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Distance protection and the importance of precision measuring equipment

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Abstract. As we know short circuits are an inevitable phenomenon for the electrical power system. These damages must be quickly detected by the relay protection system and the damaged part must be isolated quickly. The defense of a line is of particular importance. When a defense system is designed, a compromise must be made between economics and performance, independence and security, complexity and simplicity, accuracy and speed.
From a technical point of view, the correct performance of the relay protection has been of particular importance over the years. It is not desirable for a node of the system to be taken out of service due to a wrong action of the relay protection leading to energy faults, accompanied by penalties to consumers and disadvantages vis-à-vis competitors for companies operating in the energy market. In some case's the local backup protection is combined with the remote backup protection which is defined as a backup of the backup.
In numerical relays, often at the "software" level, the user can implement functions based on logical mathematical blocks. In this combination with the rapid developments in information technology with applications in the system in the electrical power system made the relay protection quite efficient and powerful, any error in the communication channels or human errors can cause the relay protection to malfunction or malfunction.
Keywords: Power System, Relay protection, damaged, energy.

1. INTRODUCTION:

Short circuits are an inevitable phenomenon for the electrical power system. These damages must be quickly detected by the relay protection system and the damaged part must be isolated quickly. But to achieve this goal a protective system with fast and safe action is necessary and essential. It will minimize the risk that a local event could bring down the entire electrical system.
The defense of a line is of particular importance. When designing a defense system, a compromise must be made between economics and performance, independence and security, complexity and simplicity, accuracy and speed.
Here the focus is on the performance of the relays from the point of view of the electrical system.
From a technical point of view, the correct performance of the relay protection has been of particular importance over the years. It is not desirable for a node of the system to be taken out of service due to a wrong action of the relay protection leading to energy faults, accompanied by penalties to consumers and disadvantages vis-à-vis competitors for companies operating in the energy market. short circuits are an inevitable phenomenon for the electrical power system. These damages must be quickly detected by the relay protection system and the damaged part must be isolated quickly. The first digital relay was developed by Rockefeller in the early 80s. Nowadays many protective relays are microprocessor based.
Substation automation includes protection, control and monitoring of power equipment.
By the measurement principle, we mean the principle in which the relays receive the electrical magnitude from the protected object and which is monitored by the protection.
Measuring the ratio between current and voltage, or impedance in the general case, gives us the distance over which the damage has occurred, and the protection is now called distance.

2.Digital Relay Technology

The first digital relay was developed by Rockefeller in the early 80s. Then many literatures reported new techniques on digital relays or numerical relays. Nowadays many protective relays are microprocessor based.

Numerical technology provides an unpredictable flexibility in relay design, flexibility that cannot be provided in static or electromagnetic relay designs.

Setting the relay parameters can affect the relay characteristics, some other relays require more information from the information system to set the boundary conditions. Intelligently determining relay parameters is a challenge for protection engineers. Protection relays and their associated equipment carry and process a large amount of data. This data can be transferred to the control center for further analyzes in real time "online" or analyzes of an "offline" nature.

Substation automation encompasses the protection, control and monitoring of power equipment. A modern microprocessor-based relay protection with communication facility can also protect, control and monitor functions. The data network can link digital relays to form a substation automation. The centralized system can coordinate all protection parameters and transfer them to the relays. Computer processing power and telecommunications technology are like a rocket going to the sky, is real-time protection and adaptive coordination setting of relay parameters are possible according to changes in electrical system configurations. The measurement of the ratio between the current and the voltage that is the impedance in the general case gives us the distance at which the damage has occurred and the protection is now called distance.

To ensure selectivity, the value of the measured electric quantity is usually used as information (I, U, S, Z), but often this is not enough, and the time of relay operation is added to this information. In this case, by using both of these, sufficient selectivity is ensured by which only the damaged element or the minimum possible part of the system where the damage has occurred is switched off.

The distance relay protection is a universal device for protection, control and automation, its high level of flexibility makes it suitable to be applied at all voltage levels.

With this relay you are ideally equipped for the future:

• it provides investment security
• and also saves on operating expenses.

