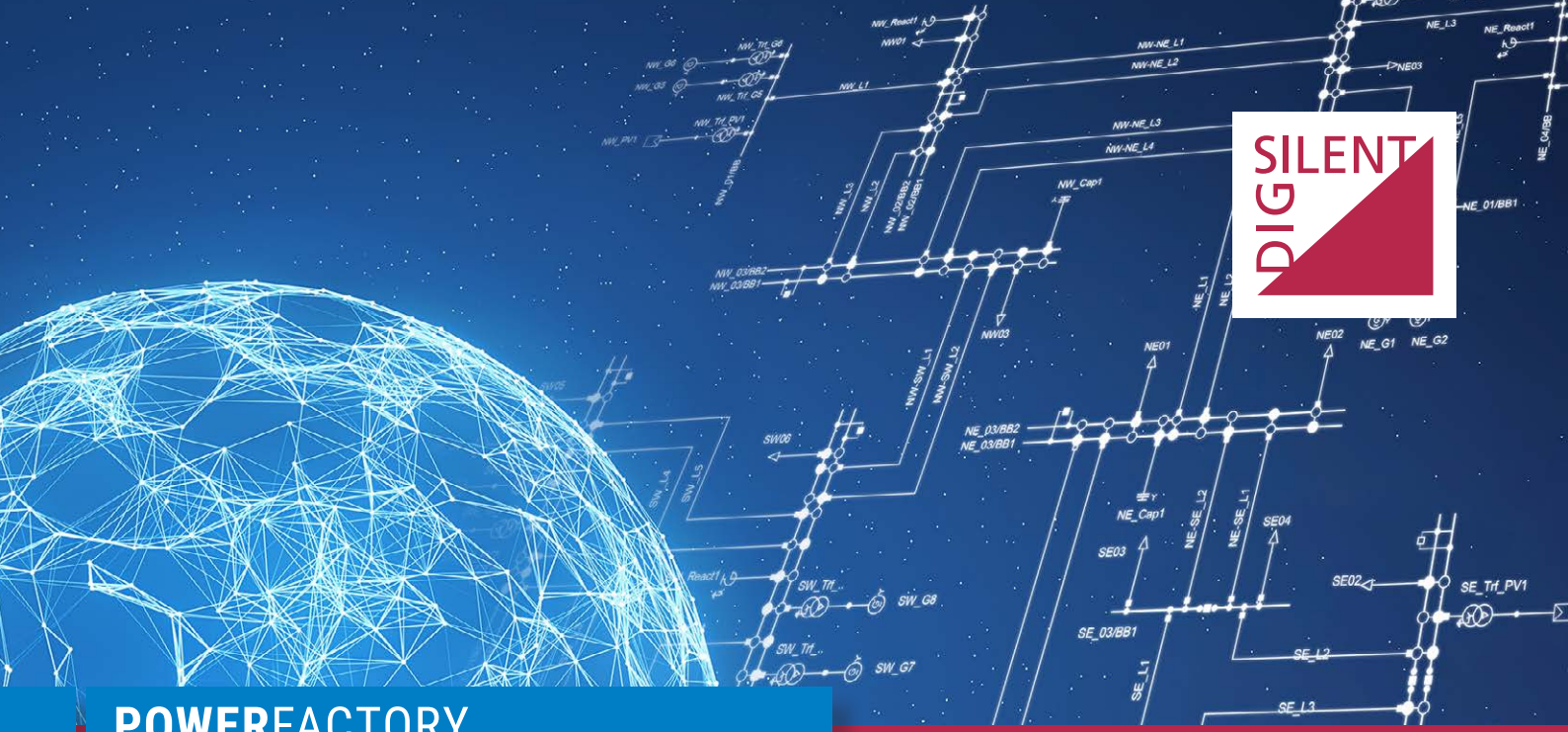

POWERFACTORY

PowerFactory 2021

Technical Reference

Toshiba GRZ100

PF2021

POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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Contents

1 Model information

Manufacturer Toshiba

Model GRZ100

Variants The Toshiba GRZ100 PowerFactory relay model can be used to simulate the firmware versions of the Toshiba GRZ100 relay up to revision 0.5.

2 General description

The Toshiba GRZ100 is a line distance protection relay with additional overcurrent and voltage protective elements.

The Toshiba GRZ100 PowerFactory relay model consists of a main relay model and the following sub relays:

- Phase Distance elements (F21)
- Ground Distance elements (F21)
- Overcurrent elements (F50 - F51 - F46)
- Voltage elements (F27 - F59)
- Phase selection UVC
- Polarizing
- Power Swing
- Out of step

The Toshiba GRZ100 PowerFactory relay model has been implemented trying to simulate the protective functions more commonly used.

