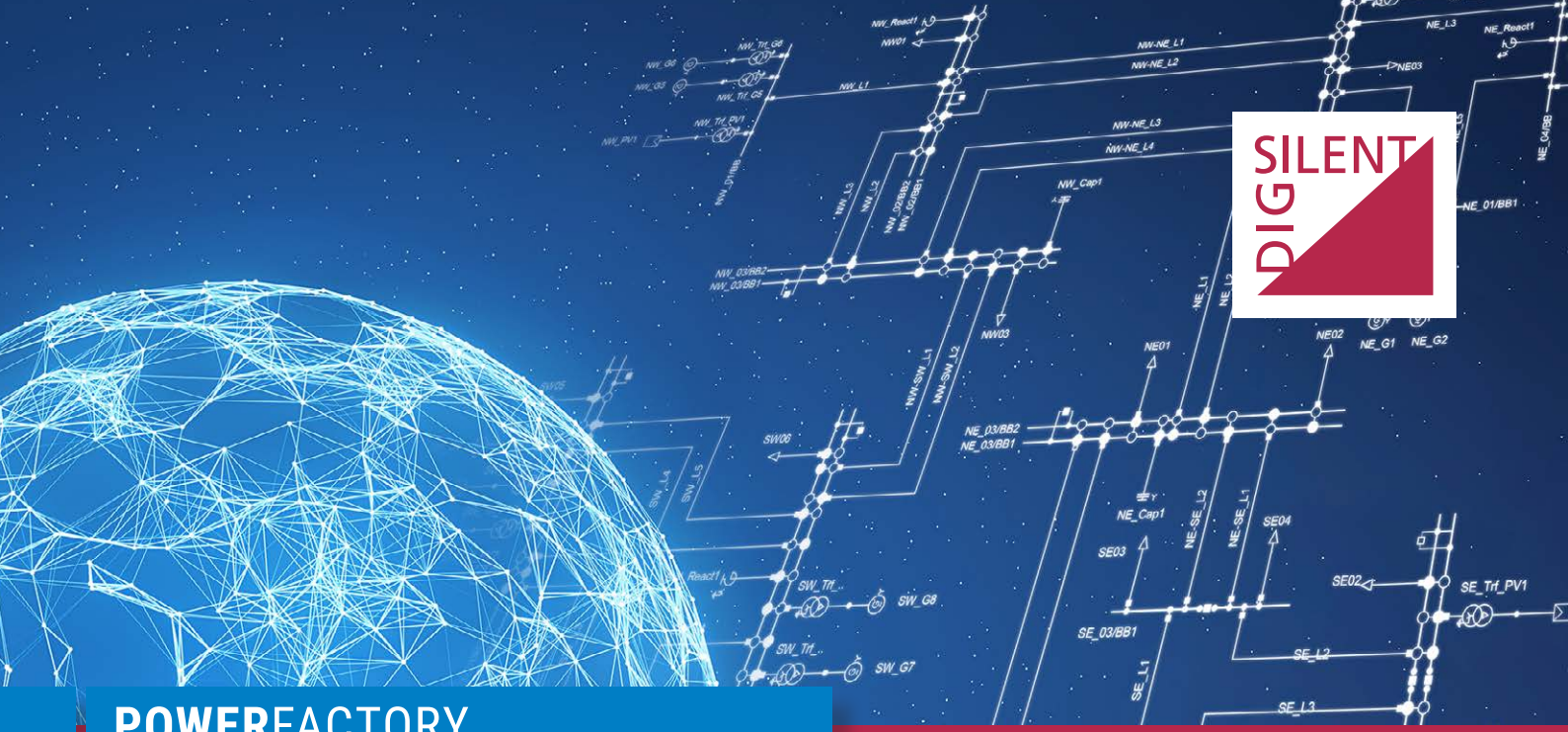

POWERFACTORY

PowerFactory 2021

Technical Reference

GE UR G60

PF2021

POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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Contents

1 Model information

Manufacturer GE

Model UR G60

Variants The GE UR G60 PowerFactory relay model can be used to model the different firmware versions of the GE UR G60 relay up to revision 5.7.

2 General description

The GE UR G60 is a generator protection relay with additional differential, frequency, over flux, voltage and overcurrent protective elements. The GE UR G60 PowerFactory relay model has been implemented trying to simulate the protective functions more commonly used.

The GE UR G60 PowerFactory relay model consists of a main relay model and the following sub relays:

- Overcurrent elements(F50-F51-F46)
- Voltage elements(F27-F59)
- Frequency(F81)
- Phase Distance elements (F21)
- Differential(F87)
- Loss of excitation(F40)
- Out of step

The main relay contains the measurement and acquisition units, the output logic and all other sub relays.

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

3 Supported features

3.1 Measurement and acquisition

The voltage and the current are measured by four current transformers (”Ct”, ”Mutual Ct”, ”Neutral Ct1” and ”Neutral Ct2” blocks) and one voltage transformer (”Vt” block). Two additional current transformers are used by the differential element: the ”Remote Ct1” and the ”Remote Ct2” block represent the CTs located at the other line terminals.

Nine measurement units (”Measurement”, ”Meas delta” , ”Measurement Seq”, ”Meas Neutral1 I”, ”Meas Neutral2 I” , ”Meas Mutual”, ”Measurement(remote 1)”, ”Measurement Seq Remote 1” and ”Measurement(remote 2)” block) are fed by these CTs and the VT.

3.1.1 Available Units

- Ct.
- Mutual Ct.
- Neutral Ct1.
- Neutral Ct2.
- Vt.
- Remote Ct1.
- Remote Ct2.
- Measurement.
- Meas delta.
- Measurement Seq
- Meas Neutral1 I.
- Meas Neutral2 I.
- Meas Mutual.
- Measurement(remote 1).
- Measurement Seq Remote 1.
- Measurement(remote 2).