Distance relay protection is used in the protection of aerial and cable lines at all voltage levels from 5 to 765 kV.

The advantages and disadvantages of distance protection are as follows.

a) Advantages:

• It is selective line protection in networks,
• The action time of the relay is usually very small,
• This protection is backup protection with the second and third zones for other subsequent relays,
• The first zones which cover at least 85% of the protected line are fast-acting and have absolute selectivity,
• Not affected by addition and change of load up to the rated load of the line

b) Disadvantages:

• the sensitivity depends on the impedance of the load, and the action of the protection is influenced by:
• Short line,
• Power fluctuations,
• Impact of damage resistance,
• High cost, optional functions increase the cost of the relay,

In order to enable the evaluation between the normal and damaged regimes, a zone of normal operation and an area of abnormal operation were used. If the apparent impedance seen by the distance relay is outside the damage zone the relay will not send an impulse to the circuit and if it sees this impedance inside the damage zone then it will operate.

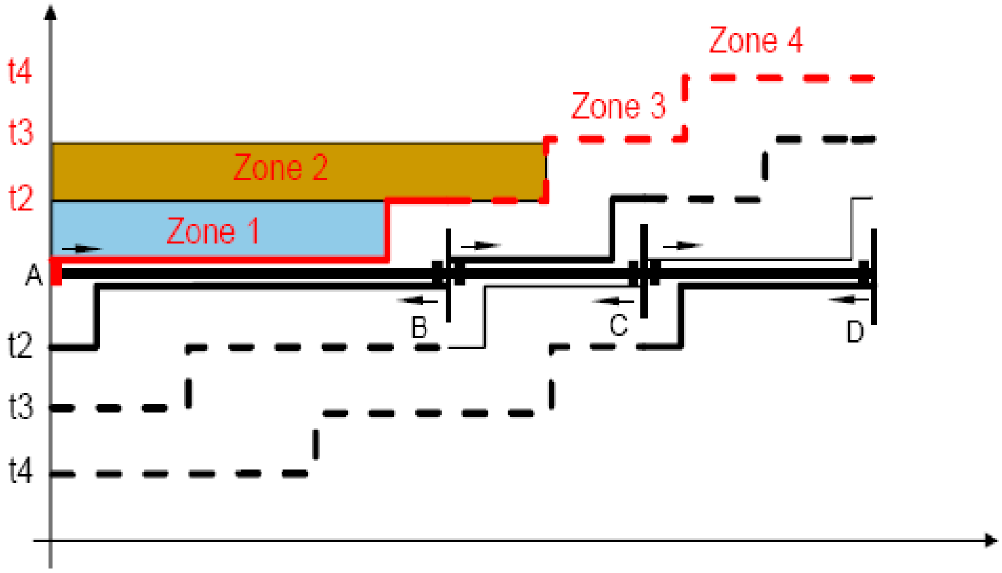


Figure 1 Distance protection. Working principle

3. Results:

We have taken as an example the testing of a protection in the electricity system of Kosovo. First, to use this device, the corresponding software licensed by the OMICRON company must be installed, depending on the type of device we want to test, the configuration of the OMICRON connection to the device we want to test also changes.

In our case of distance protection, we connect three currents, three voltages and the tripping terminals of the circuit breaker in order to simulate the short circuit and the tripping time as accurately as possible.

