization Equipment. Utilization equipment is defined as the collection of electrical and electronic equipment which requires electrical power.

3.1.1.7 Voltage Drop. Voltage drop is defined as the voltage difference between the power source and the utilizing equipment.

3.1.1.8 Voltage Sag. Voltage sag is defined as the expected voltage drop over a short duration of time as the result of stepping up a load in the power distribution system. Voltage sag is to be controlled by the voltage regulation function of the power sources; however, the response time of the power source is slower than the demand of the step load, resulting in a temporary decrease in the power source voltage until the power source adjusts and recovers the power source voltage back to steady state conditions.

3.1.1.9 Voltage Ripple. Voltage ripple is defined as the AC noise remaining in the DC output after AC to DC conversion. Voltage ripple is unavoidable from power conversion and undesirable to utilization equipment. The amplitude of ripple is measured as the maximum absolute value of the difference between the steady state and the instantaneous DC voltage.

3.1.1.10 Distortion. Distortion is defined as unavoidable frequency variation and harmonics of the voltage ripple creating unwanted noise from the power generation equipment.

3.1.1.11 Distortion Spectrum. The distortion spectrum is defined as the maximum allowable limit of distortion expressed in decibels above 1 microvolt as a function of frequency.

3.1.1.12 Distortion Factor. The distortion factor is defined as the ratio of distortion to the steady state voltage.

3.1.2 Requirements

3.1.2.1 Power Sources. Electrical power sources shall generate power in accordance with normal mode characteristics when measured at the input power terminals of the electrical power utilization equipment.

3.1.2.2 Power Distribution Equipment. Power distribution equipment shall operate fully as required in its development specification when supplied power in accordance with the required characteristics in normal mode.

3.1.2.3 Utilization Equipment. Utilization equipment shall operate fully as required in its development specification when supplied power in accordance with the required characteristics in normal mode.

3.1.3 Electrical Characteristics. The electrical characteristics, when measured at the terminals of the utilization equipment, shall be in accordance with Table 1.

Steady-state Voltage	565V – 635V (600V +/- 35V)
Normal Transients	475V – 725V for 15ms (See Figure 3)
Ripple Amplitude	9V
Distortion Factor	0.015
Distortion Spectrum	See Figure 4

