DIDACTIC SOFTWARE TOOL FOR PROTECTIONS FUNCTIONS OF DIGITAL RELAYS, STUDIES AND VERIFICATION OF COORDINATION AND SELECTIVITY

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ABSTRACT

The process of training professionals in testing and programming protection relays has a highly cost in money and time.
A laboratory for protection training must be equipped with numerical protection which costs between 5 to 10 thousand dollars, and a numerical test set which cost is over 50 thousand dollars.
You must multiply the cost in equipment by the number of students.
This project offers an efficient, low cost solution in training professionals in this area.
We develop a software application to emulate numerical protection relays, protection relay configuration software and a numerical test set.
One objective is that the user feels like he is programming and testing a real numerical protection relay with a real numerical test set.
The configuration screens could be designed to make the student familiar with a particular protection relays manufacturer. In the same way the test routine could be designed to match a popular test set software. The software runs over MS Windows operating system machines.
This first version of the software emulates a multifunction protection relay with the following functions:
- Instantaneous Over Current;
-Time over Current with ANSI, IEC and definite time characteristic;
·-Directional Over Current;
·-Over Voltage;
·-Under Voltage;
·-Four cycles Recloser;
This first version of the software emulates a test set with the following test routines:
- Quick test where you can set any value of currents, voltages and phase angles. A timer with millisecond accuracy is available for operating time measurement. Also is possible increase or decrease a magnitude automatically in steps and intervals programmable.
- Automatic over Current Test where you configure the minimum and maximum Current applied and the number of points to test. The software applies the test a show results graphically.
·- Angle Ramp Test where you can test the threshold of Directional over Current protection.
·- Recloser cycle sequence test.

INTRODUCTION

We developed an educational software using Visual Basic 2008, which provides a virtual panel with three protective relays, containing features and functionality of digital relays, and a specific source for testing relays. Figure 1 shows the initial screen of the software.

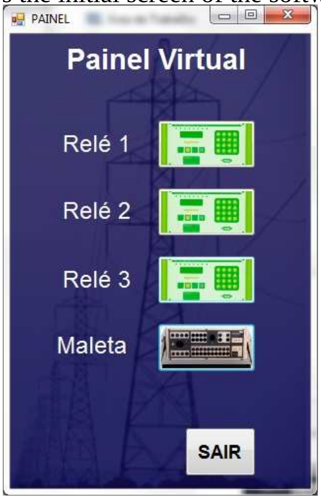

Figura 1 - Start screen

One must consider the connection of the current in series between the case and the relays, that is, the output current Ia of the case, which circulates in the first current input of the first relay is the same as that circulating in the first input current relay 2 and 3 relay. Likewise is considered to currents Ib and Ic. To tension the connection is in parallel, ie, the output voltage Va of the case is connected to the first voltage input of the three relays. Likewise is considered to tension Vb and Vc.
The results of operating times are not displayed simply as a calculation result. For each protection function is associated with an algorithm and the result is presented after the operating time elapsed. With this, the software operates in a manner closer to reality. For the operation of the case there is also a testing algorithm which is associated processed in a separate routine routine relay. The results are theoretical values due to the processing algorithm for each function and processing capabilities of the computer as well as the number of tasks that are running at the same time, however, since the processing capacity of a computer is greater that of a digital protection relay times of operation have smaller errors than those presented by digital relays. This behavior has been demonstrated in the test results.

DESCRIPTION OF RELAY PROTECTION

Fields configuration of protection functions available in this software are presented in the same way that the software used in the relay configuration Ingeteam the PL300, so that the user has an environment with characteristics very similar to those that find the actual operation of equipment. In Figure 2 you can see the screen of the software to emulate one of the three relays. In the left part of the screen marked "STATE", shows the values of voltage and current being injected by the test kit and just below the LEDs for signaling start shooting and protection functions. You can also view the fields on this screen configuration settings of the following protection functions:

- overcurrent phase and neutral;
- instantaneous overcurrent phase and neutral;
- overcurrent phase.

