NEW APPROACHES TO THE TESTING AND THE OPERATION TESTS OF ELECTRIC PROTECTIONS

Jaroslav Pospíšil
Czech Republic
pospisil@protection.cz

Zygmunt Kuran
Poland
lab.eaz@ien.com.pl

ABSTRACT

This article deals with new techniques of testing the electric protections by the help of digital testing equipments enabling automatic procedures, e.g. dynamic tests. To check correct operations of electric protections, primary test simulations are recommended, especially for ground-fault protections in MV lines.

INTRODUCTION

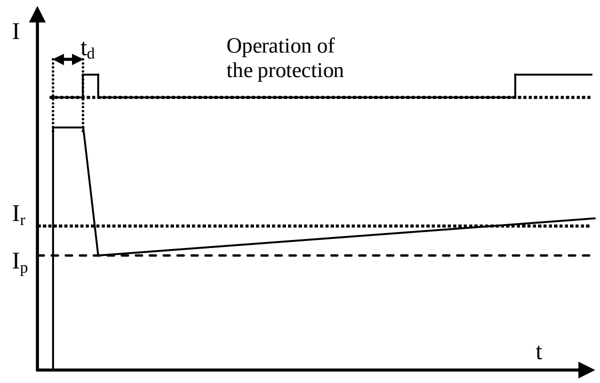
Conditions of the development of the automation of the secondary testing of the electric protections and the automatics are due to the existence of digital testing equipments. Simulated current and voltage values at the set frequency and phase shift are microprocessor-calculated as standard signals that are generated by the secondary amplifier, with any operating period and a set wave form. They differ from the standard equipments in dynamic mode accuracies.
It is very important to check correct behaviours of electric protections under the real operating conditions by means of primary tests, first of all by ground-fault simulations.

IMPERFECTIONS OF STANDARD TESTING METHODS OF THE PROTECTIONS

Static measurement of the starting value and the time-delayed relay release

If there is no setting information on a time-delayed relay, the time needed for an accurate measurement of its starting value is much longer than the time delay itself. The setting is applied to current, voltage and directional protection, etc. The testing time could be shorter, if the setting and the accuracy class of the relay are known. E.g., if the current value of the time-delayed current protection is step-increased and the current increases with the trend of 0,025 A/s, the starting value of the relay I_r can be stated with an accuracy up to 1 %. The testing time is much longer than the setting time of the time delay t_d.

For an example of shortening the testing time - see *Picture 1*. This picture also shows a quickest standard way of measuring the starting and release values – by the static method. E.g. you can set such a current value so that the relay starts its operation and the time delay t_d is measured. Than the current value is reduced in order to read the release value I_p. The standard release factor value is 0,95. That resulting starting value is by approx. 5 % higher. The release value I_p can be determined without a delay, i.e. much quicker than the starting value. From the release value I_p the current can be slowly increased with the trend 1% during the period t_d until the starting value I_r is reached. A correct starting value will be determined within the period of several t_d. The static method does not define the relay behaviour at dynamic conditions.



Picture 1 Testing of starting and release values of the time-delayed current protection by the „trend" method

TESTING OF DIGITAL PROTECTIONS

Older types of protections usually consist of individual protective functions and can be tested step by step, while modern digital protections are supplied all at the same time. They most often influence the same output relay and it is hard to recognize what protection has operated. The protection file must be re-programmed for the testing period and the protection must be tested with a simultaneous check of output relays and protection supplies, so that they will be selectively activated.

For any digital protections the release time cannot be measured - after every operation 1-second tripping signal is created, regardless of criteria functions. The release time is generally given by the overshoot period that can be measured by the help of the digital tester.

The overshoot period – this is a parameter for the time-delayed protections. This determines the period between the jump reduction of the criteria value to the moment of the operation of the protection. The criteria value will be changed from a maximum one to such a load value that will emerge after the fault clearing. The criteria value disappears before the operation and at the same time the protection starts its operation. For various types of protections this period varies from 30 ms to 150 ms. The shortest period for the selective protection timing must be longer than the sum of the following periods – the operating period of the switch and the overshoot period. Only for some protection designs the overshoot period can be replaced with the release period. If a time stepping of the protections must be reduced, the real overshoot period must be defined – measured by the help of the digital testers.

