Possibilities of testing a overcurrent and earth fault protective relay SPAJ140C

[1]Michal ŠPES, [2]Ľubomír BEŇA, [3]Jakub URBANSKÝ, [4]Michal MÁRTON

[1] Katedra elektroenergetiky, Fakulta elektrotechniky a informatiky, Technická Univerzita v Košiciach, Slovenská Republika
[2] Katedra elektroenergetiky, Fakulta elektrotechniky a informatiky, Technická Univerzita v Košiciach, Slovenská Republika
[3] Katedra elektroenergetiky, Fakulta elektrotechniky a informatiky, Technická Univerzita v Košiciach, Slovenská Republika
[4] Katedra elektroniky a multimediálnych telekomunikácií KEMT, Fakulta elektrotechniky a informatiky, Technická Univerzita v Košiciach, Slovenská Republika

[1]Michal.Spes@tuke.sk, [2]Lubomir.Bena@tuke.sk, [3] Jakub.Urbansky@tuke.sk
[4]Michal.Marton@tuke.sk

***Abstract* — Power system is formed by a machine for generation, transformation, transmission and distribution of a electric energy. To ensure reliability of power system is protection system important part of power system. Electric protective relay is component part of protection system. Function of electric protective relay is based on input information and setting value to decide whether there is a failure or allowable operating condition. Based on identification failure condition inside a protected system, electric protective relay must give a command to shut down a failure system. This paper deals with a describing and testing of overcurrent protective relay SPAJ 140C.**

***Keywords* — Overcurrent protection relay, short-circuit, reactances, power system, SPAJ 140C**

I. Introduction

Electric protective relay are devices, that compares actual measured value of current in power system with a setting start current value. In case that measured value of current exceeds a start current value, electric protective relay activates tripping parts of protection relay and give a command for disconnection fault part of power system [1].

Electric protective relay can be classified according to several criteria. First class is according to the type o fault that must be identified [2]:

- Short-circuit electric protective relay,
- Overloading electric protective relay,
- Overvoltage electric protective relay,
- Undervoltage electric protective relay,
- Electric protective relay for earth fault connection,
- Electric protective relay for reverse power flow,
- Electric protective relay for loss of excitation,
- Electric protective relay for asymmetry (of current or voltage),
- Frequency protective relay [2].

According to the principle of activity are divided protective relay on:

- Current protection,
- Distance protection,
- Voltage protection,
- Comparative protection,
- Power protection,
- Reactance protection,
- Frequency protection,
- Asymmetry protection [2].

According to the time of tripping are divided protective relay on:

- Immediately acting,
- Definite time,
- Time dependent [2].

Electric protective relay are complicated technical devices that are important part of power system. They are placed on them following requirements as reliability of function of electric power relay, selectivity and speed of activity [2].

Reliability of function of electric power relay is defines as ability to perform operation in accordance the algorithm of electrical protective relay within the time [2].

Selectivity of electrical protective relay is ability to disconnect only failure part of power system. Other devices without a failure must remain in operation [2].

Speed of activity of power relay is operation time. It is a time of identification a failure to sending trip command for circuit breaker [2].

II. Overcurrent protective relay

Overcurrent protective relay reacts to current which exceeds the value of secondary starting current I_{2r} set on protective relay. Schematic representation of an overcurrent protective relay is on following figure (Fig. 1) [2].

It if formed from following parts: starting current member *RC*, time member *CC*, end member *KR*.

Starting current member are falling in to the each phase of secondary winding of current transformer. For their activity need secondary current from current transformer. Time member and end member need for their activity power supply. We can follow operation overcurrent protective relay from figure [2].

As result of failure *F1* on the cable outlet it occurs an increase of current I_2 on secondary side of current transformer. This failure current exceeded set current value I_{2r} a least in one phase of starting current member *RC*. Starting current member brought into the operation a time member *CC*. Time member after deduction of the set time put into the operation end member *KR*. End member *KR* close the electrical circuit of power breaker. Power breaker disabled a failure *F1*. Disabling a failure *F1* is short-circuit current interrupted [2].