TABLE 1 ELECTRICAL CHARACTERISTIC FOR 600V SYSTEM

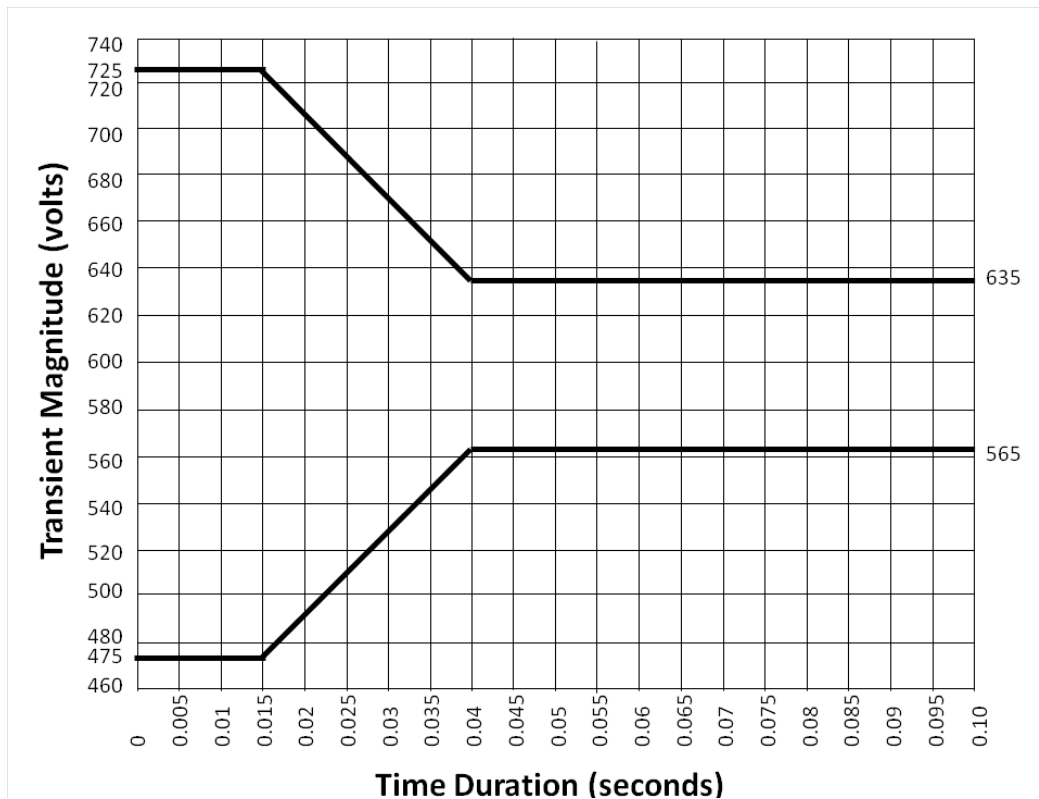


FIGURE 3: NORMAL TRANSIENTS

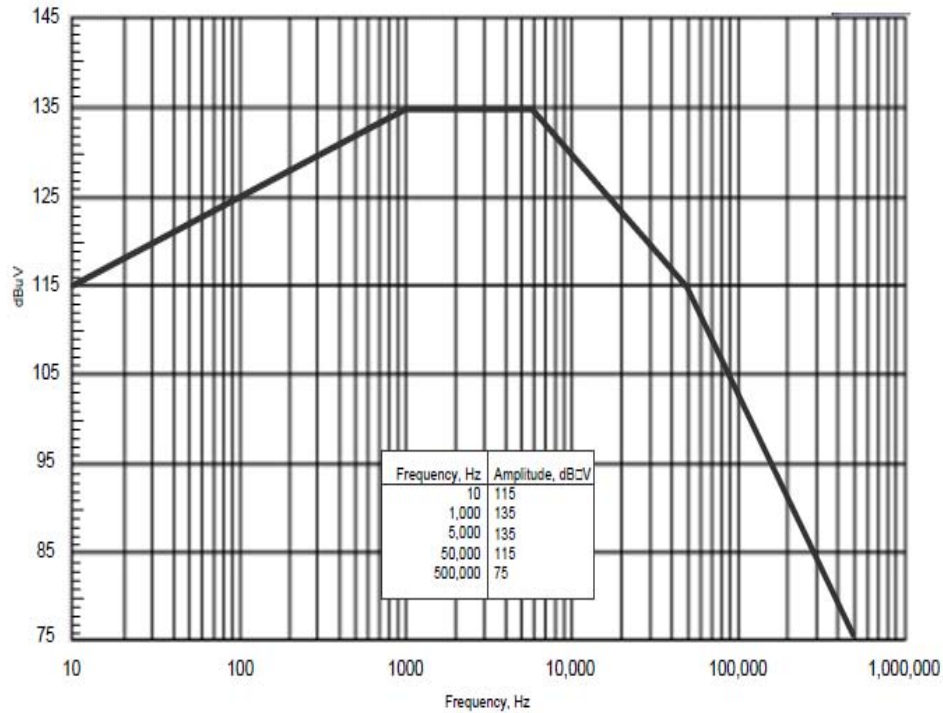


FIGURE 4: DISTORTION SPECTRUM

3.2 Fault Clearing Mode. The fault clearing mode is defined by the degraded quality of power delivered such that it does not comply with the electrical characteristic requirements for the normal mode of operation but does not exceed the characteristics for fault clearing mode. This is typical when a failure occurs in utilization equipment or the power feed to the utilization equipment, and protective devices in the power system are working to clear the fault and return the system to normal operation. In fault clearing mode, the over-current failure may overload the power sources such that the source cannot maintain voltage regulation. Some failure mode effects of power sources may also result in operation with these power characteristics.

3.2.1 Definitions

3.2.1.1 Over-current Fault. An over-current fault is defined as a short circuit fault of the utilization equipment or of the power distribution equipment delivering power to the utilization equipment. The over-current fault is a temporary condition that will result in clearing of the fault (i.e. tripping of a circuit breaker) to disconnect the fault from the power supply.

3.2.1.2 Over-current Fault Detection. Over-current fault detection is defined as the ability to sense over-current conditions of a power feed relative to that power line rating. Over-current fault detection is used to

initiate fault clearing of a power line fault. Fault clearing operations limit the time duration of under-voltage faults.

3.2.1.3 Under-voltage Fault. An under-voltage fault is defined as the normal operation of a power source which is overloaded and pulled low as the result of an over-current failure which is not yet cleared by the power distribution system. Under-voltage faults may also be a failure mode effect of a failed power source.

