

## Efficient, Easy and Standardized Testing of Electromechanical Relays by Using a Library of Test Templates

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### Abstract

Standardized testing of protection relays is a big challenge for electric utilities. But the importance and the need for establishing a testing standard are increasing more and more. For modern relays with its hundreds of relay parameters and its increasing number of protection functions the standardization seems to be a must. The use of modern technologies is mandatory. But how does a test for a single function relay – e.g. an electromechanical relay – fit to this approach. Normally there is a need of having a powerful test set, information about the specialties of the dedicated relay and the knowledge about testing this kind of protection relays. And in the end this test has to be stored in a database. In many cases the tests of the electromechanical relay is fulfilled with an older test set. That means manually testing and of course the test report has to be written by hand, too.

OMICRON provides a library of test plans for years. This library is called PTL (**P**rotection **T**esting **L**ibrary) and it uses the newest software features of the Test Universe software and supports test plans for single function protection relays. This paper describes the idea of these templates and points out the advantages and the differences of the test plan for single function relays to the test plans of multifunctional relays of the PTL.

### Keywords

single function relay, protection testing, automatic testing, standardized testing.

### Introduction

In 2008, electric utilities worldwide purchase up to \$850 million of protective relays each year. Although much of these relays are numerical relays, still up to 10% of these are electromechanical relays. North American utilities account for up to \$35 million in annual purchases of electromechanical relays [4].

Although electromechanical relays are normally single function devices, testing of these relays poses special challenges due to the behavior of the electromechanical movements. With many utilities losing testing expertise, knowledge of testing these relays are also lost.

The benefits of having automatic test plans for different electromechanical relays that are intuitive and user-interactive help the utilities to train new employees for relay testing and as well to maintain a high level of quality assurance for their relay testing program. Automatic testing also ensures repeatability and allows for proper comparison or trending of relay behavior.

All the test templates are supported by the manufacturer of the relay test set, so that utilities do not need to be concerned about maintenance of the test templates over time.



Figure 1: Test setup for testing EM relay (Transformer differential relay BDD from GE)

### A standardized testing approach

The need for standardization has increased during the last years. Due to the fact that over the years different testing philosophies and different testing approaches have been evolved and not at least different knowledge, opinions and skills of testing people are recognized, it is getting more and more important to standardize the testing procedure. This standardization leads to

- The test person saves time for developing a test.
- As all the plans include the same tests, the testing quality can be better controlled and improved.
- Working together as a team is easier.
- Company know-how can be added to the standard.
- It is possible to test all generations of protection devices with the same test equipment.

In general there are a lot of possibilities establishing testing standards. Two main types of standardization are [2]:

- Standard for testing a dedicated protection function

- Standard for testing a dedicated protection application (e.g. line protection for highest voltage).

An example of a standard for testing a dedicated protection function is the definition of a test plan for testing the transformer differential protection function:

- Configuration or stabilization test
- Pickup test
- Operating characteristic test
- Trip time test
- Harmonic blocking test

The standard should also include which fault loops are used and e.g. defines the number and position of the test shots.

Once these steps are defined and the tests are standardized it is possible to increase the automation level of relay testing.

### Automated Relay Testing (Protection Testing Library)

The OMICRON Protection Testing Library (PTL) provides a good basis for designing testing standards. The PTL contains of many small items, which are designed to test protection devices in an easy and automated manner.

The first release of the PTL was in spring 2007 and the focus was on providing testing solutions for numerical relays. Additionally to the standardization approach the idea was to help the users analyzing the relay behavior. But with the experiences of the last years there is a very good chance of having the same testing tools working in different worlds, the protection world of the numerical relays with their huge number of settings and the electromechanical relay world with a handful number of relay parameters and a fixed setup.

A PTL item contains of (no matter if it is for a testing a single function or multifunctional relay):

- One test template to support many different relay variants. Results in this test template are automatically assessed based on tolerances as suggested by the relay manufacturer.
- Automatic calculation of the tripping characteristic regarding to the relay settings.
- A test report is generated automatically.
- A user manual with useful information for testing the dedicated relay.

For numerical relays the main protection functions and some of the most important functions are covered in the PTL.

### Multi function vs. single function relays

There are some essential differences between modern numerical relays and electromechanical relays:

- The number of protection functions is extremely different
- The number of parameters is extremely different
- The application range of electromechanical relays is limited

Due to these limitations it is possible to cover 100% of needed tests of a single function relay in an automated test template. The PTL items for single function relays are designed for the most common application. That means that is possible to have these relays tested in a fully automated way.

