

Broken Conductor Detection with SIPROTEC 7SJ80

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1. Application

In most cases faults on a power system occur between one phase and ground or two phases and ground. These arise from lightning discharges and other over-voltages which initiate flashovers. They may be caused by birds on overhead lines or mechanical damage to cables etc.

Because of remarkable increase in current, those faults are easily detectable in most applications.

Series or open circuit fault can also cause unbalanced faults on the system.

Reason for this can be broken conductors, mal-operation of single phase switchgear or the operation of fuses.

These faults will not cause an increase in phase current on the system and hence are not detectable by standard overcurrent relays.

However, they will produce an unbalance and a resultant level of negative phase sequence current, which can be detected.



2. Functionality

It would be easy to utilize a negative phase sequence over current relay to detect this condition. However, if the line is on light load, the negative sequence current may be very close to, or less than, the full load steady state unbalance arising from CT errors, load unbalance etc.

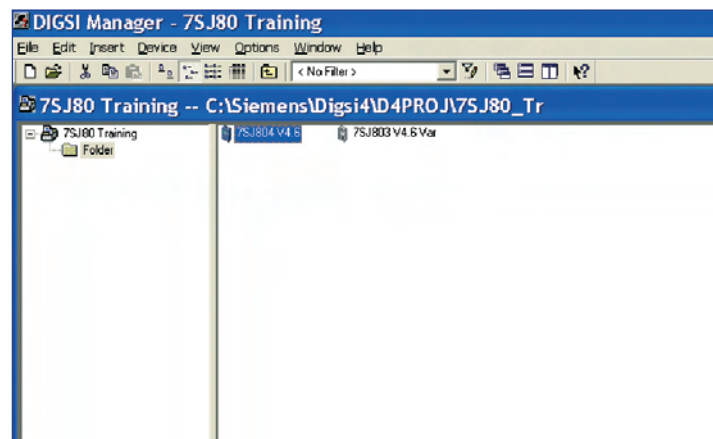
That means a simple negative sequence element would not operate with this load conditions.

On the other hand such kind of faults will produce a measurable zero sequence current. But even this will not be sensitive enough. Further disadvantage, if a transformer (Y/Delta) would be part of the protected object, I_0 value can not be used to detect fault on both sides of the transformer.

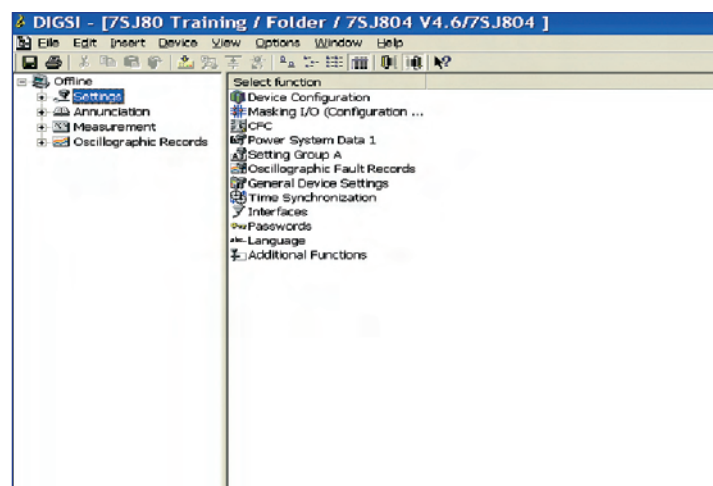
To detect such kind of faults it is necessary to evaluate the ratio of negative to positive phase sequence current (I_2/I_1).

Since the ratio is approximately constant with variations in load current, a more sensitive setting may be achieved.

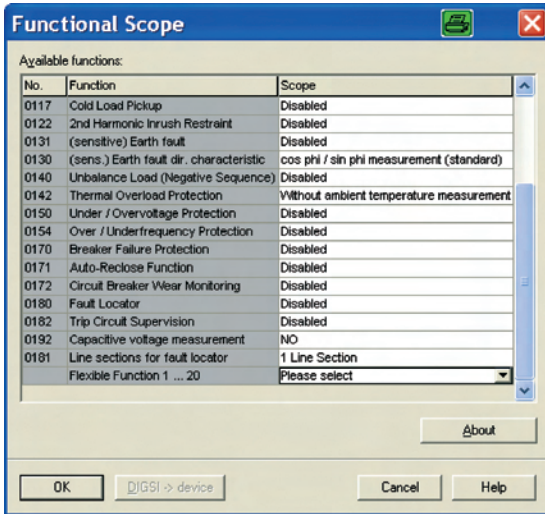
By using one of the flexible protection functions in **7SJ80** over-current protection device, it is easily possible to create the requested element.



