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PERFORMANCE SPECIFICATION

INTEGRATED POWER MANAGEMENT CENTER (IPMC)

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

1. SCOPE

1.1 Scope. This specification covers the Integrated Power Management Center (IPMC) for use on shipboard power systems for surface ships and submarines. The IPMC is an electrical device that receives shipboard power and provides power distribution (see 6.3.5), power switching (see 6.3.7), power conditioning (see 6.3.3), and power control (see 6.3.4) to shipboard loads. The IPMC may be composed of an enclosure assembly, one or more input power connections, and one or more output connections.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

FEDERAL STANDARDS

FED-STD-595/26307	-	Gray, Semigloss

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-S-901	-	Shock Tests, H.I. (High-Impact), Shipboard Machinery, Equipment, and Systems, Requirements for
MIL-DTL-917	-	Electric Power Equipment, Basic Requirements for
MIL-DTL-2036	-	Enclosures for Electric and Electronic Equipment, Naval Shipboard
MIL-DTL-15024	-	Plates, Tags, and Bands for Identification of Equipment, General Specification for
MIL-T-16366	-	Terminal, Electrical Lug and Conductor Splices, Crimp Style

Comments, suggestions, or questions on this document should be addressed to Commander, Naval Sea Systems Command, ATTN: SEA 05S, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard DC 20376-5160 or emailed to CommandStandards@navy.mil, with the subject line “Document Comment”. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla.mil.

MIL-PRF-24712	-	Coatings, Powder, Thermosetting
MIL-PRF-32168	-	Variable Speed Drive System for Induction and Synchronous Machines

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-108	-	Definitions of and Basic Requirements for Enclosures for Electric and Electronic Equipment
MIL-STD-130	-	Identification Marking of U.S. Military Property
MIL-STD-167-1	-	Mechanical Vibrations of Shipboard Equipment (Type I – Environmental and Type II – Internally Excited)
MIL-STD-202	-	Electronic and Electrical Component Parts
MIL-STD-461	-	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
MIL-STD-681	-	Identification Coding and Application of Hookup and Lead Wire
MIL-STD-704	-	Aircraft Electric Power Characteristics
MIL-STD-740-2	-	Structureborne Vibratory Acceleration Measurements and Acceptance Criteria of Shipboard Equipment
MIL-STD-1310	-	Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility, Electromagnetic Pulse (EMP) Mitigation, and Safety
MIL-STD-1399	-	Shipboard Systems
DOD-STD-1399-070-1	-	Shipboard Systems, Section 070-Part 1, D.C. Magnetic Field Environment (Metric)
MIL-STD-1399-300	-	Shipboard Systems, Section 300B, Electric Power, Alternating Current
MIL-STD-1399-390	-	Shipboard Systems, Section 390, Electric Power, Direct Current, (Other Than Ship’s Battery) for Submarines (Metric)
MIL-STD-1472	-	Human Engineering
MIL-STD-1474	-	Noise Limits
MIL-STD-1686	-	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)

DEPARTMENT OF DEFENSE HANDBOOKS

MIL-HDBK-454	-	General Guidelines for Electronic Equipment
MIL-HDBK-470	-	Designing and Developing Maintainable Products and Systems

(Copies of these documents are available online at http://quicksearch.dla.mil.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

NAVAL SEA SYSTEMS COMMAND (NAVSEA) PUBLICATIONS

S0400-AD-URM-010/TUM - Tag-Out Users Manual

S9086-KC-STM-010/300 - NSTM Chapter 300, Electric Plant-General

(Copies of these documents are available online at https://nll.ahf.nmci navy mil, requested by phone at 215-697-2626, or requested by email at nllhelpdesk@navy mil. These publications can be located by searching the Navy Publications Index for the TMIN without the suffix.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC. (IEEE)

IEEE 1012 - Standard for System and Software Verification and Validation

IEEE 1413 - Standard Framework for Reliability Prediction of Hardware

IEEE 1413.1 - Guide for Selecting and Using Reliability Predictions Based on IEEE 1413

IEEE 1709 - Recommended Practice for 1 kV to 35 kV Medium-Voltage DC Power Systems on Ships

(Copies of these documents are available online at www.ieee.org.)

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 12207 - Systems and Software Engineering – Software Life Cycle Processes

IEC 60947 - Low-voltage switchgear and controlgear

(Copies of these documents are available online at http://webstore.iec.ch.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 First article. When specified (see 6.2), a sample shall be subjected to first article inspection in accordance with 4.2.

3.2 IPMC basic design and interface requirements. The IPMC basic design requirements shall be in accordance with MIL-DTL-917. The IPMC interface requirements shall be in accordance with MIL-STD-1399-300, MIL-STD-1399-390, and MIL-STD-704.

3.2.1 Input/output electrical isolation. The IPMC shall provide input and output galvanic isolation in order to electrically isolate the IPMC in the event of an internal component failure.

3.2.2 Input power operation. The IPMC input power shall be designed to operate from multiple sources and transfer manually and automatically. The IPMC shall have transfer test functionality.

3.2.2.1 Input power automatic operation. When power sharing is not specified or used, the IPMC shall monitor the power supplied from the power source(s). A source shall be considered "available" when the source is within preset levels [see 3.5.1.1a(2)]. The IPMC shall provide automatic transfers regardless of the phase angle of the sources. The IPMC shall allow for operation with a preferred source, in which case the unit shall preferentially power the load from that source, provided it is available. When the source is not within preset levels, the IPMC shall transfer to an alternate source provided an alternate source is available. The IPMC shall initiate an automatic re-transfer.

3.2.2.2 Input power manual operation. To ensure fail-safe operation, the IPMC shall have a manual selection for transferring power sources. During the manual operation, the IPMC input power automatic functions shall be disabled. Manual transfer shall be initiated by activating a switch or button on the front panel.

3.2.3 Input circuit breakers. Input circuit breakers shall be installed at the input cable interface of the IPMC.

a. For IPMCs rated less than or equal to 100 Ampere (A) nominal current, input circuit breakers shall be installed in accordance with MIL-DTL-917. The input circuit breaker shall be rated to interrupt the full fault current and shall only be activated when overload protection, line-to-line fault protection, three-phase fault protection, and short circuit protection have not cleared the fault. The input circuit breaker shall be accessible to the operator for reset.

b. For IPMCs rated greater than 100 A nominal current, input circuit breakers shall be in accordance with MIL-DTL-917 or shall provide a disconnect signal, which shall be sent to the input source(s) for isolation. The input circuit breaker shall be rated to interrupt the full fault current and shall only be activated when overload protection, line-to-line fault protection, three-phase fault protection, and short circuit protection have not cleared the fault. The input circuit breaker shall be accessible to the operator for reset.

3.3 Power quality performance requirements.

3.3.1 Input power. Unless otherwise specified (see 6.2), the IPMC shall operate with power sources up to 1000 Volt (V) direct current (DC) as specified in IEEE 1709 and 440 V root mean square (V_{rms}) alternating current (AC) power as specified in MIL-STD-1399-300, Type I power. For 650 VDC, see Appendix A. The IPMC shall be self-protecting against damage from improper phase rotation and from single-phasing.

3.3.2 Output power.

3.3.2.1 AC output power quality. Unless otherwise specified (see 6.2), the AC output power quality of the IPMC shall meet the power quality requirements of MIL-STD-1399-300 and MIL-STD-704 at the user interface (load input terminals). When specified in 6.2, output power quality characteristics may be as identified in table B-I of Appendix B. The IPMC shall provide proper phase rotation.

3.3.2.2 DC output power quality. Unless otherwise specified (see 6.2), the DC output power quality of the IPMC shall meet the power quality requirements of MIL-STD-1399-390, MIL-STD-704, and IEEE 1709 at the user interface (load input terminals). When specified in 6.2, output power quality characteristics may be as identified in table B-II of Appendix B or Appendix C. Load broad-band impedance characteristics that will affect power quality shall be identified in 6.2.

3.3.2.3 Output power interface requirements. Special IPMC output power interface requirements exist in the Fleet. These special requirements shall be identified and specified (see 6.2).

3.3.2.4 Output power interface requirements for type III power. Unless otherwise specified (see 6.2), the IPMC shall be capable of maintaining Type III power at the output interface during load changes of up to 100 percent.

3.3.2.5 Output voltage harmonics. Unless otherwise specified (see 6.2), output voltage harmonics shall be in accordance with MIL-STD-1399-300 regardless of load conditions.

3.4 Input and output power module design coordination. An input power module shall be capable of providing sufficient power to allow all output modules to be operated at full load. The quantity and type of input modules and output modules to be incorporated in the IPMC shall be as specified (see 6.2).

3.5 Supervisory control and data acquisition (SCADA).

3.5.1 Supervisory control. The IPMC shall provide local supervisory control. When specified (see 6.2), remote control requirements shall be provided. The following supervisory control functions shall be available (see 6.2).

