Appendix A - Generator Relay Settings

Effective Date: November 20, 2024

Review By Date: November 20, 2026

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Generator Relay Settings and Modeling Form				
Generator Protection Function and Description	**Description**	**Discussion**	**Setting and Element Tripped**	**Applicable Standard PSSe Model Selection**
21 – Phase Distance, Device 21 is not used in all generator protection schemes.	The 21 relay measures impedance derived generator terminal voltage divided by generator stator current. The 21 relay provides backup protection for system faults that are not cleared by transmission system protective relays. Never used with device 51V.	Settings should be used for planning and system studies, either through explicit modeling of the function or through monitoring impedance swings at the relay location in the stability program—and applying engineering judgment. Anytime relay settings are to be modified, ISO must be notified at least 120 days prior to making the change.	Provide settings on the basis of the equipment primary side and elements tripped: Zone 1 – Trip Setting, Time Zone 2 – Trip Setting, Time and elements tripped.	DISTR1 Mho, impedance, or reactance distance relay
24 – Volts/Hz, Device 24 is not used in all generator protection schemes.	Excessive Volts/Hertz levels increase core flux and successive iron and heat damage to generators and step-up transformers. Excessive Volts/Hertz may occur due to a “runaway” voltage regulator or islanding with sudden load loss	Regional UFLS program design must be coordinated with these settings. Settings should be used for planning and system studies, either through explicit modeling of the function or through monitoring voltage and frequency performance at the relay location in the stability program	Provide settings: Provide Limiter Settings and trips <u>Discrete Trips:</u> Underfrequency: Trip 1: Volts/Hz per unit, Time T1 Trip 2: Volts/Hz per unit, Time T2 Provide Settings/ Coordination with Transformer Damage Curve (on separate sheet)	VPERHZU1

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25 – Synchronizing or Synch Check	Ensures the generator is synchronized with power system when the generator breaker is closed.	It is not necessary to provide synchronizing or synch check relay settings to ISO	It is not necessary to provide settings information for this relay to ISO	No specific model
27 – Generator Unit Undervoltage Protection	The 27 relay measures voltage at the generator's terminals and trips the generator if voltage is lower than a preset value for a preset length of time.	Settings should be used for planning and system studies through explicit modeling of the function. • Must coordinate with transmission line reclosing	Provide Under Voltage Trip Settings and delay timing on equipment primary basis, Elements Tripped (Coordinated with PRC-024 curves) <u>Discrete Trips:</u> Undervoltage: Trip 1: Volts Primary, Time T1 Trip 2: Volts Primary, Time T2 Provide Settings/ Coordination with Continuous Curve (on separate sheet)	VGTDCAT Under/over voltage generator bus disconnection relay or VTGTPAT Under/over voltage generator trip relay

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27 – Plant Auxiliary Undervoltage.	Plant Auxiliary undervoltage relaying will trip plant auxiliaries such as feed pumps. Once auxiliary equipment trips, then the main generation equipment will trip. Only auxiliary equipment that will trip due to relay action needs to be modeled; other tripping induced by low voltage such as motor contactor dropout or motor stalling does not need to be reported at this time.	The IEEE Standard C37.102 – IEEE Guide for AC Generator Protection [2] – does not recommend use of the 27 function for tripping, but only to alarm to alert operators to take necessary actions. If used for tripping, provide settings and tripped elements to ISO.	Voltage Level and Under Voltage Trip Settings on equipment primary basis if operation results in the loss of a generator	VGTDCAT Under/over voltage generator bus disconnection relay or VTGTPAT Under/over voltage generator trip relay
27 – Plant High-Voltage system-side undervoltage		Settings should be used for planning and system studies through explicit modeling of the function.	Provide Under Voltage Trip Settings and delay timing on equipment primary basis, Elements Tripped (Coordinated with PRC-024 curves) <u>Discrete Trips:</u> Undervoltage: Trip 1: Volts Primary, Time T1 Trip 2: Volts Primary, Time T2 Provide Settings/ Coordination with Continuous Curve (on separate sheet)	VGTDCAT Under/over voltage generator bus disconnection relay or VTGTPAT Under/over voltage generator trip relay

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32 – Reverse Power	This is a directional relay element used to prevent generators from motoring if the prime mover fails.	Settings and elements tripped are provided to ISO.	Provide Trip Settings on equipment primary basis and Elements Tripped	User model until library model is available.
40 – Loss of Excitation (LOE)	The loss of excitation is the accidental loss of connectivity or DC supply voltage to the rotor field winding. This can be damaging to the generator with violent vibrations (slipping a pole) or rotor heating (running as asynchronous machine).	Loss-of-field excitation on a synchronous generator is detrimental to both the generator and the power system. Settings used for planning and system studies	Provide Trip Settings on Equipment primary basis and Equipment Tripped	LOEXR1T Loss of excitation distance relay
46 – Negative phase sequence overcurrent	Generator negative sequence currents are caused by an unbalanced load condition. Damaging negative sequence is usually caused by an open conductor or unbalanced fault which leads to severe generator field heating.	It is not necessary to provide settings to the ISO.	It is not necessary to provide settings information for this relay to ISO	Not available for modeling
50/27 – Inadvertent energizing	If a generator on turning gear is energized from the power system then it will accelerate like an induction motor. This is caused by breaker configuration misoperations. While the machine is accelerating, high currents induced into the rotor may cause significant damage in only a matter of seconds	It is not necessary to provide settings to the ISO.	It is not necessary to provide settings information for this relay to ISO	Not available for modeling