The main relay contains the measurement and acquisition units, the starting unit (”UVC” block), 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 three current transformers (”Ct”, ”Mutual Ct” and ”Neutral Ct” block) and one voltage transformer (”Vt” block).

Four measurement units (”Measurement”, ”Meas delta” , ”Measurement Seq”, and ”Meas Mutual” block) are fed by these CTs and the VT.

3.1.1 Available Units

- One three phase current transformer element (”Ct” block).
- One single phase current transformer converting the ground current (”Neutral Ct” block).
- One single phase current transformer element converting the ground current along an adjacent line (”Mutual Ct” block).
- One three phase voltage transformer element (”Vt” block).
- One three phase measurement element fed by the ’Ct” current transformer (”Measurement” block).
- One three phase measurement element calculating the phase-phase current and voltage values (”Meas delta” block).
- One three phase measurement element calculating the sequence values (”Measurement Seq” block).
- One single phase measurement element calculating the values of the neutral current along an adjacent line (”Meas Mutual” block).

3.1.2 Functionality

The input signals are sampled at 48 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 Phase selection UVC

3.2.1 Functionality

This ”UVC” block contains the elements which detect a fault and select the faulted phase(s).

The following equations have been implemented:

$$|V| <= V_s \qquad (1)$$

$$|V - IZ_s| <= V_s \qquad (2)$$

$$-V_s <= Vsin\theta <= V_s \qquad (3)$$

$$0 < cos\theta <= |IZ_s| \qquad (4)$$

A phase trip is declared when for the phase equation (1) or equation (2) or both equation (3) and equation (4) are verified.
A ground fault is declared (and the *yearth* output signal is set equal to ”on”) when only one phase trip has been detected. A phase fault is declared (and the *ynearth* output signal is set equal to ”on”) when more than one phase trip has been detected.

3.2.2 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, the addresses are the setting numbers as listed at pag 358 of [1]):

Address	Relay Setting	Model block	Model setting	Note
214	UVCV	UVC	Replica Impedance (Zm)	
215	UVCZ	UVC	Relay Angle (phi)	
216	UVCθ	UVC	Input Setting (Ipsetr)	

3.3 Phase Distance elements (F21) subrelay

This subrelay contains the distance protection elements which monitor the phase-phase loops.

3.3.1 Available Units

- Nine under impedance quadrilateral elements (”Z1S Quadrilateral”, ”Z1XS Quadrilateral”, ”Z2S Quadrilateral”, ”Z3S Quadrilateral”, ”Z4S Quadrilateral”, ”ZFS Quadrilateral”, ”ZR1S”, ”ZR2S”, and ”ZNDS Quadrilateral” block).
- Four mho elements (”Z3S Mho”, ”Z4S Mho”, ”ZNDS Mho”, and ”ZR2S Mho” block).
- One directional element (”Directional” block).
- Seven timers (”TZ1S”, ”TZ2S”, ”TZ3S”, ”TZFS”, ”TZNDS”, ”TZR1S”, and ”TZR2S’ block).
- One reclosing block (”Reclosing” block).
- Two load encroachment elements (”BNDS”, and ”Blinder” block).
- One ancillary logic element (”Reverse blocking logic” block).
- One output logic element (”Starting” block).

3.3.2 Functionality

The subrelay consists of nine polygonal elements, four mho elements and 2 load encroachment elements monitoring the phase-phase distance loops. The polygonal elements and the mho must be enabled or disabled accordingly with the ”ZS-C” setting value.
The reach of both the polygonal elements (except ”ZNDS Quadrilateral”)and the mho elements (except ”ZNDS Mho”) is limited by the ”Blinder” element. The ”ZNDS Quadrilateral” element and the ”ZNDS Mho” element are restraint by the ”BNDS” load encroachment element.

A reclosing element can be configures to provide up to 4 breaker reclosing attempts when the fault has been cleared by the distance elements. Single shot reclosing can be also set.
Single phase or 3 phase trip and reclosing can be set in the *Operation Mode* tab page of the "Reclosing" element dialog.

The load encroachment elements limit the trip zone of both the polygonal and the mho elements.

An unique timer is connected to each mho/polygonal element couple.