3.5.1.1 Input control functions. The IPMC shall have provisions for automatically or manually accepting power from multiple ship service power sources (see 3.3.1). The following control features shall be provided when two or more sources are utilized:

a. Power source selection mode – source transfer (see 6.3.8)

(1) Select normal source or alternate source or sharing mode

(2) Select transfer criteria – re-transfer condition (normal seeking or power seeking), transfer time, and over and under voltage (see 6.2)

b. Power source sharing mode

(1) Select normal source or alternate source as the active primary input source or select input power sharing

(2) Select input power sharing percentage shall be adjustable and power sharing shall have a tolerance of 5 percent of rated load (see 6.2)

(3) Enable/Disable input power source sharing is accomplished via controls

3.5.1.2 Operating controls functions.

a. Switching output power modules on/off.

b. Output voltage settings.

c. Output current settings.

d. Output frequency settings.

e. Load shed criteria – priority sequence, automatic, remote digital signal, or operator selection (see 6.2).

f. Load shed re-energization criteria – priority sequence, automatic or operator selection (see 6.2).

g. Emergency shutdown at Human Machine Interface (HMI) and front panel switch (see 3.8.8) – all input and output circuits are shutdown.

h. Fault management settings.

i. Event logging.

j. Tagout of input/output modules.

k. Load monitoring.

3.5.2 Data acquisition, storage, and display.

3.5.2.1 Data acquisition and display. The IPMC shall have provisions to acquire and display the following information. Additional data display requirements shall be as specified (see 6.2).

a. Input module parameters (voltage [V], current [A], frequency [Hz], power factor [pf] (see 6.3.6), power [kW]).

b. Individual output power module parameters (V, A, Hz, pf, kW).

c. Individual output power module status (on/off or faulted).

d. System configuration (mimic).

e. Source selected.

f. Load shedding and re-energization status (see 3.5.1.2e, 3.5.1.2f, and 6.2).

g. Equipment Performance Monitoring (EPM) (see 3.6.4).

h. Output external faults and types of faults (see 3.6.1).

i. Control status (local or remote) (see 3.5.1 and 6.2).

j. If in emergency shutdown.

3.5.2.2 Data acquisition and storage. The IPMC shall have provisions to acquire and store the following information. Additional data storage requirements shall be as specified (see 6.2).

a. Input power module parameters.

b. Output power module parameters.

c. EPM parameters (see 3.6.4).

d. Output external faults.

3.5.3 Cybersecurity. Cybersecurity (see 6.3.1) shall be in accordance with Appendix D.

3.6 Fault management.

3.6.1 System faults. The IPMC shall detect, isolate, and report output faults specified in table I and table II. Fault management criteria shall be as specified (see 6.2).

TABLE I. AC fault management characteristics.

Characteristic	Requirement
Fault Type	**3-phase, 3-wire, ungrounded; Single-phase, 2-wire, ungrounded; 3-phase, 4-wire**
1. Overload Protection	Adjustable delay and indication and interruption
2. Line-to-Line and 3-Phase Fault Protection	Adjustable delay and indication and interruption
3. Line-to-Ground Fault Detection – Ungrounded System	Continuous monitoring and indication
4. Line-to-Ground Fault Detection – Low Impedance Grounded System	Adjustable delay and indication and interruption

TABLE II. DC fault management characteristics – 2-wire ungrounded.

Characteristic	Requirement
1. Overload Protection	Adjustable delay and indication and interruption
2. Short-Circuit Protection	Adjustable delay and indication and interruption
3. Line-to-Ground Fault Detection – Ungrounded System	Continuous monitoring and indication
4. Line-to-Ground Fault Detection – Low Impedance Grounded System	Continuous monitoring and indication and interruption

3.6.2 Over/Under voltage protection. The IPMC shall monitor the output voltage. When specified (see 6.2), the IPMC shall be capable of turning off the output if the voltage is not in accordance with the specified settings in 6.2.

3.6.3 Over/Under frequency protection. The IPMC shall monitor the output frequency. When specified (see 6.2), the IPMC shall be capable of turning off the output if the frequency is not in accordance with the specified settings in 6.2.

3.6.4 Equipment performance monitoring (EPM). EPM capabilities shall be provided to support operation and maintenance. The IPMC shall be capable of monitoring the normal mode of operation of IPMC critical component and modules for the purpose of detecting, recording, and reporting faults of the types identified in 3.6.1 and 3.6.4.1. Tactical fault override (battle short) requirements shall be as specified (see 6.2).

3.6.4.1 Fault detection. The IPMC shall detect and display the following equipment faults at the HMI panel and provide output for remote monitoring:

a. Loss of cooling fan
b. Loss of output power of operating power module
c. Over temperature of each power module
d. Failure of power modules to respond to operating control command
e. Communications failure – internal
f. Communications failure – remote
g. Over/Under voltage protection (see 3.6.2)
h. Over/Under frequency protection (see 3.6.3)

3.6.4.2 Fault disposition. The IPMC shall report a fault for an abnormal external or internal operating condition that requires immediate shutdown of the IPMC or one of its subcomponents. The IPMC shall secure the necessary components or subcomponents to protect the equipment in response to the fault detected. The IPMC shall maintain subcomponents and systems which can be safely operated during the fault in order to provide availability of non-affected outputs. Faults, such as alarms, shall be reported locally and remotely via visual and audible indication, as specified (see 6.2). A fault shall not be cleared until a local or remote reset has been issued to acknowledge the condition and the condition that caused the fault no longer exists. Component failure or fault shall be identified to the Line Replaceable Units (LRUs) level and indicated locally or remotely, as specified (see 6.2).

3.6.5 Fault isolation. Fault isolation prevents catastrophic events on individual modules from interfering with the IPMC overall operation. Fault isolation shall be provided for input, internal bus link, and output voltage interfaces. The IPMC modules shall provide isolation between each field circuit, resulting in increased noise immunity and limited damage to the system due to an electrical malfunction of the field wiring. The IPMC shall continue to operate within required power quality parameters in the event of input power quality fluctuations and any load variations inside MIL-STD-1399-300 interface requirements, unless otherwise specified (see 6.2).

3.6.5.1 Ground faults. The IPMC shall be designed to continue to operate with the presence of a single ground fault on any input interface, internal bus link, and output interface. The IPMC components shall be able to withstand expected system DC voltage offset at the interface due to grounded condition at any location in the power distribution system.

3.6.5.2 Ground fault detection. The IPMC shall provide ground fault detection capability with an adjustable threshold to continuously monitor the system and provide alarm when a ground fault condition exists on any input interface, internal bus link, and output interface. The IPMC shall be capable of detecting impedance (both resistance and reactance) to ground as specified (see 6.2) without affecting the ground isolation of the system.

3.6.5.3 Ground fault location. When specified (see 6.2), the IPMC shall be capable of locating the ground fault upstream, internal, or downstream to an individual interface without requiring operator intervention or interruption of power to the load. The IPMC shall report the location of the ground fault.

3.6.5.4 Common mode current. When specified (see 6.2), the IPMC shall monitor common mode current on all input and output interfaces and report alarm when it exceeds the common mode current limits as specified (see 6.2). When the IPMC is part of a subsystem, common mode current shall be coordinated with ground fault detection and location.

3.7 Electrical power requirements. Electrical power requirements shall be in accordance with MIL-STD-1399-300. A list of electrical tests is provided in Appendix E.

3.7.1 Full load operating temperature. The IPMC shall operate at full load conditions without exceeding the temperature rise limits of MIL-DTL-917. Tests to verify the full load operating temperature shall be conducted in accordance with 4.9.1.

3.7.2 Insulation integrity.

3.7.2.1 Insulation resistance. The IPMC insulation resistance shall be greater than 10 megohms in accordance with MIL-DTL-917. Tests to verify insulation resistance shall be conducted in accordance with 4.9.2.

3.7.2.2 Dielectric withstand. The IPMC shall meet the requirements of MIL-STD-202, Test Method 301, for dielectric withstanding voltage. Tests to verify the dielectric withstand shall be conducted in accordance with 4.9.3.

3.7.2.3 Creepage and clearance distances. Creepage and clearance distances shall be in accordance with MIL-DTL-917.

3.7.3 Source-to-source impedance. Unless otherwise specified (see 6.2), the source-to-source impedance shall not be less than 1.3 megohms at 68 °F (20 °C) and shall be not less than 0.8 megohms at 122 °F (50 °C) with a minimum load of 15 A on one source and the other source in standby. Standby is an operating state where a particular IPMC input power modules and supervisory control are powered and available and the output power is off.