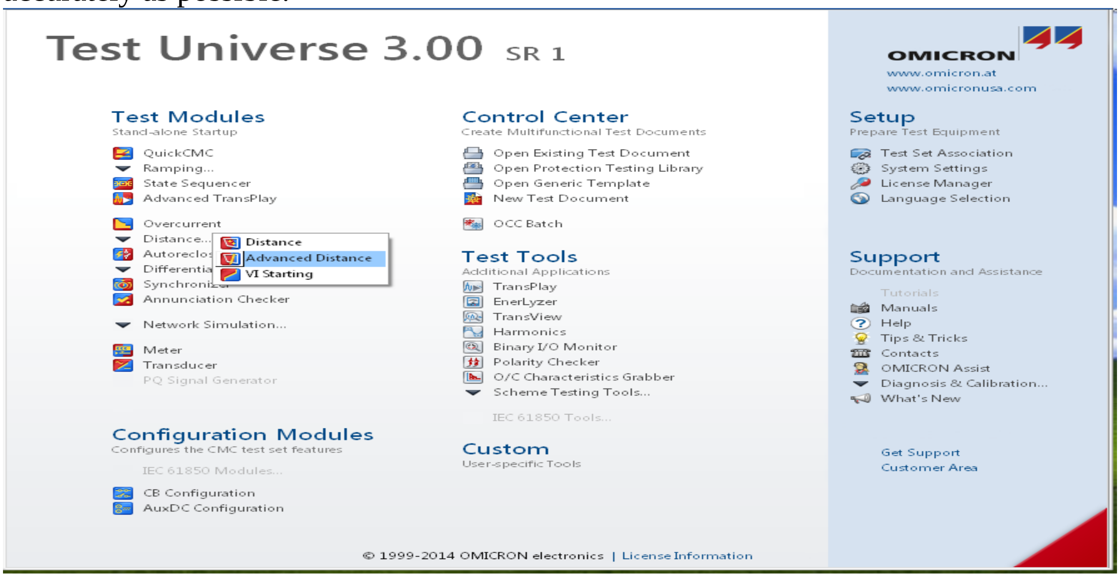


Figure 2 The first page of testing a remote protection

After the many steps that we followed through the Omicron device, we had to fill in the details for the line where we tested it, starting from the line name, length, load and any other information. And in order to be able to write all this information, it was necessary to follow a series of steps where at the end of all the testing we obtained the results as below.After we have tested the Omicron line as a smart device, it generates a report with all the details and the results of how the test went.

LP 267 NS Kosova A:

Test Object - Device Settings

Substation/Bay:

Substation:	Kosovo A / Substation / 220 Kv	Substation address:	
Bay:	D08 - LP-267	Bay address:	

Device:

Name/description:	Kosovo A / Substation / 220 Kv /D08 - LP-267	Manufacturer:	
Device type:	7SA611	Device address:	
Serial/model number:			
Additional info 1:			
Additional info 2:			

Nominal Values:

f nom:	50.00 Hz	Number of phases:	3
V nom (secondary):	100.0V	V primary:	100.0 V
I nom (secondary):	1.000A	I primary:	1.000 A

Residual Voltage/Current Factors:

VLN / VN:	1.732	IN / I nom:	1.000

Limits:

V max:	120.0 V	I max:	10.00 A

Debounce/Deglitch Filters:

Debounce time:	5.000 ms	Deglitch time:	0.000 s

Overload Detection:

Suppression time:	50.00 ms

Test Object - Other RIO Functions

CB Configuration

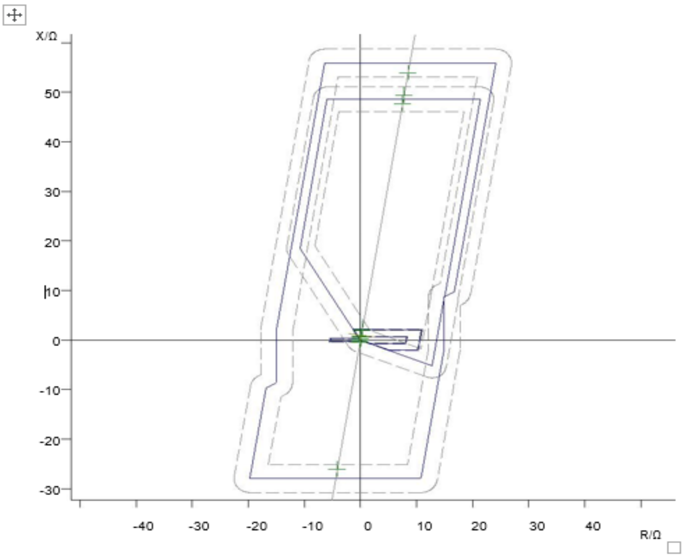
Description	Name	Value
CB trip time	CB trip time	50.00 ms
CB close time	CB close time	100.00 ms
Times for 52a, 52b in percent of CB time	52a, 52b % of CB	20.00 %

Test Object - Distance Settings

Figure 3 The first part of the report with main line data and test data.