3.2.1.4 Trip. The definition of trip is to automatically open a power line in the distribution equipment in order to clear a power line over-current fault that has been detected.

3.2.1.5 Surge. The definition of a surge is to over-deliver power from a source such that the voltage is driven up beyond what is necessary to maintain nominal voltage levels. It is normal for a power supply operating as intended to surge for a short duration as a result of a step load shed or a fault clearing operation.

3.2.1.6 Over-voltage Fault. The definition of an over-voltage fault is the condition where a power surge drives the distribution system voltage above the limits of a normal transient. Over-voltage faults occur as a result of a surge or a failed power source.

3.2.2 Requirements

3.2.2.1 Performance of Power Sources. Power sources shall continue to deliver power, but may not be able to maintain the characteristics required in normal mode (degraded power), until the fault is cleared.

3.2.2.2 Performance of Power Distribution Equipment. Power distribution equipment shall continue to deliver power, as received from the power sources through to the utilization equipment, but may operate in a degraded mode of operation while it attempts to isolate the fault. Power distribution equipment shall continue to protect against over-current and arc flash, independently of the power management control system.

3.2.2.3 Performance of Utilization Equipment. Utilization equipment is permitted a degradation or loss of function unless otherwise specified in its detailed performance requirements. The vehicle system designers shall allocate additional requirements where needed to assure necessary operation of specialized equipment which has a function to perform when the vehicle power distribution system is not in the normal mode of operation (starting engines, tripping circuit breakers, power source failure modes, etc).

3.2.2.4 Safe Operation in Fault Clearing Mode. Power distribution and utilization equipment shall include fail-safe designs to assure that equipment will not operate in an uncontrolled or unsafe manner as defined by the system safety requirements.

3.2.2.5 Avoidance of Damage in Fault Clearing Mode. Power distribution and utilization equipment shall not be damaged.

3.2.2.6 Automatic Recovery to Normal Mode. The power source shall recover automatically to normal mode characteristics when the fault is cleared. Power distribution and utilization equipment shall recover automatically to their full performance when input power is returned to normal characteristics.

3.2.3 Electrical Characteristics

3.2.3.1 Design Threshold for Damage. The electrical characteristics in Fault Clearing mode shall not exceed the limits of Figure 5 below.

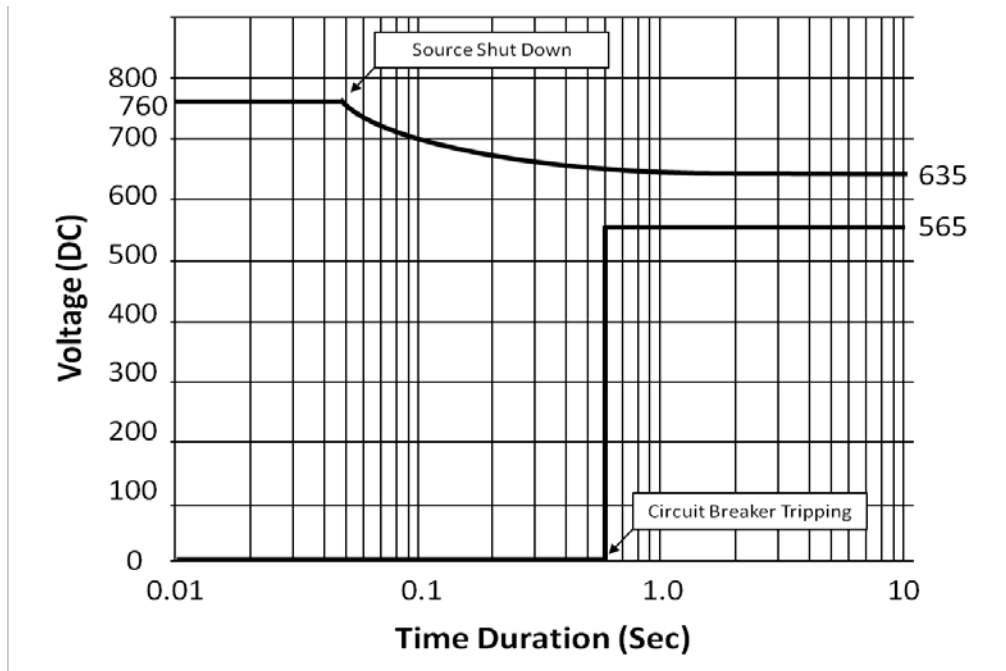


FIGURE 5: LIMITS FOR OVER-VOLTAGE AND UNDER-VOLTAGE

3.3 Failure Mode. The definition of the failure mode is when an unusual and extraordinary fault of the power sources or power distribution system has occurred such that the system voltage exceeds the design limits of the power system equipment and components. The purpose of specification of failure mode is to prohibit catastrophic propagating faults.