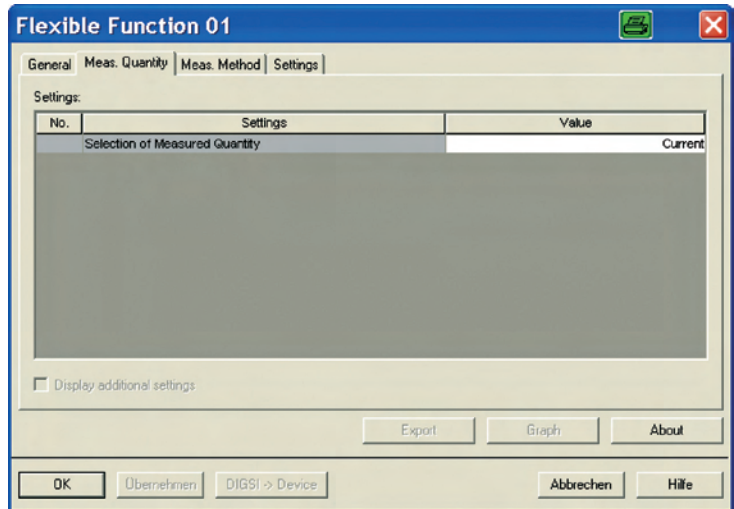
Under chapter SETTINGS, open Device Configuration.



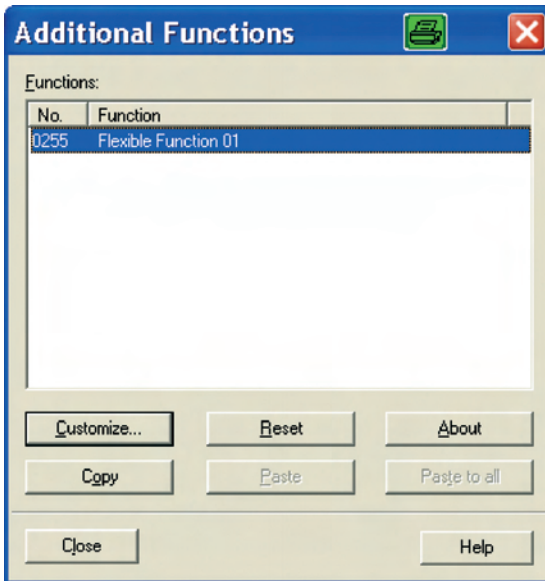
Scroll down, than select Flexible Function and activate e.g. Flexible Function 01.



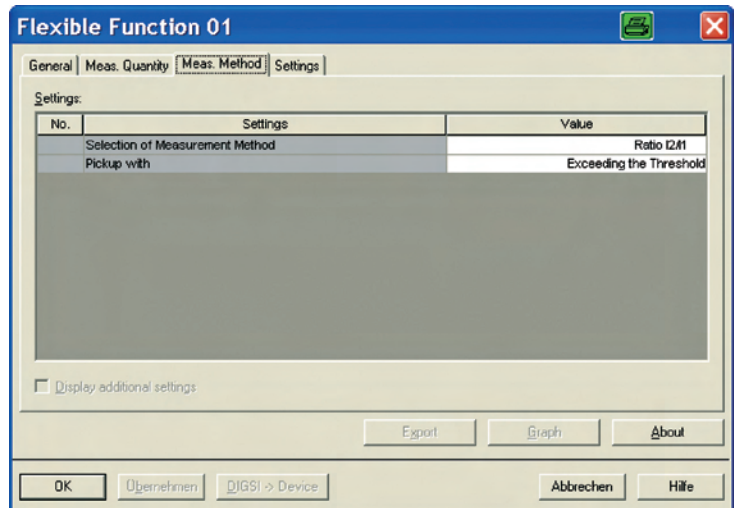
Meas. Quantity must be changed to CURRENT.



Then select Additional Function, choose Customize.

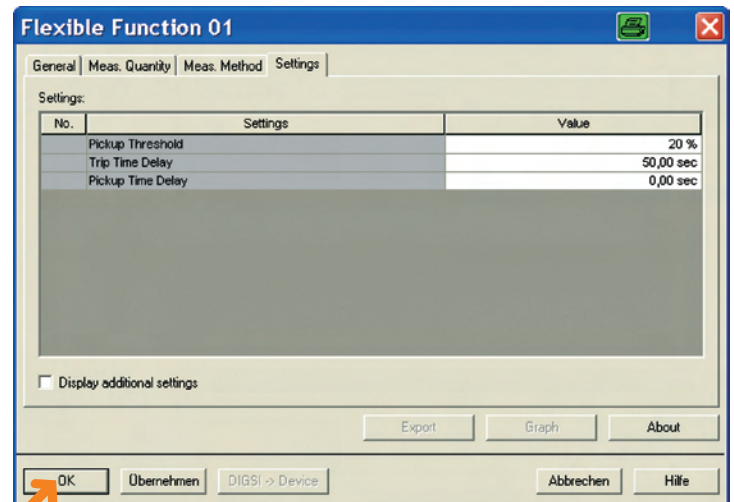
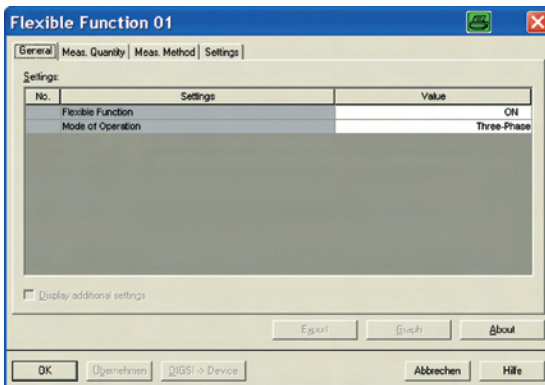