Figure 3 shows first the main data of the birth as we can see in the report, but also the main data of the test, i.e. at what time it started, which part of the line was tested, how much was the load, etc.

As we mentioned above, the working principle of distance protection is to work with areas, and according to this principle, the line testing was also done in our case.
In the following, we will present only the main test results for the 3 main areas of distance protection, because the generated report is very long and in more detail, so it was not possible to present all of them.

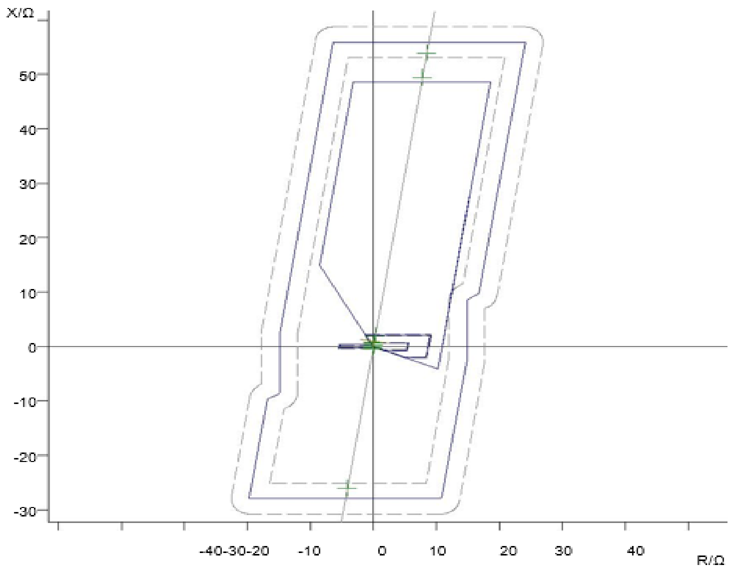


Shot Test: Fault Type L1-L2

|Z|	Phi	%	% of	t nom	t act.	Dev.	ITest	Result
191.3 mΩ	81.00 °	n/a		0.000 s	14.30 ms	14.30 ms	2.000 A	Passed
572.3 mΩ	81.00 °	n/a		0.000 s	33.70 ms	33.70 ms	2.000 A	Passed
763.8 mΩ	81.00 °	n/a		400.0 ms	418.8 ms	4.7 %	2.000 A	Passed
2.000 Ω	81.00 °	n/a		400.0 ms	423.5 ms	5.875 %	2.000 A	Passed
50.00 Ω	81.00 °	n/a		3.600 s	3.634 s	0.95 %	1.200 A	Passed
54.61 Ω	81.00 °	n/a		3.600 s	3.633 s	0.9278 %	1.099 A	Passed
95.76 mΩ	-99.00 °	n/a		3.000 s	3.033 s	1.103 %	2.000 A	Passed
303.1 mΩ	-99.00 °	n/a		3.000 s	3.033 s	1.093 %	2.000 A	Passed
390.4 mΩ	-99.00 °	n/a		3.600 s	3.633 s	0.9194 %	2.000 A	Passed
26.41 Ω	-99.00 °	n/a		3.600 s	3.633 s	0.9194 %	2.000 A	Passed

Figure 4 Test data between two phases L1-L2

In this part of figure 4, the test for L1-L2 is presented, and as can be seen in the figure, certain areas that have reacted are highlighted and are shaded with colors. As far as this part is concerned, everything was in order and the remote protection acted on time.