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, the addresses are the setting numbers as listed at pag 356 of [1]):

Address	Relay Setting	Model block	Model setting	Note
23	ZS-C	Z3S Mho<->Z3S Quadrilateral Z4S Mho<->Z4S Quadrilateral ZNDS Mho<->ZNDS Quadrilateral	Out of Service (outserv)	Enable the mho elements when *ZS-C* is *Mho* Enable the quadrilateral elements

Address	Relay Setting	Model block	Model setting	Note
		ZR2S Mho<->ZR2S		when *ZS-C* is *Quad*
95	Z1S	Z1S Quadrilateral	+X Reach (Xmax)	
98	Z1XS	Z1XS Quadrilateral	+X Reach (Xmax)	
99	Z1Sθ1	Z1S Quadrilateral	+X Angle (beta)	
100	Z1Sθ2	Z1S Quadrilateral	Relay Angle (phi)	
		Z2S Quadrilateral	Relay Angle (phi)	
		Z3S Quadrilateral	Relay Angle (phi)	
		Z4S Quadrilateral	Relay Angle (phi)	
		ZFS Quadrilateral	Relay Angle (phi)	
101	BFR1S	Z1S Quadrilateral	+R Resistance (Rmax)	
102	BFRXS	Z1XS Quadrilateral	+R Resistance (Rmax)	
103	Z2S	Z2S Quadrilateral	+X Reach (Xmax)	
104	BFR2S	Z2S Quadrilateral	+R Resistance (Rmax)	
105	ZFS	ZFS Quadrilateral	+X Reach (Xmax)	
106	BFRFS	ZFS Quadrilateral	+R Resistance (Rmax)	
107	Z3S	Z3S Quadrilateral	+X Reach (Xmax)	
108	Z3Sθ	Z3S Mho	Relay Angle (phi)	
109	ZBSθ	Directional	Directional Angle, alpha (alpha)	
		ZR1S	-X Angle (alpha)	Set alpha = - ZBSθ
		ZR2S	-X Angle (alpha)	Set alpha = - ZBSθ
110	BFRS	Blinder	BFR (BFR)	
113	BFLSθ	Blinder	BFL ang (BFLang)	
		ZR1S	-R Angle (gamma2)	
		ZR2S	-R Angle (gamma2)	
114	ZR1S	ZR1S	+X Reach (Xmax)	
115	ZR2S	ZR2S	+X Reach (Xmax)	
116	Z4S	Z4S Mho	Replica Impedance (Zm)	
119	Z4BSθ	Z4S Quadrilateral	Relay Angle (phi)	
120	BRRS	Blinder	BRR (BRR)	
		ZR1S	+R Resistance (Rmax)	
		ZR2S	+R Resistance (Rmax)	
122	BRLS	Blinder	BRL (BRL)	
		ZR1S	-R Resistance (Rmin)	
		ZR2S	-R Resistance (Rmin)	
123	BRLSθ	Blinder	BRL ang (BRLang)	
		Directional	Directional Angle, phi (phi)	
124	ZNDS	ZNDS Quadrilateral	ZReach (Zmax)	
		ZNDS Mho	Replica Impedance (Zm)	
125	BNDS	BNDS	BND (BND)	
126	TZ1S	TZ1S	Time Setting (Tdelay)	
127	TZ2S	TZ2S	Time Setting (Tdelay)	
128	TZFS	TZFS	Time Setting (Tdelay)	
129	TZ3S	TZ3S	Time Setting (Tdelay)	
130	TZR1S	TZR1S	Time Setting (Tdelay)	
131	TZR2S	TZR2S	Time Setting (Tdelay)	
132	TZNDS	TZNDS	Time Setting (Tdelay)	
284	TRDY1	Reclosing	Reset Time (resettime)	
285	TSPR1	Reclosing	Reclosing int 1 1Ph-Grnd faults (recltime11ph)	
286	TTPR1	Reclosing	Reclosing interval 1 (recltime1)	

Address	Relay Setting	Model block	Model setting	Note
288	TW1	Reclosing	Closing command duration (closingcomtime)	
293	TS2	Reclosing	Reclosing interval 2 (recltime2)	
295	TS3	Reclosing	Reclosing interval 3 (recltime2)	
297	TS4	Reclosing	Reclosing interval 4 (recltime2)	

3.4 Ground Distance elements (F21) subrelay

This subrelay contains the distance protection elements which monitor the phase-ground loops.

3.4.1 Available Units

3.4.2 Available Units

- Nine under impedance quadrilateral elements (”Z1G Quadrilateral”, ”Z1XG Quadrilateral”, ”Z2S Quadrilateral”, ”Z3G Quadrilateral”, ”Z4G Quadrilateral”, ”ZFG Quadrilateral”, ”ZR1G”, ”ZR2G”, and ”ZNDG Quadrilateral” block).
- Four mho elements (”Z3G Mho”, ”Z4G Mho”, ”ZNDG Mho”, and ”ZR2G Mho” block).
- One directional element (”Directional” block).
- Seven timers (”TZ1G”, ”TZ2G”, ”TZ3G”, ”TZFG”, ”TZNDG”, ”TZR1G”, and ”TZR2G’ block).
- One reclosing block (”Reclosing” block).
- Two load encroachment elements (”BNDG”, and ”Blinder” block).
- One ancillary logic element (”Reverse blocking logic” block).
- One output logic element (”Starting” block).