3.3.1 Definitions

3.3.1.1 Design Limits. Design limits are defined as the over-voltage and under-voltage time envelope that power system equipment and components are required to survive without failure.

3.3.1.2 Arc Flash. Arc flash is a dangerous high voltage fault that can cause tremendous damage to equipment and severe injury to personnel. If a short circuit fault initiates an electrical arc and the high voltage power source has sufficient energy to sustain the arc, then the resulting combination of plasma, molten metal, and intense heat can blast outward with extreme force.

3.3.1.3 Propagating Faults. Propagating faults are defined as new faults which result from the failure mode effects of previous faults. Ideally, all faults are to be contained; however in a limited integration space (such as a ground combat vehicle system), sometimes propagating faults cannot be avoided. The purpose of understanding propagating faults is to prioritize fault containment activities specifically to eliminate catastrophic propagating faults.

3.3.1.4 Catastrophic Propagating Faults. Catastrophic propagating faults are defined as a primary fault in a high voltage power system which propagates to stored fuel, ammunition, and personnel with catastrophic results. Catastrophic propagating faults due to arc-flash events must be prevented through appropriate fault containment measures.

3.3.1.5 Fault Containment. Fault containment is defined as the use of design measures for high voltage power systems to prevent fault propagation which could result in damage to equipment and hazards to personnel. The primary objective of fault containment is to minimize the risk of catastrophic propagating faults. Individual fault containment methods could include, but are not limited to:

- (a) sturdy enclosures that can contain an arc-flash;
- (b) guards to deflect arc-flash away from fuel, ammo, and personnel;
- (c) compartments to isolate fuel, ammo, and personnel; and
- (d) physical space to separate fuel, ammo, and personnel.

3.3.2 Requirements

3.3.2.4 Fault Containment. At least 2 methods of fault containment shall be employed for each installation of a high voltage source, power distribution equipment, and utilization equipment. Automatic fire suppression subsystems, arc-flash suppression devices and safety software programs/algorithms are encouraged but shall not be counted in the two required methods of fault containment.

3.3.3 Electrical Characteristics

3.3.3.1 Minimum Design Limits. Design limits for high voltage power sources, power distribution equipment, and utilization equipment shall exceed the over-voltage and under-voltage limits given in Figure 3.

3.4 Chassis Isolation and Ground Isolation Fault Monitoring.

3.4.1 Definitions

3.4.1.1 Chassis Ground Isolation. Chassis ground isolation is defined as the design intention to avoid a path from positive and negative high voltage power lines to chassis ground. For practical purposes, a minimum resistance value is required as a worst case condition.

3.4.1.2 Resistive Grounding. Resistive grounding is defined as a grounding practice used in designing a balanced two-rail power distribution system. All power sources, distribution equipment, and utilization equipment are required to have both positive and negative power rails isolated from chassis ground. The power system is then balanced by intentionally grounding both power rails to chassis via a fixed resistor.

3.4.1.3 Ground Isolation Fault (GIF). A ground isolation fault is defined as a fault that results in degradation of isolation of either power rail in a balanced resistive grounded high voltage power system. Single ground isolation faults have no hazardous affects to equipment or personnel. However, ground isolation faults are a key safety issue in high voltage power systems, because a second occurrence of a ground isolation fault has potential to be catastrophic. Therefore a high premium is paid in due diligence of design and maintenance such that the first ground isolation fault is identified and corrected expediently.

3.4.1.4 GIF Detection. GIF detection monitors for voltage imbalance between the two rails of a balanced high voltage power system. As the isolation to chassis degrades, the balance will shift away from chassis ground (zero volts) and drift toward the rail opposite of the ground fault.

3.4.1.5 GIF Maintenance. Ground isolation fault maintenance is defined as the maintenance activity to find the root cause of the ground isolation fault and to repair/replace the equipment responsible for the fault.

