ZESZYTY NAUKOWE POLITECHNIKI RZESZOWSKIEJ 296, Elektrotechnika 36
RUTJEE, z. 36 (1/2017), styczeń-czerwiec 2017, s. 7-14

Michal ŠPES[1]
Ľubomír BEŇA[2]
Miroslav MIKITA[3]
Michal MÁRTON[4]
Henryk WACHTA[5]

TESTING OF DIGITAL PROTECTION RELAY REF543

This article describes the digital protective relay REF 543 and its testing possibilities. The aim of this work is to verify overcurrent, undervoltage and overvoltage protection functions by indirect method using test equipment CMC 156. Among other things, IED REF 543 will be presented along with its features. The work is a space reserved for the description of the testing methods of protective relay.

Keywords: protection relay, REF 543, testing of operation, direct and indirect method.

1. Introduction

Operational reliability and safety of the electricity system (ES) depends not only on the use of the latest technology and knowledge of management of ES but due to the rapid progress of the transients and on the prevention of negative impacts of disturbances also for the correct choice of protective relays or digital relays [1]. Any such equipment must be subject to functional and system-based testing prior to its putting into service while verifying the functionality and operation of the individual protective functions for the protected equipment.

[1] Michal Špes, Department of Electric Power Engineering at Technical University of Košice, Mäsiarska 74, 041 20 Košice, 00421 55 602 3584, Michal.Spes@tuke.sk
[2] Ľubomír Beňa, Department of Electric Power Engineering at Technical University of Košice, Mäsiarska 74, 041 20 Košice, 00421 55 602 3561, Lubomir.Bena@tuke.sk
[3] Miroslav Mikita, Department of Electric Power Engineering at Technical University of Košice, Mäsiarska 74, 041 20 Košice, 00421 55 602 3560, Miroslav.Mikita@tuke.sk
[4] Michal Márton, Department of Electronics and Multimedia Communications at Technical University of Košice, Park Komenského 13, 041 20 Košice, Michal.Marton.3@student. tuke.sk
[5] Corresponding author: Henryk Wachta, Politechnika Rzeszowska, Katedra Energoelektroniki, Elektroenergetyki i Systemów Złożonych, ul. W. Pola 2, 35-959 Rzeszów, 17 865 1977, hwachta@prz.edu.pl

The outcome of the test is a protocol that includes the results of testing to all fault conditions that may endanger the protected equipment. When testing the electrical protection relays we use two methods of verification activities: direct and indirect method [3].

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

This fact is used in indirect test methods when we connect electrical protection to a protective test device that secondary injects the voltage and current test voltage while monitoring the protection response. Direct method protection testing is one of the most important tests where we verify the functionality of the entire device and the connection. Against 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.

This method verifies the operation of the relay, the correctness of wiring system, the connection of instrument transformers.

2. Feeder terminal REF 543

Feeder Terminal REF 543 (Fig. 1) is designed for protection, control, measurement and supervision in medium voltage networks.

Fig. 1. Feeder terminal REF543 [2]

The REF 543 feeder terminal can be used with different kinds of switchgear, including single bus bar, double bus bar and duplex systems [2]. The protection functions also support different types of networks, such as isolated neutral networks, resonant-earthed networks and partially earthed networks. The application area also covers medium-sized three phase asynchronous motors as well as protection and control of shunt capacitor banks used for reactive power compensation. In addition to protection, measurement, control, condition monitoring and general functions, the REF 543 feeder terminals are provided with a large amount of PLC functions, which allow for several automation and sequence logic functions, needed for substation automation, to be integrated into one unit.

The data communication properties include the following communication standards: SPA bus, LON bus, IEC 60870-5-103, IEC 61850 via SPA-ZC 400, Profibus DPV1 via SPA-ZC 302, DNP 3.0 and Modbus communication with higher level equipment. Further, the LON communication together with the PLC functions minimizes the need for hardwiring between the feeder terminals.

3. Configuration and testing of overcurrent protective functions

Testing and configuration of the digital protective relay REF 543 is possible using the programming interface PCM600 or using the control keys located on the front panel of this terminal.

In terms of configuration, it is necessary to identify the active group functions. Available are group 1 or 2. Configuring the functions of one group is independent of the configuration of the second group.

To verify the operation of the protective relay, the following overcurrent functions and their characteristics were configured:

- definite time (NOC3 LOW),
- definite time (NOC3 HIGH),
- definite time (NOC3 INST).

The configuration values of the protective functions are shown in the Table 1.

Table 1. Summary of configuration parameters of overcurrent functions

Protective function	**Parameters**	**Set value**
NOC3 INST	Start value	3 x I_N
	Operating delay time	0.04 s
	Directional mode	Non directional
NOC3 HIGH	Start value	2.5 x I_N
	Operating delay time	0.30 s
	Directional mode	Non directional
NOC3 LOW	Start value	2 x I_N
	Operating delay time	0.60 s
	Directional mode	Non directional

The actual verification activities of the terminal is based on the connection and configuration of the test equipment CMC 156 of relays, which includes the same configuration parameters as the IED REF 543. It is also necessary to set the allowed tolerance of the current (0.05A) and time (0.04s).