3.4.3 Functionality

The subrelay consists of nine polygonal elements, four mho elements and 2 load encroachment elements monitoring the phase-phase distance loops. The polygonal elements and the mho must be enabled or disabled accordingly with the ”ZG-C” setting value.
The reach of both the polygonal elements (except ”ZNDG Quadrilateral”)and the mho elements (except ”ZNDG Mho”) is limited by the ”Blinder” element. The ”ZNDG Quadrilateral” element and the ”ZNDG Mho” element are restraint by the ”BNDG” load encroachment element.

A reclosing element can be configures to provide up to 4 breaker reclosing attempts when the fault has been cleared by the distance elements. Single shot reclosing can be also set.
Single phase or 3 phase trip and reclosing can be set in the *Operation Mode* tab page of the "Reclosing" element dialog.

The load encroachment elements limit the trip zone of both the polygonal and the mho elements.

An unique timer is connected to each mho/polygonal element couple.

3.4.4 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, the addresses are the setting numbers as listed at pag 357 of [1]):

Address	Relay Setting	Model block	Model setting	Note
23	ZG-C	Z3G Mho<->Z3G Quadrilateral	Out of Service (outserv)	Enable the mho elements

Address	Relay Setting	Model block	Model setting	Note
		Z4G Mho<->Z4G Quadrilateral		when *ZG-C* is *Mho*
		ZNDG Mho<->ZNDG Quadrilateral		Enable the quadrilateral elements
		ZR2G Mho<->ZR2G		when *ZG-C* is *Quad*
133	Z1G	Z1G Quadrilateral	+X Reach (Xmax)	
134	Z1XG	Z1XG Quadrilateral	+X Reach (Xmax)	
135	Z1Gθ1	Z1G Quadrilateral	+X Angle (beta)	
136	Z1Gθ2	Z1G Quadrilateral	Relay Angle (phi)	
		Z2G Quadrilateral	Relay Angle (phi)	
		Z3G Quadrilateral	Relay Angle (phi)	
		Z4G Quadrilateral	Relay Angle (phi)	
		ZFG Quadrilateral	Relay Angle (phi)	
137	BFR1G	Z1G Quadrilateral	+R Resistance (Rmax)	
138	BFRXG	Z1XG Quadrilateral	+R Resistance (Rmax)	
139	Z2G	Z2G Quadrilateral	+X Reach (Xmax)	
140	BFR2G	Z2G Quadrilateral	+R Resistance (Rmax)	
141	ZFG	ZFG Quadrilateral	+X Reach (Xmax)	
142	BFRFG	ZFG Quadrilateral	+R Resistance (Rmax)	
143	Z3G	Z3G Quadrilateral	+X Reach (Xmax)	
144	Z3Gθ	Z3G Mho	Relay Angle (phi)	
145	ZBGθ	Directional	Directional Angle, alpha(alpha)	
		ZR1G	-X Angle (alpha)	Set alpha = - ZBGθ
		ZR2G	-X Angle (alpha)	Set alpha = - ZBGθ
146	BFRG	Blinder	BFR (BFR)	
149	BFLGθ	Blinder	BFL ang (BFLang)	
		ZR1G	-R Angle (gamma2)	
		ZR2G	-R Angle (gamma2)	
		Directional	Directional Angle, phi(phi)	Set phi = BFLGθ-90
150	ZR1G	ZR1G	+X Reach (Xmax)	
151	ZR2G	ZR2G	+X Reach (Xmax)	
152	Z4G	Z4G Mho	Replica Impedance (Zm)	
153	Z4BGθ	Z4G Quadrilateral	Relay Angle (phi)	
120	BRRG	Blinder	BRR (BRR)	
		ZR1G	+R Resistance (Rmax)	
		ZR2G	+R Resistance (Rmax)	
155	BRLG	Blinder	BRL (BRL)	
		ZR1G	-R Resistance (Rmin)	
		ZR2G	-R Resistance (Rmin)	
158	BRLGθ	Blinder	BRL ang (BRLang)	
165	ZNDG	ZNDG Quadrilateral	ZReach (Zmax)	
		ZNDG Mho	Replica Impedance (Zm)	
166	BNDG	BNDG	BND (BND)	
167	TZ1G	TZ1G	Time Setting (Tdelay)	
168	TZ2G	TZ2G	Time Setting (Tdelay)	
169	TZFG	TZFG	Time Setting (Tdelay)	
170	TZ3G	TZ3G	Time Setting (Tdelay)	
171	TZR1G	TZR1G	Time Setting (Tdelay)	
172	TZR2G	TZR2G	Time Setting (Tdelay)	
173	TZNDG	TZNDG	Time Setting (Tdelay)	
284	TRDY1	Reclosing	Reset Time (resettime)	
285	TSPR1	Reclosing	Reclosing int 1 1Ph-Grnd faults (recltime11ph)	

