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Robust Combat Power and Energy Controls

Model Requirements Framework

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1 Introduction

Add intro. See [1].

2 Intended Uses of the Models

Table 2.1: Table USYS

ID	Description	Cited Functions
USYS0002	The model is intended to be used for abnormal operating conditions.	
USYS1001	The model is intended to be used for steady-state or quasi-steady-state assessment of power flow within the system.	F001, F002, F003, F004, F005, F006, F007, F008, F009, F010, F011, F012
USYS1002	The model is intended to be used for steady-state or quasi-steady-state assessment of voltage and current magnitudes (and angles, where applicable) within the system.	F003, F004, F005, F006, F007, F008, F009, F010, F012
USYS2001	The model is intended to be used for small signals transient stability analysis.	F003, F004, F005, F006, F007, F008, F009, F010, F011, F012
USYS2002	The model is intended to be used for large signals transient stability analysis.	F003, F004, F005, F006, F007, F008, F009, F010, F011, F012

3 Requirements for Component Models

3.1 Power Generation Module

Table 3.1: Table RPGM

ID	Description	Cited Uses
RPGM1000	**Normal Operating Conditions**	
RPGM1001	The model shall properly represent steady-state voltage and current magnitude and phase (as applicable) based on normal loading conditions.	USYS1002, USYS1101, USYS1102, USYS2001, USYS2002, USYS3001, USYS4001, USYS4002, USYS4003, USYS4004, USYS5001
RPGM1004	The model shall present proper impedance characteristics at its AC terminals to small signal perturbations up to the frequency specified by f_{sim} for normal loading conditions.	USYS2001
RPGM1005	The model shall properly represent the effects of load perturbations on the generator frequency, voltage magnitude, field winding voltage and current, and governor and AVR.	USYS2001, USYS2002, USYS3001, USYS4001
RPGM1009	The model shall accurately represent the transient response of the component (up to the frequency specified by f_{sim}) to transient changes in load current.	USYS4001
RPGM2000	**Common-Mode Modeling**	
RPGM3000	**Abnormal Operating Conditions**	
RPGM3010	**The model shall represent appropriate behavior for overload conditions.**	
RPGM4000	**Thermal**	
RPGM5100	**Startup**	
RPGM5200	**Shutdown**	

Table 3.2: Table APGM

ID	Description	Analysis	Cited Requirements
APGM001	Steady-state operation as a function of loading conditions. The component should be subjected to a range of apparent power values and power factors. As a minimum, the component should be tested at minimal load and full load at minimum expected power factors.	Voltage magnitude and frequency should be characterized, along with current magnitude and phase angle.	RPGM1001

Table 3.2: Table APGM

ID	Description	Analysis	Cited Requirements
APGM001F	Execute activity APGM001. The model should be tested for loading conditions in excess of rated power and for power factors below the expected minimum power factor. The model should also be tested for leading power factor loads.	Measurements and analyses for APGM001 activities should be assessed, as appropriate.	RPGM3002
APGM002	Impedance measurements. Small-signal current perturbations should be applied at the terminals of the PGM over a frequency range of interest for steady-state loading conditions. A range of loading conditions should be considered.	Appropriate AC impedance (e.g. DQ-axis) shold be characterized at the AC terminals.	RPGM1004, RPGM1008
APGM002B	Execute activity APGM002. The model should be tested for loading conditions above rated power and for power factors below the expected minimum power factor. The model should also be tested for leading power factor loads.	Measurements and analyses for APGM002 activities should be assessed, as appropriate.	RPGM3002
APGM003	Frequency response to active power oscillations. Small oscillations in the load active power should be applied over a frequency range of interest. Characterization should be done over a range of loading conditions, including minimal loading and full loading at unity and the minimal expected power factor.	The frequency response of voltage magnitude and frequency to small oscillations in load active power should be characterized over a frequency range of interest. Frequency response of the field winding voltage and current, along with governor and AVR response should also be characterized.	RPGM1005
APGM003B	Execute activity APGM003. The model should be tested for loading conditions above rated power and for power factors below the expected minimum power factor. The model should also be tested for leading power factor loads.	Measurements and analyses for APGM003 activities should be assessed, as appropriate.	RPGM3002
APGM004	Frequency response to reactive power oscillations. Small oscillations in the load active power should be applied over a frequency range of interest. Characterization should be done over a range of loading conditions, including minimal loading and full loading at unity and the minimal expected power factor.	The frequency response of voltage magnitude and frequency to small oscillations in load reactive power should be characterized over a frequency range of interest. Frequency response of the field winding voltage and current, along with governor and AVR response should also be characterized.	RPGM1005