3.7.4 Electromagnetic interference (EMI). The IPMC input and output shall meet the EMI requirements specified in MIL-STD-461 for surface ship, below deck and submarine, internal to pressure hull, installations; additionally, Method CS115 is to be performed when specified by the procuring activity (see 6.2).

3.7.5 Endurance. Unless otherwise specified (see 6.2), the IPMC shall meet endurance requirements when tested in accordance with 4.9.6.

3.7.6 Grounding, bonding, and shielding. The IPMC shall incorporate the electrical grounding, bonding, and shielding provision in accordance with MIL-STD-1310. Provision shall be available for terminating the ground shields on incoming and outgoing cables. MIL-HDBK-454 may be used for guidance.

3.7.6.1 Chassis grounding. All external parts capable of electrical conduction shall be at ground potential at all times in accordance with MIL-STD-1310.

3.7.7 DC magnetic field radiated susceptibility. The radiated susceptibility, DC magnetic field shall not exceed the limits specified in DOD-STD-1399-070-1.

3.7.8 Power module ratings. Power module ratings shall be as specified (see 6.2). Appendix F provides guidance on power module ratings.

3.7.9 Efficiency. Input to output total efficiency shall be 95 percent or better at rated load and 90 percent or better at loads greater than 80 percent of the output rating. The partial load efficiencies shall be provided by the vendor. The no-load losses of power electronic conversion equipment shall not exceed 1 percent of nominal rating.

3.7.10 Energization. Unless otherwise specified (see 6.2), the IPMC shall be fully operational within 10 seconds.

3.7.11 Motor control criteria. When specified (see 6.2), the IPMC shall provide motor control and variable speed drive (VSD). MIL-PRF-32168 should be used for guidance.

3.8 Mechanical/physical requirements.

3.8.1 Materials. Materials shall be capable of meeting all of the operational, safety, and environmental requirements specified herein in accordance with MIL-DTL-917.

3.8.1.1 Recycled, recovered, environmentally preferable, or biobased materials. Recycled, recovered, environmentally preferable, or biobased materials should be used to the maximum extent possible, provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

3.8.1.2 Prohibited materials. Prohibited materials as specified in MIL-DTL-917 shall not be used.

3.8.2 Parts. Parts shall be in accordance with the requirements of MIL-DTL-917.

3.8.3 Electrical insulation. Electrical insulating materials shall be in accordance with the requirements of MIL-DTL-917.

3.8.4 Nameplates. Nameplates shall be in accordance with MIL-DTL-15024.

3.8.5 Communication protocol. The IPMC shall be capable of communication with external equipment. The communication protocol shall be open architecture as specified (see 6.2).

3.8.6 Processes. Corrosion treatment, painting, soldering, brazing, and welding shall be in accordance with MIL-DTL-917.

3.8.6.1 Plating. Preparation of bus bar connection surface areas shall prevent degradation from corrosion and other environmental conditions so as to minimize the resistivity and heating in accordance with MIL-DTL-917.

3.8.6.2 Painting. The painting process used on the IPMC shall be in accordance with the requirements of MIL-DTL-917. Color shall be No. 26307 as specified by FED-STD-595. Powder coating in accordance with MIL-PRF-24712 is the preferred method for painting.

3.8.7 Electrical interfaces.

3.8.7.1 Cable entrance. Cable entrance shall be in accordance with MIL-DTL-2036.

3.8.7.2 Cable lug terminals. Where used, cable lug terminals shall be in accordance with MIL-T-16366 and MIL-DTL-917. In accordance with MIL-DTL-2036, enclosures shall provide for convenient access to terminals and all working parts for the purpose of installation, repair, and adjustment.

3.8.7.3 Wire identification. Wire identification shall be in accordance with MIL-DTL-917.

3.8.7.4 Wire, wiring methods, and bus bars. Wire, wiring methods, and bus bars shall be in accordance with the requirements of MIL-DTL-917. Color-coded wire may be used in accordance with MIL-STD-681.

3.8.7.5 Printed wiring assemblies. Printed wiring assemblies shall be in accordance with MIL-DTL-917.

3.8.8 Emergency stop/input and output disable. There shall be a physical emergency shutdown switch marked as emergency stop on the front panel of the IPMC. The emergency stop shall be in accordance with IEC 60947. The emergency stop shall cause the immediate removal of all input sources to the IPMC by tripping breakers to the IPMC. The voltage to trip the breakers shall be specified in 6.2. The emergency stop shall also act to disable the IPMC outputs to provide electrical galvanic isolation for the output modules individually. The emergency stop or output disable circuit design shall be fail-safe, causing a trip in the event of cable damage. When remote control is specified (see 6.2), an IPMC shall have the ability to accept external hard-wired emergency stop or output signal. The emergency stop or output circuit shall be a hard-wired interface without any software control processing in the loop. The IPMC shall require operator intervention to restart after an emergency stop.

3.8.9 Human engineering. The HMI shall be in accordance with MIL-STD-1472. HMI equipment labeling conventions shall be as specified (see 6.2).

3.8.10 Electrostatic discharge (ESD) protection requirements. When specific parts, modules, connectors/receptacles, or subassemblies sensitive to damage by ESD are used, the devices shall be clearly marked with ESD labeling in accordance with MIL-STD-1686. The symbol shall be located in a position readily visible to personnel when that assembly is incorporated into its next higher assembly.

3.8.11 Enclosure integrity. Enclosures shall meet the performance requirements of MIL-DTL-2036 for Class 1 enclosures, as supplemented by MIL-STD-108. Degree of enclosure protection shall be as specified (see 6.2).

3.8.12 Thermal management. The cooling method shall be in accordance with MIL-DTL-917.

3.8.13 Acoustic requirements.

3.8.13.1 Airborne noise. The IPMC airborne noise requirements shall be in accordance with MIL-STD-1474 and the grade level shall be as specified (see 6.2).

3.8.13.2 Structureborne noise. The IPMC structureborne noise requirements shall be in accordance with MIL-STD-740-2 and the grade level shall be as specified (see 6.2).

3.8.14 Accessibility. The IPMC should meet the accessibility guidelines of MIL-HDBK-454.

3.8.15 Lifting provisions. Lifting provisions shall be in accordance with MIL-DTL-2036 and lifting channels, angles, and lifting eyes shall be provided on top of the IPMC of sufficient strength and number for lifting, handling, and installation on the ship. Additionally, replacement bolts, with all necessary washers to maintain drip-proof integrity, shall be provided in order for the lifting components to be replaced when the IPMC is installed on the ship. Enclosure shall not fracture or deform when tested in accordance with 4.10.4.

3.8.16 Mounting details. Mounting details shall be in accordance with MIL-DTL-917 and MIL-DTL-2036. Enclosure mounting shall be as specified (see 6.2).

3.9 Modularity.

3.9.1 Modular design. Components of the IPMC shall be constructed in a building block approach using discrete, removable components with common parts to minimize repair, maintenance, and replacement time. The level of modularity shall support the mean time to repair (MTTR) requirements of 3.17. Modules shall be interchangeable between different size enclosure assemblies, with the exception that a large input/output module for large current applications may not be required to fit in an enclosure assembly that does not have that current carrying capacity.

3.9.2 Power module replacement. The IPMC shall provide a means to detect if the power module of a different rating is inserted into a slot programmed for a specific power module rating. A warning signal at the local HMI panel shall be provided and the inserted power module will fail to energize.

3.10 Environmental requirements.

3.10.1 Operating climate conditions.

3.10.1.1 Temperature. The IPMC shall operate as specified during and subsequent to exposure to ambient and storage temperatures in accordance with MIL-DTL-917. The external temperature of the IPMC shall not exceed 167 °F (75 °C).

3.10.1.2 Humidity. The IPMC shall operate satisfactorily during and subsequent to the temperature test defined in 4.11.1. There shall be no faults or failure of modules and the enclosure temperature shall not exceed 149 °F (65 °C) during the test.

3.10.2 Shock. The IPMC shall meet the Grade A, Class 1, Type A shock acceptance requirements of MIL-S-901 when tested in accordance with 4.11.3. Mechanical switches shall not change state during shock.

3.10.3 Vibration. The IPMC shall meet the Type I vibrations requirement of MIL-STD-167-1 when tested as specified in 4.11.4. The IPMC will perform its functions during and after vibration testing. There shall be no evidence of electrical damage, mechanical damage, or loosening of parts.

3.10.4 Inclined operation. The IPMC shall perform satisfactorily when in inclined operation in accordance with MIL-DTL-917.

3.11 Electrical safety. Electrical safety requirements for the IPMC shall be in accordance with MIL-DTL-917 and MIL-STD-1472. Safety features of the IPMC should be in accordance with MIL-HDBK-454 to allow for tagout protection using S0400-AD-URM-010/TUM. Personnel protection from hazardous voltages shall support the guidelines established in S9086-KC-STM-010/300.

