

Test Tutorial

Equipment Type: Protection Relay

Brand: SIEMENS

Model: <u>7SA611</u>

Function: <u>68 or RPSB - Power Swing Blocking (PSB) & 78 or</u> <u>PPAM - Out of step (OoS)</u>

Tool Used: <u>CE-6006, CE-6707, CE6710, CE-7012 or CE7024</u>

Objective: <u>Test of PSB and OoS in Conditions of Synchronous,</u> Asynchronous and Faulted Power Oscillations.</u>

Version Control:

Version	Descriptions	Date	Author	Reviewer
1.0	Initial Version	06/04/2022	M.R.C.	G.C.D.P.



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A.1 Terminal Designations	
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Statement of responsibility

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Suggestions for improvement of this material are welcome, just user contacts us via email suporte@conprove.com.br.

The tutorial contains knowledge gained from the resources and technical data at the time was writing. Therefore, CONPROVE reserves the right to make changes to this document without prior notice.

This document is intended as a guide only; the manual of the equipment under test should always be consulted.



The equipment generates high current and voltage values during its operation. Improper use of the equipment can result in material and physical damage.

Only suitably qualified people should handle the instrument. It should be noted that the user must have satisfactory training in maintenance procedures a good knowledge of the equipment under test and also be aware of safety standards and regulations.

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INSTRUMENTOS PARA TESTES ELÉTRICOS Sequence for testing the 7SA611 relay in the PSB_OoS software

1. Relay Connection to CE-6710

Appendix A-1 shows the relay terminal designations.

1.1 Auxiliary Source

Connect the positive (red terminal) of the Auxiliary Source to pin F1 (UH+) of the relay and the negative (black terminal) of the Aux Source Vdc to pin F2 (UH-) of the relay.



1.2 Current and Voltage Coils

To establish the connection of voltage coils, connect channels V1, V2 and V3 with pins R15, R17 and R18 of the relay terminal and common to pin R16. To establish the connection of the current coils, connect channels I1, I2 and I3 with pins Q1, Q3 and Q5 of the relay terminal and make a short circuit between pins Q2, Q4 and Q6.







1.3 Binary Inputs

Connect the binary inputs of the CE-6710 to the binary outputs of the relay:

- BI1 to pin R1 and its common to pin R4.
- BI2 to pin R3 and its common to pin R4.
- BI3 to pin R5 and its common to pin R4.



Figure 3

2. Communication with the 7SA61 relay

First, open "*DIGSI*" and connect an Ethernet (or serial) cable from the notebook to the relay. Then double click on the software icon.



After opening the program, the substation that contains the relay in question (7SA61) is selected. After selecting the relay, right-click and select the "*Open Object*" option and then select the connection mode, as shown in the following figures.



🛃 DIGSI Manager	- [Carvalho C:\Siemen:	VDigsi4VD4projVCarvalh	•]	
🛃 Eile Edit Insert	<u>D</u> evice <u>V</u> iew <u>O</u> ptions <u>W</u> i	ndow <u>H</u> elp		
		< No Filter >	• 🏏 🖻 🗖	<u>k?</u>
Carvalho	👌 7SA611 V4	.6 🍵 7SJ612 V4.6	🏮 7UM623 V4.6	🏮 7UT613 V4.6
		Figure 5		
	Open device		×	
	Connection type	Connection properties		
	C Offline	No settings required for this connection	i type.	
	C Direct			
	C USB			
	Ethernet			
	ОК	Ca	incel Help	
		Figure 6		

3. Parameterization of relay 7SA61

3.1 Device Configurations

After the connection has been established, access the relay's general settings by double-clicking the left button on *"Settings"* repeat the operation for *"Device Configuration"*.



JIGSI - [Carvalho / Folder / 7SA611 V4.6/7SA611 V04.68.03]							
📴 File Edit Insert Device View Options Window Help							
📙 🚑 X 🖻 🖻 🖨 🕍 🎭 🏾	I 🕅 💀 🕮 🗰 🗰 🗰 🕺						
⊡ Image: Settings Image: Settings Image: Setings Imag	Select function Device Configuration Masking I/O (Configuration Matrix) CFC Power System Data 1 Setting Group A Cocillographic Fault Records General Device Settings Time Synchronization Interfaces Passwords						
 Fig	abcLanguage Ture 7						

On the "Functional Scope" screen, disable all functions leaving only the "21 Distance protection pickup program" and "68 Power Swing detection" functions enabled. This prevents trips from other functions from interfering with the test. After the adjustments, click "OK".

	Function	Scope	1
0103	Setting Group Change Option	Disabled	-
0110	Trip mode	1-/3pole	
0114	21 Distance protection pickup program	Z< (quadrilateral)	ъ
0120	68 Power Swing detection	Enabled	
0121	85-21 Pilot Protection for Distance prot	Disabled	
0122	DTT Direct Transfer Trip	Disabled	
0124	50HS Instantaneous SOTF	Disabled	=
0125	Weak Infeed (Trip and/or Echo)	Disabled	
0126	50(N)/51(N) Backup OverCurrent	Disabled	
0131	50N/51N Ground OverCurrent	Disabled	
0132	85-67N Pilot Protection Gnd. OverCurrent	Disabled	
0133	79 Auto-Reclose Function	Disabled	
0134	Auto-Reclose control mode	with Trip and Action time	-
0135	25 Synchronism and Voltage Check	Disabled	
0136	81 Over/Underfrequency Protection	Disabled	
0137	27, 59 Under/Overvoltage Protection	Disabled	
0138	Fault Locator	Disabled	~

Figure 8



3.2 Masking I/O

The next step is to adjust the relay output. To access these parameters, double-click the left button on "Masking I/O (Configuration Matrix)" as shown in the next figure.



Binary output BO1 is designated for sending the tripping of zones 1, 2, 3 and 4. In order to aid the test, LED 1 is used to signal the tripping of zone 1, LED 2 to signal the zone 2 tripping, LED 3 to signal zone 3 tripping and LED 4 to signal zone 4 tripping. Binary output BO3 is designed for power swing blocking, to signal the signal sending, use LED 5.