Table 3.2: Table APGM

ID	Description	Analysis	Cited Requirements
APGM004B	Execute activity APGM003. The model should be tested for loading conditions above rated power and for power factors below the expected minimum power factor. The model should also be tested for leading power factor loads.	Measurements and analyses for APGM004 activities should be assessed, as appropriate.	RPGM3002
APGM007	Load ramps. The load active and reactive power levels should be ramped from initial values to specified target values, holding for a specified duration, and ramping the load active and reactive power levels back to the intial values. Tests should consider constant power loads, as well as constant impedance loads. Tests should consider power ramp rates up to the limits of relevant standards.	Response quantities should be charaterized for deflection of the voltage magnitude and frequency.	RPGM1009, RPGM1010
APGM007B	Execute activity APGM007. Load levels above the specified rating of the component should be tested, and power factors below the expected minimum power factor should be tested. Tests should include ramp rates beyond the limits of relevant standards.	Measurements and analyses for APGM007 activities should be assessed, as appropriate.	RPGM3002
APGM008	Modulation of load power. These tests should include modulation of the load power over a range of modulation frequencies and magnitudes. These should minimally include testing corner cases for required operation as specified in relevant standards or specifications.	Response quantities which should be characterized include the maximum deflection and modulation of the voltage magnitude and frequency during the event, along with modulation of the AC currents.	RPGM1009, RPGM1010
APGM008B	Execute activity APGM008. Modulation of load power should be tested at points exceeding limits of relevant standards or specifications.	Measurements and analyses for APGM008 activities should be assessed, as appropriate.	RPGM3002

3.2 AC/DC PCM

Table 3.3: Table RPCM

ID	Description	Cited Uses
RPCM1000	**Normal Operating Conditions**	
RPCM1001	The model shall properly represent steady-state voltage and current magnitude and phase (as applicable) based on source and loading conditions.	USYS1002, USYS1101, USYS1102, USYS2001, USYS2002, USYS3001, USYS4001, USYS4002, USYS4003, USYS4004, USYS5001
RPCM1004	The model shall present proper impedance characteristics at its DC terminals to small signal perturbations up to the frequency specified by f_{sim}.	USYS2001
RPCM1005	The model shall present proper impedance characteristics at its AC terminals to small signal perturbations up to the frequency specified by f_{sim}.	USYS2001
RPCM1006	The model shall properly represent the frequency distrubance propogation from the AC to the DC terminals	USYS2001
RPCM1007	The model shall properly represent the frequency distrubance propogation from the DC to the AC terminals	USYS2001
RPCM1008	The model shall properly represent the frequency response of the component for small signal perturbations in input control signals, up to the frequency specified by f_{sim}.	USYS2001, USYS2002, USYS3001, USYS4001
RPCM1009	The model shall accurately represent the transient response of the component (up to the frequency specified by f_{sim}) to transient changes in load and/or source conditions.	USYS2001, USYS2002, USYS3001
RPCM1012	The model shall properly represent the response of the component to large signal changes in input control signals, up to the frequency specified by f_{sim}.	USYS1001, USYS1002, USYS3001
RPCM2000	**Common-Mode Modeling**	
RPCM3000	**Abnormal Operating Conditions**	
RPCM3002	The model shall properly represent terminal voltage characteristics when subjected to loading conditions outside of normal operating boundaries	USYS0002, USYS1101, USYS1102, USYS4001, USYS4002, USYS4003
RPCM3003	The model shall properly represent terminal voltage and current characteristics when subjected to source conditions outside normal operating boundaries.	USYS0002, USYS1101, USYS1102, USYS4001, USYS4002, USYS4003
RPCM3004	The model shall represent appropriate behavior for overload conditions.	USYS0002, USYS1101, USYS1102, USYS4001, USYS4002, USYS4003
RPCM3007	The model shall properly represent the dynamic response of the component to large, abrupt changes in loading or system impedance.	USYS2002, USYS4001, USYS8006, USYS8007

