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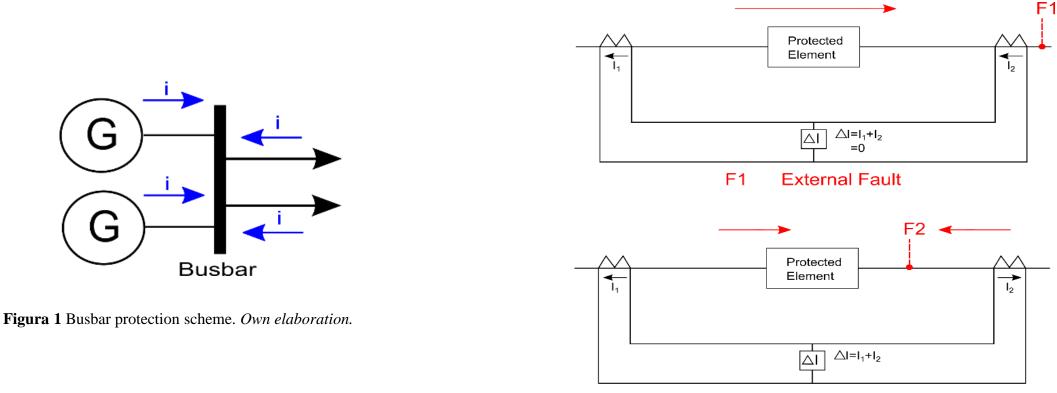
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Title: Development of busbar differential protection algorithm on PSCAD

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Introduction (Differential Protection Concept)



F2 Internal Fault

Figura 2 Differential protection internal and external faults. Own elaboration.

Objectivo

To develop an academic numerical Busbar Differential Protection on PSCAD (Power System Computer Assisted Design) and analyze the operation and behavior of this protection for the different types of faults, whether internal or external.

Justification

The developed Busbar Differential Protection can be used as simulation exercises for the undergraduate engineering students to better comprehend the operation of differential protection when there is an internal or external fault.

Hypothesis

The developed numerical Busbar Differential Protection on PSCAD should be sensitive enough to operate only for internal faults, in this case, faults on busbar. Whereas the algorithm should discriminate and not operate for any external faults whether they are single-phase, double-phase or even three-phase.

Methodology

(4)

$$I_{op_{me}} = |\overline{I_1} + \overline{I_2} + \overline{I_3} \dots \overline{I_n}|$$
(1)

$$I_{rest} = |\overline{I_1}| + |\overline{I_2}| + |\overline{I_3}| \dots |\overline{I_n}|$$
 (2)

$$I_{diff} = 1 A \tag{3}$$

$$I_{op_{cal}} = I_{diff} + k I_{rest}$$

- \rightarrow The measured tripping current
- \rightarrow The restraint current
- \rightarrow The differential current
- \rightarrow The calculated tripping current

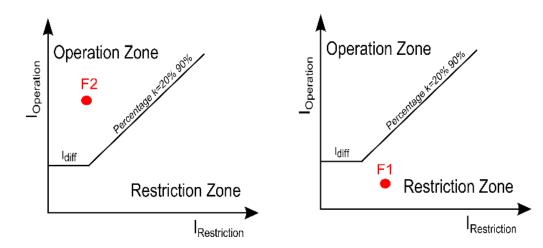


Figura 3 Differential protection characteristics: tripping zone and restraint zone.

Methodology

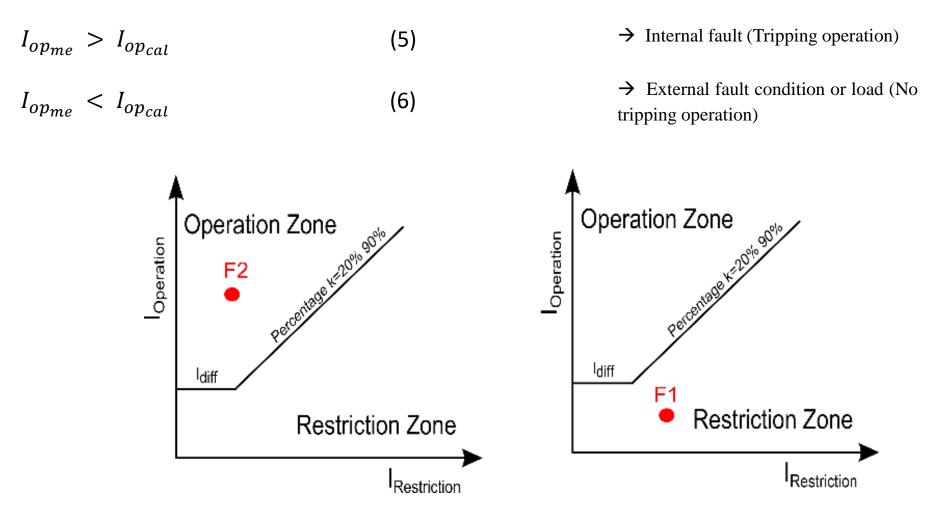
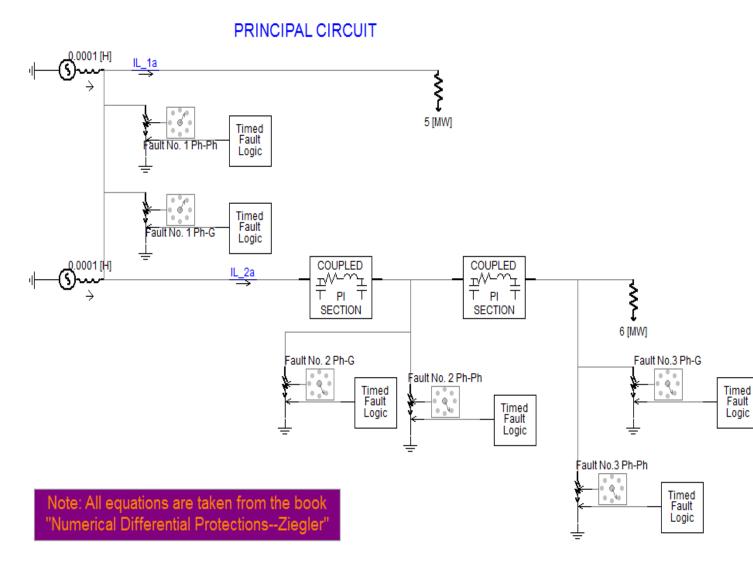