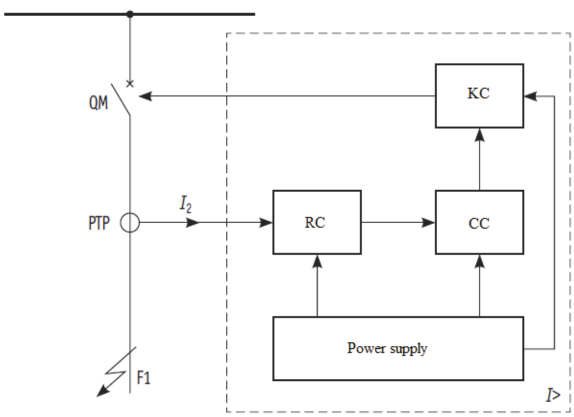

Figure 1 Block scheme of overcurrent protective relay [2]

III. Calculation theory for setting start current of overcurrent protective relay

For correct setting of start current I_r line outlets we need to know current ratios, mainly values of short-circuit current, sizes permissible overload current and nominal current. Sizes of short-circuit current at the same configuration of power system can be different. Size of short-circuit current depends on power of the power source. For the above reasons we need to know maximal short-circuit current I_{kmax} and minimal short-circuit current I_{kmin}, which may occur at the site of installation overcurrent protective relay [2].

For calculation I_{kmax} we need take into account the most unfavorable conditions in the protected system. Conversely for calculation I_{kmin} we must take account the formation of a short-circuit current at the time of the smallest load [2].

Protection settings of power relay is done for a given operational scheme of power system. This setting of protective relays must ensure selective disabling all types of faults [2].

On the following figure are shown current ratios which may occur in normal operation and fault conditions. Power lines with nominal current I_N, can be loaded with maximal allowed current I_{pmax}. On the outlet for power lines can be allowed current overload. Size of this current is characterized by maximum starting current I_{zmaxM}. Substation can be powered by external power lines, which are equipped with automatics reclosing. Turning on a power lines by a automatic reclosing after no voltage break occurs current surges I_{zmaxOZ}. Area of short-circuit current is characterized by a change of effective short-circuit current values I_k. The fair values of short circuit current are in the range I_{kmax} and I_{kmin} [2].

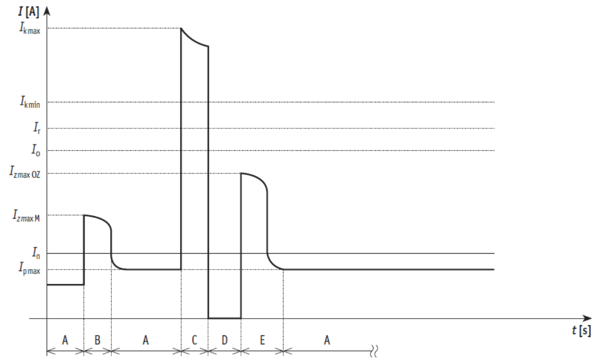

Figure 2 Current ratios on power lines outlets by a different operation conditions [2]

IV. Overcurrent and earth-fault relay SPAJ 140 C

The combined overcurrent and earth-fault relay SPAJ 140 C is used for the selective short-circuit and earth-fault protection of radial feeders in solidly-earthed, resistance-earthed or impedance-earthed power systems. This integrated protection relay includes an over-current unit and an earth-fault unit with flexible tripping and signaling facilities. These relays can also be used for other applications, which require single, two, or three-phase over-current protection. This combined over-current and earth-fault relay also includes a circuit-breaker failure protection unit [5].

Connection of protective relay is realized through current transformers, it being possible to use the secondary side current 1A or 5A [5].

The principle activities of overcurrent or earth-fault unit is essentially identical. The fault leads to increase of operating current in one or more phases, depending on the type of fault. The fault current exceeds the set current value, which activates a time member of the protective relay. After deduction of the preset time delay instructs closing relay that closes the circuit breaker contacts and subsequent disconnection of the fault line [5].

This digital protective relay includes the following protective functions [5]

• ANSI 51 - Three-phase overcurrent protection with a lower setting range and an independent or with the inverse time characteristics,

• ANSI 50 - Three-phase overcurrent protection with higher adjustment range and immediate action, or with definite time characteristic

• ANSI 51N – Earth-fault protection, the lower range-building and with the independent or dependent time characteristic.

• ANSI 50N - Earth-fault protection with greater range to-building and immediate action, or with definite time characteristic

• ANSI 51BF - Protection of the failure of the circuit breaker.

Figure 3 Overcurrent and earth-fault relay SPAJ 140 C [5]

V. Possibilities of testing protective relay

Operational reliability and safety of the electricity system (ES) de-pends not only on using the latest technology and knowledge of management of ES but due to the rapid course of the transients and avoid negative impacts of disturbances also from the correct choice of protective terminals or digital relays [3].

Any such installation prior to commissioning should be subject to functional and system testing in the factory, with verified the functionality and operation of various protection functions to the protected equipment.

