



POWERFACTORY

PowerFactory 2021

Technical Reference

ABB REF 550

POWER SYSTEM SOLUTIONS
MADE IN GERMANY

F2021

Publisher:

DlgSILENT GmbH
Heinrich-Hertz-Straße 9
72810 Gomaringen / Germany
Tel.: +49 (0) 7072-9168-0
Fax: +49 (0) 7072-9168-88
info@digsilent.de

Please visit our homepage at:
<https://www.digsilent.de>

Copyright © 2021 DlgSILENT GmbH

All rights reserved. No part of this
publication may be reproduced or
distributed in any form without written
permission of DlgSILENT GmbH.

November 15, 2019
PowerFactory 2021
Revision 924

Contents

1 Model information	1
2 General description	1
3 Supported features	1
3.1 Measurement and acquisition	1
3.1.1 Available Units	2
3.1.2 Functionality	2
3.1.3 Data input	2
3.2 Protective elements	2
3.2.1 Available Units	3
3.2.2 Functionality	3
3.2.3 Data input	5
3.3 Output logic	9
3.3.1 Available Units	9
3.3.2 Functionality	9
3.3.3 Data input	9
4 Features not supported	10
5 References	11

1 Model information

Manufacturer ABB

Model REF 550

Variants The ABB REF 550 PowerFactory relay models simulate the features available in the ABB REF 550 relay.

2 General description

The ABB REF 550 is an advanced feeder protection system with the newest innovation in protection, control and automation features. The REF550 is the ideal solution designed for protecting and controlling distribution and subtransmission line systems. The REF550 offers the latest HIF Detect (High Impedance Fault detection) technology and a complete package of protection functionality such as: phase and ground instantaneous and time overcurrent protection; negative-sequence overcurrent protection; under/over single and three phase and ground, as well as negative sequence over voltage control and alarm; multi-shot reclosing; and over/under frequency protection for load-shedding application, breaker failure, synchronism check.

The ABB REF 550 relay has been modeled using two PowerFactory ABB REF 550 relay models which include most of the protective elements available in the relay.

The following model versions are available in the "ABB REF 550" folder:

- REF 550 1A
- REF 550 5A

The PowerFactory ABB REF 550 relay model consists of the measurement and acquisition units, the overcurrent, frequency, voltage and distance protective elements, and the output logic.

The model implementation has been based on the information available in the relay manual [1].

3 Supported features

3.1 Measurement and acquisition

It represents the interface between the power system and the relay protective elements.

The primary current is converted by one three phase current transformer ("Ct-3P" block) and one single phase core current transformer ("Ct-E/N" block), the primary voltage is converted by one three phase voltage transformer ("Vt-3P" block) and one single phase voltage transformer ("Vt-O" block) . The converted current and voltages are then measured by one 3 phase measurement unit ("Measure" block), by one 3phase sequence measurement unit ("Measure Seq" block), by one single phase measurement unit ("Measure SEF" block), and by one frequency measurement unit ("Meas Freq" block).

A relay input signal can be used to monitor to the power system *Cold load* condition.

3.1.1 Available Units

- one 3 phase current transformer ("Ct-3P" block).
- one single phase current transformer ("Ct-E/N" block).
- one 3 phase voltage transformer ("Vt-3P" block).
- one single phase voltage transformer ("Vt-O" block).
- one 3 phase measurement element ("Measure" block).
- one 3 phase sequence measurement element ("Measure seq" block).
- one single phase measurement element ("Measure SEF" block).
- one frequency measurement element ("Meas Freq" block).
- one relay input signal ("BrkClose-ColdLoad" signal).

3.1.2 Functionality

The "Ct-3P" and the "Ct-E/N" block represent ideal CT. Using the CT default configuration the current at the primary side is converted to the secondary side using the CT ratio. The CT saturation and/or its magnetizing characteristic are not considered. Please set the "Detailed Model" check box in the "Detailed Data" tab page of the CT dialog and insert the data regarding the CT burden, the CT secondary resistance and the CT excitation parameter if more accurate simulation results are required.