The automation range of testing the electric protections and automatics can be very different. In the maximum version we can imagine that all protection's inlets and outlets are connected to the testing equipment. The control program sets appropriate values of binary and generated analogue signals and at the same time outlet conditions are checked. For a full test of the equipment, it would be necessary to observe the optical signals and the records on operation and event histories. A protection manufacturer needs such a system while for the operation there are required analogue measurements and output signals, as to the automatic protection testing.

TESTING EQUIPMENT PARAMETERS

In the power supply there are installed current protections with the rated current of 5 A first of all and the testing equipment is needed – the current value of 20 In, i.e. 100 A, is required. Current parameters of major part of foreign testing equipments conform to the rated current of the protections In = 1 A. To test the versions 5 A, an additional amplifier is used and the price and the weight of the testing equipment is higher.

Research works in both companies - Protection & Consulting,s.r.o. / CZ / and Instytut Energetyki / Poland / - are aimed to the realization of such a testing equipment that can be used for all types of MV protections, motor protections, AR (automatic recloser) and FLS (frequency load shedding) automatics, transformer and generator protections. These protections' rated currents are usually 5 A. The testing equipments are designed like control panels. PC can be used for the testing automation.

New testing equipments include digital generators of control signals and high-quality secondary amplifiers. With such a design of the testing equipment there are problems neither with setting the phase, nor with the testing period or with automation of the tests.

The secondary amplifier is the basic element of the new testers' generation. This amplifier is realized without the current transformer. The elimination of the current transformer cuts the weight and direct-current component processes can be generated.

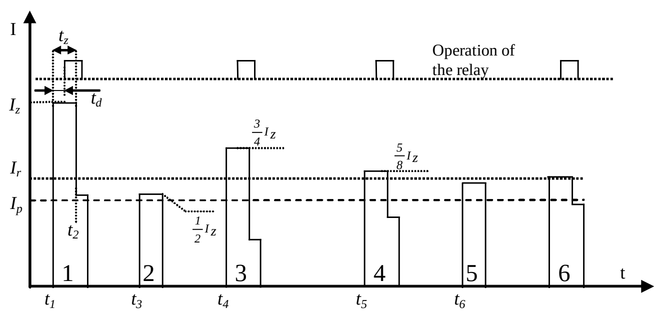
AUTOMATIC TESTING

Usually dynamic and static tests can be identified. Dynamic tests are the tests with a jump set of measured values. Static tests are the tests with step-by-step changes of set values.

The selected test must correspond with real conditions as much as possible. There are different requirement to the overload and short-circuit protections. In fact the short circuit is the most significant fault that emerges and disappears suddenly and accidentally, whereas the fading process is quite complicated. The current does not return to the load conditions after its switch-off, but it is increased by dynamic component of motor currents that have not been supplied correctly during the short-circuit.

Dynamic tests of starting and release values of the time-delayed protection

After a full analysis the interval splitting method has proved as a progressive one. For this method see *Picture 2* – e.g. testing of the time-delayed over-current protection with the starting value I_r and with the time delay t_d,



Picture 2 - Testing of starting and release values of the time-delayed protection with the progressive approximation method – interval splitting

The current Iz for the period t_z will do the first short circuit during the time t_1,. Current parameters have been selected so that the protection would definitely operate. In the moment t_2 the current value will be changed for the load value. In this moment the protection release value is tested.

The current $0{,}5I_z$ will do the second short circuit during the time t_3 . This test shows that the starting value of the tested protection is between $0{,}5I_z$ and I_z. In the moment t_4 another short circuit will be done for half amplitude of this range, i.e. $\frac{3}{4}I_z$. Current values $\frac{5}{8}I_z$, $\frac{9}{16}I_z$, $\frac{19}{32}I_z$ will do the next short circuits 4, 5, 6. If the first test has been done by the current smaller than 2 I_r than in the step 10 a starting value will be determined with a better accuracy than 0,5 % I_r.
This method can be also used for dependant and multi-step protections.

