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MODELING OF DIRECTIONAL OVERCURRENT RELAY IN DIGSILENT

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Abstract- Directional overcurrent relaying (67) refers to relaying that can use the phase relationship of voltage and current to determine direction to a fault. In this paper, directional overcurrent relay SPAS348C is introduced. At first structure of this relay is reviewed then with regard to characteristics of SPAS348C, this relay is modeled and this model is added to DigSILENT library. In this paper, one method was presented that in this method each relay can be modeled and applied in simulation project. Finally, we can apply this model to simulation of power system.

Keywords: Directional Overcurrent Relay, SPAS348C, DigSILENT, Modeling.

I. INTRODUCTION

An overcurrent relay in a looped or networked system needs a directional element to determine fault direction and supervise the overcurrent element to provide more performance that is precise. Directional overcurrent relays are used to protect interconnected power systems and looped distribution systems. The fault direction may be forward (between relay and grid), or reverse (between relay and source), the normal power flow being from source to the grid. Known directional overcurrent relays rely on a reference voltage phasor for estimating direction of the fault, requiring both current and voltage sensors.

The DigSILENT software is very effective in design, calculation, and simulation of power system but there are some restrictions in these simulations projects. For example, models of all types of relays that are used in power systems are not available in DigSILENT library. The aim of this paper is presenting a method that by using it we can modeling of intended relay and add to DigSILENT library. Finally, we can apply all types of relays in simulation of protection schemes. In this paper directional overcurrent relay SPAS348C is considered.

II. CHARACTERISTICS AND APPLICATION OF SPAS348C

The feeder protection relay SPAS348C is designed for applications that require to directional phase overcurrent, directional short-circuit and directional earth-fault protection. Typically, this relay is used for overcurrent and earth-fault protection of feeders and busbars in distribution substations provided with multiple feeders supplied from the same high voltage busbar system via power transformers [1]. In addition, these relays are applied for the selective short-circuit and earth-fault protection of parallel feeders between substations and for feeder protection in ring-type and meshed distribution networks. Further, the directional relay is used for the protection of radial feeders with a small back-feed of energy from a generator in the consumer end feeder. This relay includes three protection relay modules as Two directional overcurrent relay modules SPCS4D11 and SPCS4D12, and one directional earth-fault relay module type SPCS 2D26.

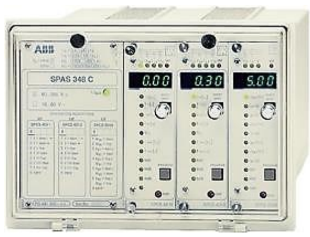

Figure 1. Directional overcurrent relay SPAS348C [1]

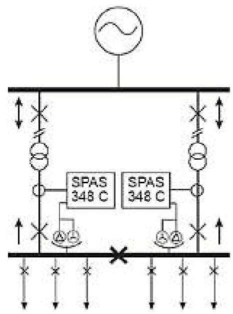

Figure 2. Directional overcurrent relay SPAS348C [1]

A. Relay Modules SPCS4D11 and SPCS4D12

These relay modules have three overcurrent stages:

1- A directional low-set stage $I >$ with definite time and inverse time mode of operation.

2- A directional high-set stage $I >>$ with a setting range of 0.5-40$\times I_n$.

3- A non-directional high-set stage $I >>>$ with a setting range of 2-40$\times I_n$.

The directional overcurrent modules SPCS4D11 and SPCS 4D12 are identical except for the phase currents and phase-to-phase voltages measured by the modules. This is expressed in Table 1.

Table 1. Requirement currents and voltages of relay modules [1]

Module	Current and Voltage
SPCS4D11	I_{L1} , U_{23} and I_{L3} , U_{12}
SPCS4D12	I_{L1} , U_{23} and I_{L2} , U_{31}

B. Relay Module SPCS2D26

This relay module has two overcurrent stages:

1- Directional or non-directional low-set neutral overcurrent stage I_{01}> with definite time characteristic.

2- Directional or non-directional high-set neutral overcurrent stage I_{02}> with definite time characteristic.

When required, both directional neutral overcurrent stages of directional earth-fault protection can be configured to operate as residual voltage stages. Then relay module includes three separate adjustable residual voltage stages.