The input signals are sampled in the relay model at 20 samples/cycle; a DFT filter operating over a cycle calculates the current values used by the protective elements. Please notice that no info is available in the manual about the sampling rate. For this reason an implementation common in many protective relays has been used.

The "BrkClose-ColdLoad" relay input signal is connected to the "Cold load Time" and "Neutral Cold load Time" block and is supposed to transfer the status (*open* equal to '0', *close* equal to '1') of the power breaker.

3.1.3 Data input

No manual data input is required in the measurement blocks. Please use the relay model version with the secondary rated current equal to the secondary rated current of the available CTs.

If no core CT is available assign the 3 phases CT also to the "Ct-E/N" slot. If no open delta VT is available assign the 3 phases VT also to the "Vt-0" slot.

3.2 Protective elements

A set of inverse time and definite time overcurrent elements models the relay phase, negative sequence and earth overcurrent protective functions. The inverse characteristics available in the relay are available as well in the inverse time model block.

Four phase mho distance elements with positive and negative sequence starting logic are simulated.

The overvoltage, undervoltage and frequency (with minimum voltage inhibition threshold) protection elements are also modeled.

3.2.1 Available Units

- One phase time overcurrent element ("51P(3I>)" block).
- One phase time overcurrent element ("51N(IN>)" block).
- Three phase overcurrent instantaneous elements ("50P1 (3I>1)", "50P2 (3I>2)" and "50P3 (3I>3)" block).
- Three ground overcurrent instantaneous elements ("50N1 (IN>1)", "50N2 (IN>2)" and "50N3 (IN>3)" block).
- One sensitive earth fault element ("50N2(I0>2)" block).
- Two negative sequence time overcurrent elements ("46-1(Insc>1)", "46-2(Insc>2)" block).
- One phase directional overcurrent elements 67("67P (3I>)" and "Dir Phase OC" block).
- One ground directional overcurrent elements 67("67N (IN>)", "Dir EF I0" and "Dir EF I2" block). Depending up on the activated polarizing type the "Dir EF I0" or the "Dir EF I2" block must be manually disabled.
- Four frequency elements with voltage block threshold("81S-1", "81S-2", "81R/O-1", "81R/O-2" and "81 V" block)
- One phase overvoltage element ("59 (U>)" block).
- One phase undervoltage element ("27 (U<)" block).
- One zero sequence overvoltage element ("59G (U0>)" block).
- One negative sequence overvoltage element ("47 (U2>)" block).
- One reclosing block ("79 Reclosing" block).
- Four zones of phase impedance protection using positive sequence or negative sequence supervision and voltage buffer feature (up to 6 cycles) for close faults ("I1 Supervisioning 21P-1", "I2 Supervisioning 21P-1", "21P-1", "21PT-1", "I1 Supervisioning 21P-2", "I2 Supervisioning 21P-2", "21P-2", "21PT-2", "I1 Supervisioning 21P-3", "I2 Supervisioning 21P-3", "21P-3", "21PT-3", "I1 Supervisioning 21P-4", "I2 Supervisioning 21P-4", "21P-4", "21PT-4" and "Polarizing" block).
- Two cold load timers ("Cold load Time" and "Neutral Cold load Time" block, to activate the feature the "BrkClose-ColdLoad" relay input signal must be set).