### Special solution for single function relays

In contrast to test templates developed for multifunction numerical relays single function relays require the following features:

- Easy and logical entry of setting parameters (in difference to numerical relays it is not possible to emulate the relay manufacture software). The challenge is to digitize the potentiometers or jumpers in meaningful way.
- Pop-up dialog boxes with instructions to help guide the tester through the procedure as well as wiring connections.
- Instructions on what to do when a test fails.
- Support variants of the same relay with different setting parameters, operating characteristics, and wiring connections.

A typical GE type IAC overcurrent relay has over 60 variants. The test template for the IAC relay allows the user to select the variant from a list box (see figure 2). Once selected, the appropriate wiring diagram and characteristics are automatically selected.

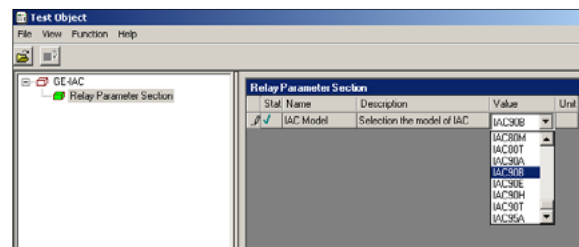


Figure 2: Selecting the relay model

The workflow for testing single function relays consists of the following easy and logic steps:

1. Entering/Checking the relay settings
2. Wiring/Connections
3. Pre-test instructions
4. Test and assessment
5. Report generation

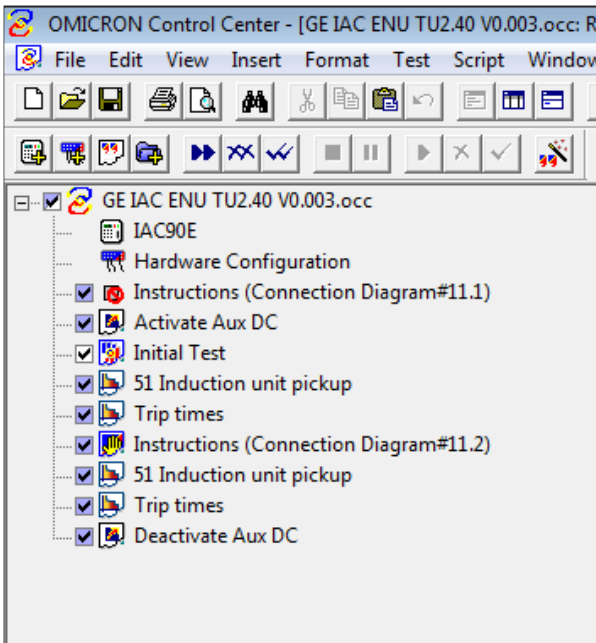


Figure 3: Workflow for testing single function relays

At the beginning the test template has to be opened. From this point on the automatism of the test template is running and the guidance for the user is active. The experienced user can cancel the guidance through the entire test (see figure 4).

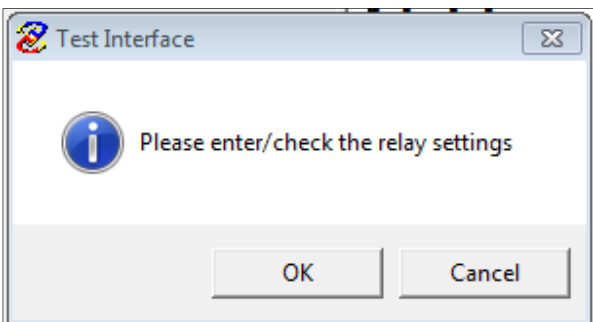


Figure 4: Using the template with/without guidance

The confirmation of this information window with OK starts to the *five steps* workflow for testing single function relays.

#### Step 1: Entering/Checking the relay settings

The setting screen will start automatically. The user can easily enter the relay settings. If there are many settings on the relay, the setting screen may be distributed over two or more dialog boxes.

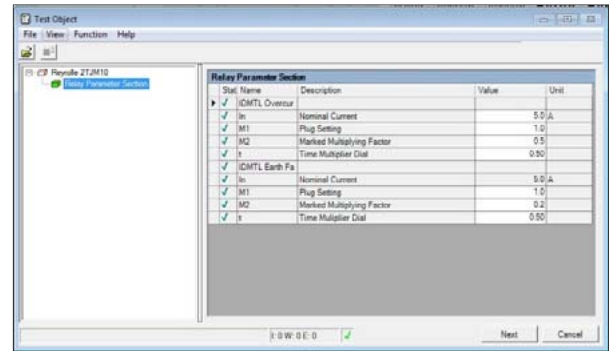


Figure 5: Entering relay settings

It is possible to navigate through the dialog boxes and switch between the multiple setting screens by using the *next* or *previous* buttons.