3.11.1 Input power module source-to-source galvanic isolation. Input power modules shall have source-to-source galvanic isolation for load center maintenance. Each input power module shall have means to provide a convenient, visual galvanic isolation (air gap) to protect personnel and to allow for a tag to be applied in accordance with S0400-AD-URM-010/TUM.

3.11.2 Output power module-to-load galvanic isolation for maintenance. Output power modules shall have module-to-load galvanic isolation for load maintenance. Each output power module shall have a means to provide convenient, visual galvanic isolation (air gap) to protect personnel and to allow for a tag to be applied in accordance with S0400-AD-URM-010/TUM.

3.11.3 Warning labels. Warning labels shall be in accordance with MIL-DTL-917.

3.12 Instruction sheets. When specified (see 6.2), instruction sheets for installation shall be in accordance with MIL-DTL-2036.

3.13 Diagrams for customer interface. Each IPMC shall include a wiring diagram and a schematic diagram. The information shall be protected in accordance with Method 1 of MIL-DTL-2036 and shall be attached to the inside of the enclosure door in accordance with MIL-DTL-2036. Wiring diagrams shall include wire numbers, component identification, and fuse size and type, if applicable.

3.14 IPMC and module identification. Unless otherwise specified (see 6.2), the IPMC and individual modules shall be marked with the following information in accordance with MIL-STD-130 for unique item identifier data set Construction #2:

a. Issuing agency code
b. Manufacturer
c. Part number
d. Lot
e. Serial number
f. Rating – maximum input power
g. National stock number (when available)
h. Name of device
i. Year manufactured

3.15 Embedded software. Embedded software (firmware) used in the IPMC shall appear on the nameplate by name or part number, or both, the version number, or designator. Equipment furnished with embedded software and/or calibration software shall have software developed in accordance with IEC 12207 and certified by independent V&V (Verification and Validation) testing to IEEE 1012.

3.16 Reliability. When specified (see 6.2), a reliability mean time between failures (MTBF) prediction shall be in accordance with IEEE 1413 utilizing IEEE 1413.1 prediction methodologies.

3.17 Maintainability. MTTR shall be as specified (see 6.2). See MIL-HDBK-470 for guidance.

3.18 IPMC measurement accuracy. The IPMC measurement accuracy shall be ±1.0 percent of full scale for current, ±1.0 percent of full scale for voltage, and ±1.0 percent of full scale for frequency.

3.19 Size and weight. The size and weight restrictions of the IPMC shall be as specified (see 6.2).

3.20 Grab rails. When specified (see 6.2), grab rails or handles specified in MIL-DTL-16036 shall be provided at the IPMC HMI and local controls. Grab rails/bars shall be attached in such a manner that hinged or removable panels can be opened or removed without removal of the rail from the member to which it is attached.

4. VERIFICATION

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. First article inspection (see 4.2).

b. Conformance inspection (see 4.3).

4.2 First article inspection. First article inspection shall be accomplished on a complete IPMC in accordance with table III.

4.3 Conformance inspection. Conformance inspection shall be performed to verify that the IPMC meets specification requirements prior to acceptance and shall include the tests specified in table III.

4.4 Test conditions. Unless otherwise specified herein, tests shall be conducted under a normal ambient temperature of 77 °F (25 °C).

TABLE III. First article and conformance inspections and tests.

Tests	Requirement Paragraph	First Article Inspection	Conformance Inspection
Examination	4.5	4.5	4.5
Input Power Quality	3.3.1	4.6.1, 4.6.1.1, 4.6.1.2	4.6.1, 4.6.1.1, 4.6.1.2
Output Power Quality	3.3.2	4.6.2, 4.6.2.1	4.6.2, 4.6.2.1
Input and Output Power Module Design Coordination	3.4	4.6.3	4.6.3
SCADA	3.5	4.6.4	4.6.4
Power Source Selection	3.5.1.1a	4.6.4	--
Output Voltage Settings – within range of 3.3.2	3.5.1.2b	4.6.4	4.6.4
Output Current Settings – within range of 3.3.2	3.5.1.2c	4.6.4	4.6.4
Output Frequency Settings – within range of 3.3.2	3.5.1.2d	4.6.4	4.6.4
Emergency Shutdown – all output circuits are shutdown	3.5.1.2g and 3.8.8	4.10.8	4.10.8
Fault Management	3.6	4.7	4.7
Full Load Operating Temperature	3.7.1	4.9.1	--
Insulation Resistance	3.7.2.1	4.9.2	4.9.2
Dielectric Withstand Voltage	3.7.2.2	4.9.3	4.9.3
Source-to-Source Impedance	3.7.3	4.9.4	4.9.4
EMI	3.7.4	4.9.5	--
Endurance	3.7.5	4.9.6	--
DC Magnetic Field Emission	3.7.7	4.9.7	--
Power Module Rating	3.7.8	4.9.8	--
Efficiency	3.7.9	4.9.9	--
Energization	3.7.10	4.9.10	--
Enclosure Integrity	3.8.11	4.10.1	--
Airborne Noise	3.8.13.1	4.10.2	--

TABLE III. First article and conformance inspections and tests – Continued.

Tests	Requirement Paragraph	First Article Inspection	Conformance Inspection
Structureborne Noise	3.8.13.2	4.10.2	--
Accessibility	3.8.14	4.10.3	--
Lifting	3.8.15	4.10.4	--
Power Module Withdraw, Insertion	3.9.2	4.10.5	--
Module Replacement	3.9.2	4.10.7	--
Temperature	3.10.1.1	4.11.1	--
Humidity	3.10.1.2	4.11.1, 4.11.2	--
Shock	3.10.2	4.11.1, 4.11.3	--
Vibration	3.10.3	4.11.1, 4.11.4	--
Inclined Operation	3.10.4	4.11.5	--
Galvanic Isolation	3.11.1, 3.11.2	4.12.1, 4.12.2	--
Embedded Software Verification and Validation	3.15	4.13	4.13
Measurement Accuracy	3.18	4.14	4.14

4.5 Examination. Each IPMC shall be examined for compliance with the requirements specified in table III. This element of inspection shall encompass all visual examinations and dimensional measurements. The examination shall be conducted during first article and conformance inspection using the classifications of defects as specified in table IV as applicable. Noncompliance with any specified requirements or presence of one or more defects preventing or lessening maximum efficiency shall constitute cause for rejection.

TABLE IV. Classification of defects.

Categories	Defects	Related Requirements Paragraph
Critical		
001	IPMC input is not electrically isolated from the output as required.	3.2.1
002	Input power operation not as required.	3.2.2, 3.2.2.1, 3.2.2.2
003	Input breakers not as required.	3.2.3
004	IPMC is not compatible with special power interface requirements.	3.3.2.3
005	Output voltage harmonics not as required.	3.3.2.5
006	Input control – power source selection mode – source transfer not as required.	3.5.1.1a
007	Input power source sharing not as required.	3.5.1.1b
008	Switching output power modules on/off control not as required.	3.5.1.2a
009	Load re-energization criteria not as required.	3.5.1.2f
010	Ability to set fault management settings not as required.	3.5.1.2h
011	Tagout of output modules not as required.	3.5.1.2j, 3.11

TABLE IV. Classification of defects – Continued.

Categories	Defects	Related Requirements Paragraph
Critical		
012	Cybersecurity not approved or implemented in accordance with applicable standards.	3.5.3
013	Fault system design and operation not as specified.	3.6.4.2
014	Fault isolation not as required.	3.6.5
015	Electrical power requirements not as required.	3.7
016	Grounding, bonding, and shielding not as required.	3.7.6
017	When specified in 6.2, motor control and variable speed drive (VSD) not as required.	3.7.11
018	Prohibited materials are used.	3.8.1.2
019	Insulating material not as specified or not provided as required.	3.8.3
020	Processes not as required.	3.8.6
021	Plating not as required.	3.8.6.1
022	Power interface not as required.	3.8.7.1
023	Mounting not as specified.	3.8.16
024	Electrical safety (design, interlock, main power switch, grounding, high voltage warning labels, etc.) not as required.	3.11
025	Warning labels not as specified.	3.11.3
026	When specified in 6.2, grab rails not provided as required.	3.20
Major		
101	Ability to maintain Type III power during load changes not as required.	3.3.2.4
102	When specified (see 6.2), remote control not provided as required.	3.5.1
103	Load shed criteria not as required.	3.5.1.2e
104	Event logging not as required.	3.5.1.2i
105	Load monitoring not as required.	3.5.1.2k
106	Data acquisition, storage, and display not as required.	3.5.2.1, 3.5.2.2
107	When specified in 6.2, over/under voltage protection not as required.	3.6.2
108	When specified in 6.2, over/under frequency protection not as required.	3.6.3
109	EPM not as required.	3.6.4
110	Power module current rating does not match requirement.	3.7.8
111	Materials not as required.	3.8.1
112	Use of recycled, recovered, environmentally preferable, or biobased materials not as required.	3.8.1.1
113	Parts not as required.	3.8.2
114	Nameplates not as specified.	3.8.4

TABLE IV. Classification of defects – Continued.