3.2.2 Functionality

The PF model contains all the protective elements available in the relay. The inverse time overcurrent elements support the following trip characteristics:

- ANSI extremely inverse

- ANSI inverse
- ANSI long time ext inv
- ANSI long time inverse
- ANSI long time very inv
- ANSI recloser curve #8
- ANSI short time ext inv
- ANSI short time inverse
- Definite time (50)
- Definite time (51)
- Inverse Instantaneous
- Standard Instantaneous
- User Prog. Curve#1
- User Prog. Curve#2
- User Prog. Curve#3

For most of the trip characteristics a reset characteristic can be used; the following reset characteristics are available:

- ANSI extremely inverse reset
- ANSI inverse reset
- ANSI long time ext inv reset
- ANSI long time inverse reset
- ANSI long time very inv reset
- ANSI recloser curve #8 reset
- ANSI short time ext inv reset
- ANSI short time inverse reset
- ANSI very inverse reset
- Definite time (50)
- Definite time (51)

Please notice that the *User Prog. Curve#1*, *User Prog. Curve#2*, and *User Prog. Curve#3* curve characteristic can be freely set by the user inserting up to 10 current, time values. Each characteristic is shared by any instance of the ABB REF 550 relay model.

The *Cold Load* condition is declared when the "BrkClose-ColdLoad" relay input signal becomes '1' and is maintained for the time defined in the "Cold Load Time" and in the "Neutral cold load Time" block. The relevant signals are used to block part of the phase and the ground overcurrent elements. The block logic can be modified in the "Logic" tab page of the "Logic" block.

3.2.3 Data input

The relationships between the relay settings and the model parameters can be found in the following table (the relay model parameter names are listed between brackets)::

Address	Relay Setting	Model block	Model setting	Note
	51P (3I>) Curve Selection	51P (3I>)	Out of Service (outserv)	Out of service when <i>Curve Selection</i> is <i>Disable</i>
	51P (3I>) Pickup	51P (3I>)	Characteristic (pcharac)	
	51P (3I>) Time Dial	51P (3I>)	Current Setting (Ipsetr)	
	51P (3I>) Time Delay	51P (3I>)	Time Dial (Tpset)	Active in the relay only with the Definite Time curve
	51N (IN>) Curve Selection	51N (IN>)	Time Dial (Tpset)	Out of service when <i>Curve Selection</i> is <i>Disable</i>
	51N (IN>) Pickup	51N (IN>)	Out of Service (outserv)	
	51N (IN>) Time Dial	51N (IN>)	Characteristic (pcharac)	
	51N (IN>) Time Delay	51N (IN>)	Current Setting (Ipsetr)	Active in the relay only with the Definite Time curve
	50P1 (3I>>1) Curve Selection	50P1 (3I>>1)	Time Dial (Tpset)	Out of service when <i>Curve Selection</i> is <i>Disable</i>
	50P1 (3I>>1) Pickup	50P1 (3I>>1)	Out of Service (outserv)	
	50P1 (3I>>1) Time Dial	50P1 (3I>>1)	Characteristic (pcharac)	
	50N1 (IN>>1) Curve Selection	50N1 (IN>>1)	Current Setting (Ipsetr)	Out of service when <i>Curve Selection</i> is <i>Disable</i>
	50N1 (IN>>1) Select	50N1 (IN>>1)	Time Dial (Tpset)	
	50N1 (IN>>1) Pickup	50N1 (IN>>1)	Out of Service (outserv)	
	50N1 (IN>>1) Time Dial	50N1 (IN>>1)	Characteristic (pcharac)	
	50P2 (3I>>2) Select	50P2 (3I>>2)	Out of Service (outserv)	
	50P2 (3I>>2) Pickup	50P2 (3I>>2)	Pickup Current (Ipset)	
	50P2 (3I>>2) Time Delay	50P2 (3I>>2)	Time Setting (Tset)	
	50N2 (IN>>2) Select	50N2 (IN>>2)	Out of Service (outserv)	
	50N2 (IN>>2) Pickup	50N2 (IN>>2)	Pickup Current (Ipset)	
	50N2 (IN>>2) Time Delay	50N2 (IN>>2)	Time Setting (Tset)	
	50N2 (I0>2) Select	50N2 (I0>>2)	Out of Service (outserv)	
	50N2 (I0>2) Pickup	50N2 (I0>>2)	Pickup Current (Ipset)	
	50N2 (I0>2) Time Delay	50N2 (I0>>2)	Time Setting (Tset)	
	50P3 (3I>>3) Select	50P3 (3I>>3)	Out of Service (outserv)	
	50P3 (3I>>3) Pickup	50P3 (3I>>3)	Pickup Current (Ipset)	
	50N3 (IN>>3) Select	50N3 (IN>>3)	Out of Service (outserv)	
	50N3 (IN>>3) Pickup	50N3 (IN>>3)	Pickup Current (Ipset)	
	67P (3I>-->) Select	67P (3I>-->)	Out of Service (outserv)	
	67P (3I>-->) Curve Selection	67P (3I>-->)	Characteristic (pcharac)	
	67P (3I>-->) Pickup	67P (3I>-->)	Current Setting (Ipsetr)	
	67P (3I>-->) Time Dial	67P (3I>-->)	Time Dial (Tpset)	

