

# INVERTER-BASED GENERATION INTERCONNECTION SETTINGS GUIDE

General Settings Guidelines  
Protection & Control Policy # 378

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## 1 Purpose

This document is written for PacifiCorp customers, consulting engineers, and internal Protection & Control (P&C) reviewers. It outlines basic protection requirements for customer-owned inverter-based generation with a required protective relay (per PacifiCorp Policy 138). This general guide provides insight into the basic protection elements reviewed by PacifiCorp.

This guide does not contain every setting a relay requires to operate. All provided values are superseded by any requested changes from a PacifiCorp P&C engineer.

Whether a relay is required (and which functions are required) is determined by the PacifiCorp interconnection process (including the interconnection agreement, applicable screens/studies, and PacifiCorp Policy 138). If there is any conflict between this guide and project-specific PacifiCorp requirements, the project-specific requirements govern.

Unless otherwise specified by the project, settings and measurements in this guide are assumed to be based on the relay's connected instrument transformers (VT/PT and CT) at the point of common coupling (PCC). Per-unit values are referenced to nominal service voltage at the PCC. Time values shown as cycles assume a 60 Hz system.

## 2 Reference Documents

PacifiCorp Policy 138, Distributed Energy Resource (DER) Interconnection Policy

IEEE Standard 1547-2018, IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces

IEEE Standard C37.2-2008, IEEE Standard for Electrical Power System Device Function Numbers, Acronyms, and Contact Designations

## 3 Definitions

- **(27) Undervoltage relay:** A device that operates when its input voltage is less than a predetermined value.
- **(32) Directional power flow relay:** A device that operates on a predetermined value of power flow in a given direction, such as reverse power flow (32R).
- **(50) Instantaneous overcurrent relay:** A device that operates with no intentional time delay when the current exceeds a preset value. The suffix TD should be used (e.g., 50TD) to describe a definite time overcurrent function.
- **(51) Inverse time overcurrent relay:** A device that functions when the ac input current exceeds a predetermined value, and in which the input current and operating time are inversely related through a substantial portion of the performance range.
- **(59) Overvoltage relay:** A device that operates when its input voltage exceeds a predetermined value.

- **(81) Frequency relay:** A device that responds to the frequency of an electrical quantity, operating when the frequency or rate of change of frequency exceeds (81O) or is less than (81U) a predetermined value.
- **Approved generation capacity:** The maximum generation/export capability approved by PacifiCorp for the project (which may be less than inverter nameplate). Use the value stated in the interconnection agreement and/or PacifiCorp project documentation.
- **CLOSE:** The relay permissive/enable logic used to allow a close (manual or automatic), where implemented. Some projects may not implement a relay-controlled CLOSE permissive.
- **Communications (com) loss:** Loss of the required communications channel or supervision used for transfer trip or other required protection functions, as defined by the project scheme.
- **Contingent requirement:** Additional functionality that is determined by site specific criteria. This functionality will be called out in the system impact study.
- **e-settings file:** The native settings file for the specific relay software platform (for example, an SEL acSELEerator settings file or equivalent for the manufacturer) that allows PacifiCorp to review all settings.
- **PCC:** Point of common coupling between the customer facility and the utility system.
- **Transfer trip (direct transfer trip):** A communications-based trip signal initiated by an upstream protective device/system to cause the customer interconnection device to open.
- **TRIP:** The relay output logic that commands the protective device (breaker/recloser/contactor, as applicable) to open.

#### 4 General Relay Requirements

Per PacifiCorp Policy 138, all relays shall have the following functional attributes:

1. Meet design criteria listed in IEEE 1547-2018
2. Minimum required protection elements
  - a) Voltage – 27, 59
  - b) Frequency – 81U, 81O
  - c) Overcurrent – 50, 50TD, 51 (phase and ground)
3. Contingent Requirements
  - a) Direct transfer trip capability
    - i. The relay must be equipped with the ability to receive a transfer trip signal
  - b) Reverse power flow – 32R
    - ii. The relay must be equipped with reverse power flow sensing
4. Uninterruptable power supply (UPS)
  - a) Must be able to power the protective device and relays should normal power source fail for a minimum of one hour

## 5 Settings Review Submissions

PacifiCorp generally requests that customers submit the following relay setting information for power company review. The company may request additional information depending on the complexity of the installation.

1. Latest electrical one-line or drawing set of proposed installation
  - a) Ensure the correct number and size of inverters are listed
  - b) If primary metered, ensure transformers have impedances and winding configuration listed
2. Complete e-settings (native relay settings file) file of proposed settings
  - a) This will include all settings, even those that are not being used
3. PDF version of settings
  - a) The PDF serves as an interim backup if the e-setting file becomes corrupted or cannot be opened and must be resent
4. Contact information for customer's engineer for settings-related questions

## 6 General Settings Ranges

All values provided in this table are general and are provided for reference only.

Any requested changes during the settings review process supersede any value given below.