Figura 3 Differential protection characteristics: tripping zone and restraint zone.

Simulación



Parámetros	Valores
Gen 1 and 2	10 MVA
Internal Gen L	0.1 mH
Line 1	< 80 km
Line 2	> 240 km
Load 1	5 MW
Load 2	6 MW

Table 1 Test system data. Own elaboration.

Figure 4 Principal circuit under study in PSCAD.

Simulation

PHASE TO GROUND FAULT CONTROL PANEL

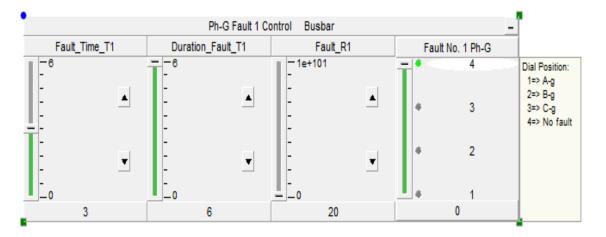


Figure 5 Phase to ground fault control in the protected zone (busbar).

Own elaboration.

PHASE TO PHASE FAULT CONTROL PANEL

F	h-Ph Fault 1 Control Busba	ar <u>–</u>	1
Fault_Time_1	Duration_Fault_1	Fault No. 1 Ph-Ph	1
		* 10 * 9 * 8 * 7 * 6 * 5 * 4 * 3 * 2 - 1	Dial Position: 1=> no fault (0) 2=> no fault (0) 3=> no fault (0) 4=> AB-g 5=> AC-g 6=> BC-g 7=> ABC-g 8=> AB 9=> AC
3	6	0	10=> no fault (0)

Figure 6 Phase to phase fault control in the protected zone (busbar).

Simulation

CIRCUIT BREAKER TRIPPING

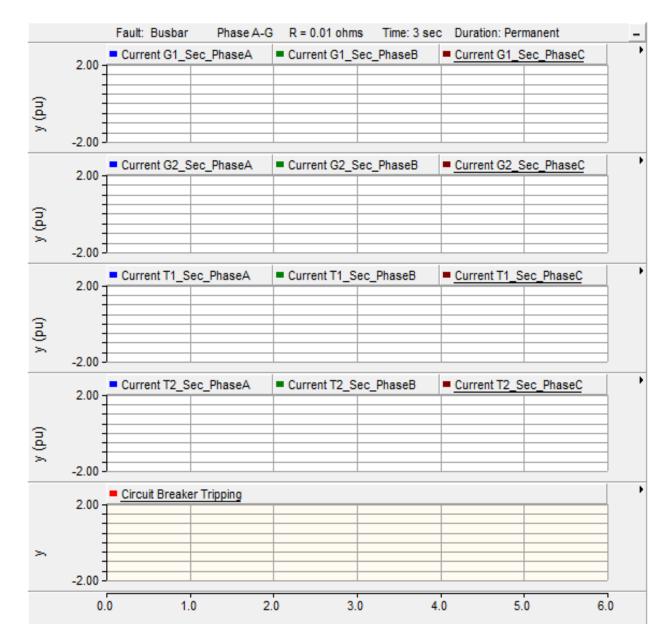


Figure 7 (a) Generator 1 currents. (b) Generator 2 currents. (c) 5 MW load currents. (d) 6 MW load currents. (e) Display of open or closed breakers: a "0" for closed breakers and a "1" for opened breakers.

Results Case 1.- Internal fault of phase A to ground in the principal busbar (R = 0.01ohms).