Address	Relay Setting	Model block	Model setting	Note
286	TTPR1	Reclosing	Reclosing interval 1 (recltime1)	
288	TW1	Reclosing	Closing command duration (closingcomtime)	
293	TS2	Reclosing	Reclosing interval 2 (recltime2)	
295	TS3	Reclosing	Reclosing interval 3 (recltime2)	
297	TS4	Reclosing	Reclosing interval 4 (recltime2)	

3.5 Overcurrent elements (F50 - F51 - F46) subrelay

3.5.1 Available Units

- One 3 phase inverse time non directional overcurrent elements (”OCI” block).
- One 3 phase definite time non directional overcurrent elements (”OC” block).
- Two earth directional elements (”Earth Directional Forward” and ”Earth Directional Reverse” block).
- One earth current inverse time directional overcurrent elements (”EFI” block).
- One earth current definite time directional overcurrent elements (”EF” block).
- Three timers (”DEFBT”, ”TDEF”, and ”TDER” block).
- One thermal image element (”Thermal” block).
- One output logic element(”Output Logic” block).

3.5.2 Functionality

The model contains the relay overcurrent protective elements and the thermal image element.

The earth directional elements (”Earth Directional Forward” and ”Earth Directional Reverse” block) output signals can be delayed by separated timers for the forward and the reverse direction. An additional backup trip or alarm signal activated by the directional element si available and be set in the ”DIP Settings” tab page of the ”Output Logic” element.

The inverse time overcurrent elements support the following trip characteristics:

- ”Standard Inverse”
- ”Very Inverse”
- ”Extremely Inverse”
- ”Long Time Inverse”

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, the addresses are the setting numbers as listed at pag 358 of [1]):

Address	Relay Setting	Model block	Model setting	Note
52	OCBT	OC	Out of Service (outserv)	
53	OCIBT	OCI	Out of Service (outserv)	
54	MOCI	OCI	Characteristic (pcharac)	
55	EFBT	EF	Out of Service (outserv)	
59	DEFBTAL	DEFBT	Out of Service (outserv)	
60	DEFI	Earth Directional Forward	Tripping Direction (idir)	Set equal to *Forward* when DEFI=F
		Earth Directional Reverse	Tripping Direction (idir)	Set equal to *Reverse* when DEFI=R

Address	Relay Setting	Model block	Model setting	Note
61	MEFI	EFI	Characteristic (pcharac)	
84	THMT	Thermal	Out of Service (outserv)	
196	DEFFI	Earth Directional Forward	Operating Current (curopur)	In the ”Voltage Polarizing” tab page
197	DEFFV	Earth Directional Forward	Polarizing Voltage (upolur)	In the ”Voltage Polarizing” tab page
198	DEFRI	Earth Directional Reverse	Operating Current (curopur)	In the ”Voltage Polarizing” tab page
199	DEFRV	Earth Directional Reverse	Polarizing Voltage (upolur)	In the ”Voltage Polarizing” tab page
200	DEFθ	Earth Directional Forward	Max. Torque Angle (mtau)	In the ”Voltage Polarizing” tab page
		Earth Directional Reverse	Max. Torque Angle (mtau)	In the ”Voltage Polarizing” tab page
201	TDEF	TDEF	Time Setting (Tdelay)	
202	TDER	TDER	Time Setting (Tdelay)	
203	OC	OC	Pickup Current (Ipsetr)	
204	TOC	OC	Time Setting (Tset)	
205	OCI	OCI	Current Setting (Ipsetr)	
206	TOCI	OCI	Time Dial (Tpset)	
207	TOCIR	OCI	Reset Delay (ResetT)	
208	EF	EF	Pickup Current (Ipsetr)	
209	TEF	EF	Time Setting (Tset)	
210	EFI	EFI	Current Setting (Ipsetr)	
211	TEFI	EFI	Time Dial (Tpset)	
212	TEFIR	EFI	Reset Delay (ResetT)	
258	THM	Thermal	Current Setting (Ipsetr)	
260	TTHM	Thermal	Time Dial (Tpset)	