3 Supported features

Address	Relay Setting	Model block	Model setting	Note
	67P (3I>->) Time Delay	67P (3I>->)	Time Dial (Tpset)	Set only with the Definite Time curve
	67P (3I>->) Maximum Torque angle	Dir OC	Max Torque Angle (mtau)	In the "Voltage Polarizing" tab page
	67N (IN>->) Select	67N (IN>->)	Out of Service (outserv)	
	67N (IN>->) Curve	67N (IN>->)	Characteristic (pcharac)	
	67N (IN>->) Pickup	67N (IN>->)	Current Setting (Ipsetr)	
	67N (IN>->) Time Dial	67N (IN>->)	Time Dial (Tpset)	
	67N (IN>->) Time Delay	67N (IN>->)	Time Dial (Tpset)	Set only with the Definite Time curve
	67N (IN>->) Max Torque angle	Dir EF	Max Torque Angle (mtau)	In the "Voltage Polarizing" tab page
	79M Reset time Pickup	79 Reclosing	Reset Time (resetime)	
	79M Open interval time	79 Reclosing	Reclosing Interval 1 (recltime1)	
		79 Reclosing	Reclosing Interval 2 (recltime2)	
		79 Reclosing	Reclosing Interval 3 (recltime3)	
	79M Number of reclosures	79 Reclosing	Operations to lockout (oplockout)	Set "Number of reclosures" + 1
	81 Select	81R1	Out of Service (outserv)	
		81R2	Out of Service (outserv)	
		81S1	Out of Service (outserv)	
		81S2	Out of Service (outserv)	
	81R1 Load Shed pickup	81R1	Frequency (Fset)	
	81R1 Shed time delay	81R1	Time Delay (Tdel)	
	81R2 Load Shed pickup	81R2	Frequency (Fset)	
	81R2 Shed time delay	81R2	Time Delay (Tdel)	
	81S1 Load Shed pickup	81S1	Frequency (Fset)	
	81S1 Shed time delay	81S1	Time Delay (Tdel)	
	81S2 Load Shed pickup	81S2	Frequency (Fset)	
	81S2 Shed time delay	81S2	Time Delay (Tdel)	
	81V Voltage Block	81V	Pickup Voltage (Uset)	
	Cold Load Time	Cold load Time	Time Setting (Tdelay)	
	Neutral Cold Load Time	Neutral cold load Time	Time Setting (Tdelay)	
	46-1 (Insc>1) Curve Selection	46-1 (Insc>1)	Out of Service (outserv)	Out of service when Curve Selection is Disable
			Characteristic (pcharac)	
	46-1 (Insc>1) Pickup	46-1 (Insc>1)	Current Setting (Ipsetr)	
	46-1 (Insc>1) Time Dial	46-1 (Insc>1)	Time Dial (Tpset)	
	46-1 (Insc>1) Time Delay	46-1 (Insc>1)	Time Dial (Tpset)	Set only with the Definite Time curve
	46-2 (Insc>2) Curve Selection	46-2 (Insc>2)	Out of Service (outserv)	Out of service when Curve Selection is Disable
			Characteristic (pcharac)	
	46-2 (Insc>2) Pickup	46-2 (Insc>2)	Current Setting (Ipsetr)	
	46-2 (Insc>2) Time Dial	46-2 (Insc>2)	Time Dial (Tpset)	
	46-2 (Insc>2) Time Delay	46-2 (Insc>2)	Time Dial (Tpset)	Set only with the Definite Time curve
	27 (U<) Select	27-1 (U<)	Out of Service (outserv)	