3.4.1.6 Catastrophic GIF. The catastrophic GIF is defined as the condition when both positive and negative rails of the high voltage system suffer from a loss of isolation. The loss of isolation may result from a fault in equipment or from a human conducting pathway of a maintainer in contact with chassis ground and one high voltage power rail. With faults on both rails, full potential of the high voltage power source can surge unlimited into the ground fault and/or human maintainer.

NOTE: Because of the significant hazard associated with catastrophic GIF, expedient GIF maintenance is absolutely essential for high voltage safety.

3.4.2 Requirements

3.4.2.1 Chassis Ground Isolation. All distribution and utilization equipment shall isolate both high voltage power rails from chassis by a minimum of 10 MOhms.

3.4.2.2 Resistive Grounding. Military ground vehicles shall reference high voltage power rails to ground by connecting both rails to chassis via two balanced resistors (one from each power rail).

3.4.2.3 GIF Detection. Military ground vehicles shall have GIF detection.

3.4.2.4 Clearing of Ground Faults. Military ground vehicles shall be designed to automatically isolate and clear ground fault(s) upon detection.

3.4.2.5 GIF Status Indication. Military ground vehicles shall indicate a GIF to the crew.

3.4.2.6 Performance During GIF. Power sources, distribution equipment, and utilization equipment shall meet their performance requirements (as limited by the power quality mode) during a ground fault.

3.5 High Voltage Electrical Safety

3.5.1 Definitions

3.5.1.1 High Voltage Hazards. A high voltage hazard is defined as a risk of electrocution or burns due to accidental contact of personnel with high voltage conductors and/or arc flash.

3.5.1.2 Exposure to High Voltage. Exposure to high voltage is defined as an opportunity for personnel to come in contact with high voltage power conductors.

3.5.1.3 High Voltage Interlocks. High voltage interlocks are defined as essential high voltage safety circuits which are intended to eliminate exposure to high voltage hazards resulting from disconnected power lines. The interlock is said to be “locked” when the interlock circuit can prove that the power line is connected and exposure to high voltage is not possible. Passive interlock circuits in the utilization equipment enable power sources to verify that the interlock circuit is “locked” before the utilization equipment is powered up. The interlock is said to be “unlocked” when the power line is known to be disconnected or when the status cannot be determined due to a failure of the interlock circuit.

3.5.1.4 Pre-charge. Pre-charge is defined as the slow controlled activation of a high voltage power line through a current limiting device. The main purpose of pre-charge is to verify safety (i.e. potential for arc flash and/or catastrophic GIF) of the power line prior to unlimited activation. Another purpose is to limit the harmful inrush of current into the power line capacitors in the utilization equipment. Pre-charge assumes that utilization equipment is commanded to a low power state until pre-charge is successful.

3.5.1.5 Galvanic Isolation. Galvanic isolation is defined as the separation within power converters between input and output power. This isolation is typically achieved by means of transformers with physically different input and output windings which are Faraday-shielded to contain the flow of common-mode noise. With adequate separation, power converters will not impact the voltage reference on the low voltage side when a ground fault is present on the high voltage side.

3.5.2 Requirements

3.5.2.1 Prevention of Exposure to High Voltage. Military ground vehicles shall be designed such that all crew and maintenance personnel are protected against accidental contact with high voltage conductors.

Military ground vehicles shall be designed such that all vehicle maintenance can be performed with the high voltage system unpowered.

3.5.2.2 Visual Identification of High Voltage Cables. All electrical cables which carry high voltage power lines shall be prominently marked with bright orange identification.

3.5.2.3 Safety Ground for Equipment. All equipment enclosures which contain high voltage electrical circuits shall be constructed of conductive materials and shall be grounded to vehicle chassis.

3.5.2.4 High Voltage Interlocks. All high voltage electrical cables shall include high voltage interlocks from the output connector of the power source through to the input connector of the load. High voltage interlock circuits shall be passive circuits in the utilization equipment. When unlocked, the interlock shall prevent activation of the high voltage power line and deactivate the power line if already active.

3.5.2.5 Fail-safe. High voltage interlock circuits shall be designed such that failure of the interlock circuit shall result in the unlocked status.

3.5.2.6 Active Discharge of Power Lines. High voltage power systems shall discharge power lines in event of an unlocked interlock.