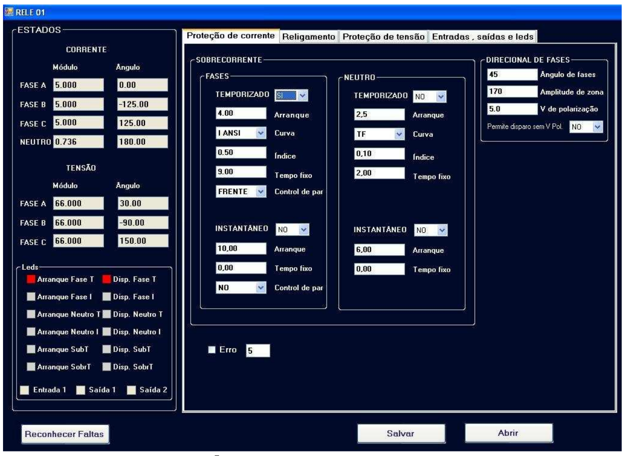

Figure 2 - Screen relay 1

To adjust the curve of performance of the functions of overcurrent phase and neutral options are ANSI and IEC curves.
There is a function that enables the insertion of a random error in the times of operation of the overcurrent functions, which according to Professor Eloi Rufato Junior advisor for this study, would have a useful didactic, because with this function you can simulate the error made by actual relays, such as errors algorithms, hardware, caused by temperature changes waveform (harmonics) errors in analog-to-digital converters, bringing this way into the software, the ability to simulate the problems encountered in practical application protection equipment, which is not provided by the simulation software currently.

LEDs signaling trigger the relay, after being activated, remain in this state even if the trigger condition disappears. Only be disabled through the lack of recognition that can be performed on-screen relay operating clicking the lack recognize**.**

Fields adjustment protection functions have the same value limits, maximum and minimum, used in the software configuration of the relay PL300. The settings configured in the relay during testing can be saved in files and retrieved later. Events generated during testing are stored in a file for later analysis.

DESCRIPTION OF TEST CASE

The features of briefcase tests available in this software are based on the operating software of Omicron CMC156 briefcase, providing technicians and engineers who will work with the software, a simulation closer to reality, as if using a device marketed by manufacturers of equipment testers for protective relays.
In Figure 3, we can see the module's Quick briefcase test, in which you can perform manual tests.

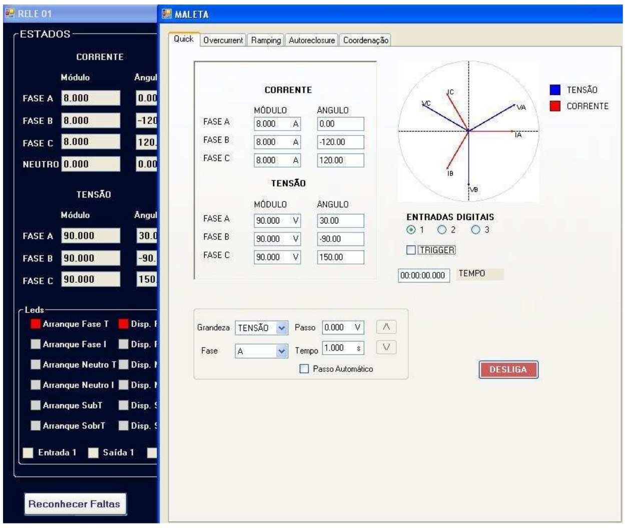

Figure 3 – Quick Menu

In this screen can be inserted into the values of the voltages and currents with their respective phase angles that will be injected in the relays. Just as in a real briefcase, the maximum voltage is 115.47 Vac and maximum current is 12.50 A. These maximum values are based on nominal values of current and voltage supplied by the secondary of CTs and VTs. In the right part of the screen shows the voltages and currents in vector form.
Also, it is possible to increase, manually or automatically, the value of current or voltage of one or three phases. This increase can be positive or negative. This module can be performed tests of the functions of overcurrent, overvoltage and undervoltage.
The digital inputs the briefcase serve to detect the firing of one of the relays. If the trigger is selected, the count is performed between the time when the briefcase is on and shooting greeted by a digital input.
Overcurrent module, illustrated in Figure 4, is used for automatic testing functions of overcurrent, and instantaneous timer.