3 Supported features

Address	Relay Setting	Model block	Model setting	Note
	27 (U<) Pickup	27-1 (U<)	Pickup Voltage (Usetr)	
	27 (U<) Time Delay	27-1 (U<)	Time Delay (Tdel)	
	59 (U>) Select	59-1 (U>)	Out of Service (outserv)	
	59 (U>) Pickup	59-1 (U>)	Pickup Voltage (Usetr)	
	59 (U>) Time Delay	59-1 (U>)	Time Delay (Tdel)	
	47 Select	47 (U>)	Out of Service (outserv)	
	47 Pickup	47 (U>)	Pickup Voltage (Usetr)	
	47 Time Delay	47 (U>)	Time Delay (Tdel)	
	59G Select	59G (U>)	Out of Service (outserv)	
	59G Pickup	59G (U>)	Pickup Voltage (Usetr)	
	59G Time Delay	59G (U>)	Time Delay (Tdel)	
	32N-2(I2->) Select	32N2 (I2>->)	Out of Service (outserv)	
	32N-2(I2->) Max. Torque Angle	32N2 (I2>->)	Max. Torque Angle (mtau)	In the "Voltage Polarizing" tab page
	32P-2(I1->) Select	32P2 (I1>->)	Out of Service (outserv)	
	32P-2(I1->) Torque Angle	32P2 (I1>->)	Max. Torque Angle (mtau)	In the "Voltage Polarizing" tab page
	21P Zone 1 Select	21P-1	Out of Service (outserv)	Out of service when <i>Select</i> is <i>Disable</i>
		21P-1	Tripping Direction (idir)	Set when <i>Select</i> is <i>Enable-Forward</i> or <i>Enable-Reverse</i>
	21P Zone 1 Impedance	21P-1	Replica Impedance (Zm)	
	21P Zone 1 Characteristic Angle	21P-1	Relay Angle (phi)	
	21P Zone 1 Time Delay	21PT-1	Time Setting (Tdelay)	
	I1 Supervision Zone 1	I1 Supervisioning 21P-1	Pickup Current (Ipsetr)	
	I2 Supervision Zone 1	I2 Supervisioning 21P-1	Pickup Current (Ipsetr)	
	21P Zone 2 Select	21P-2	Out of Service (outserv)	Out of service when <i>Select</i> is <i>Disable</i>
		21P-2	Tripping Direction (idir)	Set when <i>Select</i> is <i>Enable-Forward</i> or <i>Enable-Reverse</i>
	21P Zone 2 Impedance	21P-2	Replica Impedance (Zm)	
	21P Zone 2 Characteristic Angle	21P-2	Relay Angle (phi)	
	21P Zone 2 Time Delay	21PT-2	Time Setting (Tdelay)	
	I1 Supervision Zone 2	I1 Supervisioning 21P-2	Pickup Current (Ipsetr)	
	I2 Supervision Zone 2	I2 Supervisioning 21P-2	Pickup Current (Ipsetr)	
	21P Zone 3 Select	21P-3	Out of Service (outserv)	Out of service when <i>Select</i> is <i>Disable</i>
		21P-3	Tripping Direction (idir)	Set when <i>Select</i> is <i>Enable-Forward</i> or <i>Enable-Reverse</i>
	21P Zone 3 Impedance	21P-3	Replica Impedance (Zm)	
	21P Zone 3 Characteristic Angle	21P-3	Relay Angle (phi)	
	21P Zone 3 Time Delay	21PT-3	Time Setting (Tdelay)	
	I1 Supervision Zone 3	I1 Supervisioning 21P-3	Pickup Current (Ipsetr)	
	I2 Supervision Zone 3	I2 Supervisioning 21P-3	Pickup Current (Ipsetr)	