3.1.2 Functionality

The input signals are sampled at 20 samples/cycle; a DFT filter operating over a cycle calculates then the voltage and current values used by the protective elements.

3.1.3 Data input

The nominal current and the nominal voltage values MUST be entered in all the measurement units.

3.2 Overcurrent elements(F50-F51-F46) subrelay

3.2.1 Available Units

- One 3 phase inverse time directional overcurrent elements with voltage restraint (”Phase Toc 1” block, the relevant restraint blocks is ”V restraint Toc 1”).
- Two 3 phase definite time directional overcurrent elements (”Phase Ioc 1” and ”Phase Ioc 2” block).
- One 3 phase directional elements (”DirPhase 1” block) which can be used to control the phase overcurrent blocks.
- One neutral inverse time directional overcurrent elements (”Neutral Toc 1” block).
- Two neutral definite time directional overcurrent elements (”Neutral Ioc 1” and ”Neutral Ioc 2” block).
- Four neutral definite time directional overcurrent elements (”DirNeutral 1 Fwd” and ”DirNeutral 1 rev” are modelling the first neutral directional element, ”DirNeutral 2 Fwd” and ”DirNeutral 2 rev” are modelling the second neutral directional element).
- One ground inverse time overcurrent elements (”Ground Toc 1” block).
- One ground definite time overcurrent elements (”Ground Ioc 1” block).
- Four negative sequence directional elements (”DirNegSeq Fwd 1” and ”DirNegSeq 1 Rev” are modelling the first neutral directional element, ”DirNegSeq 2 Fwd” and ”DirNegSeq 2 Rev” are modelling the second neutral directional element).
- Two generator unbalance elements (”Gen Unbal STG1” and ”Gen Unbal STG2” block). Please notice that the generator unbalance nominal current (”Gen Unbal Inom”) must be inserted in the ”Gen Umbal Inom” block (in the ”Logic” tab page).
- One output element opening the associated breaker (”Output logic” block).

3.2.2 Functionality

Please notice that the input values are always phasors calculated by the measurement DFT filter. In the relay each directional element contains the settings for both the forward and the reverse direction trip: in the model it’s modeled by two directional blocks (i.e. the relay ”Neutral overcurrent directional OC1” is represented in the model by the ”DirNeutral 1 Fwd” and the ”DirNeutral 1 Rev” block). The trip direction of the neutral and of the negative sequence elements is set in the ”Logic” tab page of the ”Output logic” element. Each Ioc and Toc block can be set with a user configurable resetting time.

The inverse time overcurrent elements support the following trip characteristics:

- ”Definite time”
- ”IEEE Extremely Inverse”
- ”IEEE Very Inverse”
- ”IEEE Moderately Inverse”
- ”IEC Curve A”
- ”IEC Curve B”

- ”IEC Curve C”
- ”IEC short inverse”
- ”IAC Extremely Inverse”
- ”IAC Short Inverse”
- ”IAC Very Inverse”
- ”IAC Inverse”
- ”I2t”
- ”Recloser Curve” (31 curves)

The neutral and negative sequence directional elements can be set with a user configurable positive sequence current restraint. The negative sequence directional elements don’t support the ability to set the zero sequence current as operating current. The phase inverse elements can be used with a voltage restraint feature. The voltage restraint feature can be activated in the ”Logic” tab page of the ”V restraint Toc1” and of the ”V restraint Toc2” block. Set equal to one the ”VrestraintON” variable to enable the feature.

3.2.3 Data input

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

Address	Relay Setting	Model block	Model setting	Note
	PHASE TOCx[1] FUNCTION	Phase Toc x[1]	Out of Service (outserv)	
	PHASE TOCx[1] PIKCUP	Phase Toc x[1]	Current Setting (Ipset)	
	PHASE TOCx[1] CURVE	Phase Toc x[1]	Characteristic (pcharac)	
	PHASE TOCx[1] TD MULTIPLIER	Phase Toc x[1]	Time Dial (Tpset)	
	PHASE TOCx[1] RESET	Phase Toc x[1]	Reset Characteristic (resetdis)	
	PHASE TOCx[1] VOLTAGE RESTRAINT	V restraint 1	VrestraintON (VrestraintON)	To disable the voltage restraint set VrestraintON = 0 in the ”Logic” tab page
	PHASE TOCx[1] BLOCK	Phase Toc x[1]	Tripping direction (idir)	Set ”None” if the element is not controlled by the directional element
	PHASE IOCx[1] FUNCTION	Phase Ioc x[1]	Out of Service (outserv)	
	PHASE IOCx[1] PICKUP	Phase Ioc x[1]	Current Setting (Ipset)	
	PHASE IOCx[1] PICKUP DELAY	Phase Ioc x[1]	Time Dial (Tpset)	
	PHASE IOC[1] RESET DELAY	Phase Ioc x[1]	Reset Delay (ResetT)	
	PHASE IOC[1] BLOCK	Phase Ioc x[1]	Tripping direction (idir)	Set ”None” if the element is not controlled by the directional element
	PHASE DIR 1 FUNCTION	DirPhase 1	Out of Service (outserv)	