Table 3.4: Table APCM

ID	Description	Analysis	Cited Requirements
APCM001	Steady-state operation as a function of loading conditions and primary terminal voltage conditions. The component should be subjected to a range of load power values and voltage magnitude and frequency values at the primary terminals. If applicable, also vary operating temperatures.	The EM secondary terminal voltage should be characterized, along with current magnitudes and angles at the primary terminals.	RPCM1001
APCM001F	Execute activity APCM001. The model should be subjected to load power values exceeding ratings and limits of relevant standards/specifications.	Measurements/analyses for APCM001, APCM001B, APCM001C, APCM001D, and APCM001E should be assessed as appropriate.	RPCM3004
APCM001G	Execute activity APCM001. The model should be subjected to primary terminal voltage conditions exceeding ratings and limits of relevant standards/specifications.	Measurements/analyses for APCM001, APCM001B, APCM001C, APCM001D, and APCM001E should be assessed as appropriate.	RPCM3003
APCM002	Small-signal perturbations should be applied at the input terminals of the AFE for steady-state loading conditions. If applicable, condition should include power flow in both directions by the AFE. The component should be tested with the voltage magnitude and frequency of perturbations held to within the steady-state limits specified by the relavant standards.	Appropriate AC impedance at primary terminals should be characterized. The frequency response of the voltage magnitude at the DC terminals to small oscillations in voltage magnitude at the AC terminals should also be characterized over a frequency range of interest.	RPCM1005, RPCM1006
APCM002B	Execute activity APCM002. The model should be tested for loading conditions above rated power.		RPCM3004
APCM002C	Execute activity APCM002. The model should be tested for source conditions exceeding the limits specified by the relevant standards.		RPCM3003
APCM003	Small-signal frequency response at secondary terminals. Apply small oscillations in load current at the secondary terminals within the steady-state limits specified by the relavant standards. Also includes characterization of propagation of load power disturbances into the source.	The impedance at the secondary terminals should be characterized. The frequency response of power draw at the primary terminals to small oscillations in load power at the secondary terminals should be characterized over a frequency range of interest.	RPCM1004, RPCM1007
APCM003B	Execute activity APCM003. The model should be tested for loading conditions above rated power.		RPCM3004

Table 3.4: Table APCM

ID	Description	Analysis	Cited Requirements
APCM003C	Execute activity APCM003. The model should be tested for source conditions exceeding the limits specified by the relavant standards.		RPCM3003
APCM004	Characterization of response to large signal load power oscillations. The component should be subjected to a range of pulse loading events consisting of varying period, magnitude, duty cycle, and ramp rate connected at the output terminals of EM. Also, the component should be subjected to a sequence of multi-level load pulsations of varying period and duty cycle.	Placeholder: Identify response quantities to capture power ramp rates at primary terminals, excursions of secondary voltage, etc.	RPCM1009
APCM004B	Execute activity APCM004. The model should be tested for loading conditions above rated power.		RPCM3004
APCM004C	Execute activity APCM004. The model should be tested for source conditions exceeding the limits specified by the relavant standards.		RPCM3003
APCM004D	Execute activity APCM004. The model should be tested for load characteristics exceeding the limits specified by the relevant standards.	This should include ramp rates in excess of specified limits.	RPCM3002
APCM005	Small-signal perturbations should be applied to the secondary voltage bias signal for steady-state loading conditions. If applicable, conditions should include power flow in both directions by the AFE. The component should be tested with the voltage magnitude and frequency of perturbations held to within the steady-state limits specified by the relavant standards.	The frequency response of the voltage magnitude at the secondary terminals to small oscillations in the secondary voltage bias signal should be characterized.	RPCM1008
APCM005B	Execute activity APCM005. The model should be tested for loading conditions above rated power.		RPCM3004
APCM005C	Execute activity APCM005. The model should be tested for source conditions exceeding the limits specified by the relavant standards.		RPCM3003
APCM008B	Execute activity APCM008. The model should be tested for loading conditions above rated power.		RPCM3004