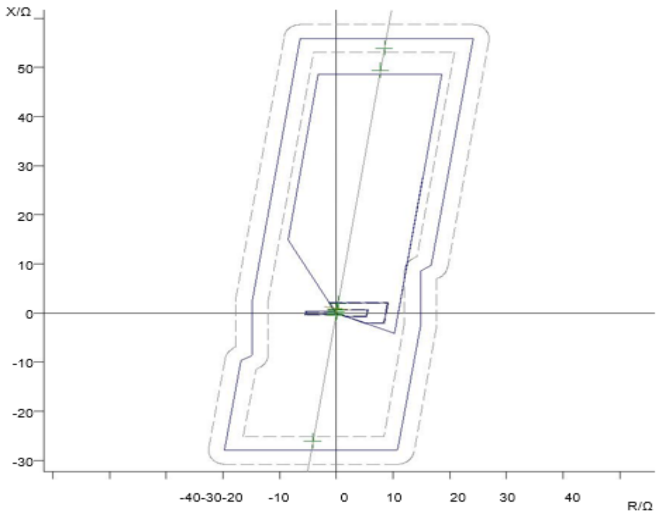


Shot Test: Fault Type L2-L3

|Z|	Phi	%	% of	t nom	t act.	Dev.	ITest	Result
191.3 mΩ	81.00 °	n/a		0.000 s	13.80 ms	13.80 ms	2.000 A	Passed
572.3 mΩ	81.00 °	n/a		0.000 s	23.90 ms	23.90 ms	2.000 A	Passed
763.8 mΩ	81.00 °	n/a		400.0 ms	413.2 ms	3.3 %	2.000 A	Passed
2.000 Ω	81.00 °	n/a		400.0 ms	423.1 ms	5.775 %	2.000 A	Passed
50.00 Ω	81.00 °	n/a		3.600 s	3.634 s	0.9389 %	1.200 A	Passed
54.61 Ω	81.00 °	n/a		3.600 s	3.633 s	0.9278 %	1.099 A	Passed
95.76 mΩ	-99.00 °	n/a		3.000 s	3.038 s	1.28 %	2.000 A	Passed
303.1 mΩ	-99.00 °	n/a		3.000 s	3.034 s	1.12 %	2.000 A	Passed
390.4 mΩ	-99.00 °	n/a		3.600 s	3.634 s	0.9361 %	2.000 A	Passed
26.41 Ω	-99.00 °	n/a		3.600 s	3.634 s	0.9528 %	2.000 A	Passed

Figure 5 Test data between two phases L2-L3

In this part of figure 5, the test for L2-L3 is presented, and as can be seen in the figure, certain areas that have reacted are highlighted and are shaded with colors. As far as this part is concerned, everything was in order and the remote protection acted on time.