[1] x = 1,2

Address	Relay Setting	Model block	Model setting	Note
	PHASE DIR 1 ECA	DirPhase 1	Max Torque Angle (mtau)	”Voltage Polarizing” tab page
	PHASE DIR 1 POLV1 THRESHOLD	DirPhase 1	Polarizing voltage (upolu)	”Voltage Polarizing” tab page
	NEUTRAL TOC1 FUNCTION	Neutral Toc 1	Out of Service (outserv)	
	NEUTRAL TOC1 PIKCUP	Neutral Toc 1	Current Setting (Ipset)	
	NEUTRAL TOC1 CURVE	Neutral Toc 1	Characteristic (pcharac)	
	NEUTRAL TOC1 TD MULTIPLIER	Neutral Toc 1	Time Dial (Tpset)	
	NEUTRAL TOC1 RESET	Neutral Toc 1	Reset Delay (ResetT)	
	NEUTRAL TOC1 BLOCK	Output logic	Neutral1_Forward	Set equal to ”TRIP”
			Neutral1_Reverse	only the variable corresponding
			Neutral1_None	to the desired direction
	NEUTRAL IOC x[1] FUNCTION	Neutral Ioc x[1]	Out of Service (outserv)	
	NEUTRAL IOCx[1] PICKUP	Neutral Ioc x[1]	Current Setting (Ipset)	
	NEUTRAL IOCx[1] PICKUP DELAY	Neutral Ioc x[1]	Time Dial (Tpset)	
	NEUTRAL IOCx[1] RESET DELAY	Neutral Ioc x[1]	Reset Delay (ResetT)	
	NEUTRAL IOCx[1] BLOCK	Output logic	Neutralx[1]_Forward	Set equal to ”TRIP”
			Neutralx[1]_Reverse	only the variable corresponding
			Neutralx[1]_None	to the desired direction
	NEUTRAL DIR OCx[1] FUNCTION	DirNeutral x[1] Fwd	Out of Service (outserv)	
	NEUTRAL DIR OCx[1] POS SEQ RESTRAINT	DirNeutral x[1] K In	K (K)	In the ”Logic” tab page
	NEUTRAL DIR OCx[1] FWD ECA	DirNeutral x[1] Fwd	Max. Torque Angle (mtau)	In the ”Voltage polarizing” tab page
		DirNeutral x[1] Rev		
	NEUTRAL DIR OCx[1] FWD LIMIT ANGLE	DirNeutral x[1] Fwd	Angle Operating Sector (phisec)	
	NEUTRAL DIR OCx[1] FWD PICKUP	DirNeutral x[1] Fwd	Operating Current (curopu)	In the ”Voltage polarizing” tab page
	NEG SEQ DIR OCx[1] REV LIMIT ANGLE	DirNeutral x[1] Rev	Angle Operating Sector (phisec)	
	NEUTRAL DIR OCx[1] REV PICKUP	DirNegSeq x[1] Rev	Operating Current (curopu)	
	GROUND TOC1 FUNCTION	Ground Toc 1	Out of Service (outserv)	
	GROUND TOC1 PIKCUP	Ground Toc 1	Current Setting (Ipset)	
	GROUND TOC1 CURVE	Ground Toc 1	Characteristic (pcharac)	
	GROUND TOC1 TD MULTIPLIER	Ground Toc 1	Time Dial (Tpset)	
	GROUND TOC1 RESET	Ground Toc 1	Reset Delay (ResetT)	
	GROUND IOC1 FUNCTION	Ground Ioc1	Out of Service (outserv)	
	GROUND IOC1 PICKUP	Ground Ioc1	Current Setting (Ipset)	
	GROUND IOC1 PICKUP DELAY	Ground Ioc1	Time Dial (Tpset)	

Address	Relay Setting	Model block	Model setting	Note
	GROUND IOC1 RESET DELAY	Ground Ioc1	Reset Delay (ResetT)	
	NEG SEQ DIR OCx[1] FUNCTION	DirNegSeq Fwd x[1]	Out of Service (outserv)	
	NEG SEQ DIR OCx[1] OFFSET	DirNegSeq x[1] Offset	ZOFFSET	In the ”Logic” tab page
	NEG SEQ DIR OCx[1] POS SEQ RESTRAINT	DirNegSeq x[1] K I2	K (K)	In the ”Logic” tab page
	NEG SEQ DIR OCx[1] FWD ECA	DirNegSeq Fwd x[1]	Max. Torque Angle (mtau)	In the ”Voltage polarizing” tab page
		DirNegSeq Rev x[1]		
	NEG SEQ DIR OCx[1] FWD LIMIT ANGLE	DirNegSeq Fwd x[1]	Angle Operating Sector (phisec)	
	NEG SEQ DIR OCx[1] FWD PICKUP	DirNegSeq Fwd x[1]	Operating Current (curopu)	In the ”Voltage polarizing” tab page
	NEG SEQ DIR OCx[1] REV LIMIT ANGLE	DirNegSeq Rev x[1]	Angle Operating Sector (phisec)	
	NEG SEQ DIR OCx[1] REV PICKUP	DirNegSeq Rev x[1]	Operating Current (curopu)	
	GENERATOR UNBAL FUNCTION	Gen Unbal STG1	Out of Service (outserv)	
	GENERATOR UNBAL INOM	Gen Umbal Inom	GenUnbalInom (GenUnbalInom)	In the ”Logic” tab page
	GENERATOR UNBAL STG1 PICKUP	Gen Unbal STG1	Current Setting (Ipset)	
	GENERATOR UNBAL STG1 K VALUE	Gen Unbal STG1	Time Dial (Tpset)	
	GENERATOR UNBAL STG1 TMIN	Gen Unbal STG1	Min. Time (udeftmin)	
	GENERATOR UNBAL STG1 TMAX	Gen Unbal STG1	Max. Time (udeftmax)	
	GENERATOR UNBAL STG1 K RESET	Gen Unbal STG1	Reset Delay (ResetT)	
	GENERATOR UNBAL (STG1) BLOCK	Output logic	NegativeSequence1_Forward	Set equal to ”TRIP”
			NegativeSequence1_Reverse	only the variable corresponding
			NegativeSequence1_None	to the desired direction
	GENERATOR UNBAL STG2 PICKUP	Gen Unbal STG2	Pickup Current (Ipset)	
	GENERATOR UNBAL STG2 DELAY	Gen Unbal STG2	Time Setting (Tset)	
	GENERATOR UNBAL (STG2) BLOCK	Output logic	NegativeSequence2_Forward	Set equal to ”TRIP”
			NegativeSequence2_Reverse	only the variable corresponding
			NegativeSequence2_None	to the desired direction