Categories	Defects	Related Requirements Paragraph
Major		
115	Communication protocol not as required.	3.8.5
116	Painting not as specified.	3.8.6.2
117	Cable entrances not as specified.	3.8.7.1
118	Cable lug terminals not as required.	3.8.7.2
119	Wire identification not as required.	3.8.7.3
120	Wire, wiring methods, marking, and bus bars not as specified.	3.8.7.4
121	Printed wiring assemblies not as required.	3.8.7.5
122	Human engineering not in accordance with MIL-STD-1472.	3.8.9
123	Devices not marked with ESD as required.	3.8.10
124	Thermal management not as specified.	3.8.12
125	Modular design not as required.	3.9.1
126	When specified in 6.2, instruction sheets not as required.	3.12
127	Interface diagrams not as specified.	3.13
128	IPMC and module identification not as required.	3.14
129	Embedded software identification not as required.	3.15
130	When specified in 6.2, reliability prediction not provided as required.	3.16
131	MTTR not as specified.	3.17
132	Size and weight not as required.	3.19
Minor		
201	Creepage and clearance distances not as specified.	3.7.2.3

4.6 Power quality testing.

4.6.1 Input power quality. Unless otherwise specified (see 6.2), power testing shall be performed in accordance with MIL-STD-1399-300 and IEEE 1709 input requirements. When specified in 6.2, input power quality characteristics or 650 VDC may be as identified in table A-I of Appendix A.

4.6.1.1 Phase rotation. The IPMC shall be tested to verify that improper phase rotation input shall not damage the IPMC.

4.6.1.2 Single-phasing. The IPMC shall be tested to verify that the loss of one or two input phases shall not damage the IPMC.

4.6.2 Output power quality. Unless otherwise specified (see 6.2), power testing shall be performed in accordance with MIL-STD-1399-300, MIL-STD-1399-390, and MIL-STD-704 output requirements. When specified in 6.2, output power quality characteristics may be as identified in table B-I and table B-II of Appendix B.

4.6.2.1 AC output phase rotation. The AC output modules shall be tested to assure they are providing MIL-STD-1399-300 phase rotation.

4.6.3 Input and output power module design coordination. Verify that the IPMC input power module's sizing is sufficient to power the output modules at full load.

4.6.4 SCADA. The requirements in 3.5 shall be verified. The verification can be done during other testing. Verify that supervisory control and remote control are available on the IPMC. Verify that control selection can be exercised on the IPMC.

4.7 Output fault management. The IPMC shall be verified to detect, isolate, and report output faults (see 3.6).

4.8 Ground fault. The IPMC shall be tested in accordance with the MIL-STD-1399-300 grounding tests. Unless otherwise specified (see 6.2), the ground fault impedance shall be in accordance with MIL-STD-1399-300. The ground fault test shall be performed on the input interface, internal bus link, and output interface of the IPMC. The IPMC shall locate the ground fault as specified (see 3.6.5.3 and 6.2). The common mode current shall be recorded and tested as specified (see 3.6.5.4 and 6.2).

4.9 Electrical testing.

4.9.1 Full load operating temperature. The full load temperature test shall be conducted in accordance with MIL-DTL-917.

4.9.2 Insulation resistance. The insulation resistance shall be measured in accordance with MIL-DTL-917.

4.9.3 Dielectric withstand voltage. Dielectric withstanding voltage tests shall be conducted in accordance with MIL-STD-202, Test Method 301. Test conditions shall be in accordance with MIL-DTL-917.

4.9.4 Source-to-source impedance. The IPMC shall be tested for source-to-source impedance at 68 °F (20 °C) and at 122 °F (50 °C) in accordance with 3.7.3.

4.9.5 EMI. The IPMC shall be subjected to the EMI tests specified in 3.7.4. Acceptance criteria shall be as specified in MIL-STD-461.

4.9.6 Endurance. While operating on 440 V, 60 Hz, Type I input power, the IPMC shall be subjected to the following endurance test (see 3.7.5):

a. Energize the IPMC at 122 °F (50 °C) for 15 hours (13 hours at full rated load and 2 hours at no load). During full rated load, the AC output modules shall be operated at full rated power (kVA) at 0.8 pf. Then reduce temperature to ambient of 77 °F (25 °C) for 5 hours (3 hours at full rated load and 2 hours at no load). Shut the power off and reboot the system. Repeat the 20-hour endurance cycle 10 times. If failure occurs during the test, the cause of the failure and the correction shall be recorded.

b. The input current, input voltage, input frequency, output current, output voltage, output frequency and output power, test chamber ambient temperature, and outside chamber ambient temperature shall be recorded hourly. Any turn-on problems, faults, and failures shall be recorded during each full rated load and no load cycle for any input or output module and the IPMC.

4.9.7 DC magnetic field radiated susceptibility. The switch shall be tested for radiated susceptibility, DC magnetic field in accordance with DOD-STD-1399-070-1.

4.9.8 Power module rating tests. The IPMC shall be tested to verify power output module ratings. All output modules shall be operated simultaneously at rated load for 4 hours.

4.9.9 Efficiency test. The efficiency test shall be performed on the IPMC from input to output with all output power modules operating at rated value. Efficiency shall be calculated by means of the following formula:

$$\text{Overall percent efficiency} = \frac{\text{Output power} \times 100}{\text{Input power}}$$

4.9.10 Energization test. The IPMC shall be de-energized for a minimum of 16 hours at 77 °F (25 °C). Nominal input power shall be applied to the IPMC. The output modules shall provide full output performance and power quality requirements in the time frame specified in 3.7.10. The IPMC shall have a temporary input power interruption for 10 seconds and after power is restored, the output modules shall provide full output performance and power quality requirements in the time frame specified in 3.7.10.

4.10 Mechanical/physical testing.

4.10.1 Enclosure integrity. The IPMC shall be tested in accordance with MIL-DTL-2036 for Class 1 enclosures, as supplemented by MIL-STD-108, to determine the effectiveness of the enclosure as specified in 3.8.11.

4.10.2 Acoustics. The IPMC shall be tested for airborne acoustics in accordance with MIL-STD-1474 and for structureborne in accordance with MIL-STD-740-2. When specified, see 6.2 for additional specific requirements.

4.10.3 Accessibility. Accessibility should be in accordance with MIL-HDBK-454.

4.10.4 Lifting test. Complete IPMC assemblies shall be lift tested. An additional 25 percent of weight shall be added to the enclosure and the IPMC shall be suspended by lifting provisions for a minimum of 5 minutes.

4.10.5 Power module withdrawal/insertion test. With the IPMC de-energized, a power module shall be withdrawn and re-inserted. When the power module is removed, the voltage on the output power pins of the power module shall be immediately measured. The voltage between power pins and from the power pins to ground shall not exceed 30 V. A different power module of the same rating shall be withdrawn and inserted 20 times without failure (Failure means that the module either cannot be inserted or that the module after insertion does not meet its requirements.). After the final insertion, the IPMC shall be energized. The voltage to the loads shall be verified to be in accordance with the requirements of MIL-STD-1399-300, MIL-STD-1399-390, and MIL-STD-704.

4.10.6 Grounding, bonding, and shielding. The ohmic resistance between the IPMC enclosure case and the ground stud shall be measured in accordance with MIL-STD-1310.

4.10.7 Power module replacement test. A higher-rated power module shall be replaced with a lower-rated unit. The IPMC shall indicate on the HMI panel that an incorrect module is inserted and the incorrect module shall not energize.

4.10.8 Emergency shutdown test. The emergency shutdown capability shall cause the immediate removal of all input sources to the IPMC by tripping breakers to the IPMC. The emergency shutdown capability shall also act to disable the IPMC outputs to provide means to electrically isolate the output of the IPMC equipment. The hard-wired emergency shutdown from other locations shall cause immediate removal of all input sources and act to disable the IPMC outputs.

4.11 Environmental tests.

4.11.1 Temperature test. The IPMC shall be subjected to the following temperature test and meet the acceptance criteria in 3.10.1.1.

a. The temperature rise test shall be conducted with the equipment completely assembled. Barriers shall be placed adjacent to the enclosure to simulate shipboard installation. Temperature measurements shall be made at the following locations as a minimum. Recording shall be made at 30-minute intervals.