DIGSI - [Settings - Masking I/O (Configuration Matrix) - Carvalho / Folder / 7SA611 V4.6/7SA611]																																	
# Elle Edit Insert Device View Options Window Help - 日×																																	
🖶 🎒 👗 🗊 💼 🌮 🎎 🎘 ∓ 🌋 Indications and commands only 💽 Configured to BI, BO, or LED 💽 🗊 🗓 🖤 🗰																																	
Information Source									 Destination																								
	Number	Display text	4	т	п	F	SC					E	30										LED	Ds							S 2	X C	CM
			1	1	DI			1	2	3	4 5	5 6	7	8	9 1	0 11	12	1	2	3	4 5	6	7	8	9 1	10 1	1 12	2 13	14	D			
Device, General						1	××	1									1	8				1			1						×	×	i i i
P.System Data 1	P.System Data 1																																
Osc Device, Genera	al Settings Expan	व		8.	5	3			8				18				8	3				13					13				×		1
P.System Data 2	s			-		3	2 12	- 2	-	0	2 2		-	0	2 - 2		-	-		2		-		2	2			-	200	2 2	- 22	211	
	03801	21 TRIP		~			0 00	U	-			-				-	~	2			-	-					~	-			X		
	03811	21 TRIP 1p. Z1																U													X		
	03823	21 TRIP3p. Z1sf																U													X		
21 Dis Coursel	03824	21 TRIP3p. Z1mf						1					1					U									1				X		
21 Dis.General	03816	21 TRIP 1p. Z2	1	-		2		0				8	1			1	1	0	U			8					1				X		1
	03817	21 TRIP 3p. Z2	5	0		S	-	-	-	(a) (a)	-	-	1	-	0 - C	-	-	2	U	-	-	-	() ()	-	5	1	- 22	1	() (X	1	-
	03818	21 TRIP 3p. Z3		3		3	\$ 3	3	3	3	4 3	3	3	3	3 3	3	3	3	3	U	3	3	3	3	3 3	8	3	3	3		X		6
	03821	21 TRIP 3p. Z4					-													l	J										X		
21 Dis.ZoneQuad																																	
CO D C .	04164	68 Power Swing	1					1		U											U										X		
68 Power Swing	04166	68T Pswing TRIP									U	I						1				U									X		
Measurem.Superv								1								1															×		
EN100-Modul 1																																	
Testina				2.1		S. 1	5 - S.	1	2				2		8		2	2										1					
								Fi	igı	ure	e 1	0																					



3.3 Power System Data 1

Double-click on "Power System Data 1" to access the system settings.



Those settings highlighted in red in the next couple of figures need special attention. First the VT and CT data are shown, then the system data and finally the circuit breaker data.

3.4 Transformers

In the "Transformers" tab, configure the CT and VT ratio of the system.

Power	r Sys	stem Data 1	×					
Trans	sform	ers Power System Breaker						
<u>S</u> etti	tings:							
N	۹o.	Settings	Value					
02	201	CT Starpoint	towards Line 💌					
02	203	Rated Primary Voltage	400,0 kV					
02	204	Rated Secondary Voltage (Ph-Ph)	115 V					
02	205	CT Rated Primary Current	1000 A					
02	206	CT Rated Secondary Current	5A					
02	210	V4 voltage transformer is	Vsy2 transformer					
02	211	Matching ratio Phase-VT To Open-Delta-VT	1,73					
02	215	Matching ratio Vsy1 / Vsy2	1,00					
02	220	I4 current transformer is	Neutral Current (of the protected line)					
02	221	Matching ratio I4/lph for CT's	1,000					
		av additional settings						
	2							
		Export	<u>G</u> raph <u>A</u> bout					
	OK	Apjicar DIGSI -> Device	Cancelar Ajuda					

Figure 12



3.5 Power System

In the "*Power System*" tab, the rated frequency, the phase sequence, whether the system is grounded and how the ground compensation for ground faults will be performed.

Po	wer Sy	stem Data 1		
ſ	ransform	ers Power System Breaker		
	<u>S</u> ettings:			
	No.	Settings		Value
	0207	System Starpoint is		Solid Grounded 💌
	0230	Rated Frequency		60 Hz
	0235	Phase Sequence		ABC
	0237	Setting format for zero seq.comp. format		Zero seq. comp. factor KU and angle(KU)
			_	
	□ <u>D</u> isp	ay additional settings		
			Export	Graph About
	OK	Aplicar DIGSI -> Device		Cancelar Ajuda

Figure 13

3.6 Setting Group A

In this option, important data about the protected transmission line and the parameters of the impedance function are set, whose calculations will be shown later.







With a double click on the option "Power System Data 2".

s	etting	Group A	
	Eunctior	15:	
	No.	Function	
	0011	Power System Data 2	
	0012	21 Distance protection, general settings 21 Distance zones (guadrilateral)	
	0029	Measurement Supervision	
	Cua	tomize Reset	About
	C <u>u</u> s	<u><u>n</u>eset</u>	Apoul
-			
	<u>C</u> lo	se	Help

Figure 15

3.7 Power System Data 2

In the "*Power System*" tab, important data are parameterized, such as: full-scale measurement of voltage and current, line angle, slope angle of the distance characteristic and compensation factors for earth faults. The other tabs are not relevant for this test.

Po	wer Sy	stem Data 2 - Settings Group A	X
F	Power Sy	stem Line Status Trip 1-/3-pole	
	<u>S</u> ettings:		
	No.	Settings	Value
	1103	Measurement: Full Scale Voltage (100%)	400,0 kV
	1104	Measurement: Full Scale Current (100%)	1000 A
	1105	Line Angle	60 °
	1211	Angle of inclination, distance charact.	60 °
	1107	P,Q operational measured values sign	not reversed
	1120	Zero seq. comp. factor K0 for zone Z1	0,880
	1121	Zero seq. comp. angle for zone Z1	0,00 *
	1122	Zero seq.comp.factor K0,higher zones >Z1	0,880
	1123	Zero seq. comp. angle, higher zones >Z1	0,00 °
	☑ <u>D</u> isp	lay additional settings	
		Export	<u>G</u> raph <u>A</u> bout
	OK	Aplicar DIGSI -> Device	Cancelar Ajuda

Figure 16



3.8 21 Distance protection/ General settings

The next step in the "General" tab is to activate function 21, disable the series line compensation and adjust the load compensation, which in this case will be infinite.