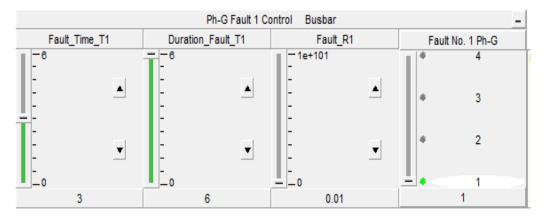


Figure 8 A-g fault adjustment (0.01 ohms), in the fault control panel.. *Own elaboration*.

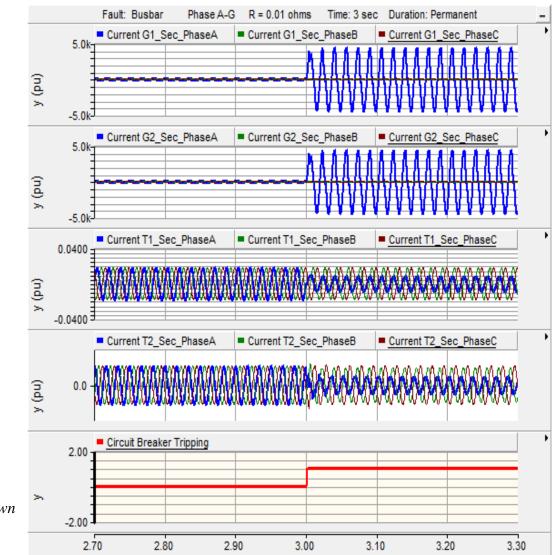


Figure 9 Fault graphs (Phase A-g R = 0.01 ohms). Internal fault. *Own elaboration.*

Results Case 2.- Internal fault of phase A to ground in the principal busbar (R = 20ohms).

Ph-G Fault 1 Control Busbar							
Fault_Time_T	1	Duration	Fault_T1	Fa	ult_R1	Fault N	lo. 1 Ph-G
	•		▲ ▼	- 1e+101 - - - - - - - - -	•	*	4 3 2
0		0		0		<u> </u>	1
3			6		20	1	.00

Figure 10 A-g fault adjustment (20 ohms), in the fault control panel. *Own elaboration*.

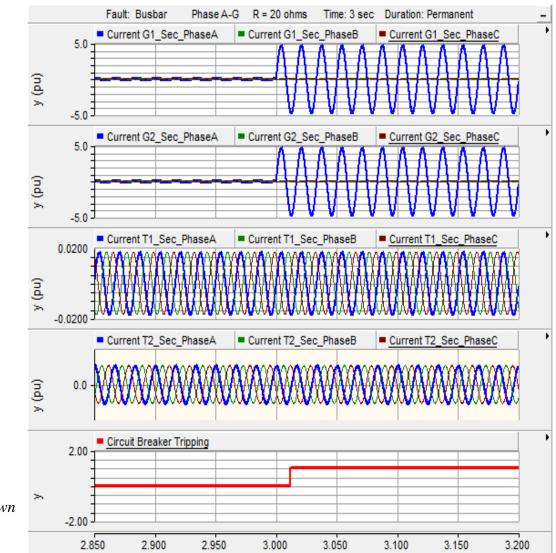


Figure 11 Fault graphs (Phase A-g R = 20 ohms). Internal fault. *Own elaboration.*

Results Case 3.- External fault phase A to phase B, distance 250 km.

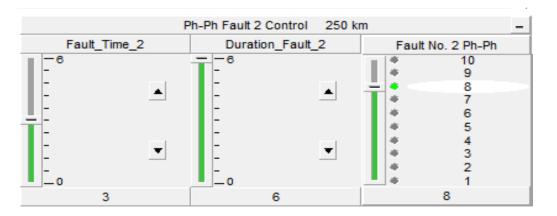


Figure 12 A-B fault adjustment. Own elaboration.

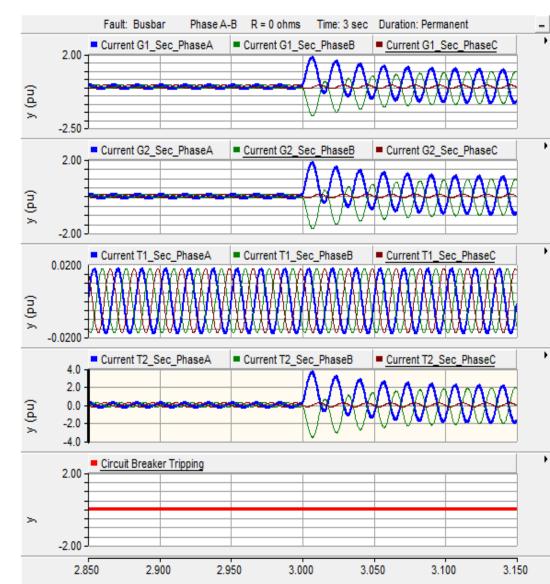


Figure 13 Ph-ph fault graphs (A-B). External fault. Own elaboration.

Conclusions

Differential Protection Overview Responses					
Cases	Internal Fault	External Fault	Protection Operation	Correct	
F=A-g R=0.01	\checkmark		Yes	Yes	
F=A-g R=20	\checkmark		Yes	Yes	
F=A-B 250km		\checkmark	No	Yes	

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