(1) Power semiconductors

(2) Power transformers and reactors

(3) Capacitors

(4) Cooling air input and output

(5) External equipment enclosure

b. Start the temperature chamber and conduct the test at an ambient temperature of 32 °F (0 °C). Energize the IPMC and load the output modules operating to the full load conditions. The temperature rise test shall be continued until the temperature rise of the parts or modules being recorded have attained a steady state condition, which is determined by the temperature remaining within a 3.6 °F (2 °C) temperature band for a period of not less than 3 hours. Repeat the test at 122 °F (50 °C).

c. The input current, input voltage, input frequency, output current, output voltage, output frequency and output power, test chamber ambient temperature, outside chamber ambient temperature, any turn-on problems, any faults, and any failures shall be recorded every 30 minutes during the test period.

4.11.2 Humidity. The humidity test shall be conducted in accordance with MIL-STD-202, Test Method 103B. Test conditions shall be in accordance with MIL-DTL-917.

4.11.3 Shock. The IPMC shall be subjected to a Grade A, Class 1, Type A shock test in accordance with MIL-S-901. The IPMC shall be qualified for hull mounted, back mounted, and for unrestricted orientation. The test shall be conducted with the input and output power module energized and supplying loads that are approximately 25 percent of the respective power module ratings. The voltages on the output power module terminals shall remain within the specified limits. The IPMC shall meet the requirements of 3.10.2 during and after the test.

4.11.4 Vibration. The IPMC vibration test shall be conducted with the IPMC in the energized condition in accordance with the Type I requirements of MIL-STD-167-1. The IPMC shall meet the requirements of 3.10.3 during and after the test.

The test shall be conducted with the input and output power module energized and supplying loads that are approximately 25 percent of the respective power module ratings. The voltages on the energized output power module terminals shall remain within the specified limits.

4.11.5 Inclined operation. The IPMC shall be subjected to an inclined operation test in accordance with MIL-DTL-917. The voltage and current shall remain within the specified limits. The test shall be conducted at 122 °F (50 °C) at a 30-degree angle for each inclined position for a duration of 1 hour.

4.12 Electrical safety.

4.12.1 Input power module source-to-source galvanic isolation. Input power module source-to-source galvanic isolation shall be verified to meet the requirements of 3.11.1. No voltage shall be present on a de-energized input module when another input module is energized.

4.12.2 Output power module-to-load galvanic isolation. Output power module-to-load galvanic isolation shall be verified to meet the requirements of 3.11.2. No voltage shall be present on a de-energized ouput module when another ouput module is energized.

4.13 Embedded software verification and validation. The IPMC embedded software shall be verified and validated in accordance with IEEE 1012.

4.14 IPMC measurement accuracy. With an input module operating at 90 percent and an output module operating at 90 percent of full load, the accuracy of input and output current, voltage, frequency, power factor, and power measurements by the IPMC shall be verified.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point’s packaging activities within the Military Service or Defense Agency, or within the military service’s system commands. Packaging data retrieval is available from the managing Military Department’s or Defense Agency’s automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

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 specification covers the Integrated Power Management Center (IPMC) for use on shipboard power systems for surface ships and submarines. The IPMC can provide distribution, switching, control, and conditioning for electrical power systems.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this specification.

b. When first article is required (see 3.1).

c. Input power quality requirements, if other than as specified in MIL-STD-1399-300 and IEEE 1709 (see 3.3.1).

d. AC output power quality requirements, if other than as specified in MIL-STD-1399-300 and MIL-STD-704 (see 3.3.2.1).

e. DC output power quality requirements, if other than as specified in MIL-STD-1399-390, MIL-STD-704, and IEEE 1709 (see 3.3.2.2).

f. Any load broad-band impedance characteristics (see 3.3.2.2).

g. Special output interface requirements (see 3.3.2.3).

h. Other than Type III power (see 3.3.2.4).

i. Special output voltage harmonics (see 3.3.2.5).

j. Quantity and type of input and output power modules (see 3.4).

k. Provide remote control requirements and communications protocol (see 3.5.1 and 3.8.5).

l. Provide supervisory control requirements (see 3.5.1).

m. Power source selection criteria (see 3.5.1.1a).

n. Provide input power source sharing percentage criteria (see 3.5.1.1b).

o. Load shed and load shed re-energization criteria (see 3.5.1.2e and 3.5.1.2f).

p. Provide data acquisition, storage, display, and display refresh requirements (see 3.5.2.1 and 3.5.2.2).

q. Requirements for data storage time (see 3.5.2.2).

r. Fault protection settings (see 3.6.1).

s. Over/Under voltage protection and settings (see 3.6.2).

t. Over/Under frequency protection and settings (see 3.6.3).

u. Tactical fault override (battle short) requirements (see 3.6.4).

v. Remote fault indicators requirement (see 3.6.4.2).

w. Remote LRU fault indicator requirement (see 3.6.4.2).

x. Ground fault impedance (see 3.6.5.2 and 4.8).

y. Ground fault location capability and testing (see 3.6.5.3 and 4.8).

z. Common mode current monitoring, reporting, and testing (see 3.6.5.4 and 4.8).

aa. Common mode current limit setpoint and testing (see 3.6.5.4 and 4.8).

bb. When a higher source-to-source impedance is required (see 3.7.3).

cc. Anticipated equipment location to meet the EMI requirements of MIL-STD-461 (see 3.7.4).

dd. Special endurance requirements, if required (see 3.7.5).

ee. Power module ratings (see 3.7.8).

ff. Energization start time (see 3.7.10).

gg. Motor control criteria (see 3.7.11).

hh. Identify communications protocol (see 3.8.5).

ii. Voltage required to trip the breakers (see 3.8.8).

jj. HMI equipment labeling conventions (see 3.8.9).

kk. Degree of enclosure (see 3.8.11).

ll. Airborne noise grade level (see 3.8.13.1).

mm. Structureborne noise grade level (see 3.8.13.2).

nn. Either bulkhead or deck mounting (see 3.8.16).

oo. Instruction sheets (see 3.12).

pp. Marking other than specified (see 3.14).

qq. Reliability MTBF prediction (see 3.16).

rr. MTTR and the scope of the time frame (see 3.17).

ss. Size and weight of IPMC (see 3.19).

tt. Specify need and location of grab rails (see 3.20).

uu. Additional input power test requirements (see 4.6.1).

vv. Additional output power test requirements (see 4.6.2).

ww. Packaging requirements (see 5.1).

xx. Configuration Data (CD) sheets (see 6.4).

yy. Security category designation (see D.3.1).

zz. When a cybersecurity analysis of threats is required (see D.3.2).

aaa. When intrusion detection is required (see D.3.3.b(7)).

bbb. Any additional cybersecurity requirements (see D.4.2).

6.3 Definitions. Definitions are in accordance with MIL-STD-1399, unless listed below.

6.3.1 Cybersecurity. Prevention of damage to, protection of, and restoration of computers, electronic communication systems, electronic communication services, wire communication, and electronic communication, including information contained therein, to ensure its availability, integrity, authentication, confidentiality, and non-repudiation.

6.3.2 Load monitoring. Load monitoring is a process for recording and analyzing changes in the voltage and current going into a load.

6.3.3 Power conditioning. Power conditioning is the ability to modify AC and DC voltage, current, and frequency such that the needs of the loads are satisfied. Traditionally, these functions are performed by transformers, rectifiers, converters, and inverters.

6.3.4 Power control. Power control monitors, processes, displays, and initiates action according to predetermined rules. Power control provides electric power routing, power quality control, and fault management. The electrical parameters monitored are voltage, current, and frequency. The IPMC monitors ship service power and output power to allow the IPMC to adjust power output to meet load interface requirements.

6.3.5 Power distribution. Power distribution conveys electrical power from a source to the load(s). Traditionally, these functions are performed by switchboards, power panels, and distribution boxes.

6.3.6 Power factor (pf). See MIL-STD-1399.

6.3.7 Power switching. Power switching is the ability to open and close an electrical circuit as follows:

a. ability to open and close a no-load electrical circuit.

b. ability to open and close an energized electrical circuit under normal operations.

c. ability to open and close an electrical circuit under abnormal conditions such as a fault.

d. ability to open one incoming circuit and immediately close on an alternate circuit to provide power to the loads being supplied.

These functions have traditionally been supplied via no-load break switches, load break switches, motor contactors, transfer switches, circuit breakers, and fuses. The IPMC may perform all of these functions via the input power modules, the output power modules, and the control module or via other functioning devices.

6.3.8 Source transfer. Source transfer is the automatic switchover from normal to alternate power sources with quality of power supplied to the loads remaining within the power quality limits.

6.4 Configuration data (CD) sheets. When specified (see 6.2), if the IPMC has adjustable configuration settings, those settings should be included with the delivery of the IPMC along with a copy of the CD sheet affixed in or on the IPMC in accordance with MIL-DTL-15024. The IPMC should also have a unique manufacturer's part number for every different configuration that is ordered. The CD sheet should also contain the model number, serial number, and the part number of the IPMC.