Testing of differential protections

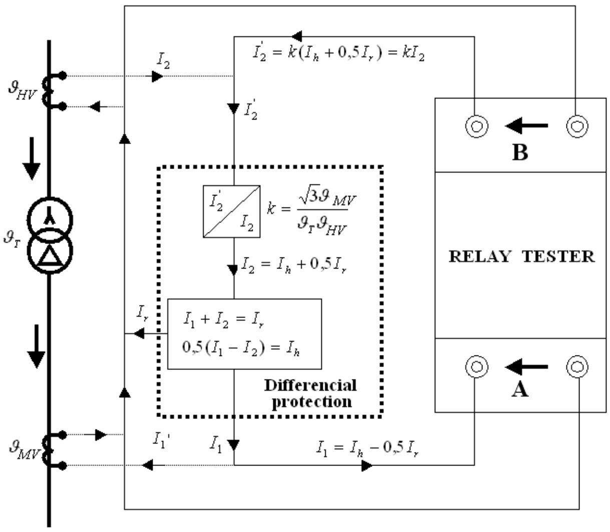
Characteristics of differential protections can be fully tested by a simulation of asymmetric short circuits by the help of two single-phase supplies. *Picture 3* shows the wiring diagram for testing the differential protection of RTCZ ½ type, where the current values of the testing equipment I1 and $I_{2'}$ are:

I_1 = Ih - 0,5 I_r,
$I_{2'} = k * (I_h + 0{,}5\ I_r) = k * I_2$

where I_h is differential current of the protection,
I_r is summation current of the protection

and the factor is defined in the formula:
$k = \sqrt{3} * \vartheta_{MV} / (\vartheta_T * \vartheta_{HV})$,

where ϑ_{MV} is the current transformer ration - MV side
ϑ_{HV} is the current transformer ration - HV side
ϑ_T is the high-power transformer ratio Yd



Picture 3 – Distribution of currents at connecting the protection RTCZ-1/2 to the testing equipment

If the currents are set in correspondence with the above-mentioned formulas, the differential protection characteristics can be tested without any additional conversions.

Testing of the stabilisation characteristic of the differential protection represents – for the set differential current value I_h - measuring of the summing current I_r at his increase till the moment when the differential protection starts to operate. If the differential protection is tested according to the *Picture 3*, it is necessary to check the possible switch-on of the compensation of the current zero-sequence component.