3.6 Voltage elements (F27 - F59) subrelay

3.6.1 Available Units

- One 3 phase inverse/definite time ph-ground voltage undervoltage elements (”UVG1” block).
- One 3 phase inverse/definite time phase-phase voltage undervoltage elements (”UVS1” block).
- One 3 phase definite time ph-ground voltage undervoltage elements (”UVG2” block).
- One 3 phase definite time phase-phase voltage undervoltage elements (”UVS2” block).
- One 3 phase inverse/definite time ph-ground voltage overvoltage elements (”OVG1” block).
- One 3 phase inverse/definite time phase-phase voltage overvoltage elements (”OVS1” block).
- One 3 phase definite time ph-ground voltage overvoltage elements (”OVG2” block).
- One 3 phase definite time phase-phase voltage overvoltage elements (”OVS2” block).
- One zero sequence definite time overvoltage elements (”OVG” block).
- Two 3 phase definite time phase-phase voltage overvoltage elements (”UVLS”, and ”UVFS” block).
- Three 3 phase definite time phase-ground voltage undervoltage elements (”UVLG”, ”UVFG”, and ”UVPWI” block).
- One output logic element(”Output Logic” block).

3.6.2 Functionality

All the over/undervoltage elements available in the relay have been implemented in the model. The ”OVG”, ”UVFS”, ”UVFG”, and ”UVPWI” element are not set to trip by default the relay; they can be used for special logics regarding the VT failure supervision, to manage the overreaching in week infeed condition or signal channel test. Specific trip logic can be inserted in the ”Logic” tab page of the ”Output Logic”element.

3.6.3 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, the addresses are the setting numbers as listed at pag 358 of [1]):

Address	Relay Setting	Model block	Model setting	Note
62	OVS1EN	OVS1	Out of Service (outserv)	outserv=1 when OVS1EN=off
			Characteristic (pcharac)	
63	OVS2EN	OVS2	Out of Service (outserv)	
64	OVG1EN	OVG2	Out of Service (outserv)	outserv=1 when OVS1EN=off
			Characteristic (pcharac)	
65	OVG2EN	OVG2	Out of Service (outserv)	
66	UVS1EN	UOVS1	Out of Service (outserv)	outserv=1 when OVS1EN=off
			Characteristic (pcharac)	
67	UVS2EN	UVS2	Out of Service (outserv)	

Address	Relay Setting	Model block	Model setting	Note
68	UVG1EN	UVG2	Out of Service (outserv) Characteristic (pcharac)	outserv=1 when OVS1EN=off
69	UVG2EN	UVG2	Out of Service (outserv)	
219	OVG	OVG	Pickup Voltage (Uset)	
220	UVFS	UVFS	Pickup Voltage (Uset)	
221	UVLS	UVLS	Pickup Voltage (Uset)	
222	UVFG	UVFG	Pickup Voltage (Uset)	
223	UVLG	UVLG	Pickup Voltage (Uset)	
224	UVPWI	UVPWI	Pickup Voltage (Uset)	
226	OVS1	OVS1	Input Setting (Ipsetr)	
227	TOS1I	OVS1	Time Dial (Tpset)	
228	TOS1	OVS1	Time Dial (Tpset)	
229	TOS1R	OVS1	Reset Delay (ResetT)	
231	OVS2	OVS2	Input Setting (Ipsetr)	
232	TOS2	OVS2	Time Dial (Tpset)	
234	OVG1	OVG1	Input Setting (Ipsetr)	
235	TOG1I	OVG1	Time Dial (Tpset)	
236	TOG1	OVG1	Time Dial (Tpset)	
227	TOG1R	OVG1	Reset Delay (ResetT)	
239	OVG2	OVG2	Input Setting (Ipsetr)	
240	TOG2	OVG2	Time Dial (Tpset)	
242	UVS1	UVS1	Input Setting (Ipsetr)	
243	TUS1I	UVS1	Time Dial (Tpset)	
244	TUS1	UVS1	Time Dial (Tpset)	
245	TUS1R	UVS1	Reset Delay (ResetT)	
246	UVS2	UVS2	Input Setting (Ipsetr)	
247	TUS2	UVS2	Time Dial (Tpset)	
249	UVG1	UVG1	Input Setting (Ipsetr)	
250	TUG1I	UVG1	Time Dial (Tpset)	
251	TUG1	UVG1	Time Dial (Tpset)	
252	TUG1R	UVG1	Reset Delay (ResetT)	
253	UVG2	UVG2	Input Setting (Ipsetr)	
254	TUG2	UVG2	Time Dial (Tpset)	

3.7 Polarizing subrelay

This subrelay contains the blocks which calculates the polarizing voltage and the operating current used by the distance elements.