Shot Test: Fault Type L1-L2-L3

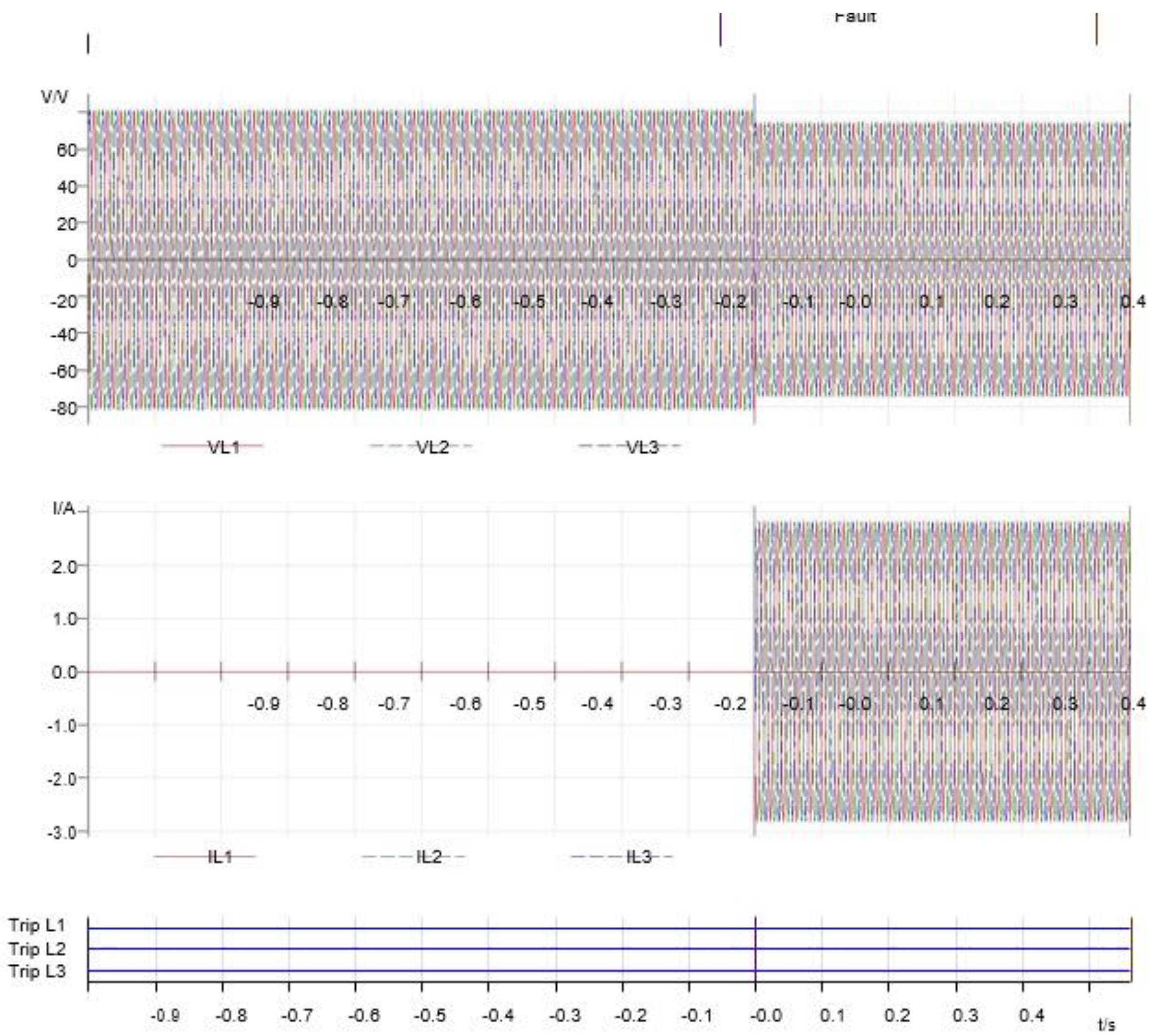
|Z|	Phi	%	% of	t nom	t act.	Dev.	ITest	Result
191.3 mΩ	81.00	n/a		0.000 s	14.50 ms	14.50 ms	2.000 A	Passed
572.3 mΩ	81.00	n/a		0.000 s	22.80 ms	22.80 ms	2.000 A	Passed
763.8 mΩ	81.00	n/a		400.0 ms	418.6 ms	4.65 %	2.000 A	Passed
2.000 Ω	81.00	n/a		400.0 ms	433.6 ms	8.4 %	2.000 A	Passed
50.00 Ω	81.00	n/a		3.600 s	3.634 s	0.9306 %	1.386 A	Passed
54.61 Ω	81.00	n/a		3.600 s	3.633 s	0.9194 %	1.269 A	Passed
95.76 mΩ	-99.00	n/a		3.000 s	3.033 s	1.103 %	2.000 A	Passed
303.1 mΩ	-99.00	n/a		3.000 s	3.033 s	1.113 %	2.000 A	Passed
390.4 mΩ	-99.00	n/a		3.600 s	3.638 s	1.053 %	2.000 A	Passed
26.41 Ω	-99.00	n/a		3.600 s	3.633 s	0.9194 %	2.000 A	Passed

Figure 6 Test data between two phases L1- L2-L3

At the very end of this test, the final part is generated where the Omicron device shows exactly whether the test has passed or not.

If the test has passed, it means that everything regarding the relay protection is in order and in case of any damage, the distance protection is ready to act in time.

So even in our case the test has passed successfully



Cursor Data

	Time	Signal	Value
Cursor 1	0.000 s	<none>	n/a
Cursor 2	3.633 s	<none>	n/a
C2 - C1	3.633 s		n/a

Test State:
Test passed

4. Conclusions:

Thesis consists theoretical analyzes of distance protection and its importance in practice, in protection and security of electric system; facilitation and flexibility that this protection offers, as well basic steps of theoretical analyzes of OMICRON device, by relevant application that helps in measurement of distance protection parameters.

Through this equipment, at the end of the thesis a real testing will be presented, by following concrete steps in order to achieve a successful testing of the equipment**.**

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