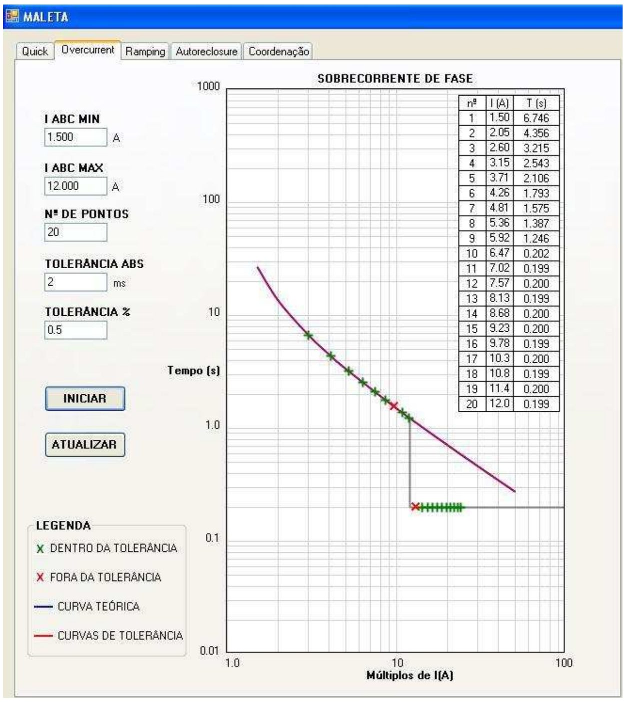

Figure 4 – Overcurrent Test Module

This module introduces the features configured in the relay in a time-current diagram. The number of test points, the initial and final value of the current, which is injected, is defined by the user. Tolerance is defined in time values or in percentage relative to the theoretical value. For each test point an assessment is carried out, and the green points indicate that the relay worked within tolerance and red points indicate that worked wrong. The values of the applied current and times of operation are presented in the table beside the curve.

The module Ramping illustrated in Figure 5, is used for automatic testing of the function of directional overcurrent phase. This module generates a phase ramp to the output current, ie the current vector rotates automatically from an initial angle to an angle which is defined by the end user. During testing you can view the status of relay trip through the smaller rectangle of this module. The thick solid line indicates when the relay is triggered and thin when not triggered.

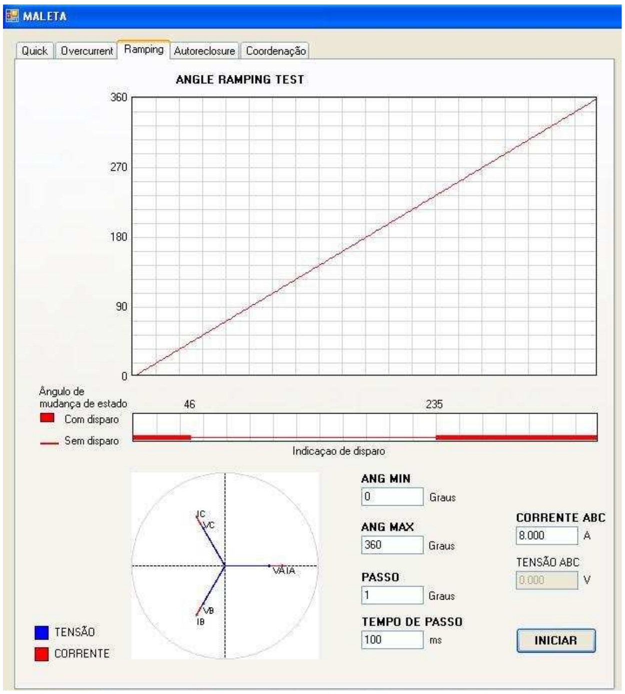

Figure 5 – Ramping Test Module

Through the coordination module, as Figure 6, you can see the curves of overcurrent configured in two of overcurrent relays are coordinated.

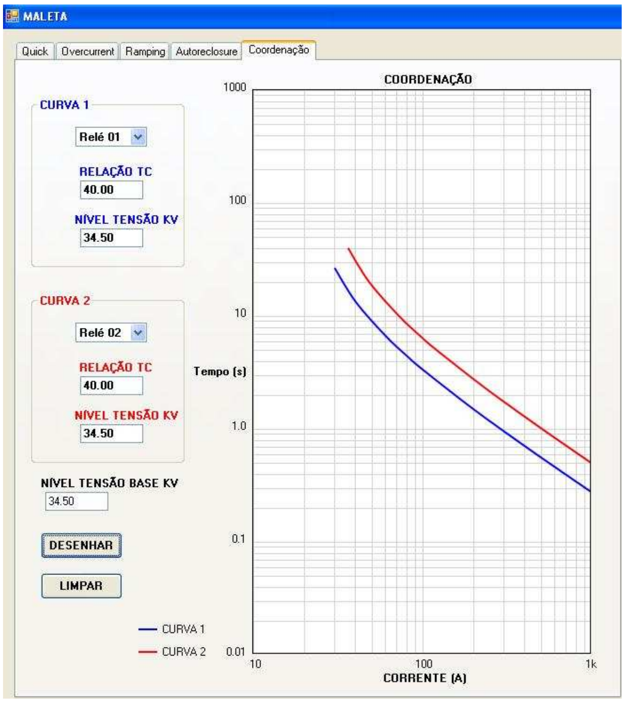

Figure 6 - Coordination Module

RESULTS

Tests were conducted with a real protective relay PL300 and the results compared with simulations in software