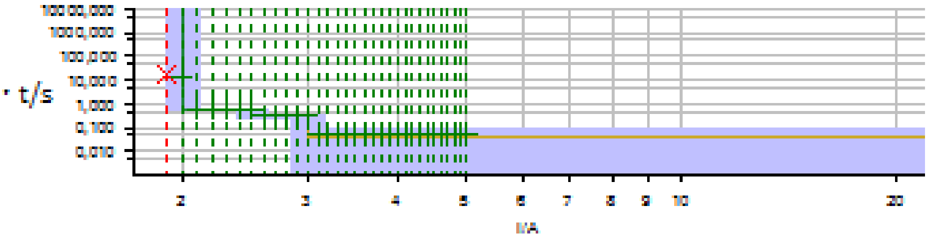

Fig. 2. Overcurrent protective characteristic

In the testing process, we specify the steps for which there is a change of injected current ranging from 1.90 A to 5.00 A. The resulting characteristic of protection with test points is marked in the Fig. 2. In the Table 2 are listed the individual test points with turn-off time of relay for protective overcurrent function NOC3 LOW. In the Table 3 and 4 are listed test points for protective overcurrent function NOC3 High and NOC3 INST. Response time of the terminal is evaluated by a test device as either passed or failed.

Table 2. Summary of test points of protective function NOC3 LOW

Type	Relative To	Factor	Magnitude	Angle	t_{nom}	t_{act}	Result
L1-E	(---)	n/a	1.90 A	n/a	No trip	15.31 s	Passed
L1-E	(---)	n/a	2.00 A	n/a	0.60 s	13.75 s	Passed
L1-E	(---)	n/a	2.10 A	n/a	0.60 s	0.61 s	Passed
L1-E	(---)	n/a	2.20 A	n/a	0.60 s	0.61 s	Passed
L1-E	(---)	n/a	2.30 A	n/a	0.60 s	0.61 s	Passed
L1-E	(---)	n/a	2.40 A	n/a	0.60 s	0.61 s	Passed

Table 3. Summary of test points of protective function NOC3 HIGH

Type	Relative To	Factor	Magnitude	Angle	t_{nom}	t_{act}	Result
L1-E	(---)	n/a	2.50 A	n/a	0.30 s	0.61 s	Passed
L1-E	(---)	n/a	2.60 A	n/a	0.30 s	0.32 s	Passed
L1-E	(---)	n/a	2.70 A	n/a	0.30 s	0.32 s	Passed
L1-E	(---)	n/a	2.80 A	n/a	0.30 s	0.32 s	Passed
L1-E	(---)	n/a	2.90 A	n/a	0.30 s	0.32 s	Passed

Table 4. Summary of test points of protective function NOC3 INST

Type	Relative To	Factor	Magnitude	Angle	t_{nom}	t_{act}	Result
L1-E	(---)	n/a	3.00 A	n/a	0.04 s	0.32 s	Passed
L1-E	(---)	n/a	3.10 A	n/a	0.04 s	0.06 s	Passed
L1-E	(---)	n/a	3.20 A	n/a	0.04 s	0.06 s	Passed
L1-E	(---)	n/a	3.30 A	n/a	0.04 s	0.06 s	Passed
L1-E	(---)	n/a	3.40 A	n/a	0.04 s	0.06 s	Passed
L1-E	(---)	n/a	3.50 A	n/a	0.04 s	0.06 s	Passed
L1-E	(---)	n/a	3.60 A	n/a	0.04 s	0.06 s	Passed
L1-E	(---)	n/a	3.70 A	n/a	0.04 s	0.06 s	Passed
L1-E	(---)	n/a	3.80 A	n/a	0.04 s	0.05 s	Passed
L1-E	(---)	n/a	3.90 A	n/a	0.04 s	0.05 s	Passed
L1-E	(---)	n/a	4.00 A	n/a	0.04 s	0.06 s	Passed
L1-E	(---)	n/a	4.10 A	n/a	0.04 s	0.05 s	Passed
L1-E	(---)	n/a	4.20 A	n/a	0.04 s	0.05 s	Passed
L1-E	(---)	n/a	4.30 A	n/a	0.04 s	0.05 s	Passed
L1-E	(---)	n/a	4.40 A	n/a	0.04 s	0.05 s	Passed
L1-E	(---)	n/a	4.50 A	n/a	0.04 s	0.05 s	Passed
L1-E	(---)	n/a	4.60 A	n/a	0.04 s	0.05 s	Passed
L1-E	(---)	n/a	4.70 A	n/a	0.04 s	0.05 s	Passed
L1-E	(---)	n/a	4.80 A	n/a	0.04 s	0.05 s	Passed
L1-E	(---)	n/a	4.90 A	n/a	0.04 s	0.05 s	Passed
L1-E	(---)	n/a	5.00 A	n/a	0.04 s	0.05 s	Passed

4. Configuration and testing overvoltage and undervoltage protective functions

To verify the overvoltage and undervoltage protective functions, the functions OV3 LOW and UV3 LOW are configured. The configuration values are given in the Table 5.