3.3 Voltage elements(F27-F59) subrelay

3.3.1 Available Units

- Three 3phase time inverse characteristic undervoltage elements (”Phase undervoltage 1”, ”Phase undervoltage 2” and ”Phase undervoltage 3”, ”Phase undervoltage 1 Mode”, ”Phase undervoltage 2 Mode”, ”Phase undervoltage 3 Mode”, ”Phase undervoltage 1 Minimum Voltage”, ”Phase undervoltage 2 Minimum Voltage” and ”Phase undervoltage 3 Minimum Voltage” block)
- One three phase time defined characteristic overvoltage element with delayed reset (”Phase overvoltage” and ”Phase overvoltage reset delay” block)
- Three zero sequence time inverse characteristic overvoltage elements with delayed reset(”Neutral overvoltage 1”, ”Neutral overvoltage 1 reset delay”, ”Neutral overvoltage 2”, Neutral overvoltage 2 reset delay”, ”Neutral overvoltage 3” and ”Neutral overvoltage 3 reset delay” block)
- Three negative sequence time defined characteristic overvoltage elements with delayed reset(”Negative Sequence overvoltage 1”, ”Negative Sequence overvoltage 1 reset delay”, ”Negative Sequence overvoltage 2”, ”Negative Sequence overvoltage 2 reset delay”, ”Negative Sequence overvoltage 3” and ”Negative Sequence overvoltage 3 reset delay” block)
- Two inverse characteristic overflux elements with delayed reset (”Volt/Hertz 1”, ”Volt/Hertz 1 T-Reset”, ”Volt/Hertz 2” and ”Volt/Hertz 2 T-Reset” block)
- One output block opening the associated breaker (”Output logic” block)

3.3.2 Functionality

All the over/undervoltage elements available in the relay except the auxiliary over/undervoltage elements have been implemented in the model. The phase undervoltage elements are supporting the following trip characteristics:

- Inverse
- Definite

The neutral overvoltage elements are supporting the following trip characteristics:

- Definite
- FlexCurve A
- FlexCurve B
- FlexCurve C

The overflux elements are supporting the following trip characteristics:

- Definite time
- Inverse curve A
- Inverse curve B

- Inverse curve C
- FlexCurve A
- FlexCurve B
- FlexCurve C
- FlexCurve D

Each undervoltage element can be set to use the phase-phase voltages or the phase-ground voltages; a minimum activation threshold is available as well.

Each overvoltage element can set with a user definable reset time.

3.3.3 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
	PHASE UVk[2]FUNCTION	Phase undervoltage k[2]	Out of Service (outserv)	
	PHASE UVk[2]MODE	Phase undervoltage k[2]Mode	MODE(MODE)	It must defined inside the ”Logic” tab page: write ”MODE=PHASEPHASE” to use the phase-phase voltage signals or ”MODE=PHASEGROUND” to use the phase-ground voltage signals
	PHASE UVk[2]PICKUP	Phase undervoltage k[2]	Input Setting (Ipset)	
	PHASE UVk[2]CURVE	Phase undervoltage k[2]	Characteristic (pcharac)	
	PHASE UVk[2]DELAY	Phase undervoltage k[2]	Time dial (Tpset)	
	PHASE UVk[2]MINIMUM VOLTAGE	Phase undervoltage k[2]Minimum Voltage	Pickup Voltage (Uset)	
	PHASE OVk[2]FUNCTION	Phase overvoltage	Out of Service (outserv)	
	PHASE OVk[2]PICKUP	Phase overvoltage	Input Setting (Ipset)	
	PHASE OVk[2]PICKUP DELAY	Phase overvoltage	Time dial (Tpset)	
	PHASE OVk[2]RESET DELAY	Phase overvoltage reset delay	Time Setting (Tdelay)	
	NEUTRAL OVk[2]FUNCTION	Neutral Overvoltage k[2]	Out of Service (outserv)	
	NEUTRAL OVk[2]PICKUP	Neutral Overvoltage k[2]	Input Setting (Ipset)	
	NEUTRAL OVk[2]CURVE	Neutral Overvoltage k[2]	Characteristic (pcharac)	
	NEUTRAL OVk[2]PICKUP DELAY	Neutral Overvoltage k[2]	Time dial (Tpset)	
	NEUTRAL OVk[2]RESET DELAY	Neutral Overvoltage k[2]reset delay	Time Setting (Tdelay)	
	NEG SEQ OVk[2]FUNCTION	Negative Sequence Overvoltage k[2]	Out of Service (outserv)	

[2] k = 1,2,3

Address	Relay Setting	Model block	Model setting	Note
	NEG SEQ OVk^2PICKUP	Negative Sequence Overvoltage k^2	Input Setting (Ipset)	
	NEG SEQ OVk^2PICKUP DELAY	Negative Sequence Overvoltage k^2	Time dial (Tpset)	
	NEG SEQ OVk^2RESET DELAY	Negative Sequence Overvoltage k^2reset delay	Time Setting (Tdelay)	
	VOLT/HZ k^2FUNCTION	Volt/Hertz k^2	Out of Service (outserv)	
	VOLT/HZ k^2PICKUP	Volt/Hertz k^2	Input Setting (Ipset)	
	VOLT/HZ k^2CURVE	Volt/Hertz k^2	Characteristic (pcharac)	
	VOLT/HZ k^2TD MULTIPLIER	Volt/Hertz k^2	Time Dial (Tpset)	
	VOLT/HZ k^2T-RESET	Volt/Hertz k^2T-Reset	Time Setting (Tdelay)	