21 Dista	nce protection, general settings - Settings Group A	X					
General	Ground faults Time Delays						
<u>S</u> ettings	- -						
No.	Settings	Value					
1201	21 Distance protection is	ON 🔻					
1202	Phase Current threshold for dist. meas.	0,50 A					
1211	Angle of inclination, distance charact.	60 °					
1208	Series compensated line	NO					
1232	Instantaneous trip after SwitchOnToFault	Inactive					
1241	R load, minimum Load Impedance (ph-g)	oo Ohm					
1242	PHI load, maximum Load Angle (ph-g)	45°					
1243	R load, minimum Load Impedance (ph-ph)	oo Ohm					
1244	PHI load, maximum Load Angle (ph-ph)	45°					
1317A	Single pole trip for faults in Z2	YES					
1357	Z1B enabled before 1st AR (int. or ext.)	NO					
▼ <u>D</u> isp	olay additional settings						
	Export	<u>G</u> raph <u>A</u> bout					
ОК	Aplicar DIGSI -> Device	Cancelar Ajuda					

Figure 17

In the *"Time Delays"* tab, the time delays of each zone are adjusted, both for three-phase faults and for ground faults.

No.	Settings	Value
1210	21 Condition for zone timer start	with distance pickup
1305	T1-1phase, delay for single phase faults	0,00 se
1306	T1multi-ph, delay for multi phase faults	0,00 se
1315	T2-1phase, delay for single phase faults	0,30 se
1316	T2multi-ph, delay for multi phase faults	0,30 se
1325	T3 delay	0,60 se
1335	T4 delay	0,90 se
1345	T5 delay	00 56
1355	T1B-1phase, delay for single ph. faults	0,00 se
1356	T1B-multi-ph. delay for multi ph. faults	0.00 se
Disp	olay additional settings	port Graph About

Figure 18



3.9 21 Impedance Distance Zones (Quadrilateral)

Set the impedance values of zones 1, 2, 3 and 4 for three-phase/single-phase faults and their respective time delays. In this test, the Z1B zone will not be used.

21	Distan	nce zones (quadrilateral) - Settings Group A			
Z	one Z1	Zone Z1B-exten. Zone Z2 Zone Z3 Zone Z4 Zone Z5			
Ş	Settings:				
1	No.	Settings	Value		
	1301	Operating mode Z1	Forward 🔻		
	1302	R(Z1), Resistance for ph-ph-faults	0,250 Ohm		
	1303	X(Z1), Reactance	0,500 Ohm		
	1304	RG(Z1), Resistance for ph-gnd faults	0,250 Ohm		
	1305	T1-1phase, delay for single phase faults	0,00 sec		
	1306	T1multi-ph, delay for multi phase faults	0,00 sec		
	1307	Zone Reduction Angle (load compensation)	0.		
J					
1		I I I I I I I I I I I I I I I I I I I			
1	Dispi	lay additional settings			
-					
		<u> </u>	t <u>G</u> raph <u>A</u> bout		
_					
	OK	Aplicar <u>D</u> IGSI -> Device	CancelarAjuda		

Figure 19

No.	Settings	Value
1311	Operating mode Z2	Forward
1312	R(Z2), Resistance for ph-ph-faults	0,500 O
1313	X(Z2), Reactance	1,000 O
1314	RG(Z2), Resistance for ph-gnd faults	0,500 O
1315	T2-1phase, delay for single phase faults	0,30 s
1316	T2multi-nh delay for multi nhase faults	0.30 s
1316	T2multi-ph, delay for multi phase faults	0,30 s
1316	T2multi-ph, delay for multi phase faults	0,30 s
1316	T2multi-ph, delay for multi phase faults	0,30 s
1316	T2multi-ph, delay for multi phase faults	0,30 s
1316	T2multi-ph, delay for multi phase faults	0,30 s
1316	T2multi-ph, delay for multi phase faults	0,30 s
1316	T2multi-ph, delay for multi phase faults	0,30 s
<u>D</u> isp	T2multi-ph, delay for multi phase faults	0,30 s
<u>D</u> isp	T2multi-ph, delay for multi phase faults	0,30 s

Figure 20



21	21 Distance zones (quadrilateral) - Settings Group A 🛛 🛛 🔀						
Z	one Z1	Zone Z1B-exten. Zone Z2 Zone Z3 Zone	Z4 Zone Z5				
	Settings:						
	No.	Settings	Value				
	1321	Operating mode Z3	Reverse				
	1322	R(Z3), Resistance for ph-ph-faults	1,000 Ohm				
	1323	X(Z3), Reactance	2,000 Ohm				
	1324	RG(Z3), Resistance for ph-gnd faults	1,000 Ohm				
	1325	T3 delay	0,60 sec				
2							
		an additional antique					
1	Dish	ay auauona seungs					
			Europt Graph About				
	0.96	-					
	OK	Aplicar <u>D</u> IGSI → Device	Cancelar Ajuda				

Figure 21

No.	Settings	Value
1331	Operating mode Z4	Non-Directional
1332	R(Z4), Resistance for ph-ph-faults	2,400 Oh
1333	X(Z4), Reactance	2,400 Oh
1334	RG(Z4), Resistance for ph-gnd faults	2,400 Oh
1335	14 delay	0,90 se

Figure 22



3.10 68 Power Swing Detection

The next step is to activate function 68, activate the power swing trip and determine the tripping time after power swing blocking.

68	Power	Swing detection - Settings Group A				X
	1					
S	ettings:					
Γ	No.	Settings			Value	
	2002	Power Swing Operating mode			all zor	nes blocked 💌
	2006	68T Power swing trip				YES
	2007	68 Trip delay after Power Swing Blocking				0,08 sec
Ľ,	_					
1	Disp	ay additional settings				
-			45. 2	1	1	
			Export	G	raph	About
						-
	OK	Aplicar DIGSI -> Device			Cancelar	Aiuda

Figure 23

4. PSB OoS software adjustments

4.1 Opening the PSB OoS

Click on the "*CTC*" application manager icon.



Click the "PSB OoS" software icon.