3.5.2.7 Discharge of High Voltage Capacitors. Utilization equipment shall assure that the voltage on internal capacitors is discharged when power lines are disconnected to a safe voltage faster than a person can be exposed to hazardous voltage.

3.5.2.8 Pre-charge Activation. The power distribution subsystem shall utilize a pre-charge circuit for safe initial activation for all high voltage power feeds. Pre-charge shall be initiated when the power feed is switched on and shall ramp up the voltage no faster than 2 seconds. When the power line has achieved 565 volts, the pre-charge circuit shall transition to full activation (current limiting function is no longer needed). If the power line does not achieve 565 volts within 30 seconds, the pre-charge circuit shall deactivate the power line.

3.5.2.9 Protection for Reverse Polarity. High voltage systems shall be designed to prevent reverse polarity connection of all high voltage connections.

3.5.2.10 Galvanic Isolation. High voltage to low voltage electrical power converters shall have at least 2500 volt galvanic separation between high voltage and low voltage inputs and outputs.

4. VERIFICATION

4.1 Definitions.

4.1.1 First Article Testing. For the purposes of this specification, first article testing is defined as a retest of system level requirements for 600V power systems (on a completed vehicle off the assembly line) that had previously been validated on prototype vehicles. One vehicle can be used to perform all verification testing specified sections 4.1.4 through 4.1.6.

4.1.2 Bench Testing. Bench testing is defined as a derived test performed on a test bench with test equipment for a subset of the power system or with individual components. Bench testing is performed when it is necessary to exercise high voltage equipment within its normal design limits which exceed what can be accomplished through normal exercise of a full-up vehicle.

4.1.3 Fault Insertion. Fault insertion is defined as the simulation of a fault in a vehicle system by replacement of a functioning high voltage component with one instrumented to induce a specific failure mode upon command of test personnel. Fault insertion will stress the system and is intended to exercise the fault clearing or fault containment features designed into the high voltage power system.

4.1.4 Electrical Characterization Testing. Electrical characterization testing is defined as measuring the electrical characteristics of a fully operational electrical power system integrated into an Army ground vehicle during routine operation. The input power terminals of utilization equipment are instrumented for voltage measurements. The vehicle system's heaviest loads are exercised to create the largest voltage transients and surges that can be created without fault insertion. Due to instrumentation added to the high voltage system, testing must be performed only in a test facility where high voltage precautions are used and high voltage safety equipment is available.

4.1.5 Non-Destructive Testing. Non-destructive testing is defined as fault insertion testing that is not intended to harm the equipment under test. Typical functions of the power system (such as tripping circuit breakers, shutdown of overvoltage power sources, high voltage pre-charge attempts into a short circuit fault, and creation of single ground isolation faults) require insertion of faults in the vehicle electrical system in order to exercise fault clearing functions and to verify the behavior of the power system in the fault clearing mode. While non-destructive testing is not intended to cause damage, it will stress the high voltage components and is therefore at risk of causing damage to the system. Due to the use of test equipment on the high voltage system for fault insertion, testing must be performed only in a test facility where high voltage precautions are used, high voltage safety equipment is available, and additional fault containment precautions are taken to separate test personnel from the increased risk of arc flash hazards.

4.1.6 Destructive Testing. Destructive testing is defined as necessary verification of vehicle design features which perform fault containment of arc flash hazards. Fault insertion (such as simultaneous double GIF and overvoltage stress testing beyond the design limits of the high voltage components) is necessary to push the high voltage system to failure during the test. The test vehicle should be monitored to verify that ammo, fuel, and personnel are adequately protected. Due to certain hazard from creation of arc flash, testing must be performed only at a facility with adequate fault containment and precautions against further propagation of damage to equipment and harm to personnel.

4.2 Sub-System Level Bench Testing

4.2.1 Voltage Regulation to Step Load. All power sources shall be bench tested with a simulated load profile (equivalent to the worst case operation of the system) to verify that electrical characteristics meet normal transient performance.

4.2.2 GIF Detection. Bench testing to measure the sensitivity of GIF detection and to verify functionality of the GIF shutdown capability shall be performed prior to installation of high voltage power sources and GIF detection in a full vehicle system.

4.2.2 Bench Testing of Protection Devices. Protection devices in all power distribution equipment shall be functionally demonstrated on the bench before allowing activation of high voltage loads in an operational vehicle.