3.7.1 Available Units

- Two polarizing elements (”Ks”, and ”KsR” block).
- Two logic blocks (”Pol Calc”, and ”Pol R Calc” block).

3.7.2 Functionality

Separated polarizing blocks are available for the forward and the reverse distance elements. Each polarizing block implements a 2 cycle voltage bffer activated by close faults; the voltage activation threshold is equal to $4\%U_n$.
The purpose of the ”Pol Calc”, and ”Pol R Calc” block is to implement the dual polarization (self-polarization plus cross-polarization). Its polarizing voltage Vp is expressed by the following equations.

For B-to-C-phase phase fault element

$V_{pbc} = 3(V_a - V_0)\angle -90^\circ + V_{bc}$

For an A-phase earth fault element

$Vpa = 3(V_a - V_0) + V_{bc}\angle 90^\circ$

where,

$V_a = A - phasevoltage$

$V_0 = zero - sequencevoltage$

$V_{bc} = B - to - C - phasevoltage$

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, the addresses are the setting numbers as listed at pag 355 of [1]):

Address	Relay Setting	Model block	Model setting	Note
159	Krs	Ks	Re/Rl (ReR1)	
160	Kxs	Ks	Xe/Xl (XeX1)	
161	Krm	Ks	Rm/Rl (RmR1)	
162	Kxm	Ks	Xm/Xl (XmX1)	
163	KrsR	KsR	Re/Rl (ReR1)	
164	KxsR	KsR	Xe/Xl (XeX1)	

Note: please don’t forget to insert inside ”Ks” and ”KsR” the value of *Line angle (lineangle)*. Such value must be equal to $\arctan(X1/R1)$ in degrees.

3.8 Power Swing subrelay

This subrelay contains the logic which detecting the power swings.

3.8.1 Available Units

- Four 3 phase load encroachment elements (”PSBOUT Phase 1”, ”PSBIN Phase 1”, ”PSBOUT Ground 1”, and ”PSBIN Ground 1” block).
- Four 3 phase polygonal elements (”PSBOUT Phase 2”, ”PSBIN Phase 2”, ”PSBOUT Ground 2”, and ”PSBIN Ground 2” block).
- One Power Swing detection element (”Power Swing” block).
- One earth definite time overcurrent element (”EFL” block).
- Two logic elements (”Logic IN OUT”, and ”Block switch” block).

3.8.2 Functionality

The Power Swing subrelay defines separated power detection zones for the phase and the ground loops.
Each couple of Polyogonal and Load Encroachment blocks (i.e.”PSBOUT Phase 1” and ”PSBOUT Phase 2”) defines a power swing detection shape. A total of four shapes, two for the phase loops and two for the ground loops are available. Two shapes (the *IN* and *OUT*) define a power detection zone which is active for the phase or for the ground loops. The ”Logic IN OUT” block combines together the phase trip signals of the polyogonal and load encroachmenet zones and calculates the trip of the power detection zones. The ”Power Swing” block calculates the time the working point spends between each external and internal detection zone. If this time is greater than the *TPSB* relay setting a power swing is detcted and the output blocking signal is activated for 500 ms.
The power swing blocking is inhibited when the earth current is greater than the earth current threshod ”ELF”.
The user can configure which distance elements are blocked by the power swing blocking signal using the dip switches present inside the ”DIP Settings” tab page of the ”Block switch” element.

3.8.3 Data input

The PSBIN reach, calculate automatically by the relay, must be set manually in the model to coordinate with the Z3 and Z4 settings. When the polygonal zones are active, the *BND(BND)* parameter of the ”PSBOUT Phase 1” block should be set equal to the *+R Resistance (Rmax)* parameter of the ”ZFS” block, the *Z Reach (Zmax)* parameter of the ”PSBOUT Phase 2” block should be set equal to the *ZReach (Zmax)* parameter of the ”ZFS” block. Same logic should be used for the relevant ground blocks.

The PSBOUT reach is equal to the PSBIN reach plus the *PSBSZ* (or *PSBGZ* for the ground loops) relay setting.