Figure 26



4.2 Configuring the Settings

When opening the software the "Settings" screen will open automatically (provided that the option "Open Settings on Start" found in the "Software Options" menu is selected). Otherwise, click directly on the "Settings" icon.



Figure 27

Inside the "Settings" screen, fill in the "General Inform." with details of the tested device, installation location and the person responsible. This makes reporting easier, as this tab will be the first to be shown.

	Constitution Report Office Forest Constitution Office Constitution	
General	General Inform. System Notes & Obs. Explanatory rigures Check List Others Connections	
	lest.	
)istance	Descr: Power Swing Block and Out of Step Date: 05/04/2022 16:00:01	
	Tested device:	
	Identif: 23031982 V Model 7SA611	~
	Type: Line Protection V Manufacturer: Siemens	~
	Location:	
	Substation: Conprove	~
	Bay: 1 ~	
	Address: Visconde de Ouro Preto 75, Custódio Pereira	~
	City: Uberlåndia V State: MG	~
	Responsible:	
	Name: Michel Rockembach de Carvalho	~
	Sector: Engineering V Registry: 0001	~
	Tool Test:	
	CE-6710 Series Num.: 01108177CCM33222211U5HVRGLGLGL2Z0RXX	_

Figure 28



4.3 System

In the following screen, within the "*Nominal*" sub tab, the values of frequency, phase sequence, primary and secondary voltages, primary and secondary currents, transformation ratios of VTs and CTs are configured. There are also two sub-tabs "*Impedance*" and "*Source*" whose data are not relevant for this test.

ngs		
General	General Inform. System Notes & Obs.	Explanatory Figures Check List Others Connections
	K < NO01 > >	
Distance	Nominal Impedance Source	a
	Frequency: 60 Hz 🗸	► Forward OF
	Phase Seq.: ABC V	
	30 power: 119 5 MVA	
	1m: 39.84 MVA	
	Drimony Victores (ED) 120.0 KV	
	(Th) 70.07.0 (V]3 E † ₀]3 E → 3
	(FN): 79,67 KV	
	Primary Current: 0,500 kA	
	Secondary Voltage (FF): 115,0 V	
	(FN): 66,40 V	
	Secondary Current: 5,00 A	
	VTR F: 1,20 k	Phase F Neutral N Ground F Displ D
	CTR F: 100.0	
	VTR D / VTR F: 1,00	Voltage Currents
	CTR E / CTR F: 1,00	1 Va 5 la k to V0: 1.00
	Invert Polarity:	FN 2 Vb F 6 lb k to V2: 1,00
	🗌 VT's F 🔄 CT's F	F & IF kto I0: 1,00
	□ VT D □ CT E	D 4 VD EP 9 IEP kto 12 1.00
-		
Default 🗸 Im	port Export	Preferences <u>O</u> K <u>C</u> ancel

There are other tabs where the user can enter notes and observations, explanatory figures, can create a *"check list"* of the procedures for carrying out the test and even create a diagram with all the schematic of the connections between the test set and the test equipment.

5. Distance Adjustments

Note: The relay will only be parameterized for two-phase and three-phase faults. For the software to perform the test properly, 4 types of zones must be inserted, all for two-phase and three-phase faults.



5.1 Distance screen > Distance Prot. Settings

If the user wants to test a ground fault during power swing blocking, it is necessary to register 4 more distinct zones and adjust the ground compensation factor, highlighted in red in the figure below.



Figure 30

5.2 Inserting Phase Zones

Note: <u>There is an extremely practical and fast way to import the characteristic</u> <u>of the zones. See Appendix C.</u>

The first zone to be entered will be zone-1 (LL+ABC). Click on the "*Insert*" field highlighted in green in the previous figure. On the settings screen, first choose the relay mask "*Siemens 7SA6/7SA8/7SL8 - Quadr.*". You must adjust the actuation time, choose the type of fault (loop) and insert the characteristics of the zone and the directionality. Adjust the tolerance values and finally click "*OK*".





Figure 31

Click on "Insert" again and adjust the values for zone 2.



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By clicking on "Insert" one more time, the values for zone 3 must be adjusted.



Figure 33

Repeat the process for zone 4.



Figure 34



6. Channel Targeting and Hardware Configurations

Click on the icon illustrated below.

🛱 🗋	🛱 📋 🚰 🚽 PSB OoS 2.02.171 (64 Bits) - CE-6710 (0301018)						
Arquivo	Home	Display	Softwa	re Option	IS		
Channels Direc	Hrd Se Sync. S Conne	et €o GO Set ⁵o SV action	OSE Set Set	Start	Stop	 Next Point Next group 	d Clear test ∰ Clear all
	avvare				Generation		

Figure 35

Channels Direct. П × Local Hard.: Nodes O Basic Adapt I/Os -Confirm Reset for Hard. Connected Model Set CE-6710 Advanced S GOOSE.. Autoassociate -Cancel Autoassociate Remotes Serial Number 03010187CCM33222211U5HVRGLGLGL2Z0RX0 V 🔽 ON Line ^s∪ S. Value. Clean -Clean ŝ Import Export Outputs: Analog. and SV Inputs: Analog. and SV Outputs: Binary, GOOSE and Analog DC Inputs: Binary, GOOSE and Analog. DC Logical **«** » Analog Outputs Sampled Value Outputs NO01 + | • m 1/1 Voltage Channels 🖓 v | 🔶 v | 🗕 v < 🔿 🔿 📥 m Descr. Hardware Node Point Nominal Line Source Frequency: 60 Hz AO V02 NO01 V2 Vb ABC Phase Seq.: R AO V03 V3 ▼ NO01 ▼ Vc • 0 OBJ AO_V04 V4 NO01 ▼ UD • 30 power: 119.5 MVA 1φ: 39.84 MVA y Voltage (FF): 138,0 KV (FN): 79,67 KV Primary Current: 0,500 kA Secondary Voltage (FF): 115,0 V 🝸 v | 🔶 v | 🗕 Current Channels (FN): 66,40 V Channel Hardware Voltage Channel Currents Descr. Node Point Secondary Current: 5,00 A AO_V01 AO_I01 1 Va 5 la AO_10 VTR F: 1,20 k FN 2 AO_V02 F AO_102 AO_102 Vb 6 lb \sim 12 NO01 ▼ Ib • CTR F: 100,0 3 Vc AO_V03 7 lc AO_103 AO_103 13 NO01 ▼ lc ▼ NO01 ▼ UD • VTR D / VTR F: 1,00 E 8 AO_104 14 Vab IE 15 NO01 - UD AO 105 FF Vbc EP 9 IEP Ŧ CTR E / CTR F: 1.00 NO01 ▼ UD -Vca ~ AO_106 16 Reverse Polarity D 4 VD ~ CT's F 🗌 VT's F k.V0 \sim k.10 CT E Calc Calc k.V2 k.l2 Equal Parameters Among Nodes k to V0 1.00 to V2 1,00 k to 10 1,00 to I2 1,00

Then click on the highlighted icon to configure the hardware.

