Chapter 13
Advanced Real-Time Tester for a Smart Power Grid

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ABSTRACT

The testing approach is facing many difficulties regarding the actual implementations in the modern smart power grids. One of these challenges is the testing of hardware devices such as protective relays, PMUs, and smart meters before its final deployment to the power grid. One way to overcome this is the real-time simulation of power grid. The hardware-under-test (HuT) is plugged to a real-time simulator via signal conditioning circuit (SCC). SCC is an interface circuit involving power amplifier and measurement sub-circuit between the real-time power grid simulator and the HuT. In this chapter, some advanced developed techniques and approaches will be presented.

INTRODUCTION

The reliability of the power system depends upon the performance of the thousands of smart devices that may be used in monitoring, protective and control system. The failure of an apparatus to operate correctly as intended may jeopardize the stability of the entire power system and its bulk elements.

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measurement sub-circuit between the real-time power grid simulator and the HuT (Faruque, M.O. et al., 2015; Hernandez, M.E. et al., 2018).

In fact, major system failures during a disturbance are more likely to be caused by unintended protective relay operation rather than by the failure of a relay to take an action. Reliability in this case has two aspects: dependability and security. Dependability is known as the degree of certainty that a relay system will operate correctly as intended. Security is the degree of certainty that a relay will operate unnecessary during any transient disturbance (Phadke, A.G., et al., 1976; Zitouni A., et al., 2018). Appropriate relay testing provides first guard against relay false-tripping. Relay testing can aid to confirm the design of relay, compare the performance of different relay typess, verify relay settings, classify system conditions that might cause unplanned relay operation, and carry out post-event analysis to understand the causes of unintentional or incorrect relay actions. Relay tester enhancements need to continue because of the use of relays in smart power grids where the conditions that are not the same as in the conventional one. This leads to new relay technologies (Dierks, K.C.A., 2006).

Disturbances include transient distortion in the voltage due to post fault, potential transformer saturation or compensator switching may affect on transmission line relays and relaying systems in various ways. The mal-operation of this relay is generally unnecessary tripping during post fault or compensator connection which produces DC offset and harmonics. This may reduce the security of protection system and hence its reliability (Abdelmoumene A., Bentarzi H., Chafai. M., Ouadi A., 2014).

This work focuses mainly on the design and the implementation of the Class D amplifier which is the amplification part of the testing system. The Class D amplifier has been used in this work to amplify the simulated disturbances that are generated by Simulink power system model to be then injected to the protective relay and monitor its response. Labview has been used for developing the graphical user interface and controlling NI 7851Board

In this research work, we have used new technology that allow designing an enhanced relay testing system which in turn can be used for improving the performance of protective relay. In order to test both security and dependability and hence the reliability, this work propose a new frame work of tester based on FPGA associated with acquisition card NI.

TESTABILITY

Protection System Reliability and Testability require in part that the protection system be designed for high functional reliability and in-service testability commensurate with the safety function to be performed. They also require a design that permits on-line periodic testing of the functioning of the protective system.

The testing of protection schemes faces many problems. Since the main function of protection equipment is taken into consideration under operation during system fault conditions, and it cannot readily be tested under normal conditions (Relay testing and commissioning, Chapter Online). This situation is aggravated by increasing the complexity of protection schemes and use of relays containing software.

Type tests are required to prove that a relay meets the published specification and complies with all relevant standards. Since the principle function of the protection relay is to operate correctly under abnormal power conditions, it is essential that the performance be assessed under such conditions. Comprehensive type tests simulating the operational conditions are therefore conducted at the manufacturer's works during the development and certification of the equipment.

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