The directional earth-fault unit measures the neutral current I_0, the residual voltage U_0 and phase angle between residual voltage and neutral current. An earth-fault stage starts if all of three criteria below are fulfilled at same time:

-The residual voltage U_0 exceeds the start level set for the U_0> stage. The setting is same for stage I_{01}> and stage I_{02}>.

- The neutral current I_0 exceeds the set start value of stage I_{01}> or stage I_{02}>.

- If the phase angle between residual voltage and neutral current falls within the operation area $\phi_b \pm\Delta\phi$, where ϕ_b is the characteristic basic angle of the network and $\Delta\phi$ is the operation sector.

The setting value of the characteristic basic angle ϕ_b of the network is selected according to the earthing principle of the network, that is, 90° in an isolated neutral network, and 0° in a resonant-earthed network, earthed through an arc suppression coil (Petersen coil), with or without a parallel resistor. The basic angle can be set at -90°, -60°, -30°, or 0° via the SGF switches [1, 2].

III. MODELING OF DIRECTIONAL OVERCURRENT RELAY SPAS348C

The DigSILENT has a section (block/frame diagram) that modeling of relay is performed in this section. This section has a tool called "Slot" that can create required block (CT, VT, measurements, etc.) to modeling of relay. For example, creating CT block has been illustrated in Figure 4. At first three different modules of relay are modeled separately then final model of SPAS348C is presented.

A. Modeling of SPCS4D11

Figure 5 shows the block diagram of SPCS4D11. This block diagram is obtained according to the specification and application of SPSC4D11 (section II-A). Current Transformer (CT) and Voltage Transformer (VT) send three-phase current and voltage to measurement unit. Measurement makes required signals of directional unit and current comparator units. Current Comparator units are used to create trip signal. Directional unit and logic units (AND) are used to modeling directional protection. The inputs of last logic unit (OR) are trip signals of stage I >, stage I >> and stage I >>>. The output of last logic unit (OR) is trip signal of SPCS4D11.

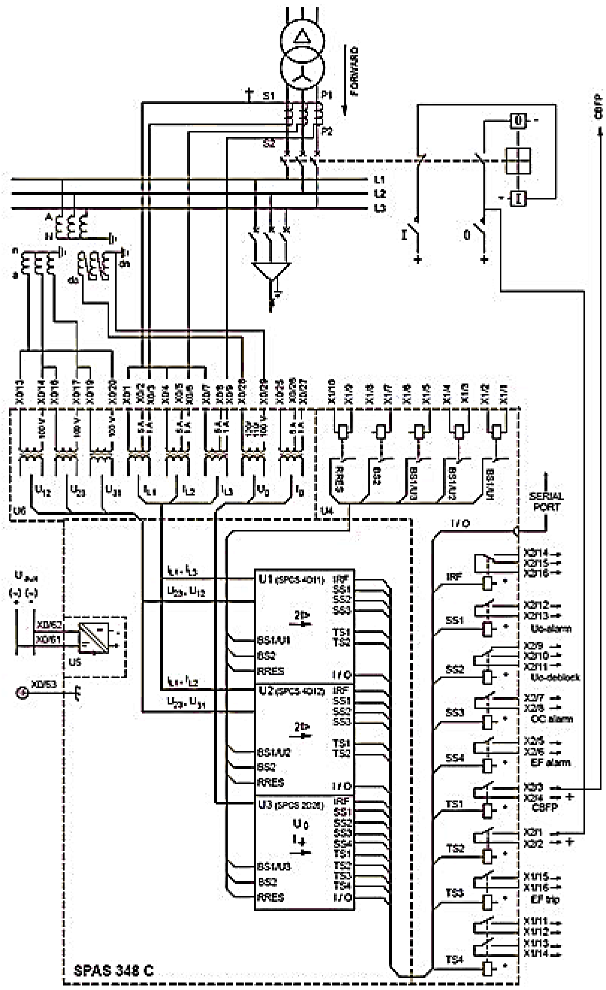

Figure 3. Block diagram of SPAS348C [1]