Meas Method selection to Ratio I₂ / I₁; pick up with exceeding the threshold.



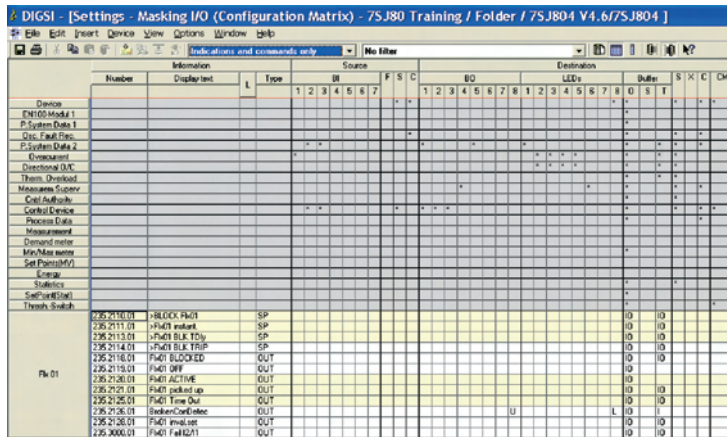
Activate Flexible Function by selecting under sheet GENERAL, Value ON.

Setting values for Pickup Threshold can be used as pre-fault setting. Time delay should be set to 50 sec.



Close this window and change to Masking I/O (configuration Matrix).

Select Flx 01, do the required configuration for Binary Outputs (BO) and LED.



You can edit text of Flex Funct by double click to field Display Text (e.g. Number 235.2126.01) change Flx01 Trip to e.g. "BrokenConDetec".

Hint: Don't forget to Save Data!

■ 3. Setting Guidelines

In the case of a single point earthed power system, there will be little zero sequence current and the ratio of I2/I1 in the protected circuit will approach 100%.

In the case of a multiple earthed power system (assuming equal impedances in each sequence network), the ratio I2/I1 will be 50%.

It must be considered, that this ratio may vary depending upon the fault location. Therefore it's recommended to apply a setting as sensitive as possible.

In practice, this minimum setting is governed by the levels of standing negative phase sequence current present on the system.

This can be determined from a system study, or by making use of the relay measurement facilities at the commissioning stage.

If the latter method is adopted, it is important to take the measurements during maximum system load conditions, to ensure that all single phase loads are accounted for.

Since sensitive settings are employed, it can be expected that the element will operate for any unbalance condition occurring on the system (for example, during a single pole auto-reclose cycle).

Therefore, a long time delay is necessary to ensure coordination with other protective devices. A time delay setting of 50 sec may be recommended.

Setting Description	Setting Range	Default Setting Steps	
Pickup Threshold	15 – 100 %	20 %	1 %
Trip Time Delay	0,00 – 3600,00 sec	1.00 sec	0,01 sec
Pick up Time Delay	0,00 – 28800,00 sec	0.00 sec	0,01 sec

Table 1 Recommended settings

■ 4. Example Setting

The following information was recorded by the relay during commissioning;

I_{full load} = 500A

I₂ = 50A

therefore the quiescent I₂/I₁ ratio is given by;

$$I_2/I_1 = 50/500 = 0.1$$

To allow for tolerances and load variations a setting of 200% of this value is recommended:

Therefore set RATIO I₂/I₁ = 20%

Set tBC = 50 s to allow adequate time for short circuit fault clearance by time delayed protections

Pick up time = 0 s , to detect this behavior immediately.

Table 1 shows the 7SJ80 setting menu for the Broken Conductor protection, including available setting ranges and default settings.

NOTE:

Inhibit broken conductor function if the three phases are less than 10% of the nominal current. This can easily be implemented by using CFC logic.

■ 5. Conclusion

Broken conductor detection is a vital contribution to protect persons during fault condition from any harm caused by high voltages.

The high sensitivity combined with flexible protection functions in SIPROTEC 7SJ80 provides easy realization of such requirement.