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, the addresses are the setting numbers as listed at pag 355 of [1]):

Address	Relay Setting	Model block	Model setting	Note
28	PSB-Z1	Block switch	Z1 block	In the ”DIP Settings” tab page
29	PSB-Z1X	Block switch	Z1X block	In the ”DIP Settings” tab page
30	PSB-Z2	Block switch	Z2 block	In the ”DIP Settings” tab page
31	PSB-Z3	Block switch	Z3 block	In the ”DIP Settings” tab page
33	PSB-ZF	Block switch	ZF block	In the ”DIP Settings” tab page
34	PSB-ZR1	Block switch	ZR1 block	In the ”DIP Settings” tab page
35	PSB-ZR2	Block switch	ZR2 block	In the ”DIP Settings” tab page
178	PSBSZ	PSBOUT Phase 1	BND(BND)	Set ”PSBOUT Phase 1” BND=”PSBIN Phase 1” BND + PSBSZ
		PSBOUT Phase 2	Z Reach (Zmax)	Set ”PSBOUT Phase 2” Zmax=”PSBIN Phase 2”Zmax + PSBSZ
179	PSBGZ	PSBOUT Ground 1	BND(BND)	Set ”PSBOUT Ground 1” BND=”PSBIN Ground 1” BND + PSBSZ
		PSBOUT Ground 2	Z Reach (Zmax)	Set ”PSBOUT Ground 2” Zmax=”PSBIN Ground 2”Zmax + PSBSZ
182	TPSB	Power Swing	tP1 (tP1)	In the ”Timers” tab page
213	EFL	EFL	Pickup Current (Ipsetr)	

3.9 Out of step subrelay

This subrelay contains the logic which detecting the out of step condition.

3.9.1 Available Units

- Two 3 phase polygonal elements (”Zm”, and ”Zn” block).
- One Out of Step detection element (”OST” block).
- Two logic elements (”Logic A-B-C”, and ”Outer zone logic” block).
- Two timers (”TOST1”, and ”TOST2” block).

3.9.2 Functionality

The Out of step subrelay detects a out of step condition counting the intersections with the boundaries of zone *A*, *B*, and *C*. The zones are defined in the model by the intersections between two quadrilateral zones named *Zm* and *Zn*. The zone trips activation can be delayed by two independent timers.

3.9.3 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, the addresses are the setting numbers as listed at pag 355 of [1]):

Address	Relay Setting	Model block	Model setting	Note
83	OST	OST	Out of Service (outserv)	
183	OSTR1	Zm	+R Reach (Rmax)	
		Zn	-R Reach (Rmin)	
184	OSTR2	Zm	-R Reach (Rmin)	
		Zn	+R Reach (Rmax)	
185	OSTXF	Zm	+X Reach (Xmax)	
		Zn	+X Reach (Xmax)	
186	OSTXB	Zm	-X Reach (Xmin)	
		Zn	-X Reach (Xmin)	
187	TOST1	TOST1	Time Setting (Tdelay)	
188	TOST2	TOST2	Time Setting (Tdelay)	

3.10 Output logic

3.10.1 Available Units

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

3.10.2 Functionality

Each *Output Logic* block can operate the power breaker. Please disable the ”Output Logic” block to disable the relay model ability to open the power circuit.

The ”Output Logic” block can trigger a 3 phase trip or a single phase trip for phase ground faults or a two phase trip for phase-phase faults. The output signals are *yout* (3 phase trip), *yout_A* (phase A trip), *yout_B* (phase B trip), *yout_C* (phase C trip).

3.10.3 Data input

The ”Output Logic” block can be configured to trigger a 3 phase trip selecting the *yout* trip signal in the ”Tripping signals” (sTripsig) combo box in the ”Basic Data” tab page and setting the *single_pole_trip* and the *two_poles_trip* variable equal to ”NOTRIP” in the ”Logic” tab page.

The single phase trip can be enabled setting the *single_pole_trip* variable equal to ”TRIP” and the *two_poles_trip* variable equal to ”NOTRIP” in the ”Logic” tab page.

The two phase trip can be enabled setting the *single_pole_trip* variable equal to ”NOTRIP” and the *two_poles_trip* variable equal to ”TRIP” in the ”Logic” tab page.

4 Features not supported

The following features are not supported:

- Pilot accelerated trips (DUTT, POTT, PUTT etc.).
- Broken Conductor Protection.
- Switch-Onto-Fault Protection.
- Stub Protection.
- Voltage and Synchronism Check Elements OVL, UVL, OVB, UVB, and SYN.
- Current Change Detection Elements OCD and OCDP.
- Negative Sequence Directional Elements DOCNF and DOCNR
- Breaker Failure.
- Voltage Transformer Failure Supervision.
- Fault Locator.

5 References

[1] Toshiba Corporation Fuchu Operations - Industrial and Power Systems and Services, 1, Toshiba-cho, Fuchu-shi, Tokyo, Japan. *INSTRUCTION MANUAL DISTANCE RELAY GRZ100 - ***B6 F 2 S 0 8 4 6 Ver.0.5*, 2005.