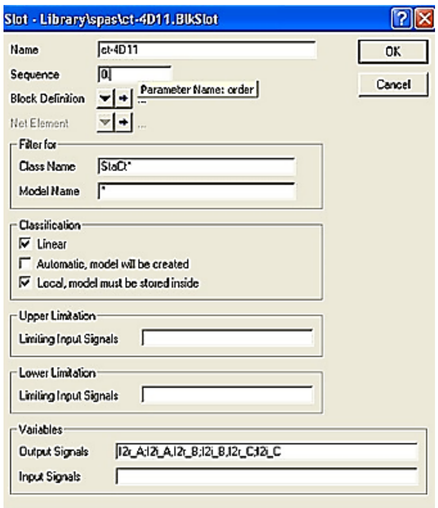

Figure 4. Creating CT block

B. Modeling of SPCS4D12

Modeling of SPCS4D11 and SPCS4D12 are identical. After completing the modeling of relay this model was added to library and the model was applied in simulation of power system then the relay setting in grid should be in accordance with Table 1.

C. Modeling of SPCS2D26

Figure 6 shows the block diagram of SPCS2D26. This block diagram is obtained according to the specification and application of SPSC2D26 (section II-C).

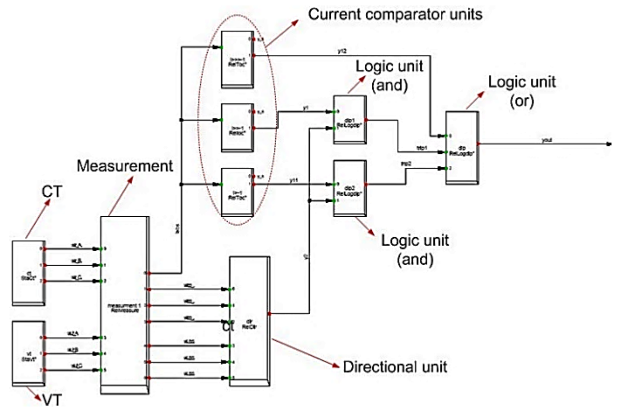

Figure 5. Block diagram of SPCS4D11

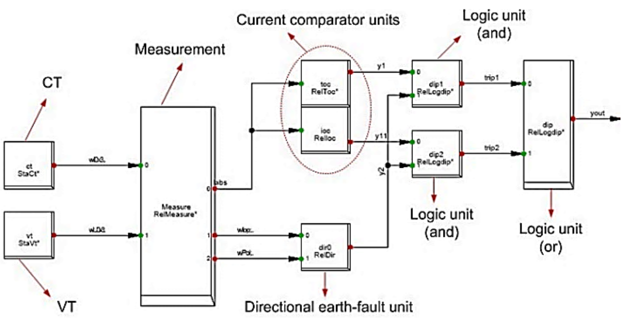

Figure 6. Block diagram of SPCS2D26

Current Transformer (CT) and Voltage Transformer (VT) send neutral current and residual voltage to measurement unit. Measurement makes required signals of directional unit and current comparator units. Current Comparator units are used to create trip signal. Directional unit and logic units (AND) are used to modeling of directional protection. The inputs of last logic unit (OR) are trip signals of stage I_{01} and stage I_{02}. The output of last logic unit (OR) is trip signal of SPCS2D26.

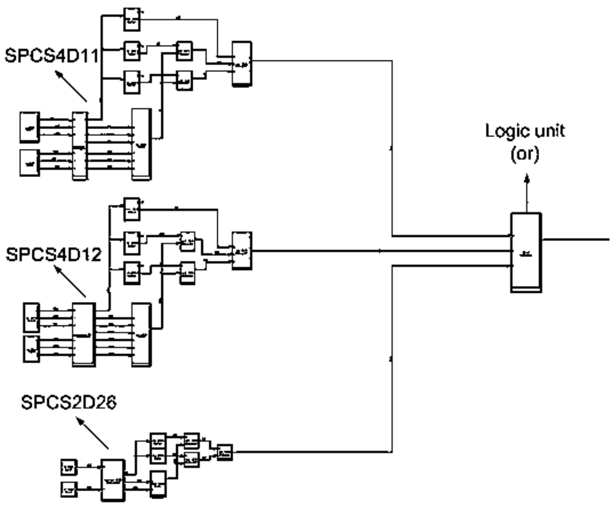

Figure 7. Block diagram of SPAS348C

D. Modeling of SPAS348C

Figure 7 shows the final block diagram of SPAS348C. The inputs of last logic unit (OR) in Figure 3 are trip signals of relay modules SPCS4D11, SPCS4D12, and SPCS2D26. The output of last logic unit (OR) in Figure 3 is trip signal of directional overcurrent relay SPAS348C.