Figure 36

Choose the channel configuration, adjust the auxiliary source, the method of stopping the binary inputs and click "OK".



ings	
aster Slave 1 Slave 2	Main Sampled Value Others
Model CE-6710 Serial Number 01108177CCM33222211U5HVRGLGLGL2Z0RXX Analog Outputs: Standard - Voltages: ••••••••••••••••••••••••••••••••••••	Binary Outputs: Auxiliar Source: Initial State Initial State BO1: NO BO2: NO BO4: NC BO5 and BO6 type: - 60 V
2 x 600 V; 180 VA 2 x 300 V; 150 VA 1 x 600 V; 350 VA 1 x 300 V; 250 VA	○ Conventional BO5: NO - 48 V BO6: NO - 24 V ○ IRIG (BO5) / Clock (BO6) - Other - Off
Customized Assoc. Standard - Currents: • 6 x 32 A: 220 VA • 3 x 64 A: 400 VA • 2 x 96 A: 550 VA • 11	Binary / Analog Inputs: BI1: BI - Contact BI2: BI - Contact BI3: BI - Contact BI4: BI - Contact BI5: BI - Contact
2 x 10.00 A; 300 VA 1 x 192 A; 1100 VA 1 x 6,00 A; 360 VA 1 x 6,00 A; 360 VA 14 15 16	BI6: BI - Contact BI7: BI - Contact BI8: BI - Contact BI9: BI - Contact BI9: BI - Contact BI10: BI - Contact BI11: BI - Contact
 1 x 75 A; 700 VA 1 x 50 A; 700 VA 	BI12: BI - Contact Considers absolute values to Voltage-BI AI 1-6 : 2V; 20V; 600V AI 7-12 : 200mV; 2V; 600V
Customized Assoc.	<u>OK</u> <u>Cancel</u>

Figure 37

On the next screen choose "Basic" and on the next window (not shown) choose "YES", finally click on "Confirm".

Cha	nels Direct.		– 🗆 X				
tes Local	Model Reset for Hard. CE-6710 O Adva	nced	Confirm				
Remo	03010187CCM33222211U5HVRGLGLGL2Z0RX0 V V ON L	ine ^s . S. Value	Import Export				
	Figure 38						

7. Restore Layout

Due to the great flexibility that the software presents, allowing the user to choose which windows are presented and in which position, this command is used to restore the default settings. Click on *"Recreate Charts"* and on *"Restore Layout"*.



🍄 🗋 💣 🛃 🤿 PSB OoS 2.02.171 (64	Bits) - CE-6710 (0110817)			
Arquivo Home Display Softwar	re Options			
Channels Direc & Sync. Set & Sync. Set Channels	Start Stop	Image: Settings Image: Waveform Settings Image: Waveform Image: Settings Image: Waveform Image: Settings Image: Setting sett	Present Report	Recreate Restore Charts Layout
Hardware	Generation	Options	Report Units	Layout
	Figure 39			

8. Test structure for PSB_OoS functions

8.1 Test Settings

By clicking on the "*Test Settings*" tab, the user must direct the channels and adjust the binary inputs as follows:

- BI01 = Dist Trip;
- BI02 = PSB Alarm;
- BI03 = Trip OoS.

Enable a pre-simulation condition with nominal conditions and 0.1s.

# + D	🚰 🛃 🚽 PSB OoS 2.02.1	171 (6	i4 Bits) - C	E-6006 (11502	214)								- o ×
Arquivo	Home Display	Softv	are Optior	ns									~ 🕜
Channel Direc	Hrd Set 😵 GOOS Sync. Set 5, SV Set Connection Hardware	SE Set t	Start	Stop Stop	Next Point 🧹 Next group 省 neration	Clear test Clear all	Settings	Present Report Report	 P) (S) abs rel Units 	Recreate Charts	Restore Layout Layout	View	
System	Simulation Trajectories S	Simula	tion Te	est Settings									
Genera	ation Channels Direc.		🔄 Enable	e Pre-Simulation	n 1	Enabl	e Pre-Simulation 2	🗆 E	nable Post-	Simulation			VTRNeutral/VTRPhase:
	Generation Channel		Mode	Nor	minal 👻	1							1,00
Va Vb	Va (Hrd: V1) Vb (Hrd: V2)	•	V1 V2	66,40 V 66,40 V	0 ° 240.0 °								CTRGround/CTRPhase:
Vc VD	Vc (Hrd: V3)	• •	V3	66,40 V	120,0 °	-							Inv. Phase VTs
la	la (Hrd: I1)	•	11	5,00 A	0*								U Inv. Neutral VT
lb	Ib (Hrd: 12)	•	12	5,00 A	240,0 °								Inv. Phase CTs
lc	Ic (Hrd: 13)	•	13	5,00 A	120,0 °								U Inv. Ground CT
Binary BO GO Si	outputs & Goose - Simulation 0; 0; 1; 1; 0; 0 mulate Error Sampled Value /	Y GO	Binary outp BO GO Simul	e Pre-Simulatio puts & Goose - 0; 0; 1; late Error Sam	I: 100,00 ms								
PS	SB Alarm BIO2 (Hrd: BI2)												Continuous Generation Among Trajectories in 😒
													Reset Time: 100,00 ms
ſ	Dist. Trip BI01 (Hrd: BI1)	<u> </u>											No. of repetitions in case of generation error: 2
C	DoS Trip BI03 (Hrd: BI3)	×											Stop the test at the first failure
Trigg	er Interf. Software	~	Trigger	r Logic 🛄									Based Only on Values Generated
	Wait for PPS (Trigger	r Delay 0,00 s	4								Cycle to Cycle Generation
10	New New						Aux S	ource: 110,	00 V H	leating:	0%		
								Figu	re 40)			

8.2 System Simulation

For the "System Simulation" test, a study must be carried out in order to simplify the system to two voltage sources with a line between them so that the power oscillations will occur according to these parameters. As we do not have this study, we chose the option "Trajectories Simulation".