Table 3.4: Table APCM

ID	Description	Analysis	Cited Requirements
APCM008C	Execute activity APCM008. The model should be tested for source conditions exceeding the limits specified by the relavant standards.		RPCM3003
APCM008D	Execute activity APCM008. Tests should include ramp rates beyond the limits of relevant standards.		RPCM3002
APCM009	Modulation of load power. These tests should include modulation of the load power over a range of modulation frequencies and magnitudes. These should minimally include testing corner cases for required operation as specified in relevant standards or specifications.	Response quantities which should be characterized include the maximum deflection and modulation of the voltage magnitude at the secondary terminals during the event.	RPCM1009
APCM009B	Execute activity APCM009. The model should be tested for loading conditions above rated power.		RPCM3004
APCM009C	Execute activity APCM009. The model should be tested for source conditions exceeding the limits specified by the relavant standards.		RPCM3003

3.3 AC Load

Table 3.5: Table RLDA

ID	Description	Cited Uses
RLDA1000	**Normal Operating Conditions**	
RLDA1001	The model shall accurately represent the steady-state power draw of the load during relevant states, modes, and/or conditions when supplied with a power source in normal operating conditions.	USYS1001, USYS1002
RLDA1002	The model shall be configurable to include worst-case dynamic loading when supplied with a power source in normal operating conditions (i.e., large-signal dynamics).	USYS2002, USYS3001
RLDA1005	The model shall accurately represent the small-signal input impedance of the load at the AC interface when supplied with a power source in normal operating conditions (as defined in relevant standard/specification).	USYS2001
RLDA2000	**Common-Mode Modeling**	
RLDA3000	**Abnormal Operating Conditions**	
RLDA3001	The model shall be numerically stable when supplied with a power source in abnormal operating condtitions(abnormal conditions include circuit breaker opening, over/under voltage, over/under frequency).	USYS1002

Table 3.5: Table RLDA

ID	Description	Cited Uses
RLDA3008	The model shall represent appropriate behavior when supplied with a power source in abnormal operating conditions (e.g. over/under voltage, over/under frequency).	
RLDA4000	**Thermal**	
RLDA5100	**Startup**	
RLDA5200	**Shutdown**	

3.4 Bi-Directional Energy Magazine

The bi-directional EM should adhere to the requirements identified for the AC/DC PCM in Section 3.2. Additionally, this component should adhere to the requirements in Table 3.6.

Table 3.6: Table RBEM

ID	Description	Cited Uses
RBEM1000	**Normal Operating Conditions**	
RBEM1012	The model shall accurately represent the state-of-charge estimation of the energy storage media of the component.	USYS1001, USYS1002, USYS1101, USYS1102, USYS2002, USYS3001
RBEM2000	**Common-Mode Modeling**	
RBEM3000	**Abnormal Operating Conditions**	
RBEM3013	The model shall properly represent behavior at extreme states-of-charge.	USYS0002
RBEM3014	The model shall properly represent the efficiency of the energy storage media during charge and discharge under all operating conditions.	USYS1001, USYS1002, USYS1101, USYS1102, USYS2002, USYS3001

4 Conclusion

Add conclusion.

References

[1] James Langston, Mark Stanovich, Christian Schegan, Deanna Temkin, Herbert Ginn, Tuyen Vu, David Wetz, Aaron Cramer, Rob Cuzner, and Dan Opila. Plan for RCPC demonstrations, version 1.0. Technical report, RCPC, September 2021.

A Acronyms and Glossary

ATG Auxiliary Turbine Generator

CHIL Controller Hardware-in-the-Loop (Simulation)

EM Energy Magazine

EMC Energy Management Control

EMT Electromagnetic Transient (Simulation)

ESM Energy Storage Module

FNC Future Naval Capability

HIL Hardware-in-the-Loop

IPS Integrated Power System

LC Load Center

LVAC Low Voltage Alternating Current

LVDC Low Voltage Direct Current

ML Mission Load

MTG Main Turbine Generator

MVAC Medium Voltage Alternating Current

MVDC Medium Voltage Direct Current

PCM Power Conversion Module

PEMC Power and Energy Management Control

PGM Power Generation Module

PHIL Power Hardware-in-the-Loop (Simulation)

RTDS® Real Time Digital Simulator[1]

PMM Propulsion Motor Module

RCPC Robust Combat Power and Energy Controls

SoC State of Charge

UPS Uninterruptible Power Supply

[1]RTDS is a registered trademark of RTDS Technologies

B RCPC Goals and Functions

Table B.1: Table GRCPC

ID	Description
G101	Optimize/improve system efficiency.
G102	Maintain loads in fulfillment of mission objectives.
G103	Optimize/improve longevity of components.
G104	Enable adherence to interface standards.
G105	Enable reduction in the size and/or weight of the system.