In addition to the relay settings some more parameters are important for the creation of a proper test plan. Therefore relay general information (e.g. serial no., location, etc.) and tolerance for the test (a default value is given from relay specification) has to be entered or has to be confirmed.

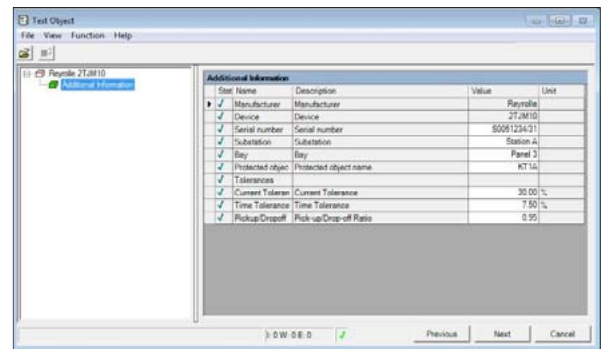


Figure 6: Additional information (relevant for the test template)

These settings are used to set up the tolerances in the test modules or for creating the test report.

#### Step 2: Wiring/Connections

The wiring diagram is shown with some instructions how to connect the relay and the test set (see figure 7).

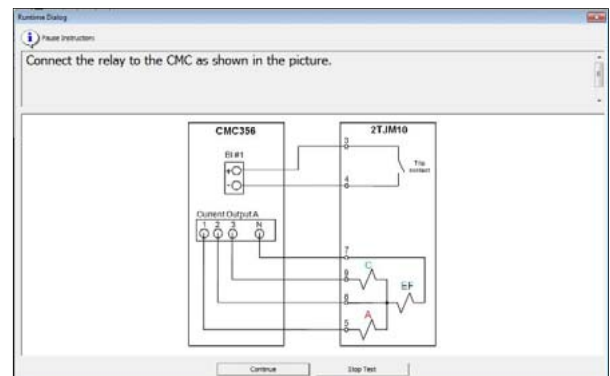


Figure 7: Wiring diagram

After the wiring the setup of the hardware has to be checked. The information window guides to the hardware configuration of the test plan (see figure 8).

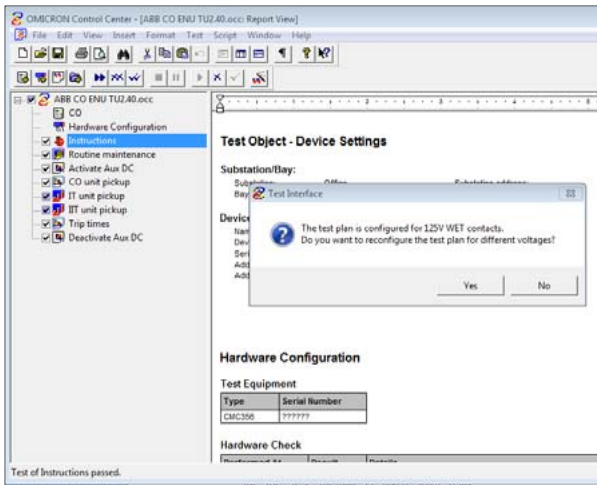


Figure 8: Pre-Configured 125V WET contacts

The test plan is pre-configured for e.g. 125V wet contacts. This can be adapted to the conditions of the actual substation. The tests can be performed all at once, or can be executed one by one.

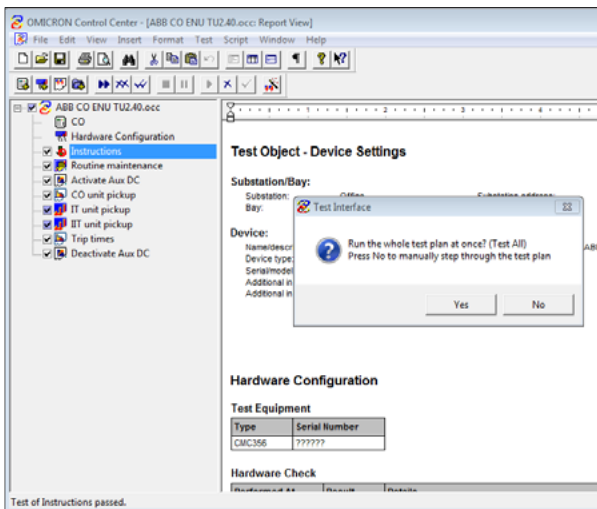


Figure 9: Single tests or test all

Step 3: Pre-test instructions

Step 3 of the workflow provides pre-test instructions and references to the tester.