INSTRUMENTOS PARA TESTES ELÉTRICOS 8.3 Synchronous Oscillation Trajectory Simulation

In the following test, a synchronous oscillation is simulated, where the activation of the Power Swing Alarm is expected. To perform the test click on "*New Trajectory*" then choose the number of points, impedance and angle values. The next step is to enter the rate of change of the impedance which must be different from "0". Choose the value of dZ/dt equal to 20.0 Ω /s.





Insert/Edit Points	
Insert/Edit	General Options
Edit Trajectory	Trajectory System Fault Evaluation
N <u>e</u> w Trajectory ❤	Source E : 115,0 V 0 °
Trajectories <u>G</u> roups	Set Z by: ZS; KS ✓ Mod. ZS 4.00 Ω Mod. KS 1.00
Remove	Ang ZS 80.00 * Ang KS 0 *
Remove <u>A</u> ll	
	<u>C</u> onfim Ca <u>n</u> cel

Figure 42



It is not necessary to make any adjustments in the "Fault" tab. The next step in the "Evaluation" tab is to set the "Operation" field to "Yes" and the "Interface" to "PSB Alarm" then click on "Confirm".

ert/Edit	General Options	
<u>E</u> dit Trajectory	Trajectory System Fault Evaluation	
New	Operation: 🔵 No 🚺 Yes	Interface: PSB Alarm \checkmark
Trajectory	Evaluation Time	
Trajectories <u>G</u> roups	Reference for Start Time Count:	Pre-Simulation 1 \sim
	Nominal Time: 50,00 ms	
Remove	Positive Time Tolerance: 30,00 ms	3
Remove <u>A</u> ll	Negative Time Tolerance: 30,00 ms	3
		<u>C</u> onfirm Ca <u>n</u> cel

Figure 43

Start the generation by clicking on the icon highlighted below or using the command "Alt + G".



Figure 44

After the end of the test, it is possible to visualize the waveforms, actuation of the binary inputs and the impedance and power trajectories.



INSTRUMENTOS PARA TESTES ELÉTRICOS 🚈 | 🗋 🗃 🚽 = | PSB OoS 2.02.171 (64 Bits) - CE-6006 (1150214) ð rquivo Home Display Software Options Image: Hord Set Scopes set Image: Start Hardware Generation Options Report Units System Simulation Trajectories Simulation Test Settings Insert/Edit Points Chart Waveform Phasors Trajectory General Options Insert/Edit Legend XIΩ ---- Trai Not Tested Edit Trajectory Trajectory System Fault Evaluation - Traj. Tested Interface: PSB Alam 3,00 Operation: 🔵 No 🛛 🔘 Yes New Trajectory Colors: Not Test Passed Evaluation Time 2,00 Trajectories <u>G</u>roups Pre-Simulation 1 Information: Nominal Time: 50,00 ms Positive Time Tolerance: 30,00 ms Remove 1,00 Atual Point: - |Z|: - Ø: Negative Time Tolerance: 30,00 ms Remove All 0 - R: - X: -1.00 Test Points • Points Tested -2,00 No. N° of Points Enabled Trajectory Fault Trajectory Interface Operating Operated Status 01 . No 0,500 s PSB Alarm Operation Yes Passed -3.00 Type: Individual V Seneral Info. Operation Time -4.00 -3,00 -2,00 -1,00 0 1.00 2,00 3,00 4,00 Errors List Protection Status Aux Source: 110,00 V Heating: 🚯 ON Line New ... 0% Figure 45

8.4 Simulation of Asynchronous Oscillation Trajectories

Click on the "*New Trajectory*" icon, use the highlighted points and keep the impedance variation of the previous test.

4]	× ^ 8
Signed Field Start Stop > Next Point ✓ Clear test Mode Waveform Mode Waveform	P Image: Second secon
System Simulation Trajectories Simulation Test Settings	
/Insert/Edit Points	Chart Waveform Phasors Trajectory
Insert/Edit General Options Edit Trajectory Trajectory System Trajectory Fault Evaluation New Trajectores Namber of Points: 2 → 2000 Ω/s Fault Evaluation Bemove Remove βl aZ/at Constant: 20.00 Ω/s Total	x(t) Legend: 300
Cancel Cancel Points Points Tested	
No. N ^e of Points Enabled Time of Trajectory Fault Trajectory Interface Operating Operated Status	
01 4 No 0.500 s PSB Alarm Operation Yes Passed	-3.00
Type: Individual Image: Constant Time Errors List Protection Status Time	-4,00 -3,00 -2,00 -1,00 0 1,00 2,00 3,00 4,00
New Aux Source: 1	10,00 V Heating: 0%
Fig	ure 46

Keep the previous test settings in the "System" tab.



Insert/Edit Points	
Insert/Edit	General Options
Edit Trajectory	Trajectory System Fault Evaluation
N <u>e</u> w Trajectory	Source E : 115,0 V 0 °
Trajectories <u>G</u> roups	Set Z by: ZS; KS ✓ Mod. ZS 4.00 Ω Mod. KS 1.00
<u>R</u> emove	Ang ZS 80.00 ° Ang KS 0 °
Remove <u>A</u> I	
	<u>C</u> onfirm Ca <u>n</u> cel

Figure 47

The next adjustment is in the *"Evaluation"* field, where the *"Operation"* should be set to *"Yes"* and the *"Interface"* to *"Trip OoS"*.

