Protection Relay Testing and Commissioning

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Protection Relay Testing and Commissioning

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The testing and verification of protection devices and arrangements introduce a number of issues. This happens because the main function of protection devices is related to operation under fault conditions so these devices cannot be tested under normal operating conditions. This problem is worsened by the growing complexity of protection arrangements, application of protection relays with extensive software functionalities, and frequently used Ethernet peer-to-peer logic. The testing and verification of relay protection devices can be divided into four groups:

- Routine factory production tests
- Type tests
- Commissioning tests
- Occasional maintenance tests

Type Tests

Type tests are needed to prove that a protection relay meets the claimed specification and follows all relevant standards. Since the basic function of a protection relay is to function under abnormal power conditions correctly, it is crucial that the operation is evaluated under such conditions. Therefore, complex type tests simulating the working conditions are completed at the manufacturer's facilities during equipment development and certification. The standards that cover the majority of relay performance aspects are IEC 60255 and IEEE C37.90. Nevertheless, compliance may also include consideration of the demands of IEC 61000, 60068 and 60529, while products intended for installation in the EU also have to comply with the requirements of EU Directives. Since type testing of a digital or numerical protection relay includes software and hardware testing, the type testing procedure is very complex and more challenging than a static or electromechanical relay.

Routine Factory Production Tests

These tests are done to show that protection relays are free from defects during the manufacturing process. Testing will be done at several stages during manufacture, to make sure problems are discovered at the earliest possible time and therefore minimize remedial work. The testing extent will be impacted by the relay complexity and past manufacturing experience.

Commissioning Tests

Commissioning tests are done to show that a particular protection configuration has been correctly used prior to setting to work. All aspects of the configuration are thoroughly verified, from installation of the correct equipment through wiring verifications and operational checks of the equipment individual items, finishing with testing of the complete configuration.

Periodic Maintenance Verifications

These are needed to discover equipment failures and service degradation so that corrective action can be taken. Because a protection configuration only works under fault conditions, defects may not be discovered for a substantial period of time, until a fault happens. Regular testing assists in discovering faults that would otherwise stay undetected until a fault happens.

Electrical Type Tests

Different electrical type tests must be completed, as follows:

Functional Tests

The functional tests consist of using the adequate inputs to the protection relay under test and measuring the performance to discover if it meets the specification. They are typically completed under controlled environmental conditions. The testing may be complex, even where only a simple relay function is being assessed. This can be understood by considering the simple overcurrent relay device shown in Table 1. To check compliance with the specification, the tests presented in Table 2 need to be carried out. This is a time-consuming process, involving many engineers and technicians. Therefore, it is expensive.

Element	Range	Step size
I>1	0.08-4.00 In	0.01 In
I>2	0.08-32 In	0.01 In
Directionality	Forward/Reverse/Non-directional	
RCA	-95° to 95°	1°
Characteristic	DT/IDMT	
Definite Time Delay	0-100 s	0.01 s
IEC IDMT Time Delay	IEC Standard Inverse IEC Very Inverse IEC Extremely Inverse IEC Long Time Inverse	
Time Multiplier Setting (TMS)	0.025-1.2	0.005
IEEE IDMT Time Delay	IEEE Moderately Inverse IEEE Very Inverse IEEE Extremely Inverse US-CO8 Inverse US-CO2 Short Time Inverse	
Time Dial (TD)	0.5-15	0.1
IEC Reset Time (DT only)	0-100 s	0.01 s
IEEE Reset Time	IDMT/DT	
IEEE DT Reset Time	0-100 s	0.01 s
IEEE IDMT Reset Time	IEEE Moderately Inverse IEEE Very Inverse IEEE Extremely Inverse US-CO8 Inverse US-CO2 Short Time Inverse	