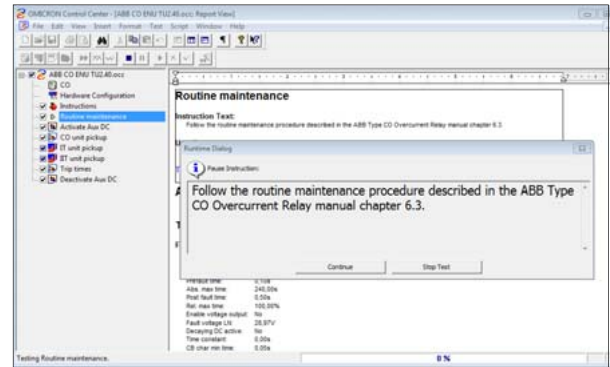
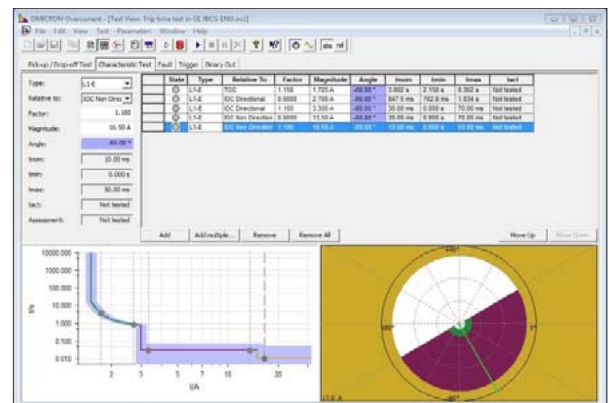


Figure 10: Pre-test information window

With these explanations the know-how of the templates designer is passed over to the template user. The information is shown right before the dedicated test module. These pause modules can also be used to store company's know-how in an easy way and teach the next generation of testers.

Step 4: Test and assessment

The relay function is tested using the standard Test Universe test modules. These modules allow testing to be visual and interactive during the test. Test points are assessed at the time of the test. If a test points fails, the user can stop the test right away and corrects the error (e.g. setting error) without having to wait until the entire test is completed. Figure 11 shows a test of the trip times for an overcurrent relay.



### Step 5: Report generation

All test shots are assessed automatically to pass or fail based on the given tolerances and the report is generated. Tools such as time-signal diagrams and characteristic view can help with trouble-shooting if needed. On the one hand the test report can be defined in a long form which contains all test information from the set up of test modules to test results and the final assessment. On the other hand a short form of the report can be created with only a short information if test has passed or failed.

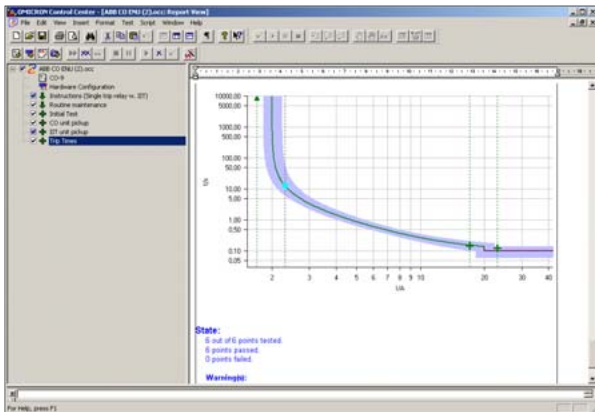


Figure 12: Test report

This 5 steps workflow demonstrates the principle, the idea and the realization of the standardized automatic test plans for single function relays. Based on this idea a lot of electromechanical relays will be integrated in the PTL. All of these test plans will follow this principle and for this it will be more clear and traceable by another person.

### Conclusion

Most of the protection engineers have to test all generations of protection relays – electromechanical relays, electrostatic and of course digital relays. Therefore they have to have a good knowledge about the different kinds of relays. For these people it will be a tremendous help to have only one test equipment to use. This means the same hardware, software for testing all these relays. The difference of the test plans is only based on the protection relay.

OMICRON provides within its Protection Testing Library a lot of these test plans using the same hardware and the newest software for all kind of protection relays. Single function relays, mostly electromechanical relays are recognized by its variants and by its specialties. The small functional range allows a 100% automated test plan. The user is guided through the template and gets valuable information important for the test, e.g. wiring the relay contacts or setting up the test device.

This paper has shown the possibility of speedy tests for conventional single function protection relays in a standardized way, by using the newest test equipment with the latest test templates of the PTL.

Because of the following aspects

- Pre-configured for routine E/M testing for the most common application
- Speedy tests possible of conventional protection devices
- Automatic assessment based on manu-facturing recommendations
- User configurable and adaptable

the use of these templates has a lot of benefits.

These PTL templates for testing single function relays are also part of standard delivery and available for free download.

### References

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