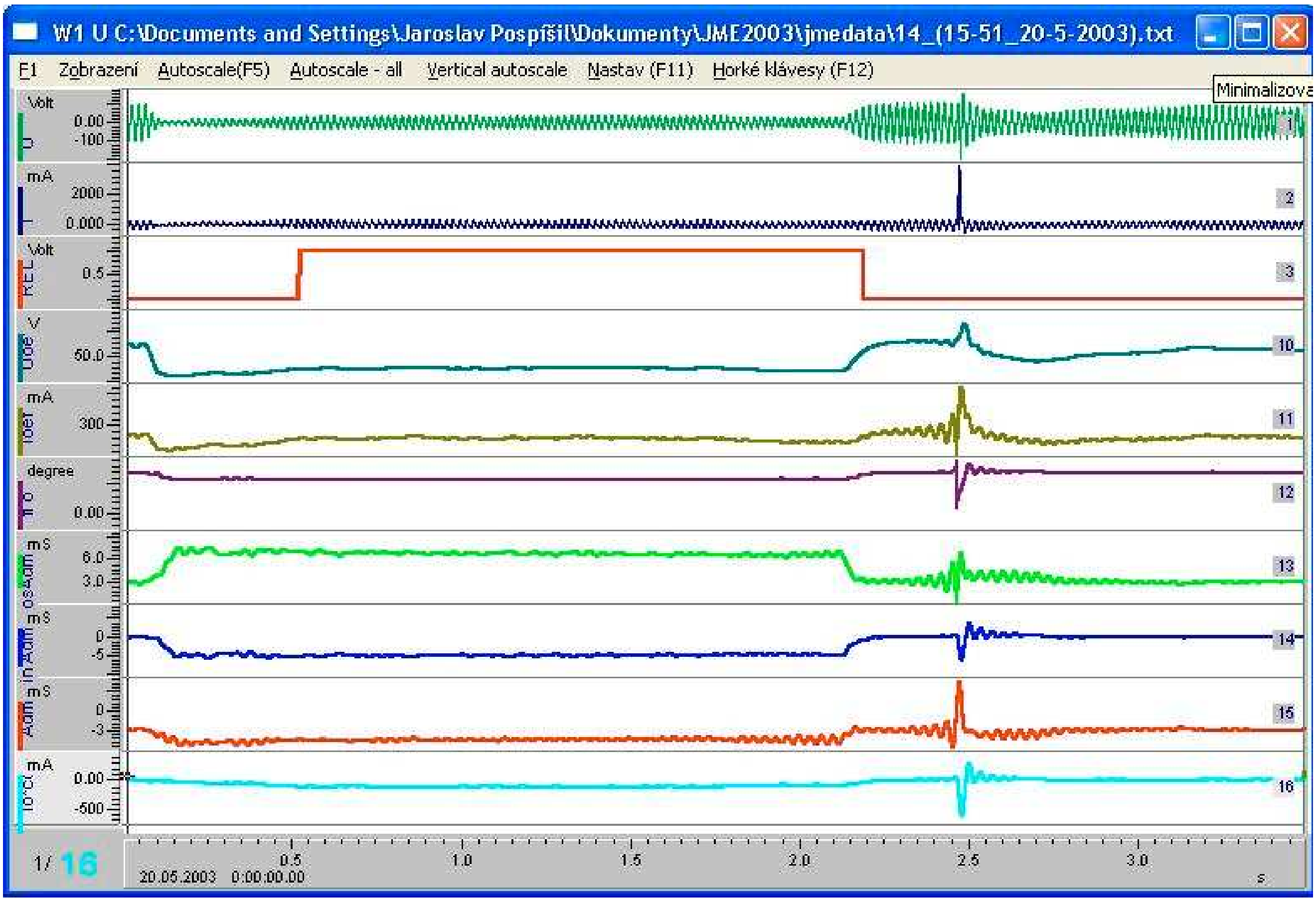
Primary tests of electric protections

When the protections are supplied from the primary side, first of all phase currents are red. If the reading corresponds with the required current, the real transformer ratio is confirmed and at the same time it is checked that the current circuits are closed. The current of the protection operation is checked too. For the purpose of primary tests we need a primary current supply – primary current value of approx. 2400 A is sufficient. It is significant to do also the primary tests in addition to the secondary tests of the electric protections. Primary tests of ground-fault protections in MV mains [3] and of protective functions of the equipment of AutoRecloser type in MV mains [4] are standard. Significant primary tests must be done also with disperse sources when they are commissioned [5] .

In the Czech Republic, there are cable lines or MV overhead lines operated as insulated, compensated or resistor-earthed ones. To indicate ground-faults in MV compensated lines, the most suitable criteria is the application of the conductance criteria Go> in co-operation with the operation of the resistor closing automatics.

At the installation and commissioning of multifunctional ground-fault protections in MV switchgears, there are realized primary tests by the help of ground fault simulation in MV outlets.

For an example of a ground fault analysis by means of a SW in real time see *Picture 4*. Measured secondary quantities are: “zero” voltage Uo in /V / and “zero” earth current Io in / mA /. Calculated quantities are: Uoef – effective value of the “zero” voltage, Ioef – effective value of the “zero” current, φo – phase shift /in degrees/ between Uo and Io, Yo - admittance in / mS /, Go – conductance in / mS /, admittance active component Yo, Bo - susceptance in mS /, admittance idle component Yo, Ifi – current active component Io in / mA /.



Picture 4 – An example of histories of measured and calculated quantities at a high-ohm ground fault in MV line

CONCLUSION

There have been mentioned the imperfections of standard testing methods that result from the static measuring methods.

The digital protections require new approaches to the testing, automatic processes with dynamic tests, e.g. the progressive approximation method by interval «splitting». For some time-delayed protections the overshoot parameter must be determined. If two single-phase supplies are used, the stabilization characteristic of the differential protection can be determined directly – ratios of CB current transformers and of the high-power transformer must be respected. It is recommended to do the secondary tests of electric protections, as well as the primary ones, especially at the testing of the proper operation of ground-fault protections in MV lines by the simulation of high-ohm ground faults.

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