Table B.2: Table FRCPC

ID	Description	Cited Goals
F001	Optimize system efficiency.	G101
F002	Improve generator/component utilization.	G101, G103, G105
F003	Mitigate effects of dynamic loads.	G101, G103, G104
F004	Reduce stress to components.	G103
F005	Mitigate effects of system disturbances.	G102
F006	Improve stability margin.	G102
F007	Decrease time to detect, locate, and isolate faults.	G102
F008	Improve regulation of electrical buses (including reduction in harmonics).	G103, G104
F009	Reduce system/subsystem startup times.	G102
F010	Enable (or reduce time for) dark ship recovery.	G102
F011	Manage dispatch of energy resources to maintain important loads.	G102
F012	Reduce reactive power supplied by generation.	G102, G103, G104

C Excluded Requirements and Activities

Table C.1: Table USYS (Excluded Items)

ID	Description	Cited Functions
USYS1003	The model is intended to be used to assess system efficiency in steady-state conditions.	F001
USYS1004	The model is intended to be used to assess heat loading of components within the system in steady-state conditions.	
USYS1005	Placeholder: Assessing thermal system.	
USYS1006	The model is intended to be used for analyses of unbalanced systems.	
USYS1101	The model is intended to be used to assess steady-state short-circuit levels within the system for line-to-line faults.	F007
USYS1102	The model is intended to be used to assess steady-state short-circuit levels within the system for faults to ground.	F007
USYS3001	The model is intended to be used for assessment of power quality and harmonics within the system.	F008
USYS4001	The model is intended to be used to assess transient voltage and currents within the system for transient events (such as short-circuits, switching, etc.) excluding short-circuits to ground and excluding assessing voltages and currents to ground.	F002, F004, F005, F007, F008, F009, F010
USYS4002	The model is intended to be used to assess transient voltage and currents within the system for transient events (such as short-circuits, switching, etc.) including short-circuits to ground and including assessing voltages and currents to ground.	F002, F004, F005, F007, F008, F009, F010
USYS4003	The model is intended to be used to verify coordination of circuit protection equipment.	F004, F005, F007, F008
USYS4004	The model is intended to be used to study circulating common-mode currents within the system.	
USYS5001	The model is intended to be used to study common-mode currents within the system, including ground currents.	
USYS8001	Placeholder: Arc flash analyses.	
USYS8002	Placeholder: EMI analysis.	
USYS8003	Placeholder: Size and weight analyses.	
USYS8004	Placeholder: Hydrodynamic analyses.	
USYS8005	Placeholder: HV safety investigation.	
USYS8006	Placeholder: Plant transitions.	
USYS8007	Placeholder: Dark ship and dead ship startup.	

Table C.2: Table RPGM (Excluded Items)

ID	Description	Cited Uses
RPGM0001	The model interface shall adhere to that specified in the MDD.	
RPGM1002	The model shall exhibit proper operation for unbalanced loading conditions within the bounds of normal operation.	USYS1006
RPGM1003	The model shall properly represent losses at steady state based on operating conditions (including loading levels, operating temperatures, etc.).	USYS1003

Table C.2: Table RPGM (Excluded Items)