The outcome of the test is a protocol that includes the results of testing to all fault conditions that may endanger the protected equipment [3].

When testing the electrical protection relays we use two methods of verification activities:
- Direct method,
- Indirect method [4].

Electrical protection relays are connected to the protected object through Current Transformers, where the secondary side of the current transformers is 5A or 1A and the secondary side of the voltage transform-ers is 100 V [4].

This fact is used to test by the indirect method on the electrical protection relay we connect to the testing equipment of electrical protection re-lays which injects secondary test voltage and current values, and watch the reaction of protection relay [4].

Testing of relay using the direct method is among the most important tests which verify the functionality of the entire device and wiring. To the indirect method, there is a fundamental difference in testing. Voltage and current is injected to the primary side of the transformer. This method of testing is difficult, since current and voltage on the primary side must respond to the operating variables [4].

This method verifies the operation of the relay, the accuracy of wiring system, the connection of instrument transformers [4].

VI. Testing of overcurrent protective relay SPAJ 140C

The overcurrent protection function consists of two parts:
- Normal inverse (I>)
- Some time (I >>).

These characteristics were tested software Test Universe, in module *Overcurrent*. The modules have been given the same values as the characteristics of the protective relay.

Table 1 Settings of overcurrent protective relay

Protective characteristic	I_{START}	t_{TRIP}
Normal inverse	0,8.I_N	0,7s
Definite time	8,0. I_N	0,2s

After connecting to the CMC 256 to the protective relay SPAJ 140C and configured for testing protective characteristics, start the test. The results of measurement are composed of individual points that have been tested and evaluated in the table.

Table 2 Results from the testing of overcurrent protective relay

	Magnitude	**tnom**	**tact**	**Result**
L1-E	0,50 A	No trip	No trip	Passed
L1-E	1,00 A	15,65 s	15,54 s	Passed
L1-E	1,50 A	5,53 s	5,45 s	Passed
L1-E	2,00 A	3,78 s	3,73 s	Passed
L1-E	2,50 A	3,04 s	3,10 s	Passed
L1-E	3,00 A	2,61 s	2,64 s	Passed
L1-E	3,50 A	2,34 s	2,33 s	Passed
L1-E	4,00 A	2,14 s	2,16 s	Passed
L1-E	4,50 A	1,99 s	1,99 s	Passed
L1-E	5,00 A	1,88 s	1,89 s	Passed
L1-E	5,50 A	1,78 s	1,78 s	Passed
L1-E	6,00 A	1,70 s	1,71 s	Passed
L1-E	6,50 A	1,64 s	1,64 s	Passed
L1-E	7,00 A	1,58 s	1,58 s	Passed
L1-E	7,50 A	1,53 s	1,09 s	Passed
L1-E	8,00 A	0,25 s	0,26 s	Passed
L1-E	8,50 A	0,25 s	0,26 s	Passed
L1-E	9,00 A	0,25 s	0,26 s	Passed
L1-E	9,50 A	0,25 s	0,26 s	Passed
L1-E	10,00 A	0,25 s	0,26 s	Passed

VII. Conclusion

This article deals with the issue of electrical protective devices. At the beginning of the article is presented the basic theory of protection and overcurrent protection. Subsequently is described protective relay SPAJ 140C along with testing. For test was used the testing device of protective relay CMC 256.

Acknowledgment

This work was supported by the Ministry of Education, Science, Research and Sport of the Slovak Republic and the Slovak Academy of Sciences under the contract No. VEGA 1/0132/15.

References

[1] M. Kolcun, V. Griger, Ľ. Beňa, J. Rusnák, "Prevádzka elektrizačnej sústavy," Košice, 2007. ISBN 978-80-8073-837-2

[2] V. Chladný, F. Janíček, A. Belaň, "Digitálne ochrany v elektrizačných sústavách," Košice, 2003. ISBN 80-89061-73-7

[3] M. Hvizdoš, M. Kmec, "Skúšanie digitálnych ochrán po-mocou testovacieho zariadenia CMC," Košice, 2013. ISBN 978-80-553-1507-2

[4] A. Apostolov, B. Vandiver,:"Scheduled testing of pro-tection relays yes or no?, OMICRON Electron., Los Angeles ISBN:978-1-4244-6073-1.

[5] ABB, "Over-current and earth-fault relay SPAJ140C," [Online].
<http://search-ext.abb.com/library/Download.aspx?DocumentID=1MRS758396&LanguageCode=en&DocumentPartId=&Action=Launch>.