Insert/Edit Points			
Insert/Edit	General Options		
Edit Trajectory	Trajectory System Fault Evaluation		
New	Operation: 🔿 No 🔹 Yes	Interface: Trip OoS	~
Trajectory	Evaluation Time		
Trajectories	Reference for Start Time Count:	Pre-Simulation 1	~
	Nominal Time: 50,00 ms		
<u>R</u> emove	Positive Time Tolerance: 30,00 ms		
Remove <u>A</u> ll	Negative Time Tolerance: 30,00 ms		
		<u>C</u> onfirm	Ca <u>n</u> cel

Figure 48

After generating the signals, check the waveforms, the performance of the binary, the impedance trajectory and the time between the blinders following the final result.



annels Direc	Hrd Set	ුලි GC t ⁵, SV tion vare	OOSE Set	Start Stop	> Next P >> Next g	oint 🧹 Clea roup C lea	ar test ar all Setting	Waveform + Phasors 5 5 6 7 7 7 7 7 7 7 7 7 7 7 7 7	Present Report Report	Control Co	Recreate R Charts L	estore View ayout •	v					
tem S	Simulation	Trajectorie	es Simulatio	n Test Set	tings									_				
Inser ert/Ec Edit 1 Traje <u>G</u> Rer Rer	t/Edit Points dit Frajectory ectories emove hove <u>A</u> II Points	General (Traject Opera Refe Non Posi	Options tory Syste ation: O No Evaluation Tim erence for Sta ninal Time: tive Time Tol ative Time Tol	m Fault 1 Yes me art Time Count: 50,00 ms lerance: olerance:	Evaluation 30,00 ms 30,00 ms	Interface: Pre-Simulati	Trip OoS	>	•	3,00 - , 2,00 - 1,00 -	×tb							Legend: Traj. Not Tr Traj. Teste Colors: Not Ter Passed Fail Information: Atual Point - [Z]: - Ø: - R: - X:
nts Te	ested	Enabled Fault	Time of Trajectory		Operating Nominal	Operated	Status			-2,00	X				Æ	A	Å,	
	2	No	450,0 ms	OoS Trip	Operation	Yes	Passed			-3,00 -			A			4	X	
<u>e:</u>	ndividual	Gene	ral Info. 🕑	Operation (] Time						-4.00 -3	8,00 -2,0	00 -1.00	0 1	.00 2.0	0 3,00	R[Ω] 4,00	

8.5 Simulation of Three-Phase Fault Trajectories

In this test, the performance of the distance trip is verified. In this case, a dZ/dt of 100.00Ω /s should be set. To do this, make the following adjustments:





The parameters of the "System" tab are the same as in the previous test. The "Fault" field must be set as follows:

Insert/Edit Points		
Insert/Edit	General Options	
Edit Trajectory	Trajectory System	Fault Evaluation
	🔽 Enable Fault	
New Trajectory	Times	Fault Mode: Constant Current 🗸 15,00 A
Trajectories	Pre-Fault: 0 s	Tipo de Falta: ABC \checkmark Fault Location: 0.500
Groups	Fault:	Fault Start Mode: Fixed Angle \checkmark
Remove	100,0 ms	Reference Phase A \checkmark
	Post Fault:	Reference Angle to Fault Start: 0 °
Remove <u>A</u> II	0 s	Fault Resistance: 0Ω
		<u>C</u> onfirm Ca <u>n</u> cel
		Figure 51

Figure 51

In the "Evaluation" option, make the following adjustments:

Insert/Edit Points			
Insert/Edit	General Options		
Edit Trajectory	Trajectory System Fault Evaluation]	
New	Operation: 🔿 No 💽 Yes	Interface: Trip Dist	\sim
Trajectory	Evaluation Time		
Trajectories <u>G</u> roups	Reference for Start Time Count:	Pre-Simulation 1	\sim
Denue	Nominal Time: 50,00 ms	_	
Kemove	Positive Time Tolerance: 30,00 ms		
Remove <u>A</u> ll	Negative Time Tolerance: 30,00 ms		
		<u>C</u> onfirm	Ca <u>n</u> cel
	Figure 52		

After generating the signals, check the waveforms, the performance of the binary, the impedance trajectory and the time between the blinders following the final result.



INSTRUMENTOS PARA TESTES ELÉTRICOS 🚈 | 🗋 🗃 🚽 = | PSB OoS 2.02.171 (64 Bits) - CE-6006 (1150214) ð Arquivo Home Display Software Options Instruction Figure Clear test Image: Bync Set Image: Stop Start Stop Next group Image: Clear test Settings Image: Clear test Direc Image: Clear test Start Stop Next group Image: Clear test Settings Image: Clear test Image: Clear Hardware Generation Options Report Units System Simulation Trajectories Simulation Test Settings Insert/Edit Points Chart Waveform Phasors Trajectory -General Options Insert/Edit - Lege ---- Trai Not Tested Trajectory System Fault Evalua Edit Trajectory Enable Fault - Traj. Tested 3,00 ~ N<u>e</u>w Trajectory ✓ 15,00 A Fault Mode: Constant Current Colors: Not Test Passed Pre-Fault: 2,00 Trajectories <u>G</u>roups Fault Start Mode: Fixed Angle Fault: 100,0 ms Information: Reference Phase A Remove 1,00 Atual Point: Post Fault: 0 s Reference Angle to Fault Start: 0 - |Z|: - Ø: Remove All **0**Ω No Offse - R: - X: Test Points Points Tested -1.00 No. Nº of Points Enabled Trajectory Fault Time of Trajectory Interface Operating Nominal Operated Status -2,00 01 No 0,500 s PSB Alarm Operation 4 Yes Passed 02 2 No 450,0 ms OoS Trip Operation Yes Passed -3.00 03 2 Yes 248,4 ms Dist. Trip Operation Yes Passed Type: Individual V General Info. Operation Time -4,00 -3,00 -2,00 -1,00 Ó 1,00 2,00 3,00 4,00 Errors List Protection Status Aux Source: 110,00 V Heating: 🚯 ON Line New 0% Figure 53

9. Report

After finishing the test, click on the icon highlighted in the previous figure or using the "Ctrl + R" command to call up the report pre-configuration screen. Choose the desired language as well as the options that should be part of the report.