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50BF – Breaker failure on generator interconnection breaker(s)	Breaker failure generally occurs with breaker trip coil failure without monitoring.	Provide clearing time to ISO upon request or upon any change in clearing time.	Trip settings on equipment primary basis, time delay, Elements Tripped	Not available for modeling
51T – Phase fault backup overcurrent 51TG – Ground fault backup overcurrent	The 51T function can be applied to provide transformer through-fault current winding protection	Refer to NERC Considerations for Power Plant and Transmission System Protection Coordination Technical Reference Document – Revision 2, July 2015 Coordination Procedures and IEEE Std. C37.91-2008, Annex A	Provide a response to indicate whether a 51T or 51TG relay is used for protection on this generator	Review model available for 51 T/G
51V – Voltage controlled or voltage restrained overcurrent	These overcurrent protective relays measure generator terminal voltage and generator stator current. Their function is to provide backup protection for system faults when the power system to which the generator is connected is protected by time-overcurrent protections.	51V not recommended when Transmission Owner uses distance line protection functions. Coordination may be difficult to achieve except on single generators connected to the power system by radial interconnection facilities. Short-circuit studies for time coordination. If used, settings should be used for planning and system studies	Provide a response to indicate whether a 51V relay used for protection on this generator	

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59 – Overvoltage	59 overvoltage protection measures generator terminal voltage to prevent insulation breakdown from sustained overvoltage	As described above, ISO studies assume adherence to the PRC-024 standard.	Setpoints on primary basis, Elements Tripped	VGTDCAT Under/over voltage generator bus disconnection relay or VTGTPAT Under/over voltage generator trip relay PSS/E
59GN/27TH – Generator Stator Ground	Stator ground fault protection uses a measurement of zero-sequence generator neutral voltage to detect generator system ground faults.	It is not necessary to provide settings to the ISO.	It is not necessary to provide settings information for this relay to ISO	No specific model
64G – Generator Grd	Generator Ground Detector	Not normally provided to ISO	It is not necessary to provide settings information for this relay to ISO	No specific model

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78 – Out of Step	Out-of-step relaying is generally required for larger machines connected to EHV systems. If a generator loses synchronism, it can result in high currents that cause mechanical forces in the generator stator windings and undesirable transient shaft torques.	Out-of-step protection uses a measure of apparent impedance derived from the quotient of generator terminal voltage divided by generator stator current. Settings should be used for planning and system studies, either by explicit modeling of the function or through monitoring voltage performance at the relay location in the stability program.	Settings on primary basis and Elements Tripped	CIROS1 Double Circle or Lens Out-of-Step Tripping or Blocking Relay or SLNOS1 Straight Line Blinder Out-of-Step Relay
81U – Underfrequency 81O – Overfrequency	Device 81/U and 81/O will trip for underfrequency or overfrequency conditions.	Settings should be used for planning and system studies, either through explicit modeling of the function or through monitoring frequency performance at the relay location in the stability program—and applying engineering judgment.	<u>Discrete Trips:</u> Underfrequency: Trip 1: Frequency F1, Time T1 Trip 2: Frequency F2, Time T2 Overfrequency: Trip 1: Frequency F1, Time T1 Trip 2: Frequency F2, Time T2 Elements Tripped If continuous tripping curves used – then provide curves on	FRQDCAT Under/over frequency generator bus disconnection relay. FRQTPAT Under/over frequency generator trip relay.

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			separate sheet.	
87G – Generator Differential 87T – Transformer Differential 87U – Overall Differential	Differential protection schemes measure the current entering and leaving a device. If the current is different then there is a fault within the device.	It is not necessary to provide device 87 settings to ISO. NERC Generator Owners and Transmission Owners should ensure proper overlap of the overall differential zone and bus differential zone, etc., are verified.	Clearing time associated with differential relay schemes and zone of coverage.	Provide Clearing Times
Over Excitation Limiters	The overexcitation limiter (OEL) prevents the AVR from trying to supply more excitation current than the excitation system can supply or the generator field can withstand.	Ensure that limiters allow for NX-12D VAR output. Note that not all excitation system models are compatible with MAXEX1 and MAXEX2; please check excitation system model and OEL model for compatibility before submitting to ISO.	Limiter Settings including any time delay on equipment primary basis and whether the limiter trips generation.	MAXEX1 Maximum excitation limiter model Or MAXEX2 Maximum excitation limiter model

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Under Excitation Limiters	The under excitation limiter (UEL) prevents the AVR from reducing excitation to such a low level that the generator is in danger of losing synchronism.	Ensure that limiters allow for NX-12D VAR output	Limiter Settings including any time delay on equipment primary basis and whether the limiter trips generation	UEL1 IEEE 421.5 2005 UEL1 under-excitation limiter UEL2 IEEE 421.5 2005 UEL2 minimum excitation limiter MNLEX1, MNLEX2, MNLEX3 Minimum excitation limiter models
Generator Step-Up Transformer Overcurrent Relay	51T	See Generator Section 51T		
Generator Step-Up Transformer Differential Relay	87T	See Generator Section 87T		

OP-24 App A Revision History

Rev No.	Date	Reason
0	02/01/19	Initial version
1	12/07/20	Periodic review performed by procedure owner; provided clarification in descriptive and criteria language where appropriate.
1.1	12/01/22	Biennial review performed by procedure owner requiring no changes; Made administrative changes required to publish a Minor Revision.
1.2	11/20/24	Biennial review performed by procedure owner requiring no changes; Made administrative changes required to publish a Minor Revision.