ID	Description	Cited Uses
RPGM1006	The model shall properly represent the frequency response of the component for small signal perturbations in the voltage bias signal, up to the frequency specified by f_{sim}.	USYS2001, USYS2002, USYS3001, USYS4001
RPGM1007	The model shall properly represent the frequency response of the component for small signal perturbations in the frequency bias signal, up to the frequency specified by f_{sim}.	USYS2001, USYS2002, USYS3001, USYS4001
RPGM1008	The model shall accurately represent harmonic content in terminal voltage for frequencies up to the frequency specified by f_{sim}.	USYS3001
RPGM1010	The model shall properly represent the dynamic response of the component to large, abrupt changes in loading or system impedance.	USYS2002, USYS4001, USYS8006, USYS8007
RPGM2001	The model shall accurately represent small-signal common-mode impedances at the AC interface up to the frequency specified by f_{sim}.	USYS4004, USYS5001
RPGM2002	The model shall accurately represent small-signal common-mode impedances at the AC interface up to the frequency specified by f_{sim}, including parasitic coupling to ground.	USYS5001
RPGM3001	The model shall be numerically stable when the load is removed or a short-circuit is applied.	USYS1002
RPGM3002	The model shall properly represent terminal voltage characteristics when subjected to loading conditions outside of normal operating boundaries.	USYS0002, USYS1101, USYS1102, USYS4001, USYS4002, USYS4003
RPGM3003	The model shall properly represent steady-state currents for line-to-line short-circuits at the AC terminals based on loading conditions.	USYS1101
RPGM3004	The model shall properly represent transient currents (up to the frequency specified by f_{sim}) for line-to-line short-circuits at the AC terminals based on loading conditions.	USYS4001, USYS4003
RPGM3005	The model shall properly represent steady-state currents for line-to-ground short-circuits at the AC terminals based on loading conditions.	USYS1102
RPGM3006	The model shall properly represent transient currents (up to the frequency specified by f_{sim}) for line-to-ground short-circuits at the AC terminals based on loading conditions.	USYS4002
RPGM3007	If applicable, the model shall be configurable to accurately represent ground faults within the component that can cause abnormal line-to-ground voltages to appear at its AC terminals. This does not include simple line-to-ground faults at the AC terminals.	
RPGM3008	The model shall accurately represent steady-state (or transient) currents for a fault within the component.	
RPGM3009	The model shall exhibit proper operation for unbalanced loading conditions outside the bounds of normal operation.	
RPGM4001	The model shall include steady-state heat loading applied to the ambient environment and active cooling systems.	USYS1004, USYS1005
RPGM5101	(Numerical stability)	
RPGM5201	(Numerical stability)	

Table C.3: Table APGM (Excluded Items)

ID	Description	Analysis	Cited Requirements
APGM001B	Execute acitivity APGM001.	Losses should be characterized.	RPGM1003
APGM001C	Execute acitivity APGM001.	Heat loading applied to ambient and cooling systems should be characterized.	RPGM4001
APGM001D	Execute acitivity APGM001.	The voltage spectra for the terminal voltages should be captured in order to characterize harmonic content produced by the source.	RPGM1008
APGM001E	Execute acitivity APGM001. The model should be subjected to a range of unbalanced loading conditions.	Voltage unbalance and current unblance should be characterized.	RPGM1002
APGM005	Characterizatoin of frequency response to oscillations in voltage bias. Small oscillations in the voltage bias signal should be applied over a frequency range of interest. Characterization should be done over a range of loading conditions, including minimal loading and full loading at unity and the minimal expected power factor.	The frequency response of voltage magnitude to small oscillations in voltage bias should be characterized.	RPGM1006
APGM005B	Execute activity APGM005. The model should be tested for loading conditions above rated power and for power factors below the expected minimum power factor. The model should also be tested for leading power factor loads.	Measurements and analyses for APGM005 activities should be assessed, as appropriate.	RPGM3002
APGM006	Characterization of frequency response to oscillations in frequency bias. Small oscillations in the voltage bias signal should be applied over a frequency range of interest. Characterization should be done over a range of loading conditions, including minimal loading and full loading at unity and the minimal expected power factor.	The frequency response of terminal frequency to small oscillations in frequency bias should be characterized.	RPGM1007
APGM006B	Execute acitvity APGM006. The model should be tested for loading conditions above rated power and for power factors below the expected minimum power factor. The model should also be tested for leading power factor loads.	Measurements and analyses for APGM006 activities should be assessed, as appropriate.	RPGM3002

Table C.3: Table APGM (Excluded Items)