Figure 54





Figure 55



APPENDIX A

A.1 Terminal Designations



Figure 56



A.2 Technical data

α = Threshold angle for the increased resis	tance toler-	10° to 90°		Increments1°					
ance									
Determination of Direction									
For all types of faults		With phase-tru	With phase-true, memorized or cross-polarized voltages						
Directional sensitivity		Dynamically ur	nlimited						
		Stationary app	rox. 1 V						
Each zone can be set to operate in forward	l or reverse di	rection, non-dire	ectional or ineffective.						
Load trapezoid:									
R _{load} = minimum load resistance	for $I_N = 1 A$	0.100 Ω to 600	0.000 Ω; ∞	Increments0.001 Ω					
	for $I_N = 5 A$	0.020 Ω to 120	0.000 Ω; ∞						
ϕ_{load} = maximum load angle		20° to 60°		Increments1°					
Dropout to pickup ratio		•							
- Currents		Approx. 0.95							
- Impedances		Approx. 1.06							
Measured value correction		Mutual impeda	ance matching for paralle	l lines (ordering option)					
Measuring tolerances for sinusoidal measu	$\left \frac{\Delta X}{X}\right \le 5\%$	for $30^\circ \le \phi_k \le 90^\circ$							
		$\left \frac{\Delta R}{R}\right \le 5\%$	for $0^\circ \le \phi_k \le 60^\circ$						
		$\left \frac{\Delta Z}{Z}\right \le 5 \%$	for $0^{\circ} \leq \phi_k \leq 90^{\circ}$						

Times

Shortest trip time	Approx. 17 ms (50 Hz) /15 ms (60 Approx. 12 ms (50 Hz) /10 ms (60	Hz) with fast relay and Hz) with high-speed relay
Dropout time	Approx. 30 ms	
Stage timers	0.00 s to 30.00 s; ∞ for all zones; separate time setting possibilities for single- phase and multiphase faults for the zones Z1, Z2, and Z1B	Increments 0.01 s
Time expiry tolerances	1 % of setting value or 10 ms	
The set times are pure delay times.	·	

The interval from fault inception to trip command is made up of the set delay time plus the measuring time. The minimum measuring time is 10 ms, for faults close to the set zone boundary the maximum measuring time is approximately 40 ms.



APPENDIX B

Equivalence of software parameters and the relay under test.

		Table 1	
PSB_OoS Software		Siemens 7SA611 Relay	
Parameter	Figure	Parameter	Figure
Mod Z0/Z1	30	Zero seq. comp. K0 for Z1	16
Ang Z0/Z1	30	Zero seq. comp. Angle for Z1	16
Zn1_Fase		Phase Distance Z1	
Distance Angle	31	Angle of inclination, distance charact.	16
Forward/Reverse/Non-	31	Operating mode Z1	19
Directional			
R	31	R(Z1), Resistance for ph-ph faults	19
X	31	X(Z1), Reactance	19
Trigger Time	31	T1 multi-ph, delay for multiphase faults	19
Zone Reduction	31	Zone Reduction Angle	19
Zn2_Fase		Phase Distance Z2	
Distance Angle	32	Angle of inclination, distance charact.	16
Forward/Reverse/Non-	32	Operating mode Z2	20
Directional			
R	32	R(Z2), Resistance for ph-ph faults	20
X	32	X(Z2), Reactance	20
Trigger Time	32	T2 multi-ph, delay for multiphase faults	20
Zone Reduction	32	Zone Reduction Angle	20
Zn3_Fase		Phase Distance Z3	
Distance Angle	33	Angle of inclination, distance charact.	16
Forward/Reverse/Non-	33	Operating mode Z3	21
Directional			
R	33	R(Z3), Resistance for ph-ph faults	21
Х	33	X(Z3), Reactance	21
Trigger Time	33	T3 multi-ph, delay for multiphase faults	21
Zone Reduction	33	Zone Reduction Angle	21
Zn4_Fase		Phase Distance Z4	
Distance Angle	34	Angle of inclination, distance charact.	16
Forward/Reverse/Non-	34	Operating mode Z4	22
Directional			
R	34	R(Z4), Resistance for ph-ph faults	22
X	34	X(Z4), Reactance	22
Temp. Disp.	34	T4 multi-ph, delay for multiphase faults	22
Zone Reduction	34	Zone Reduction Angle	22



APPENDIX C

In the DIGSI software, export the .RIO file. Open the "21 Distance zones (quadrilateral)" window and choose the "Export" option.

21 Distance zones (quadrilateral) - Setting Group A							
Z	one Z1	Zone Z1B-exten. Zone Z2 Zone Z3 Zone Z4 Zone Z5					
	Settings:						
	No.	Settings	Value				
	1301	Operating mode Z1	Forward				
	1302	R(Z1), Resistance for ph-ph-faults	0,250 Ohm				
	1303	X(Z1), Reactance	0,500 Ohm				
	1304	RG(Z1), Resistance for ph-gnd faults	0,500 Ohm				
	1305	T1-1phase, delay for single phase faults	0,00 sec				
	1306	T1multi-ph, delay for multi phase faults	0,00 sec				
	1307	Zone Reduction Angle (load compensation)	0 °				
	_						
	🗖 Displ	ay additional settings					
_							
		Export	Graph About				
	ОК	Aplicar DIGSI -> Device	Cancelar Ajuda				

Figure 57

Click "OK" on the next screen.

Rio Export		×
Maximum values		
Maximum voltage (interlinked):	120 V	
Maximum current:	10 A	
Tolerances		
Tolerance of time zones (TOL-T):	1 % (rel.)	0,1 s (from)
Tolerance of impedances (TOL-Z):	5 % (rel.)	0,1 Ohm (from)
- Factors		
Complex grounding factor power (KS):	1 R	0 X
Complex power impedance (ZS):	0,259 R/Ohm	0,966 X/Ohm
Maximum permissible fast time (TIME0MAX):	01 8	
Correction of fault impedances	0,1	
by factor I/I(nom.):	FALSE 💌	
ОК	Cano	cel Help

Figure 58



Choose a name and folder to save the file.

诸 Salvar	como >	<					
Salvar em:	📃 Área de Trabalho 💽 🗢 🔝 📸 🔻						
	OneDrive						
2	Conprove						
	Este Computador						
Nome:	zonen_A Salvar						
Tipo:	Omicron export file (*.rio) Cancelar	Ī					
Figure 59							

In the PSB OoS software, inside the "Settings" window, import the file in the ".RIO" extension.



Figure 60



The figure below shows that all zones are registered, including earth fault zones.



Figure 61