3.4 Frequency(F81) subrelay

3.4.1 Available Units

- Six under frequency elements. Each element consists of the following blocks:
  - An under voltage limit block (”UnderFreq x MinVolt”)
  - An under current limit block (”UnderFreq x5 MinAmp”)
  - An under frequency block (”UnderFreq x5”)
  - A block implementing a delayed reset (”UnderFreq x5 reset delay”)
  - A calculation and a measurement block (”UFx5 Meas switch” and ”Meas Freq UFx5”)
- Four over frequency elements. Each element consists of the following blocks:
  - An over frequency block (”OverFreq x5”)
  - A block implementing a delayed reset (”OverFreq x5 reset delay”)
- Four Frequency rate of change elements. Each element consists of the following blocks:
  - An under voltage limit block (”Freq Rate x5 Ov Supv”)
  - An under current limit block (”Freq Rate x5 Oc Supv”)
  - A under frequency limit block (”Freq Rate x5 Min Frequency”)
  - A over frequency limit block (”Freq Rate x5 Max Frequency”)
  - A frequency rate of change element (”Freq Rate x5”)
  - A block implementing a delayed reset (”Freq Rate x5 reset delay”)
  - A logic block (”Freq Rate x5 Logic”)

3.4.2 Functionality

Under frequency elements The under frequency elements are using by default the voltage signals to measure the frequency. When the voltage is smaller than the voltage threshold inserted in the ”UnderFreq x5 MinVolt” block the current signals are used to measure the frequency. If also the current is smaller than the threshold inserted in the ”UnderFreq x5 MinAmp” block the element is blocked. Each element has a frequency threshold and a trip delay and can be set with a user configurable reset delay (”UnderFreq x5 reset delay” block).

Over frequency elements Each element has a frequency threshold and a trip delay and can be set with a user configurable reset delay (”OverFreq x5 reset delay” block).

Frequency rate of change elements The frequency rate of change elements are controlled by an under frequency threshold and an over frequency threshold, by a minimum voltage threshold and by a minimum current threshold. Each element has a frequency rate of change threshold and a trip delay and can be set with a user configurable reset delay (”Freq Rate x5 reset delay” block).

3.4.3 Data input

Under frequency elements 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
	UNDERFREQ z[3]FUNCTION	UnderFreq z[3]	Out of Service (outserv)	
	UNDERFREQ z[3]MIN VOLT/AMP	UnderFreq z[3]MinVolt	Pickup Voltage (Uset)	The relay settings must be
		UnderFreq z[3]MinAmp	Pickup Current (Ipset)	transferred in both model blocks
	UNDERFREQ z[3]PICKUP	UnderFreq z[3]	Frequency(Fset)	A value smaller than the system rated frequency must be set
	UNDERFREQ z[3]DELAY	UnderFreq z[3]	Time Delay (Tdel)	
	UNDERFREQ z[3]RESET DELAY	UnderFreq z[3]reset delay	Time Setting (Tdelay)	

No user input is required for the ”UnderFreq 1 Meas switch” and the ”Meas Freq UnderFreq 1” block.

Over frequency elements 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
	OVERFREQ y[4]FUNCTION	OverFreq y[4]	Out of Service (outserv)	
	OVERFREQ y[4]PICKUP	OverFreq y[4]	Frequency (Fset)	
	OVERFREQ y[4]PICKUP DELAY	OverFreq y[4]	Time Delay (Tdel)	
	OVERFREQ y[4]RESET DELAY	OverFreq y[4]reset delay	Time Setting (Tdelay)	

No user input is required for the ”Meas Freq OverFreq” block.

Frequency rate of change elements 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
	FREQ RATE y[4]FUNCTION	Freq Rate y[4]	Out of Service (outserv)	
	FREQ RATE y[4]PICKUP	Freq Rate y[4]	Gradient df/dt (dFset)	
	FREQ RATE y[4]OV SUPV	Freq Rate y[4]	Ov Supv Pickup Voltage(Uset)	
	FREQ RATE y[4]OC SUPV	Freq Rate y[4]	Oc Supv Pickup Current(Ipset)	
	FREQ RATE y[4]MIN FREQUENCY	Freq Rate y[4]	Min Frequency Frequency (Fset)	
	FREQ RATE y[4]MAX FREQUENCY	Freq Rate y[4]	Max Frequency Frequency (Fset)	
	FREQ RATE y[4]PICKUP DELAY	Freq Rate y[4]	Time Delay (Tdel)	
	FREQ RATE y[4]RESET DELAY	Freq Rate y[4]	Time Setting (Tdelay)	

[3] z = 1,2,3,4,5,6
[4] y = 1,2,3,4

No user input is required for the ”Meas Freq OverFreq” block.

3.5 Phase Distance elements (F21) subrelay

3.5.1 Available Units

- Four mho distance elements (”Z1”, ”Z1 Ext”, ”Z2” and ”Z3” block).
- Four timers (”Z1 Delay”, ”Z1 Ext Delay”, ”Z2 Delay” and ”Z3 Delay” block).
- One polarizing element with voltage memory logic (”Polarizing” and ”Self Polar” block).
- Four directional blocks (”Z1 Dir”, ”Z1 Ext Dir”, ”Z2 Dir” and ”Z3 Dir” block).
- Four current starting super visioning elements(”Z1 Supv”, ”Z1 Ext Supv”, ”Z2 Supv” and ”Z3 Supv” block).
- Four voltage starting super visioning elements(”Z1 Volt Level”, ”Z1 Ext Volt Level”, ”Z2 Volt Level” and ”Z3 Volt Level” block).
- One output element opening the associated breaker (”Output logic” block).