Protection Element	General Range			Purpose
27—Undervoltage	Voltage in Per Unit (P.U.)		Time (sec/cycles)	IEEE 1547-2018 voltage operability ranges
	0.70		2/120	
	0.45		0.16/9.6	
59—Overvoltage	Voltage in Per Unit (P.U.)		Time (sec/cycles)	IEEE 1547-2018 voltage operability ranges
	1.1		2/120	
	1.2		0.16/9.6	
81—Frequency	Element	f (Hz)	Time (sec/cycles)	IEEE 1547-2018 frequency operability ranges
	81O	62	0.16/9.6	
	81O	61	2/120	
	81U	59	2/120	
	81U	57	0.16/9.6	
50TD—Phase Definite Time Overcurrent	<b>Pickup</b> = 110% of approved generation capacity <b>Delay</b> = 0.2 seconds			This pickup is set to limit overgeneration and to aid in tripping for faults. Notice the pickup is based on approved capacity NOT on nameplate.  Delay can change based on configuration.
51—Phase Inverse Time Overcurrent	<b>Pickup</b> = 105% of approved generation capacity			This pickup is subject to change and is used to ensure the generation will not feed a fault at the substation.
50TD—Ground Definite Time Overcurrent	<b>Pickup</b> = 0.5 amps  <b>Delay</b> = 0.2 seconds			This pickup is subject to change and is set to trip for all ground faults with a delay to ensure fault is real.  Delay can change based on configuration.
51—Ground Inverse Time Overcurrent	<b>Pickup</b> = 0.5 amps  <b>Delay</b> = 0.2 seconds			See above

Protection Element	General Range	Purpose
TRIP	<b>TRIP:</b> [...] Undervoltage (27), overvoltage (59), underfrequency (81U), over frequency (81O), inst. overcurrent (50P, 50G), inverse time overcurrent (51P, 51G)  <u>Contingent additional elements</u> - Transfer trip signal - Communications loss	TRIP equation must open for all voltage, frequency, or overcurrent elements.  <u>Contingent options:</u> presence of a transfer trip signal or loss of communications from upstream protective device must cause a trip.
CLOSE	<b>CLOSE:</b> [...] NOT TRIP  <u>Contingent additional elements</u> - NOT transfer trip signal - NOT communication loss	CLOSE equation must ensure voltage, frequency, or overcurrent elements are NOT active.  <u>Contingent options:</u> presence of a transfer trip signal or loss of communications from upstream protective device must prevent the relay from closing.
<b>Optional Functionality</b>		
Auto Restoration	<b>Minimum Delay</b> = 5 min  <u>Contingent additional elements</u> - NOT transfer trip signal - NOT com loss	Restoration can happen when utility voltage and frequency has been stable for a minimum of 5 minutes.  <u>Contingent options:</u> presence of a transfer trip signal or loss of communications from upstream protective device must prevent relay auto restoration.

Note: The “= [...]” represents the space for additional customer logic.

<b>Contingent Conditions</b>			
<b>Contingent Requirement</b>	<b>Protection Element</b>	<b>General Range</b>	<b>Purpose</b>
Direct Transfer Trip Required	Communication Loss	Com loss = trip within 0.3 sec	Relay must be capable of alarming and fully operating for communication signal loss within 0.3 sec.  Communication loss variable can have a delay element, as long as the protective device operates in 0.3 seconds or less.
	Direct Transfer Trip Required	Transfer trip = communication signal from upstream protective device	Must be able to receive signal from an upstream protective device and disconnect immediately.
		TRIP = [...] transfer trip OR com loss	Trip must contain transfer trip and communication loss variables.
		CLOSE = [...] NOT transfer trip NOT com loss	NOT transfer trip signal to block close if trip is still active.  NOT com loss to ensure cannot close without communication restoration.
	Tag/Hold on Line	<b>Drive to lockout:</b> tag/hold enabled	Relay with communication must drive to lockout on first shot if a Tag/Hold signal is sent from upstream protective device.
Non-Exporting/Load Offset Required	32R—Reverse Power Flow	Threshold: 0.5 seconds  TRIP = [...] reverse power flow for > 0.5 seconds	Relay must detect and issue a trip signal to the protective device if reverse power flow is sensed for more than 0.5 seconds.

Note: The “= [...]” represents the space for additional customer logic.

## Appendix A: Example Relay Models by Manufacturer

### Required

Elements: undervoltage (27), overvoltage (59), underfrequency (81U), over frequency (81O), instantaneous and definite time overcurrent (50, 50TD), inverse time overcurrent (51).

Inputs: three-phase current, three-phase voltage (unless installation is single phase)

### Contingent

Elements: reverse power-flow (32R)

Outputs: Communication ports (must be able to trip relay in under 0.3 sec)

The following is not an exhaustive list of relay models, please contact a manufacturer sales representative for further information:

Relay Manufacturer	Common Models with Required Elements
ABB/Hitachi	REX610, REX615, REG15
Beckwith	M-7651A D-PAC
Basler	BE1-Flex Protection, BE1-11F
Eaton/Cooper	EDR-5000
GE	Multilin series [P14DL, P14DZ]
Schweitzer Engineering Labs (SEL)	351, 351S, 351A, 451, 751, 851
Schneider	PowerLogic P3 Protection
Siemens	SIPROTEC Series [7Sx82 (ie., 7SK82, 7SL82)]