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Development of a digital relay automated evaluation program

Ho-Woong Choi*, Byoung-Woon Min*, Byoung-Ho Lee*, Jeong-Han Kim*.

* Electro-Mechanical Research Institute, Hyundai Heavy Industries Co., Ltd., Ulsan, KOREA
(Tel:+82-31-289-5206; e-mail: heydaniel69@hanmail.net,{minbu, byeongho, mandong}@hhi.co.kr)

Abstract: This paper presents the development of a novel digital relay automated evaluation program and its important aspects. The goal of relay's test automation concept is to use the relay expert's time as efficiently as possible. It shall be the tool to increase the depth of testing while decreasing the testing time, allowing the expert to use his valuable time to eliminate possible errors in the protection system. It is the ideal method to visualize, document and handle the complexity of powerful modern protection relays.

1. INTRODUCTION

The reliability of electricity generation, transmission and distribution is directly related to the reliability and quality of the protection system. Regardless of which generation of protection equipment is protecting the individual elements of the electricity system; it is always necessary to prove its proper functioning during commissioning and again periodically after a certain duration of service.

Electromechanical relays have problems with ageing mechanisms and coils; or the static relay generation with drifting analog circuits, the digital relays struggle with software bugs and firmware updates. Complex technical devices and protection equipment can fail for any reason therefore 100% security is impossible. Due to the inactive nature of relays during proper network conditions a possible relay malfunction can only be detected at the instant of a power system fault. Thus, due to the vital role protection relays play to achieve high power system stability and also in preventing the power system owner from high financial losses due to damaged power system elements, the risk of malfunctioning relays should be minimized. Thorough commissioning and routine testing of relays should be undertaken to minimize this risk.

On the other hand, trends like liberalization of the electricity market and privatization of utilities put the relay commissioning, routine testing and protection engineering departments under pressure to save costs.

How can the quality of the protection system and as a direct result, the power system, be sustained or even improved when the staff for relay evaluation, commissioning and routine testing is generally reducing? One way to escape this dilemma is to increase the productivity of the remaining experts through automation. Automation can save the relay expert's time allowing them to concentrate on solving and analyzing actual failures during power system operation or relay commissioning and maintenance. Furthermore automation can even increase the depth of testing in a shorter time, raising not only the efficiency but also the quality.

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2. IMPORTANT ASPECTS REGARDING AUTOMATED RELAY TESTING

The following error sources should be considered:

- The firmware of modern digital relays is complex software and like all software it is not free of bugs.
- Although the influence of hardware component drift or error could be reduced in digital protection equipment (self monitoring) there is still hardware which is not monitored and which may fail.
- Dozens of parameters have to be set correctly. Only 1 wrong setting may lead to a mal-operation when correct operation would be important.
- Frequent firmware updates of modern relays are on the one hand eliminating errors, but may also be a source for new errors.
- Changes in network topology become more frequent due to trends such as distributed generation and network liberalization. Changes in relay settings are an error source and correct operation after changed settings should be verified.
- Wiring errors.

Modern multifunctional digital relays present many hurdles for test automation:

- Many, often overlapping functions, are active in parallel.
- Not every function has a dedicated contact routed for easy checking of its proper functioning.
- The parallel operation and interaction of those functions should especially be tested.
- Free programmable logic functions may differ from relay to relay and make it impossible to create standardized test plans.

General rules for successful test automation programs:

- Standardization of relays and their parameterization is the key to successful test automation.
- 100% Standardization is impossible therefore a test automation system has to provide the tools to quickly and easily adapt standard test plans to fit non standard applications.

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3. CREATIONS OF RULES

1. A relay has to be tested to its actual settings. Testing a relay to factory default settings or other changed settings does not guarantee a proper function with actual settings. -> Automatic test plans have to be adapted to fit the actual relay settings. (and not the other way round)

2. Blocking/disabling of overlapping functions for testing purposes should not be done. There is the danger that the unblocking/enabling is forgotten after the test. Secondly the influence the parallel functions may have on each other (e.g. limited processing power) is not tested. -> Test algorithms have to be smart to allow stimulation of exactly the function under test although the other functions are active in parallel. The test software must support this.

3. If there is really no way around blocking/disabling of overlapping functions for testing purposes the blocking/disabling process should be automated or the flow of testing has to contain reminders to ensure that the functions are enabled again. -> The automated test plan has to set message-breakpoints to remind the tester.

4. Routing of additional relay outputs only for testing purposes is also dangerous and may be a source of error. Again: Do not touch the relay parameterization for testing purposes. -> Test algorithms have to be smart to allow stimulation of exactly the function under test although the other functions are active in parallel. The test software must support this.

5. Testing of relays should be done against the settings calculated in the relay setting sheet. Reading the settings file directly from the relay and testing against those settings introduces the danger of (human) errors when setting the relay or unwanted re-parameterizations, for whatever reasons, are not discovered. -> Testing against the settings read directly from the relay is not covering an important error source.

6. As it is possible to freely program the logic of modern digital relays it is required that the tester can easily add new tests to a standard test plan for those "non standard" functions. ->Adaptation of standard test plans has to be easily possible.

7. Automatic assessment of test results, according to given relay tolerances, is a must. However, the automatic assessment can never fully replace the plausibility check of the results by the testing relay expert. -> Visualization and straight forward graphical representation of the results is necessary to allow the expert a quick and easy plausibility check of the test results.

8. Once a failure is found in a relay, be it the relay itself, a wrong setting or even a wrong test plan, it is important to have the appropriate analysis tools and support to quickly locate and eliminate the error source. -> Automated testing requires a very good documentation and visualization with event recordings and graphics of all the test steps. The test set should provide troubleshooting tools like transient recording, wiring checking tools or measurement functions

4. CONCLUSIONS

The goal of relay's test automation concept is to use the relay expert's time as efficiently as possible. It shall be the tool to increase the depth of testing while decreasing the testing time, allowing the expert to use his valuable time to eliminate possible errors in the protection system. It is the ideal method to visualize, document and handle the complexity of powerful modern protection relays. It is the tool to limit today's protection engineering complexity through test standardization. It is an important source of convenience in operating the protection system. The resulting thorough and repeatable test documentation is the proof of state of the art protection engineering.

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