3 Supported features

Address	Relay Setting	Model block	Model setting	Note
	21P Zone 4 Select	21P-4	Out of Service (outserv)	Out of service when <i>Select</i> is <i>Disable</i>
		21P-4	Tripping Direction (idir)	Set when <i>Select</i> is <i>Enable-Forward</i> or <i>Enable-Reverse</i>
	21P Zone 4 Impedance	21P-4	Replica Impedance (Zm)	
	21P Zone 4 Characteristic Angle	21P-4	Relay Angle (phi)	
	21P Zone 4 Time Delay	21PT-4	Time Setting (Tdelay)	
	I1 Supervision Zone 4	I1 Supervisioning 21P-4	Pickup Current (Ipsetr)	
	I2 Supervision Zone 4	I2 Supervisioning 21P-4	Pickup Current (Ipsetr)	
	Reset Mode	51P (3I>)	Reset Characteristic (reset-dis)	Set when <i>Reset Mode</i> is <i>Delayed</i>
		51N (IN>)	Reset Characteristic (reset-dis)	
		50P1 (3I>>1)	Reset Characteristic (reset-dis)	
		50N1 (IN>>1)	Reset Characteristic (reset-dis)	
		67P (3I>->)	Reset Characteristic (reset-dis)	
		67N (IN>->)	Reset Characteristic (reset-dis)	
		46-1 (Insc>1)	Reset Characteristic (reset-dis)	
		46-2 (Insc>2)	Reset Characteristic (reset-dis)	

3.3 Output logic

It represents the output stage of the relay; it's the interface between the relay and the power breaker.

3.3.1 Available Units

The output logic is implemented by the "Logic" and by the "Closing Logic" block.

3.3.2 Functionality

The "Logic" block has the task to operate the power breaker when a trip command has been issued by any protective element. The relay output signal used to operate the breaker is "yout". The "Closing Logic" block controlled by the reclosing feature ("Reclosing" block) has the purpose of generating a closing command for the power breaker when a reclosing attempt is triggered.

The trip/output logic, the *Cold Load* condition logic and the directional logic can be freely configured by the user in the "Logic" tab page of the "Logic" block.

Please notice that by default the *Cold load* condition blocks the "51P (3I>)" and the "51N (IN>)" element. The *Neutral Cold Load* condition blocks the "50N2 (IO>>2)".

No default logic is present for the directional logic. The following input signals of the "Logic" block can be used:

- fwd32P (*forward* fault detection signal, coming from the "32P2 (I1>->^f block)).
- rev32P (*reverse* fault detection signal, coming from the "32P2 (I1>->^f block)).
- fwd32N (*forward* fault detection signal, coming from the "32N2 (I2>->^f block)).
- rev32N (*reverse* fault detection signal, coming from the "32N2 (I2>->^f block)).

3.3.3 Data input

To disable the relay model ability to open the power circuit breaker disable the "Logic" block.

To disable the relay model ability to close the power circuit breaker and start a reclosing procedure disable the "Closing Logic" block.

4 Features not supported

- Synchrocheck function (25).
- 50P unit two phase tripping..
- Breaker failure.
- Voltage elements two/three phase operation mode.

5 References

- [1] ABB Inc. Substation Automation and Protection, 7036 Snowdrift Road, Allentown Pennsylvania 18106 USA. *ABB Advanced Feeder Protection System REF 550 Instruction Booklet 7.11.1.7-50 Issue A.1 March 2005*, 2005.