3.5.2 Functionality

The subrelay implements four mho tripping zones with separated directional characteristics and voltage and current super visioning elements. For the user convenience an ”Extension zone” scheme mho element with its ancillary elements has been inserted inside the model. Each mho element can be blocked by an external input signal (”iblockz1”, ”iblockz1 Ext”, ”iblockz2” and ”iblockz13” relay input signal) .The elements are also controlled by the power swing element (”Out of step (F78)” subrelay) blocking signals.

The polarizing element has been implemented with a complete support for the voltage memory activation logic but please notice that the ”FORCE MEM POLAR” variable isn’t present in the model so it cannot be set to use the memorized voltage as polarizing voltage regardless of the positive sequence voltage magnitude.

3.5.3 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
	PHS DIST Zx[5]FUNCTION	Zx[5]	Out of Service (outserv)	
	PHS DIST Zx[5]DIR	Zx[5]	Tripping Direction (dir)	
	PHS DIST Zx[5]REACH	Zx[5]	Replica Impedance (Zm)	
	PHS DIST Zx[5]RCA	Zx[5]	Relay Angle (phi)	
	PHS DIST Zx[5]REV Reach	Zx[5]	Offset Impedance (Zoff)	In the ”Offset” frame
	PHS DIST Zx[5]REV Reach RCA	Zx[5]	Offset Angle (offang)	In the ”Offset” frame

[5]x = 1,1 Ext,2,3

Address	Relay Setting	Model block	Model setting	Note
	PHS DIST Zx^{5}COMP LIMIT	Zx^5	Character. Angle (alpha)	
	PHS DIST Zx^{5}DIR RCA	Zx^{5}Dir	Directional Angle, Phi (phi)	
	PHS DIST Zx^{5}DIR COMP LIMIT	Zx^{5}Dir	Angle Operating Sector (phisec)	
	PHS DIST Zx^{5}SUPV	Zx^{5}Supv	Current I>> (ip2)	
	PHS DIST Zx^{5}VOLT LEVEL	Zx^{5}Volt Level	Pickup Voltage (Uset)	
	MEMORY DURATION	Polarizing	Memory Time (Tmem)	The setting is located in the ”Voltage Memory” tab page
	FORCE SELF POLAR	Self Polar	SELFPOLAR (SELFPOLAR)	The value of the setting must be entered in the ’Logic” tab page

3.6 Differential(F87) subrelay

3.6.1 Available Units

- One differential element (”Differential” block).
- Three current adapters for the differential element (”Winding 1 Adapter”, ”Winding 2 Adapter” and ”Winding 3 Adapter” block).
- Four restricted earth fault differential blocks (”REF1”, ”REF2”, ”REF3” and ”REF4” block).
- Four current adapters for the restricted earth fault differential element (”Winding Neutral 1 Adapter”, ”Winding Neutral 2 Adapter”, ”Winding Neutral 3 Adapter” and ”Winding Neutral 4 Adapter” block).
- Nine internal measurement element (”Diff RMS meas” block fro the differential element, ”REF1 RMS meas”, ”REF1 restr RMS meas”, ”REF2 RMS meas”, ”REF2 restr RMS meas”, ”REF3 RMS meas”, ”REF3 restr RMS meas”, ”REF4 RMS meas” and ”REF4 restr RMS meas” for the restricted earth fault differential elements).
- Four delayed reset elements for the restricted earth fault elements (”REF1 reset delay”, ”REF2 reset delay”, ”REF3 reset delay” and ”REF4 reset delay” block).
- Four logic block which allow inserting the restricted earth fault slope value (”REF1 restrain slope”, ”REF2 restrain slope”, ”REF3 restrain slope” and ”REF4 restrain slope” block).
- Some additional calculation blocks used by the restricted earth fault elements (”REF1calc”, ”REF2calc”, ”REF3calc”, ”REF4calc” block calculating the restricted earth fault differential current and I1 component of the restrain current; ”REF1 RestrainCalc”, ”REF2 RestrainCalc”, ”REF3 RestrainCalc” and ”REF4 RestrainCalc” block calculating the restrain current).

3.6.2 Functionality

3 Phase differential The 3 phase differential feature is implemented by the ”Differential” block; the block supports up to three 3phase current inputs, two current biased restraint slopes. Before being processed by the differential element the currents are recalculated, taking care of the different CT ratios, by the current adapters. The internal measurement element is calculating the RMS value of the differential current vectors returned by the differential element. The 3p phase differential element is fed by the ”Ct”, ”Remote Ct1” and ”Remote Ct2” current transformer.

Restricted earth fault differential Four restricted earth fault elements are available. The restraint logic supported by the model is affected by the following simplifications: ” The multiplier of the negative sequence component of the restraining signal (IR2) is always 3. (in the relay is 1 the first two cycles following complete de-energization) ” The post filtering isn’t present so no decaying memory is available for the restraining signal All other restraining current selection logics are fully supported. The restricted earth fault elements are connected in the following way:

The restricted earth fault elements are connected in the following way:

The relationships between the relay settings and the model parameters can be found in the following table:

Element	3 Phase current measurement CT	Neutral measurement CT
REF1	Ct	Neutral Ct1
REF2	Remote Ct1	Neutral Ct1
REF3	Ct	Neutral Ct2
REF4	Remote Ct1	Neutral Ct2

Such connection should reproduce the more common protection schemes. Other schemes can be simulated modifying the connection scheme.