ID	Description	Analysis	Cited Requirements
APGM009	Short-circuit at AC terminals. These tests should include the application of a short-circuit condition at the AC terminals of the component. Tests should include sustained short-circuit events, and should include a range of short-circuit fault impedance values for line-to-line and three-phase short-circuits.	The steady-state short-circuit current contribution from the component should be characterized, noting current-limiting behavior or tripping offline.	RPGM3001, RPGM3003
APGM009B	Execute activity APGM009.	The transient characteristics of the short-circuit current should also be noted, including the peak current and time-duration(s) for settling to steady-state current. The times to tripping or current-limiting behavior should also be noted.	RPGM3004, RPGM3006
APGM009C	Execute activity APGM009. Tests should be conducted in which line-to-ground short-circuits are applied.	For these tests, characteristics of voltages to ground should be noted, as well as currents to ground.	RPGM3005
APGM010	Placeholder: Common mode impedance characterization tests.		
APGM011	Placeholder: Generator startup.		
APGM012	Placeholder: Transients during plant transitions (e.g. transformer inrush, motor startup).		RPGM1010

Table C.4: Table RPCM (Excluded Items)

ID	Description	Cited Uses
RPCM1002	The model shall properly represent losses at steady state based on operating conditions (including loading levels, operating temperatures, etc.).	USYS1003
RPCM1003	The model shall properly represent heat loading applied to ambient and cooling systems.	USYS1004
RPCM1010	The model shall properly reflect AC terminal line imbalances during DC side loading at max loading with balanced source voltage.	USYS2002, USYS3001, USYS4001, USYS1006
RPCM1011	The model shall properly reflect AC terminal line imbalances based on imbalance in source voltage.	USYS2002, USYS3001, USYS4001, USYS1006
RPCM1013	Placeholder: Positive, negative, and zero-sequence impedance at primary terminals.	USYS1006 in conjuction with one or more of USYS2XXX, USYS3XXX, USYS4XXX
RPCM2001	The model shall properly represent common mode impedances up to the frequency specified by f_{sim}.	USYS4004, USYS5001

Table C.4: Table RPCM (Excluded Items)

ID	Description	Cited Uses
RPCM2002	The model shall properly represent common mode impedances up to the frequency specified by f_{sim}, accounting for parasitic coupling to ground.	USYS5001
RPCM3001	The model shall be numerically stable when subjected to open-circuit or short-circuit conditions at the AC and/or DC terminals.	USYS0002, USYS1101, USYS1102, USYS4001, USYS4002, USYS4003
RPCM3005	The model shall properly represent steady-state currents at the AC terminals and steady-state voltage and current at the DC terminals for line-to-line short-circuits at the AC and/or DC terminals based on source and loading conditions.	USYS1101, USYS1102, USYS4001, USYS4002, USYS4003
RPCM3006	The model shall properly represent steady-state currents at the AC terminals and steady-state voltage and current at the DC terminals for line-to-ground short-circuits at the AC and/or DC terminals based on source and loading conditions.	USYS1102, USYS4002
RPCM3008	If applicable, the model shall be configurable to accurately represent internal ground faults within the component that can cause abnormal line-to-ground voltages to appear at its AC and/or DC terminals. This does not include simple line-to-ground faults at the terminals.	
RPCM3009	The model shall properly represent transient currents (up to frequency f_{sim}) at the AC terminals and steady-state voltage and current at the DC terminals for line-to-line short-circuits at the AC and/or DC terminals based on source and loading conditions.	USYS4001, USYS4002, USYS4003
RPCM3010	The model shall properly represent transient currents (up to frequency f_{sim}) at the AC terminals and steady-state voltage and current at the DC terminals for line-to-ground short-circuits at the AC and/or DC terminals based on source and loading conditions.	USYS4002
RPCM3011	The model shall properly represent transients during plant transitions (this includes loss of parallel generator, parallel connection with other generators, energizing portions of the system, including transformer inrush, partial loss of plant, etc.).	USYS8006, USYS8007
RPCM3012	The model shall properly represent the behavior of the device when subjected to momentary loss of source followed by re-connection of source.	USYS2002, USYS4001, USYS4002, USYS4003, USYS8006, USYS8007

Table C.5: Table APCM (Excluded Items)

ID	Description	Analysis	Cited Requirements
APCM001B	Execute activity APCM001.	Losses should be characterized.	RPCM1002
APCM001C	Execute activity APCM001.	Heat loading applied to ambient and cooling systems should be characterized.	RPCM1003
APCM001D	Execute activity APCM001.	The current imbalance at the primary terminals should be characterized.	RPCM1010