development. The following is in example of how the analysis was performed.
For testing the function of overcurrent using IEC extremely inverse curves (EI), was adjusted time index (M) equal to 1 and start (Io) at 1A, ie for any current above 1A relay should trigger after the time set by expression 2:

$$T = M \times \frac{80}{\left(I/Io\right)^2 - 1} \qquad (2)$$

T: Trip time (s);
M: time index or dial;
I: measured intensity (A)
Io: setting starting current (A)
Whereas:
M = 1;
Io = 1 (A)
Table 1 shows the results of the times of operation obtained in laboratory tests with the relay PL300 and tests performed by software.

Table 1 - Results of Tests

Applied current (A)	Time (s)		Error (%)	Time (s)		Error (%)
	Expected	PL300		Expected	Software	
1,2	181,8182	173,6960	4,47%	181,8182	181,8220	0,00%
1,4	83,3333	83,4530	0,14%	83,3333	83,3410	0,01%
1,6	51,2821	51,3493	0,13%	51,2821	51,2740	0,02%
1,8	35,7143	51,3493	0,15%	35,7143	35,7060	0,02%
2,1	23,4604	51,3493	0,23%	23,4604	23,4610	0,00%
2,6	13,8889	51,3493	0,23%	13,8889	13,8810	0,06%
3,2	8,6580	51,3493	0,11%	8,6580	8,6620	0,05%
3,8	5,9524	51,3493	0,28%	5,9524	5,9520	0,01%
4,4	4,3573	51,3493	0,53%	4,3573	4,3500	0,17%
5	3,3333	51,3493	0,84%	3,3333	3,3330	0,01%
5,8	2,4510	51,3493	0,85%	2,4510	2,4530	0,08%
6,7	1,8227	51,3493	0,87%	1,8227	1,8240	0,07%
7,05	1,6426	51,3493	0,22%	1,6426	1,6460	0,17%
7,5	1,4480	51,3493	1,48%	1,4480	1,4490	0,07%
7,85	1,3196	51,3493	2,96%	1,3196	1,3180	0,12%
8,4	1,1501	51,3493	2,61%	1,1501	1,1540	0,34%
9,05	0,9888	51,3493	3,06%	0,9888	1,0020	1,33%
9,8	0,8418	51,3493	3,33%	0,8418	0,8300	1,40%
10,75	0,6983	51,3493	3,08%	0,6983	0,7030	0,67%
11,7	0,5887	51,3493	4,86%	0,5887	0,5970	1,41%

The results were within the acceptable margin of error of 5%, for operating times above 50ms.
Figure 7 shows a comparison of the results of a relay and relay real virtual simulated in software protection functions didactic.

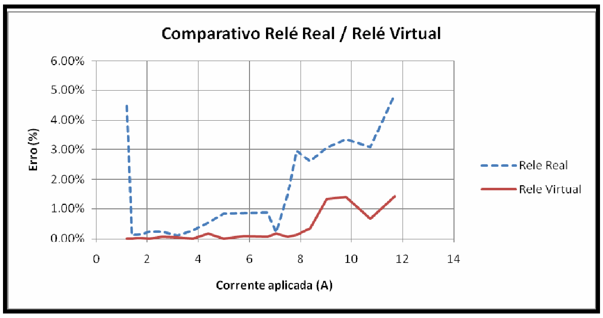

Figure 7 - Comparative Real relay - virtual relay IEC curve

CONCLUSIONS

The objective of this study was to provide students and teachers at Federal Technological University of Paraná software didactic, intended to disseminate philosophy of the protection system, providing subsidies for the development of new projects whose primary purpose is to train future professionals who will work in this area protection of electrical systems.
We developed a virtual panel with three protective relays containing features and functionality of digital relays for testing the functions of protection and coordination. To achieve this goal, we studied the protective functions, the features of digital relays and the principles and concepts of selectivity and coordination between protective relays.
The results were compared with the theoretical values, of rules, and practical by actual relays, obtaining satisfactory results. Furthermore, the interface is designed such that user to use the software, to perform tests on digital relays, similar to the mode of operation of software for real equipment.
Use of this software to study the selectivity and coordination between protective relays has the great advantage of having a reduced cost compared to the cost of purchasing equipment for the assembly of a laboratory and didactically comprises the steps for testing on protection relays.

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