6.5 Acronyms.

EMI	Electromagnetic Interference
EPM	Equipment Performance Monitoring
ESD	Electrostatic Discharge
HMI	Human Machine Interface
MTBF	Mean Time Between Failures
MTTR	Mean Time to Repair
pf	Power Factor
RMS	Root Mean Square
SCADA	Supervisory Control and Data Acquisition
THD	Total Harmonic Distortion
V	Voltage

6.6 Subject term (key word) listing.

Cybersecurity

Power conditioning

Power control

Power distribution

Power switching

Switch gear

6.7 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

INPUT POWER QUALITY FOR 650 VDC

A.1 SCOPE

This appendix covers the 650 VDC input power quality for the IPMC.

This appendix is not a mandatory part of the specification. The information contained herein is intended for guidance only.

A.2 INPUT POWER QUALITY FOR 650 VDC

Input power quality characteristics for 650 VDC are listed in table A-I.

The use of these power quality characteristics requires NAVSEA approval.

TABLE A-I. Input power quality characteristics for 650 VDC.

Characteristic	Value	
Nominal User Voltage	650 VDC	
Voltage Tolerance	±5%	
Voltage Ripple Amplitude	±1.5%	
Voltage Ripple Frequency	Largest Component of Voltage Ripple Frequency is less than 10 kHz	
Worst Case Voltage Offset from Positive Terminal to Ground	-275 VDC to +925 VDC	
Worst Case Voltage Offset from Negative Terminal to Ground	-925 VDC to +275 VDC	
Worse Case Voltage Transient Excursion (tolerance + transient)	598 to 715 VDC	
Voltage Transient Recovery Time	250 ms	
Maximum Voltage Spike	1300 V	
Voltage Spike Waveform	1.2 µs x 50 µs	
Maximum Regenerative Power	0 kW	
Maximum Load Line-to-Ground Capacitance	0.005 µF per kW or 1 µF (whichever is smaller)	
Minimum Load DC Resistance to Ground	10 MΩ	
Maximum Load Current Ripple	See the User Equipments CE01 Differential Mode Ripple Current Limits Figure of MIL-STD-1399-390	
Maximum Load Current Rate of Change	Nominal Rated Load Current (A) ≤ 186 > 186 and ≤ 371 > 371	Maximum Rate of Change (A/ms) 30 58 300

TABLE A-I. Input power quality characteristics for 650 VDC – Continued.

Characteristic	Value	
Peak Allowable In-Rush/Initialization Current	Equipment Rated Load (kW)	Multiplier of Rated Current
	< 50	10
	≥ 50 and ≤ 100	6
	> 100 and ≤ 175	4
	> 175	2
Peak In-Rush Current Rate of Change	Nominal Rated Load Current (A)	Maximum Rate of Change (A/ms)
	≤ 186	60
	> 186 and ≤ 371	115
	> 371	300

OUTPUT POWER QUALITY CHARACTERISTICS

B.1 SCOPE

This appendix covers the IPMC AC and DC output power quality characteristics.

This appendix is not a mandatory part of the specification. The information contained herein is intended for guidance only.

B.2 AC OUTPUT POWER QUALITY

AC output power quality characteristics may be as identified in table B-I.

The use of these power quality characteristics requires NAVSEA approval.

TABLE B-I. AC output power quality characteristics as measured at the output terminals.

Characteristic	Value
Output Type	**3-Phase, 3-Wire, Ungrounded, 440 V_{rms}, 200V_{rms}, 115 V_{rms}, & 3-Phase, 4-Wire 115/200 V_{rms}**
Frequency	
1. Frequency	
– Nominal	60 Hz
– Adjustable Range	50–400 Hz
2. Frequency Tolerance	±0.5%
3. Frequency Modulation	0.5%
4. Frequency Transient Tolerance/Recovery	
– On Circuit Creating Transient	±2.0%
– On Adjacent Circuits	±1.0%
5. Frequency Excursion, Worst-Case	±1.5%
6. Frequency Transient and Excursion Recovery Time	0.25 sec
Voltage	
7. Nominal User Voltage (V_{rms})	440 V, 200 V, 115 V, 115/200 V
Adjustable Range (Minimum)	440–460 V_{rms}, 115-120 V_{rms}, 115/200-120/208 V_{rms}
8. Voltage Unbalance (line-to-line)	2.0%
9. Voltage Tolerance	
– Average of Line-to-Line from Nominal	±2.0%
– Any One Line-to-Line from Nominal	±4.0%
10. Voltage Modulation	1.0%
11. Maximum Departure Voltage	±4.0%

TABLE B-I. AC output power quality characteristics as measured at the output terminals – Continued.

Characteristic	Value
12. Voltage Transient Tolerance/Recovery	
– On Circuit Creating Transient	±5.0%
– On Adjacent Circuits	±5.0%
13. Voltage Excursion, Worst-Case from Nominal	±5.5%
14. Voltage Transient and Excursion Recovery Time	0.25 sec
15. Voltage Phase Displacement	±1 degree under balanced load condition
16. Voltage Excursion During Source Transfer	
– Excursion from Nominal	±5.5%
– Recovery Time	0.8 sec
Voltage Waveform	
17. Maximum Total Harmonic Distortion (THD)	3.0%
18. Maximum Single Harmonic	2.0%
Load Current Programmability	
19. Adjustable	10-100%
NOTE: 1. 3-Phase, 4-Wire can be grounded or ungrounded (see 6.2).	

B.3 DC OUTPUT POWER QUALITY

DC output power quality characteristics may be as identified in table B-II.

The use of these power quality characteristics requires NAVSEA approval.

TABLE B-II. DC output power characteristics as measured at the output terminals – 2-wire ungrounded.

Characteristic	Value						
	650 V	**375 V**	**270 V**	**155 V**	**120 V**	**48 V**	**24 V/28 V**
Voltage							
1. Nominal Voltage	650 V	375 V	270 V	155 V	120 V	48 V	24 V
2. Adjustable Range	640-660 V	370-380 V	250-290 V	155-165 V	115-125 V	46-52 V	22-32 V
3. Voltage Tolerance	±1.0%	±1.0%	±2.0%	±1.0%	±1.0%	±2.0%	±2.0%
4. Voltage Regulation	±1.0%	±1.0%	±2.0%	±1.0%	±1.0%	±2.0%	±2.0%
5. Voltage Transient	±10%	±10%	±10%	±10.0%	±10%	±10%	±10%
6. Voltage Transient Recovery	0.2 sec	0.2 sec	0.2 sec	0.2 sec	0.2 sec	0.2 sec	0.2 sec
7. Voltage Ripple (P-P) – Maximum	3.0%	2.0%	2.0%	2.0%	2.0%	3.0%	3.0%
Current Adjustment Range							
8. Adjustable Range	50-100%	50-100%	50-100%	50-100%	50-100%	50-100%	50-100%

OUTPUT POWER QUALITY FOR 375 VDC

C.1 SCOPE

This appendix covers the 375 VDC output power quality for the IPMC.

This appendix is not a mandatory part of the specification. The information contained herein is intended for guidance only.

C.2 OUTPUT POWER QUALITY FOR 375 VDC

Output power quality characteristics for 375 VDC are listed in table B-II or table C-I when specified in 6.2.

The use of these power quality characteristics requires NAVSEA approval.

TABLE C-I. Output power quality characteristics for 375 VDC.

Characteristic	Value	
Nominal User Voltage	375 VDC	
Voltage Tolerance	±8%	
Voltage Ripple Amplitude	±2.5%	
Voltage Ripple Frequency	Largest Component of Voltage Ripple Frequency is less than 10 kHz	
Worst Case Voltage Offset from Positive Terminal to Ground	+405 VDC	
Worst Case Voltage Offset from Negative Terminal to Ground	-405 VDC	
Worse Case Voltage Transient Excursion (tolerance + transient)	327 to 420 VDC	
Voltage Transient Recovery Time	250 ms	
Maximum Voltage Spike	750 V	
Voltage Spike Waveform	1.2 µs x 50 µs	
Maximum Regenerative Power	0 kW	
Maximum Load Line-to-Ground Capacitance	0.005 µF per kW or 1 µF (whichever is smaller)	
Minimum Load DC Resistance to Ground	10 MΩ	
Maximum Load Current Ripple	See the User Equipments CE01 Differential Mode Ripple Current Limits Figure of MIL-STD-1399-390	
Maximum Load Current Rate of Change	Nominal Rated Load Current (A) ≤ 186 > 186 and ≤ 371 > 371	Maximum Rate of Change (A/ms) 30 58 125

TABLE C-I. Output power quality characteristics for 375 VDC – Continued.