3.6.3 Data input

Please note that the nominal current values MUST be entered in all the measurement unit (”Diff RMS meas” block fro the differential element, ”REF1 RMS meas”, ”REF1 restr RMS meas”, ”REF2 RMS meas”, ”REF2 restr RMS meas”, ”REF3 RMS meas”, ”REF3 restr RMS meas”, ”REF4 RMS meas” and ”REF4 restr RMS meas” for the restricted earth fault differential elements)

The relationships between the 3phase differential 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
	Stator Diff Pickup	Differential	Differential Current Base Threshold (Idiff)	
	Stator Diff CT Line End Source	Winding 1 Adapter	Current transformer ratio (CTratio)	In both blocks please don’t set the ”Nominal Terminal Phase-Phase voltage” value. Set inside ”Winding 1 Adapter” the ”Current transformer ratio” value equal to the local CT ratio (i.e. for a 2500/5 CT set ”500”, for a 400/1 CT set ”400”). Set inside ”Winding 2 Adapter”the ”Current transformer ratio” value equal to the first remote CT ratio. The ”Current transformer connection” must be left equal to ”none”.
		Winding 2 Adapter	Current transformer ratio (CTratio)	
	Stator Diff Neutral End Source	Winding 3 Adapter	Current transformer ratio (CTratio)	As above. Set the ”Current transformer ratio” value equal to the 2nd remote CT ratio.
	Stator Diff Slope 1	Differential	Restraint percentage 1 (Irestrpercent1)	
	Stator Diff Slope 2	Differential	Restraint percentage 2 (Irestrpercent2)	
	Stator Diff Break 2	Differential	Restraint 2nd slope(Ipset2)	

The relationships between the Restricted earth fault differential 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
	Restd Grnd FTy[6]pickup	REFy[6]	Pickup Current (Ipset)	
		Winding Neutral y[6]Adapter	Current transformer ratio (CTratio)	The ”Current transformer ratio” value must be equal to the neutral CT ratio (i.e. for a 1000/5 CT set ”200”, for a 100/1 CT set ”100”). Don’t set the ”Nominal Terminal Phase-Phase voltage” value.
	Restd Grnd FTy[6]slope	REFy[6]restrain slope	Slope (Slope)	The value must be entered in the ”Logic” tab page. Default string = ”Slope = 80”

[6]y = 1,2,3,4

Address	Relay Setting	Model block	Model setting	Note
	Restd Grnd FTy[6] Pickup Delay	REFy[6]	Time Setting (Tset)	
	Restd Grnd FTy[6] Reset Delay	REFy[6] reset delay	Time Setting (Tdelay)	

3.7 Loss of excitation(F40) subrelay

3.7.1 Available Units

- Two three phase mho elements (”Loss of excitation 1” and ”Loss of excitation 2” block).
- Two timers (”PKP Delay1” and ”PKP Delay2” block).
- One polarizing element (”Polarizing” block).
- One undervoltage blocking element (”UV SUPV” block).
- One undercurrent blocking element (”I1>0.05pu” block).
- One blocking logic element (”UV SUPV 1 & 2” block).
- One output element operating the associated breaker (”Output logic” block).

3.7.2 Functionality

The subrelay implements two mho zones with offset impedance. Separated time delays can be set for each zone. A combined undercurrent and undervoltage blocking logic is available, each mho zone can be set with a different blocking logic.

3.7.3 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
	LOSS OF EXCITATION FUNCTION	Loss of excitation (F40)	Out of service (outserv)	Disable the ”Loss of excitation (F40)”subrelay to disable the whole protection feature
	LOSS OF EXCITATION CENTER 1	Loss of excitation 1	ReplicaImpedance (Zm)	CENTER = Offset Impedance+(ReplicaImpedance- Offset Impedance)/2 Offset Impedance = CENTER - RADIUS ReplicaImpedance = CENTER + RADIUS/2
	LOSS OF EXCITATION RADIUS 1	Loss of excitation 1	Offset Impedance (Zoff)	RADIUS =(ReplicaImpedance- Offset Impedance)/2 Offset Impedance = CENTER - RADIUS ReplicaImpedance = CENTER + RADIUS/2
	EXCITATION V SUPV 1	UV SUPV 1 & 2	V_SUPV_1 (V_SUPV_1)	in the ”Logic” tab page
	EXCITATION V SUPV 2	UV SUPV 1 & 2	V_SUPV_2 (V_SUPV_2)	in the ”Logic” tab page
	LOSS OF EXCITATION PKP DELAY1	PKP Delay1	Time Setting (Tdelay)	
	LOSS OF EXCITATION CENTER 2	Loss of excitation 2	ReplicaImpedance (Zm)	CENTER = Offset Impedance+(ReplicaImpedance- Offset Impedance)/2 Offset Impedance = CENTER - RADIUS ReplicaImpedance = CENTER + RADIUS/2
	LOSS OF EXCITATION RADIUS 2	Loss of excitation 2	Offset Impedance (Zoff)	RADIUS =(ReplicaImpedance- Offset Impedance)/2 Offset Impedance = CENTER - RADIUS ReplicaImpedance = CENTER + RADIUS/2

Address	Relay Setting	Model block	Model setting	Note
	LOSS OF EXCITATION PKP DELAY2	PKP Delay2	Time Setting (Tdelay)	

No user input is required in the ”Polarizing” and in the ”I1>0.05pu” block.

3.8 Out of step subrelay

3.8.1 Available Units

- Three under impedance quadrilateral elements (”Inner zone polygonal”, ”Middle zone polygonal” and ”Outer zone polygonal” block).
- Three mho elements (”Inner zone mho”, ”Middle zone mho” and ”Outer zone mho” block).
- Three out of step detection and power swing elements (”Out Of Step Middle-Inner”, ”Out Of Step Outer-Middle” and ”Out Of Step Outer-Inner” block).
- An out of step trip additional delay element (”OS Time Delay” block).
- A minimum current supervision element (”I supervision” block).