Table 1. Overcurrent relay device specification

Test no.	Description
Test 1	Three phase non-directional pickup and drop off accuracy over complete current setting range for both stages
Test 2	Three phase directional pick up and drop off accuracy over complete RCA setting range in the forward direction, current angle sweep
Test 3	Three phase directional pick up and drop off accuracy over complete RCA setting range in the reverse direction, current angle sweep
Test 4	Three phase directional pick up and drop off accuracy over complete RCA setting range in the forward direction, voltage angle sweep
Test 5	Three phase directional pick up and drop off accuracy over complete RCA setting range in the reverse direction, voltage angle sweep
Test 6	Three phase polarizing voltage threshold test
Test 7	Accuracy of DT timer over complete setting range
Test 8	Accuracy of IDMT curves over claimed accuracy range
Test 9	Accuracy of IDMT TMS/TD
Test 10	Effect of changing fault current on IDMT operating times
Test 11	Minimum pick-up of starts and trips for IDMT curves
Test 12	Accuracy of reset timers
Test 13	Effect of any blocking signals, VTS, auto reclose
Test 14	Voltage polarization memory

Table 2. Overcurrent relay element functional type tests

When a modern numerical protection relay with many functions is assessed, each of which has to be type-tested, the functional type-testing involved is a significant issue. In the case of a recent relay development project, it was found that if one person had to complete all the work, it would take 4 years to write the functional type-test specifications, 30 years to complete the tests and several years to write the test reports. Automated processes and equipment are clearly needed.

Rating Tests

Rating type tests are completed to make sure that components are used within their defined ratings and that there is no fire or electric shock hazards under a normal load or fault conditions. Also, this is done along with verification that the product follows its technical specification. The following are the rating type tests done on protection relays. They are defined in IEC 60255-1.

Thermal Withstand Tests

The thermal withstand of VTs, CTs and output contact circuits are done to ensure compliance with the defined continuous and short-term overload conditions. In addition to a functional check, the pass criterion is that there is no damaging effect on the relay assembly, or circuit elements when the product is exposed to overload conditions that may be expected. Thermal withstand is evaluated over a time period of 1s for CTs and 10s for VTs.

Relay Burden Test

The auxiliary supply burdens, optically isolated inputs, VTs and CTs, are measured to determine that the product complies with its specification. The burden of products with a big number of input/output circuits is application specific, i.e., it increases according to the number of optically isolated input and output contact ports which are energized under normal power system load conditions. It is typically believed that not more than 50% of these ports will be simultaneously energized in any installation.

Relay Inputs

Relay inputs are verified over the specified ranges. Inputs include those for auxiliary voltage, VT, CT, frequency, optically isolated digital inputs, and communication elements.

Relay Output Contacts

Protection relay output contacts are type tested to make sure that they follow product specification. Special withstand and endurance type tests have to be completed using DC since the normal supply is via a station battery.

Insulation Resistance Test

The insulation resistance test is completed in line with IEC 60255-27, i.e., 500V DC. - 10%, for a minimum of 5 seconds. This is completed between all circuits and case ground, between all independent circuits and across normally open contacts. The pass criterion for a product in new condition is a minimum of 100MΩ. After a damp heat test, the pass criterion is a minimum of 10MΩ.

Auxiliary Supplies

Digital and numerical protection relays typically need an auxiliary supply to give power to the on-board microprocessor circuitry and the interfacing optoisolated input circuits and output protection relays. The auxiliary supply can h powered from a number of sources or safe su nd they may be subject to voltage dips, short relays are made to ensure that service is kept the auxiliary supply. Tests are completed for bo ins change both above and below the nominal ra t and short circuit, power dips as a percentage o otion duration and supply dips range from 2ms t up to 20ms, potentially longer, should not sta eration of output relays and watchdog contact lication, acceptance of corrupted information saved information or settings. For a longer protection relay self-recovers without the lo ings or information corruption. No operator intervention is restore operation after an interruption or supply dip. In addition to the above, the protection relay is exposed to a number of repetitive starts or a