Table 5. Summary of configuration parameters of overvoltage and undervoltage protective functions

Protective function	Parameters	Set value
OV3 LOW	Start value	1.1 x U_N
	Operating delay time	0.04 s
	Num. of start phases	3 out of 3
UV3 LOW	Start value	0.85 x U_N
	Operating delay time	0.05 s
	Num. of start phases	3 out of 3

To test these protective functions, a Ramping module was selected in the test environment TEST UNIVERSE. The actual test consists of two parts. The first part (*State 1*) the voltage drop was set from 100 V to 50 V in steps of 100 mV at 1 V/s. In the second part (*State 2*) the voltage increase was set from 50 V up to a maximum of 115 V (Table 6).

Table 6. Summary of simulated conditions

State	***State 1***	***State 2***
Start value (V)	100	50
Final value (V)	50	115
Step (mV)	100	100
Time (ms)	100	100
Ramp steps	501	651

Fig. 3 shows the progress of the test. A power relay evaluated that conditions as a fault at a value 85 V. Then it began its action as shown in Fig. 4. The terminal operates in all 501 testing points.

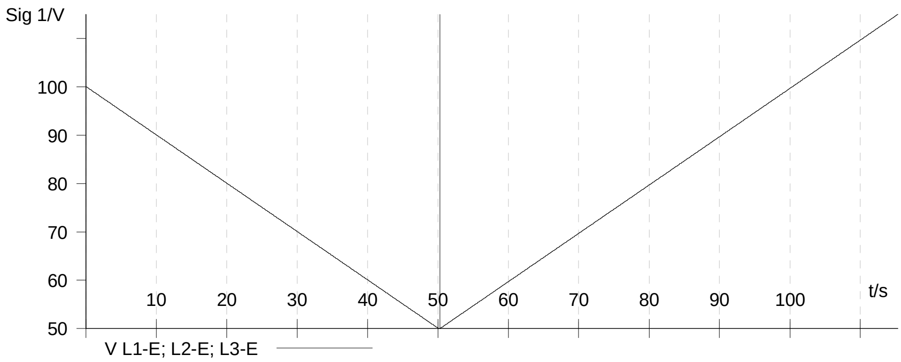

Fig. 3. The course of the injected voltage

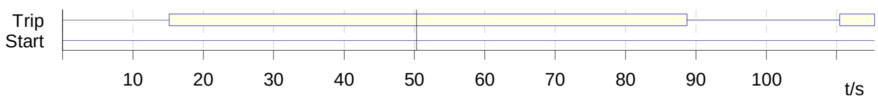

Fig. 4. Operation of protective functions

In the second part of testing (*State 2*) the voltage increase occurs. Protective relay evaluated conditions as a fault at a value 110V. Then the overvoltage protective function OV3 LOW is operated.

5. Conclusion

Before deploying protective relay in service, which are installed in switchboards as functional units for protection of generators, substations and outlets it is necessary in consideration of the importance and operational reliability of the individual components of the power system, to carry out the functional and system testing of these protective devices.

The test also corresponds to the verification of the operation of protections relay by the indirect method using the CMC156-tested test device.

This article is to point out the methods for testing the terminal, depending on whether it is a fault in which there is a change of the measured quantity, current or voltage.

Results of testing is a protocol that gives clear and accurate information about the correct operation of protective relay.

References

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

[2] ABB. "Product Guide. Feeder Protection and Control REF543". [Online].

[3] Chladný V., Janíček F., Beláň A.: *Digitálne ochrany v elektrizačných sústavách*. Košice 2003. ISBN 80-89061-73-7.

[4] Liptai P., Moravec M., Lumnitzer E., Lukáčová K.: I*mpact analysis of the electromagnetic fields of transformer stations close to residential buildings*. In: SGEM 2014, volume 1, p. 17-26, 2014, STEF92 Technology, p. 355-360. ISBN 978-619-7105-17-9.

[5] Lumnitzer E., Drahoš R., Liptai P.: *Elektromagnetické polia v životnom a pracovnom prostredí Objektivizácia a hodnotenie faktorov prostredia*. 1. vyd – Košice, Technická univerzita, 2014, s. 96. ISBN 978-80-553-1910-0.

TESTOWANIE CYFROWEGO TERMINALU ZABEZPIECZENIOWEGO REF543

S t r e s z c z e n i e

Artykuł opisuje cyfrowy terminal zabezpieczeniowy REF 543 i możliwość jego testowania. Celem tej pracy jest sprawdzenie funkcji nadprądowej, podnapięciowej i ochrony przed przepięciami metodą pośrednią z wykorzystaniem urządzenia testującego CMC 156. Wśród innych elementów pracy przedstawiono wykorzystanie REF 543 z jego funkcjami. Praca obejmuje opis metod testowania terminalu zabezpieczeniowego.

Słowa kluczowe: przekaźnik zabezpieczający, REF 543, badanie działania, bezpośrednia i pośrednia metoda

DOI: 10.7862/re.2017.1

Tekst złożono w redakcji: marzec 2017
Przyjęto do druku: maj 2017