IV. APPLYING THE MODEL OF SPAS348C IN SIMULATION OF POWER SYSTEM

At first in section of "Relay Definition" select the model of SPAS348C and add it to the DigSILENT library (Figure 8). Then relay setting in grid should be done. For example, Figure 9 shows the CT block setting in grid. Simulation of power system in Figure 10 is used for validation of relay model [3].

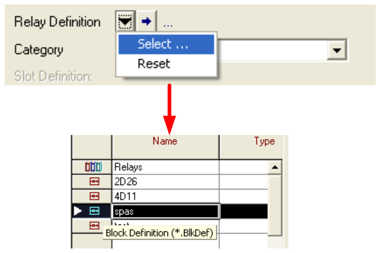

Figure 8. Add model of SPAS348C to DigSILENT library

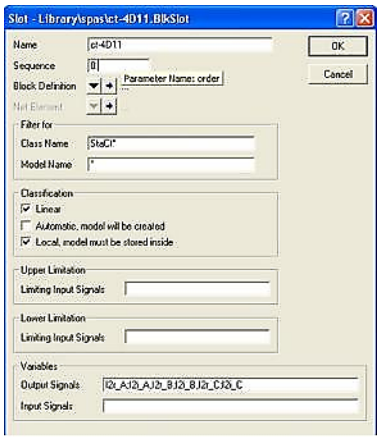

Figure 9. CT block setting in grid

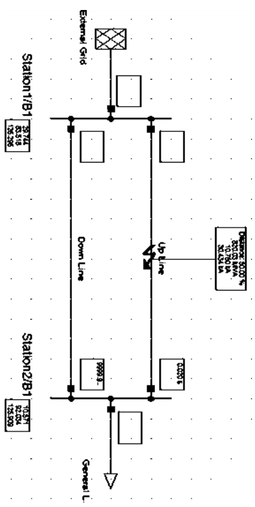

Figure 10. Applying model of SPAS348C in simulation of power system

Only two directional overcurrent relay SPAS348C are used at the ends of parallel line in power system shown in Figure 10. One short circuit is simulated at the up-line and as expected, only the relay at the end of up-line trips the circuit breaker [4, 8].

V. CONCLUSIONS

The DigSILENT software is widely used in simulation of power system and protection schemes. In this paper, one method has presented that in the method each relay can be model and apply in simulation project. In this paper, directional overcurrent relay SPAS348C has modeled that was applied in simulation of a power system for validation of relay model. One short circuit in this power system has simulated, relay performance has evaluated, and consequently accuracy of presented model has shown.

REFERENCES

[1] ABB, "SPAS348C Feeder Protection Relay User´s Manual and Technical Description", Issued 1996 Modified 2002 Version D.
[2] J. Horak, "A Derivation of Symmetrical Component Theory and Symmetrical Component Networks", Georgia Tech. Protective Relaying Conference, April 2005.
[3] L.G. Perez, "Calculation of Optimum Directional Overcurrent Relays Settings - The Parallel Lines Case", Power Engineering Review, IEEE, Vol. 20, 2000.
[4] T. Amraee, "Coordination of Directional Overcurrent Relays Using Seeker Algorithm", IEEE Transactions on Power Delivery, Vol. 27, No. 3, 2012.
[5] M. Peng, J. Lin, X. Yang, R. Feng, "Study of Directional Relay's Performances for Transmission Line's Multiple Faults", Transmission and Distribution Conference and Exhibition, Asia and Pacific, IEEE/PES, 2005.
[6] A. Ukil, B. Deck, V.H. Shah, "Smart Distribution Protection Using Current-Only Directional Overcurrent Relay", Innovative Smart Grid Technologies Conference Europe (ISGT Europe), IEEE PES, 2010.
[7] M. Khederzadeh, "Backup Protection of Distance Relay Second Zone by Directional Overcurrent Relays with Combined Curves", Power Engineering Society General Meeting, IEEE, 2006.
[8] M.H. Aslinezhad, S.M. Sadeghzadeh, J. Olamaei, "Over Current Relays Protective Coordination in Distribution Systems in Presence of Distributed Generation", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 7, Vol. 3 No. 2, pp. 40-46, June 2011.

BIOGRAPHIES

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