Characteristic	**Value**	
Peak Allowable In-Rush/Initialization Current	Equipment Rated Load (kW)	Multiplier of Rated Current
	< 15	10
	≥ 15 and ≤ 30	6
	> 30 and ≤ 50	4
	> 50	2
Peak In-Rush Current Rate of Change	Nominal Rated Load Current (A)	Maximum Rate of Change (A/ms)
	≤ 186	60
	> 186 and ≤ 371	115
	> 371	250

IPMC CYBERSECURITY REQUIREMENTS

D.1 SCOPE

This appendix covers IPMC cybersecurity requirements.

This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

D.2 APPLICABLE DOCUMENTS

D.2.1 General. The documents listed in this section are specified in Appendix D of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in Appendix D of this specification, whether or not they are listed.

D.2.2 Government documents.

D.2.2.1 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE ISSUANCES

DoDI 8500.01 - Cybersecurity

DoDI 8510.01 - Risk Management Framework (RMF) for DoD Information Technology (IT)

(Copies of these documents are available online at www.dtic.mil/whs/directives/.)

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST SP 800-53 - Security and Privacy Controls for Federal Information Systems and Organizations

(Copies of this document are available online at http://www.nist.gov.)

SPACE AND NAVAL WARFARE SYSTEMS COMMAND (SPAWAR) STANDARDS

STD-DFIA-004R0 - Defense-in-Depth Functional Implementation Architecture (DFIA) Standard

(Copies of this document are available online at https://nserc nswc navy mil/spawar/HQ/chengws/ta/Shared%20Documents/Forms/IA_Standards.aspx.)

D.3 CYBERSECURITY REQUIREMENTS

D.3.1 Security category. The generalized format for expressing the security category is confidentiality, integrity, availability, and specific impact where the acceptable values for potential impact are low, moderate, or high. The IPMC shall be designed as appropriate for the application (see 6.2). Tailored security controls from the low baseline of security controls defined in NIST Special Publication 800-53 shall ensure that the minimum assurance requirements are satisfied. The minimum security control requirements for the IPMC shall be as follows:

a. Access control shall include remote control capability. No wireless access shall be allowed.
b. Security assessment and authorization shall include continuous monitoring of IPMC interconnections.
c. Audit and accountability controls shall include time stamps.
d. Configuration management controls shall include access restrictions and configuration settings.
e. Identification and authentication controls shall include password based authentication.

f. Physical and environmental protection shall include monitoring and alarms notification.

g. System and communication protection shall include failure in a known state.

D.3.2 Analysis of threats. When specified (see 6.2), an analysis of threats shall drive the IPMC control system implementation details, both physically and with respect to cyberwarfare, to mitigate those threats and the impacts of attacks. The analysis of threats shall identify IPMC assets (e.g., control consoles, HMIs, backbone networks, control processors, communication interfaces, input/output (I/O), networks, and other such assets.) and IPMC threats, both accidental and malicious (e.g., advanced persistent threats (APTs) and threats on system availability, integrity, and authenticity). Analysis shall also identify mitigation considerations.

D.3.3 Security measures. The IPMC should consider the following security measures:

a. Physical security should provide the following:
   (1) Proper signage of equipment.
   (2) Locked enclosures for primary control elements.
   (3) Enclosures with intrusion detection.
   (4) Obstructed or removed external ports.

b. Network security should provide the following:
   (1) Disabling unused ports.
   (2) Port-based security.
   (3) Media Access Control (MAC) based security.
   (4) Disabling unused services and protocols.
   (5) Default security parameters.
   (6) Secure network protocols.
   (7) Intrusion detection (see 6.2).

c. Controller security should provide the following:
   (1) Password authentication.
   (2) Login failure lockout.
   (3) Password failure lockout.
   (4) Code protection.
   (5) Control firmware validation.
   (6) Digital signatures (such as a Common Access Card [CAC]).

d. Console and computing security should provide the following:
   (1) User access.
   (2) Application white-listing (such as running executable files other than control systems).
   (3) Operating system patching.

e. Application security should provide the following:
   (1) Virus scanning.
   (2) Secure coding practices (use the following link for guidance: https://www.securecoding.cert.org/confluence/display/seccode/SEI+CERT+Coding+Standards).
   (3) Application authentication.

f. System security should provide the following:
   (1) Virus scanning.
   (2) Change logs.
   (3) User authorization.

(4) Secure password practices.

(5) Vendor default modifications.

(6) Disabling or removal of unused ports.

(7) Protocols.

(8) Software features.

(9) System security training.

g. External interface security should provide firewalls.

D.3.4 Implementation. The IPMC design shall be implemented in consideration of the above security measures and in accordance with DoDI 8500.01, DoDI 8510.01, and STD-DFIA-004R0.

D.4 CYBERSECURITY VERIFICATION

D.4.1 Security requirements. The requirements specified in D.3 shall be verified (see table IV). Any failure to meet these requirements is cause for rejection of the IPMC.

D.4.2 Additional specified cybersecurity requirements. Any additional cybersecurity requirements as specified in 6.2 shall be verified. Any failure to meet these requirements is cause for rejection of the IPMC.

IPMC ELECTRICAL TESTS

E.1 SCOPE

This appendix covers the IPMC electrical test requirements in accordance with MIL-STD-1399-300.

This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

E.2 ELECTRICAL TESTS

User equipment interface test requirements are identified as follows:

a. Electrical power system characteristics tests
b. System grounding and ground detection tests
c. Electric power system protection tests
d. Electrical power system parameters tests
    (1) Voltage and frequency tolerance tests
    (2) Voltage and frequency transient tolerance and recovery test
    (3) Voltage spike test
e. Emergency condition tests
f. User equipment power profile testing
    (1) Type of power
    (2) Number of phases
    (3) Voltage (rms)
    (4) Line current magnitudes (rms)
    (5) Power factor (leading or lagging)
    (6) Power kilowatt (kW) rated and typical operating power profile
    (7) Surge/inrush current - peak magnitude and duration
    (8) Pulsed loading
    (9) Ramp loading
    (10) Load unbalance
    (11) Spike generation
    (12) Submarine Rigged for Reduced Electric (RRE) configuration power demand, where applicable
    (13) Line-to-ground capacitance
    (14) Line-to-ground current
g. Current waveform tests
h. Surge/inrush current tests
i. Voltage and frequency modulation tests
j. Simulated human body leakage current tests for personnel safety
k. Equipment insulation resistance tests

POWER MODULE RATINGS

F.1 SCOPE

This appendix covers power module ratings.

This appendix is not a mandatory part of the specification. The information contained herein is intended for guidance only.

F.2 POWER MODULE RATINGS

Power module ratings are listed in table F-I.

TABLE F-I. Power module ratings.

Power Modules	**Ratings (Ratings are based on maximum continuous current.)**
Input Power Modules:	
1. 440 V_{rms}, 60 Hz, 3-phase	15 A, 30 A, 50 A, 100 A, 200 A, 400 A
2. 650 VDC (see Appendix A)	50 A
3. 1000 VDC	50 A
Output Power Modules:	
1. 440 V_{rms}, 60 Hz, 3-phase	5 A, 15 A, 30 A, 50 A, 100 A, 200 A, 400 A
2. 440 V_{rms}, 400 Hz, 3-phase, 3-wire	5 A, 15 A, 30 A, 50 A, 100 A, 200 A, 400 A
3. 115 V_{rms}, 60 Hz, 3-phase, 3-wire	30 A, 60 A, 90 A
4. 115 V_{rms}, 400 Hz, 3-phase, 3-wire	25 A, 35 A, 50 A
5. 115/200 V_{rms}, 60 Hz, 3-phase, 4-wire	30 A, 60 A, 90 A, 200 A, 400 A
6. 115/200 V_{rms}, 400 Hz, 3-phase, 4-wire	35 A, 60 A, 100 A, 200 A, 400 A
7. 115 V_{rms}, 3-phase fast switch modules	10 A
8. 115 V_{rms}, 60 Hz, 1-phase, 2-wire	70 A
9. 115 V_{rms}, 400 Hz, 1-phase, 2-wire	70 A
10. 650 VDC	15 A, 30 A
11. 375 VDC (see Appendix C)	15 A, 30 A
12. 270 VDC	15 A, 30 A, 200 A
13. 240 VDC/270 VDC	20 A, 40 A
14. 155 VDC	20 A, 40 A
15. 120 VDC	10 A, 20 A, 40 A, 60 A
16. 48 VDC	50 A, 100 A
17. 28 VDC	10 A, 20 A, 40 A, 50 A, 100 A, 300 A
18. 24 VDC	50 A, 100 A, 200 A, 400 A
NOTE: Output power is equivalent to input power minus losses (see 3.7.9 for efficiency).	

Custodians:
Army – CR4
Navy – SH
Air Force – 99

Preparing activity:
Navy – SH
(Project 6110-2013-002)

Review activities:
Navy – AS, CG
Air Force – 19
DLA – GS, GS2

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil.