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A Pedagogical Proposal: Methodological Guide For Testing 87L Line Differential Relay

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ABSTRACT-

This paper presents the basic concepts of the 87L line differential protection function and the connection to a test system to check its correct operation, as an operational guide for electrical and electronic engineering students, taking into account the areas of fiber optic connection between relays, DIGSI configuration and simulation with OMICRON CMC 256 test equipment. We will work with a generic line differential protection relay to present its interconnection and configuration as a case study to provide practical and forceful solutions in line protection issues, with low operating costs and safe investments. With the incorporation of new communication technologies in electrical substations, it is very important in the didactics of the interconnection of these systems and verification of the operability for this and other devices.

Keywords: ANSI 87L, CMC 256,Line differential protection, Relay test.

I. INTRODUCTION

Companies specialized in protection systems in medium and low voltage lines develop a wide range of highly flexible digital devices both in their hardware and software structure that allows through modular structures to meet all kinds of needs that are required by the customer (Bricker, 2001). These needs cover all levels in an automated system of electrical substations, starting from level zero where the yard equipment is located and from which the measures that the devices will control and protect are taken, reaching the control center which is the last level whose communication system allows the visualization of the entire system status that the customer may require, thanks to the information sent by these devices through protocols that have been standardized in such a way that equipment from different manufacturers can be used in the development of various solutions (Nichani, 2018).

The ANSI 87 function or differential protection, consists of constantly sensing the electrical magnitudes that enter and leave a protected zone, being the 87L the assigned one whose specific function is the line differential protection, which acts making use of a CT and a differential relay at each end of the line, which read the magnitude of current that has been transformed having to be equal at both ends (AsghariGovar, 2016).

Since the distance is one of the restrictions for sending signals, the relays communicate with each other using analog or digital signals, so that their respective tripping and restriction zone is defined as the one that is between the two transformers that will give the signal between the two transformers that will give the magnitudes to be sent by signals through the relays, where the synchronism is done through a time master stored in one of the relays(Moxley, 2005).

II. PROBLEM FORMULATION

Figure 1 shows the image of the relay 7SL87, in which you can see that the device has a large display where you can see the single-line diagram of the system as all the data of the same, data that will be constantly monitored so that in any eventuality the relay can act as expected and its response is effective for the system. It also has several input and output terminals, as well as plug-in communication modules, which will allow the constant and redundant communication link between the relay and other protection and control devices that are part of the same system and even others with which it is interconnected (Siprotec, 2013).

Figure 1: Relay 7SL87. Front and rear view

Line differential protection, ANSI 87L, is the protection of a selective line that acts against single-phase or three-phase short-circuits in overhead lines, allowing fast tripping at two to six ends of the same. Its operation depends on the installation of measuring instruments (CTs) and the protection device at each end of the line to be protected. These devices exchange the measured values through communication links and operate based on a permanent comparison by tripping the assigned circuit breaker in case of a short circuit in its protection range, which is selectively delimited by the current transformers installed (Li, 2000).

Compared to generators, transformers and busbars, line measurements cannot be processed directly, since the protection range of these extends from one station to another, which is why these measurements must be transferred properly and thus ensure that the trip is verified at each end of the line and in case of a fault performed, each device has at least one interface for the communication of these data that are transmitted in digital telegrams via communication channels.

Figure 2 shows an example for a line with 3 ends, for the process each device measures the local currents, in this case, the relay measures i1 and transmits it as a complex phasor to relay 2, which adds its current measurement i2 and transmits it to relay 3 which adds its component i3, in the same way, the sum of all currents are sent in the opposite direction and thus the three devices have the total sum of the three currents (Dambhare, 2009).

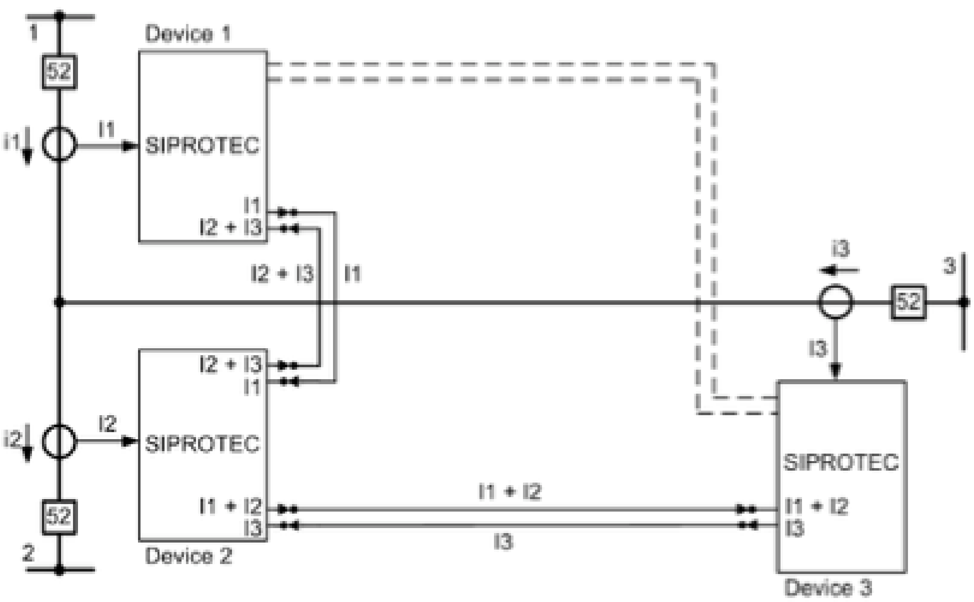

Figure 2: Example of line differential operation for a line with 6 terminal points

III. TEST DESCRIPTION

The OMICRON CMC is test equipment for protection devices such as relays and is a universal calibration tool for a wide range of measuring devices, it is composed of electronic elements operated through the Test Universe software which is composed of a series of modules that allow properly verifying the protection functions. This case allows injecting the necessary voltage and current values according to the engineering of each project, in the board where the relay to be tested is located, making the level of reliability of the test much higher and its scope as desired.

For the specific case of the project development, the CMC 256 was used, which consists of a three-phase voltage source, a single-phase voltage source, two three-phase current sources, binary inputs and outputs and a DC voltage output as shown in Figure 3.

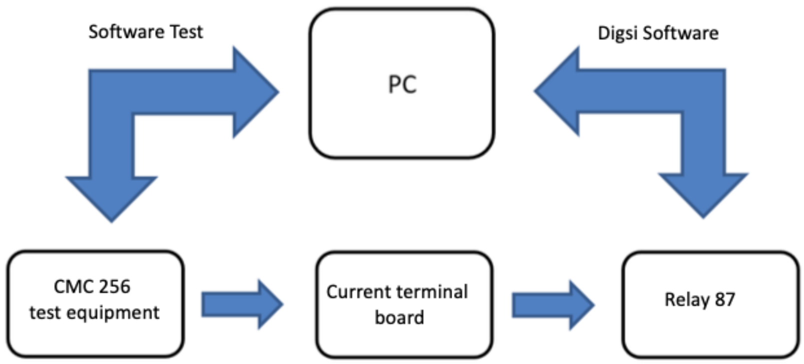

Figure 3: Block diagram of general wiring for test execution

The connection of the injection case with the board is made through flexible connectors with plug terminals, from the voltage and current sources of the OMICRON to the terminals intended for these signals on the board, these terminals are in turn wired to the relay according to the electrical plan so that all injected value must be seen both in the relay and in the DIGSI, which is the software used to perform the protection tests.

To start describing the test procedure, it is necessary to determine the communication that must be established between the relay and DIGSI, which if not done correctly does not allow a successful initialization of the relay; and between the computer, which is the display medium, and OMICRON, this connection is made by ethernet port. Figure 4 shows the test equipment and its start-up interface.

Figure 4: CMC 256 test equipment

The modular relays in their software and hardware work hand in hand with the DIGSI 5 program, which is the tool that allows parameterizing the relays and at the same time to observe all the data that he is seeing, assisting both the workflow and the planning of the operations of the different electrical systems; in Figure 5 shows the interface of the program. The connection of the relay to the computer from which the DIGSI software is accessed is made using a USB type A cable.

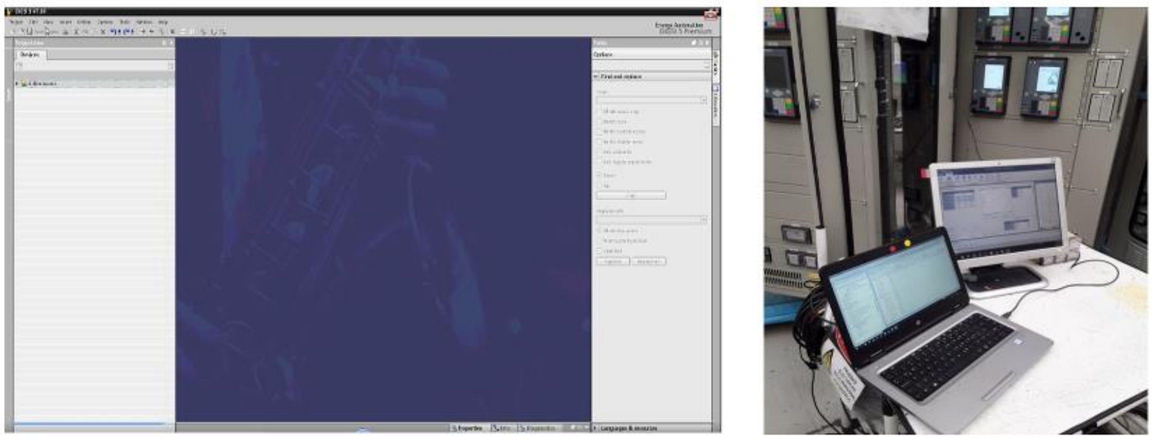

Figure 5: Connection of the relay to the computer.

To start testing the relays, the first thing to do is to create the relay and the DIGSI of the project to be tested. It should be taken into account that the latter is normally already provided by the engineering area to the protection engineers, otherwise, it should be created from the beginning with the help of the electrical drawings of the panel, configuring in the DIGSI each of the binary inputs and outputs, tripping, functional, among others. Depending on each software the steps may vary. Figure 6 shows the creation and connection of the relay under test.

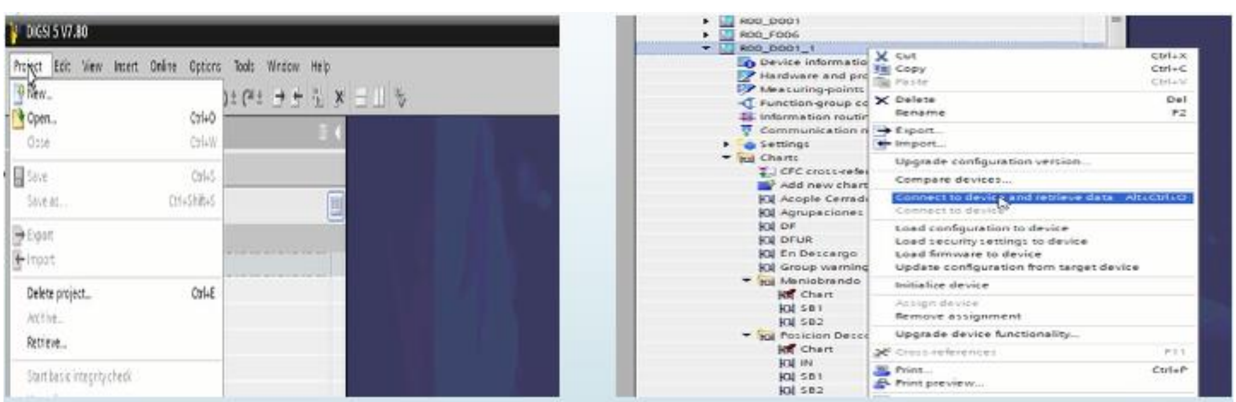

Figure 6: Relay creation and connection

Once the connection to the relay has been made, it is of vital importance to configure the communication between the two ends since it is necessary to have access to the currents that each one of them is seeing, it should be noted that since this is a FAT test, that is, it is performed in the factory, the other end of the line is not available, so the backup protection of the same board is used as a simulation of this; this configuration is done by following the following steps, first, click on the relay and enter the Hardware and protocols option as shown in Figure 7.

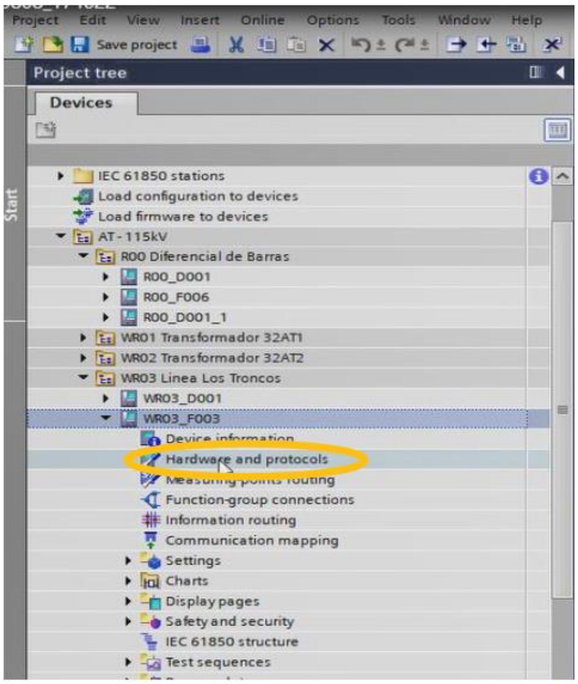

Figure 7: Relay creation and connection

The most important point of this configuration is the name of each device, as shown in figure 8, the main relay, which in this case is the one that is connected, must appear as device 1 and the backup device, which simulates the other end of the line, must be 2, although it seems an irrelevant aspect, it is important to clarify that this is a very recurrent error that does not allow the correct communication and of course, simulation if it is not done correctly.

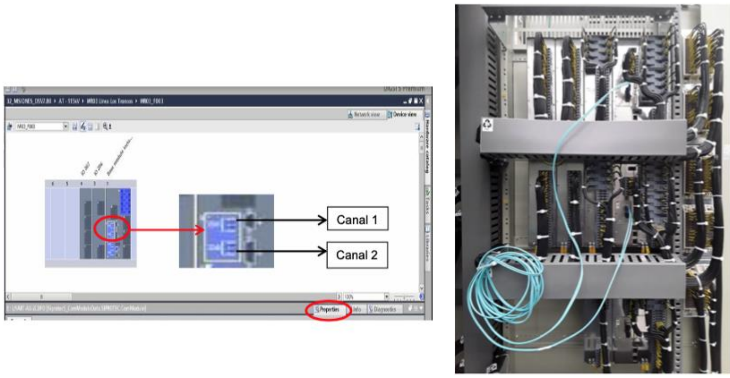

Figure 8: Configuration of the communication ports

Before starting with the tests the first thing to do is the general configuration of the data of the line and the TCs, for the configuration of the line is done in the Settings option of the DIGSI within the device created or to which it is connected, once they're in the Line option a menu will appear where you will find an item called General, where you can enter all the data concerning the line, It should be clarified that these data are provided by the engineering area and are unique for each project, however, if the case arises that they are not available to proceed with the test, they must be assumed and then perform the respective configuration with the actual data; For the configuration of the CTs, go to the Power system option and then to CT_AL, where, as for the line, a window will open in which the data corresponding to the CT, primary current, secondary current, transformer connection, are some of the data that can be configured as shown in Figure 9 and 10.

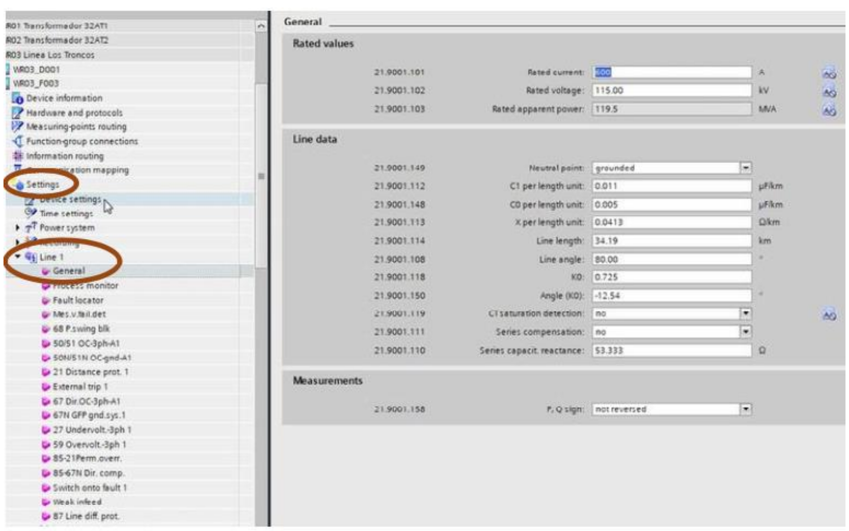

Figure 9: General data configuration of the line

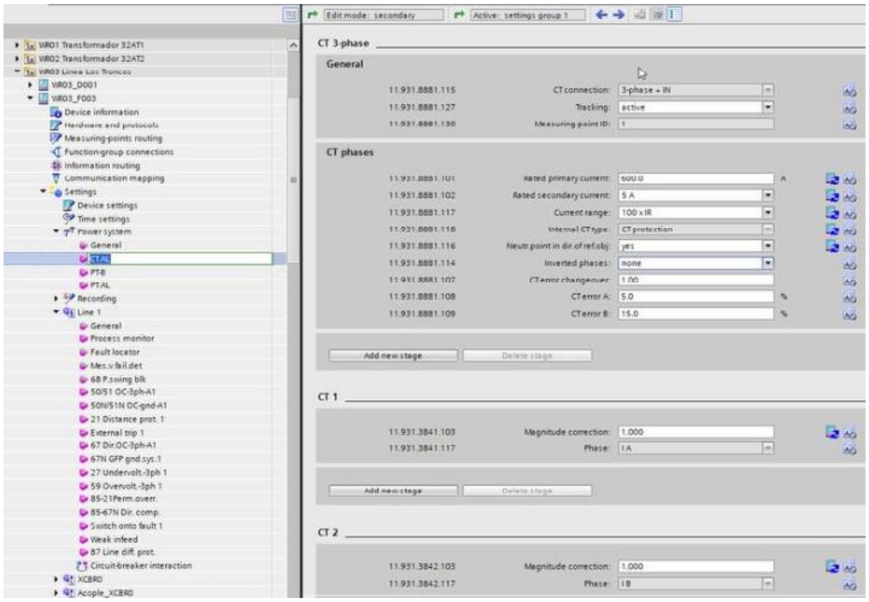

Figure 10: General data configuration of the CT

IV. RESULTS

Once all these data have been configured, we can proceed with the execution of the tests, which start with the connection of the Omicron to the respective current terminals of each relay. For the particular case of the test, the equipment - F003 and -F004 (which are the two protections of the line) will read the currents of the terminals -X011 and -X012 respectively, as shown in Figure 11.

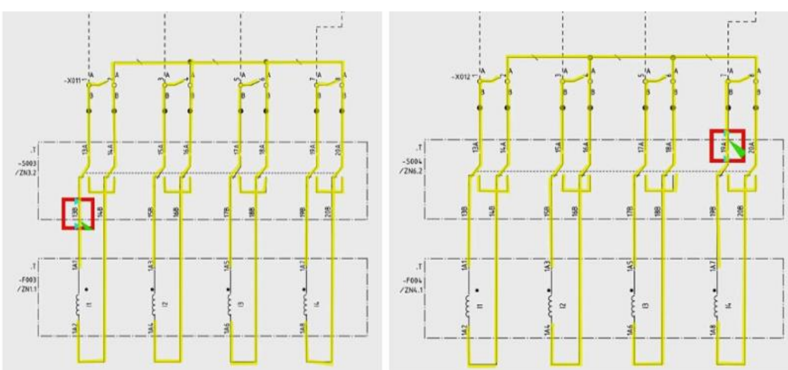

Figure 11: Electrical diagram - Relay current circuit – F003 and F004

The stability test consists of the simulation of external faults and it is verified that the relays only give the trip command when the fault is within the zone to be protected, that is to say, in this test the differential function of the relay should never trip even if the fault is three-phase, two-phase or single-phase, no matter how high the current is and whether at one end or the other, Since, when starting the injection of these currents the two CT's see the current to the same side with the same magnitude, so the relays should not trip since the area to be protected is between the two current transformers, otherwise OMICRON itself stops the test as a sign that something is wrong. In this test, the faults are performed between each of the lines to ground, between phase - phase and between the three phases.

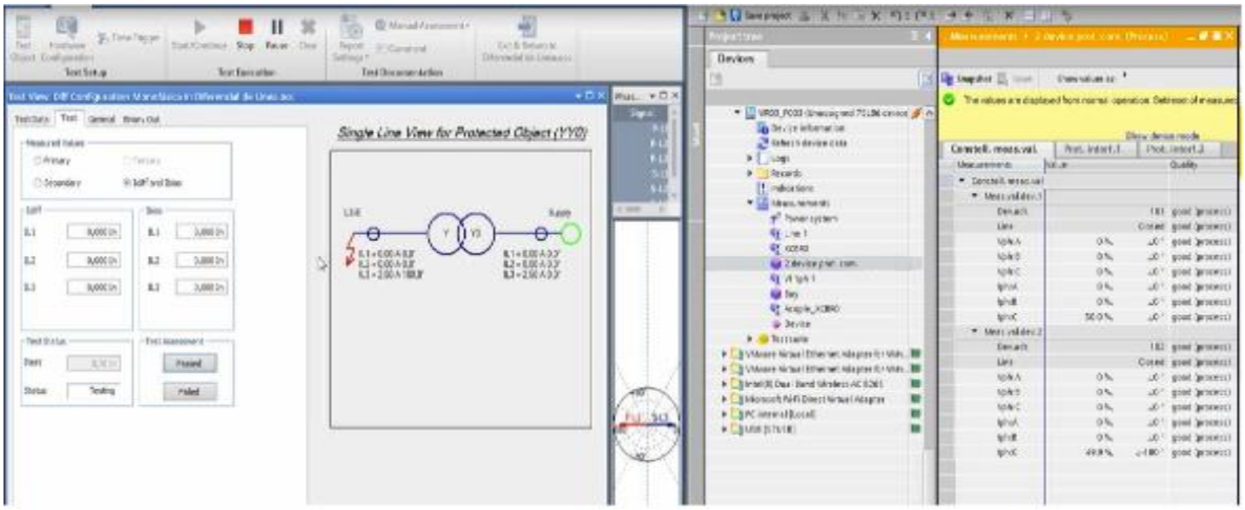

Figure 12: Stability test values

The interface of this template is shown in Figure 12 where you can see that this module is simulated as if it were a transformer, but because its connection is Y - Y0 it also serves for the case of the line, in this figure you can also see the external fault to which this line will be subjected, the position of the CT´s at each end and its current reading corresponding to each one.

V. CONCLUSIONS

It is very important in the training of electrical and electronic engineers to have tools and methodological guides in the activities they will perform in the future to perform a better job as professionals.

The realization of this type of methodological guide is of great help for the processes in a certain worksite, in the case of the testing field in panelboard factories it helps to standardize in an orderly and practical way the realization of the protection tests and facilitates the engineer the execution of the same ones, familiarizing with the devices used in a fast and safe way.

It became evident that to work on the issues of protection testing of electrical systems it is necessary to know about power systems, communication networks, electrical substations, to be able to determine if the variables and behaviors that result from the tests performed are those that are expected and needed in case of an undesired event on-site.

It is necessary to take into account that the successful development of the protection tests depends a lot on the system data supplied by the client or by the design department since in the case of not having all of them, the protection engineer must assume unknown data to enter them in the DIGSI software and the relay must be parameterized again with the real data of the system once it is in the field.

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