4.2.3 Steady-State Voltage. All power distribution and utilization equipment shall be bench tested to verify continued operation at extremes of the steady state voltage range.

4.3 Vehicle Level Testing of Voltage Regulation

4.3.1 Normal Mode Inspection. Complete vehicle system electrical characterization testing shall be performed on all prototype vehicles (representing all variants) and one first article test (for the worst case variant) to validate the design performance of the high voltage system in the normal mode of voltage regulation.

4.3.2 Fault Clearing Mode Inspection. Complete vehicle system non-destructive fault insertion testing shall be performed on at least one prototype of each vehicle variant and one first article test to demonstrate the ability to clear faults and return to Normal Mode functionality.

4.3.3 Failure Mode Inspection. Complete vehicle system destructive testing shall be performed on one prototype and one first article test to validate adequate fault containment.

4.4 Requirements Verification. The requirements in section 3 will be verified through inspection, analysis, demonstration, and/or test according to Table 2.

Section	Requirement Title	Inspection	Analysis	Vehicle Demo	Vehicle Test
3.1.2.1	Power Sources			X	
3.1.2.2	Power Distribution Equipment			X	
3.1.2.3	Utilization Equipment			X	
3.1.3	Electrical Characteristics		X		X
3.2.2.1	Performance of Power Sources			X	
3.2.2.2	Performance of Power Distribution Equipment			X	
3.2.2.3	Performance of Utilization Equipment			X	
3.2.2.4	Safe Operation on Fault Clearing Mode			X	
3.2.2.5	Avoidance of Damage in Fault Clearing Mode			X	
3.2.2.6	Automatic Recovery to Normal Mode			X	
3.2.3.1	Design Threshold for Damage		X		
3.3.2.1	Performance of Power Sources		X		
3.3.2.2	Performance of Power Distribution Equipment		X		
3.3.2.3	Installation		X		
3.3.2.4	Fault Containment	X		X	
3.3.3.1	Minimum Design Limits		X	X	
3.4.2.1	Chassis Ground Isolation				X
3.4.2.2	Resistive Grounding	X			
3.4.2.3	GIF Detection	X			
3.4.2.4	Clearing of Ground Faults			X	
3.4.2.5	GIF Status Indication			X	
3.4.2.6	Performance During GIF			X	
3.5.2.1	Prevention of Exposure to High Voltage	X			
3.5.2.2	Visual Identification of High Voltage Interfaces	X			
3.5.2.3	Safety Ground for Equipment	X			
3.5.2.4	High Voltage Interlocks	X	X		
3.5.2.5	Fail-safe	X			X
3.5.2.6	Active Discharge of Power Lines				X
3.5.2.7	Discharge of High Voltage Capacitors				X
3.5.2.8	Pre-Charge Activation				X
3.5.2.9	Protection for Reverse Polarity	X			
3.5.2.10	Galvanic Isolation	X			

TABLE 2 REQUIREMENTS VERIFICATION TABLE

5. PACKAGING

Reserved.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended Use. This document is intended to be used as a specification for developing complete high voltage power systems for Army ground vehicles.

6.1.1 Application. Each element of the vehicle electrical power system is qualified and purchased to its own specification requirements document. The specification language below is recommended. The author may tailor individual requirements; however untailed requirements should not be duplicated.

6.1.1.1 Power Sources. Item unique specifications should include the following: "This power source shall generate 600V power in accordance with MIL-PRF-GCS600A(ARMY)."

6.1.1.2 Power Distribution Equipment. Item unique specifications should include the following: "This power distribution equipment shall utilize and distribute 600V power in accordance with MIL-PRF-GCS600A(ARMY)."

6.1.1.3 Utilization Equipment. Item unique specifications should include the following: "This utilization equipment shall utilize 600V power in accordance with MIL-PRF-GCS600A(ARMY)."

6.1.2 Additional Requirements. Power systems in full compliance with this specification may not satisfactorily support all ground vehicle functional capabilities. Additional requirements outside the scope of this document may be needed.

6.2 Pulsed Loads, Unintended Power Sources, and Nonlinear Design Issues. Vehicle system developers have the responsibility to assure conformity to performance requirements in section 3 regardless of pulsed loads, regenerative energy from unintended power sources, and nonlinear design issues.

6.3 Future Considerations. High voltage power systems are expected to evolve beyond the reference architecture addressed in this initial specification. Future versions are anticipated to keep pace with emerging technology.