3.8.2 Functionality

The subrelay implements both the two steps and the three steps operation modes for the power swing blocking feature and the out of step trip. Please disable the ”Middle zone polygonal”, ”Middle zone mho”, ”Out Of Step Middle-Inner” and the ”Out Of Step Outer-Middle” block to activate the two steps operation mode. Please disable the ”Out Of Step Outer-Inner” block to activate the three steps operation mode. Both the mho operating characteristics and the quadrilateral characteristics are supported. Please use the quadrilateral characteristics also to simulate the blinder which can be used with the mho; in that case set to a very large value the ”+X” reach of the quadrilateral elements and ”+R Reach” and the ”-R Reach” equal to the blinder intersections with the R axis.

3.8.3 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
	Power Swing	I supervision	Pickup current (Ipset)	
	Power Swing Fwd Reach	Inner zone mho	Replica Impedance (Zm)	
		Middle zone mho	Replica Impedance (Zm)	
		Outer zone mho	Replica Impedance (Zm)	
		Inner zone polygonal	+X Reach (Xmax)	
	Power Swing Quad Fwd Reach Mid	Middle zone polygonal	+X Reach (Xmax)	
	Power Swing Quad Fwd Reach Out	Outer zone polygonal	+X Reach (Xmax)	
	Power Swing Fwd RCA	Inner zone mho	Relay Angle (phi)	
		Middle zone mho	Relay Angle (phi)	
		Outer zone mho	Relay Angle (phi)	

Address	Relay Setting	Model block	Model setting	Note
		Inner zone polygonal	Relay Angle (phi)	
		Middle zone polygonal	Relay Angle (phi)	
		Outer zone polygonal	Relay Angle (phi)	
	Power Swing Rev Reach	Inner zone mho	Offset Impedance (Zoff)	Insert a negative value in the mho blocks
		Middle zone mho	Offset Impedance (Zoff)	Insert a negative value in the mho blocks
		Outer zone mho	Offset Impedance (Zoff)	Insert a negative value in the mho blocks
		Inner zone polygonal	-X Reach (Xmin)	
	Power Swing Rev Reach Mid	Middle zone polygonal	-X Reach (Xmin)	
	Power Swing Rev Reach Out	Outer zone polygonal	-X Reach (Xmin)	
	Power Swing Rev RCA	Inner zone mho	Offset Angle (offang)	
		Middle zone mho	Offset Angle (offang)	
		Outer zone mho	Offset Angle (offang)	
	Power Swing Outer Limit Angle	Outer zone mho	Character.Angle (alpha)	
	Power Swing Middle Limit Angle	Middle zone mho	Character.Angle (alpha)	
	Power Swing Inner Limit Angle	Inner zone mho	Character.Angle (alpha)	
	Power Swing Outer RGT Blinder	Outer zone polygonal	+R Resistance (Rmax)	
	Power Swing Middle RGT Blinder	Middle zone polygonal	+R Resistance (Rmax)	
	Power Swing Inner RGT Blinder	Inner zone polygonal	+R Resistance (Rmax)	
	Power Swing Outer LFT Blinder	Outer zone polygonal	-R Resistance (Rmin)	
	Power Swing Middle LFT Blinder	Middle zone polygonal	-R Resistance (Rmin)	
	Power Swing Inner LFT Blinder	Inner zone polygonal	-R Resistance (Rmin)	
	Power swing Pickpup Delay 1	Out Of Step Outer-Middle	tP1(tP1)	”Timers” tab page, set ”Out Of Step Outer-Inner” for the 2 steps operation mode
		Out Of Step Outer-Inner		
	Power swing Reset Delay 1	Out Of Step Outer-Middle	tH (tH)	”Timers” tab page, set ”Out Of Step Outer-Inner” for the 2 steps operation mode
		Out Of Step Outer-Inner		
	Power swing Pickpup Delay 2	Out Of Step Middle-Inner	tP1 (tP1)	”Timers” tab page, used only for the 3 steps operation mode
	Power swing Pickpup Delay 3	Power Swing Pickup Delay 3	Time setting (Tdelay)	
	Power swing Pickpup Delay 4	Power Swing Pickup Delay 4	tP1 (tP1)	”Timers” tab page

3.9 Output logic

3.9.1 Available Units

The output logic is implemented by the ”Output Logic” block located in each subrelay and by the ”Output Logic” block located in the main relay.

3.9.2 Functionality

The ”Output Logic” block located in the main relay is operating the breaker. Please disable the ”Output Logic” block in the main relay to disable the relay model ability to open the power circuit. The signal operating the breaker is ”yout”. Height additional output signals (”H1” . . . ”H8”) freely configurable are available.

3.9.3 Data input

The configuration of the ”H1”. . . ”H8” output signals can be done in the ”Logic” tab page of the ”Output Logic” block.

4 Features not supported

4.1 Overcurrent elements(F50-F51-F46) subrelay

The following features are not supported:

- Breaker failure
- Trip bus

4.2 Voltage elements(F27-F59) subrelay

The following features are not supported:

- Third harmonic neutral undervoltage
- Auxiliary overvoltage
- Syncrocheck

4.3 Frequency(F81) subrelay

The following features are not supported:

- Turbine frequency out of band accumulated operating time

4.4 Differential(F87) subrelay

The following features are not supported:

- None

4.5 Loss of excitation(F40) subrelay

The following features are not supported:

- None

5 References

[1] GE Multilin, 215 Anderson Avenue, Markham - Ontario Canada L6E 1B3. *G60 Generator Protection System UR Series Instruction Manual G60 revision 5.7x Manual P/N 1601-0110-U2 (GEK113523A)*, 2009.