Table C.5: Table APCM (Excluded Items)

ID	Description	Analysis	Cited Requirements
APCM001E	Execute activity APCM001. The voltage imbalance applied at the primary terminals should also be varied.	The current imbalance at the primary terminals should be characterized.	RPCM1011
APCM006	Momentary loss of source and reconnection. While operating at steady-state, the voltage at the primary terminals should be removed by presenting an open circuit, holding for a specified length of time, and then reclosing the source.	Placeholder: Identify response quantities.	RPCM3001, RPCM3012
APCM008E	Placeholder: Addressing unbalanced source conditions.		RPCM1011
APCM009E	Placeholder: Addressing unbalanced source conditions.		RPCM1011
APCM010	Short-circuit at primary terminals. These tests should include the application of a short-circuit condition at the primary terminals of the component. Tests should include sustained short-circuit events, and should include a range of short-circuit fault impedance values for line-to-line and three-phase short-circuits.	The steady-state short-circuit current contribution from the component should be characterized, noting current-limiting behavior or tripping offline.	RPCM3006, RPCM3007, RPCM3010 RPCM3011
APCM010B	Execute activity APCM010.	The transient characteristics of the short-circuit current should also be noted, including the peak current and time-duration(s) for settling to steady-state current. The times to tripping or current-limiting behavior should also be noted.	RPCM3010, RPCM3011
APCM011	Short-circuit at secondary terminals. These tests should include the application of a short-circuit condition at the secondary terminals of the component. Tests should include sustained short-circuit events, and should include a range of short-circuit fault impedance values for positive to negative rail and positive rail to ground. (RPCM3004, RPCM3006) - Controller Reaction	The steady-state short-circuit current contribution from the component should be characterized, noting current-limiting behavior or tripping offline.	RPCM3006, RPCM3007, RPCM3010 RPCM3011

Table C.5: Table APCM (Excluded Items)

ID	Description	Analysis	Cited Requirements
APCM011B	Execute activity APCM011.	The transient characteristics of the short-circuit current should also be noted, including the peak current and time-duration(s) for settling to steady-state current. The times to tripping or current-limiting behavior should also be noted.	RPCM3010, RPCM3011
APCM012	Placeholder: Large ramps in voltage bias signals.		
APCM013	Placeholder: Positive, negative, and zero sequence impedance measurements at primary terminals.		RPCM1013

Table C.6: Table RLDA (Excluded Items)

ID	Description	Cited Uses
RLDA1003	The model shall accurately represent current draw when supplied by a source with unbalanced voltage within normal operating conditions.	USYS1006
RLDA1004	The model shall properly represent losses.	USYS1003
RLDA1006	The model shall accurately represent harmonic content in terminal current for frequencies up to the frequency specified by f_{sim}.	USYS3001
RLDA1007	The model shall accurately represent the transient response of the component (up to the frequency specified by f_{sim}) to transient changes in source voltage.	USYS4001
RLDA2001	The model shall accurately represent small-signal common-mode impedances at the AC interface up to the frequency specified by f_{sim}.	
RLDA2002	The model shall accurately represent small-signal common-mode impedances at the AC interface up to the frequency specified by f_{sim}, including parasitic coupling to ground.	
RLDA3002	The model shall accurately represent steady-state currents during line-to-line faults at the terminals of the load.	USYS1101
RLDA3003	The model shall accurately represent transient currents (up to a specified frequency of interest) during line-to-line faults at the terminals of the load.	
RLDA3004	The model shall accurately represent steady-state currents during line-to-ground faults at the terminals of the load.	USYS1102
RLDA3005	If applicable, the model shall be configurable to accurately represent ground faults within the load that can cause abnormal line-to-ground voltages to appear on the source. This does not include simple line-to-ground faults at the terminals of the load.	
RLDA3006	The model shall accurately represent steady-state (or transient) currents for a fault within the represented load.	

Table C.6: Table RLDA (Excluded Items)

ID	Description	Cited Uses
RLDA4001	The model shall include steady-state heat loading applied to the ambient environment and active cooling systems.	USYS1004, USYS1005
RLDA5101	(Numerical stability)	
RLDA5201	(Numerical stability)	

Table C.7: Table RBEM (Excluded Items)

ID	Description	Cited Uses