



RTE DSE – Protection Demonstration

Final Project Report

T-59G

Power Systems Engineering Research Center
*Empowering Minds to Engineer
the Future Electric Energy System*



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Power Systems Engineering Research Center

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Executive Summary

This report describes the application of setting-less relay on the RTE digital substation. We describe the model developed to simulate various events, and then play back these events into the setting-less relays to assess their performance. Four protection zones have been identified within the RTE digital substation. Use cases for each one of these protection zones have been developed with multiple events. The protection of each one of these protection zones has been studied under multiple events. Sample use cases of this testing is included in this report. A new methodology for correcting measurement errors from the instrumentation has been also developed and tested.

The basic idea of the setting-less protection relay has been inspired from the differential protection function which has a very important characteristic: it does not require coordination with any other protection functions. The differential protection monitors the validity of Kirchhoff's current law (KCL) within a protection zone. The setting-less protection can be considered as an extension and generalization of differential protection, because it can be viewed as monitoring the validity of all physical laws within the protection zone, i.e. KCL, KVL, thermodynamics, mechanical motion, etc. depending on the type of protection zone. The setting-less relay does not require coordination with any other protection function, a very big advantage. The setting-less relay replaces all the protection functions that are typically apply to a protection use using legacy protection systems.

Four protection zones have been identified within the RTE digital substation. The protection of these four zones has been studied extensively with numerical experiments as well as in the laboratory with hardware in the loop. In these studies we used a number of simulated test events. For the generation of the test events, a model of the RTE digital substation and the interconnected 220 kV and 90 kV system has been modeled with equivalent sources at the ends of the 220 kV and 90 kV transmission circuits. The model has been developed in WinIGS-T format (time domain). The report provides an overview of the model and the parameters of the major devices and the definition of the protection zones. The majority of the model parameters were provided by RTE. For missing parameter values, typical values were used. The model has been used to develop a large number of events for the purpose of testing the setting-less relay application on various protection zones of the RTE digital substation. A small number of these events are documented in a number of use cases which are included in this report.

For secure and reliable protection of power components such as a generator, line, transformer, etc. a new approach has emerged based on component health dynamic monitoring. The proposed method uses dynamic state estimation, based on the dynamic model of the component, which accurately reflects the nonlinear characteristics of the component as well as the loading and thermal state of the component.

The performance of any protection system is always dependent upon the quality and validity of the measurements, i.e. the input data into the relay. This has been recognized for any protective system and it is valid for the setting-less relays. The introduction of merging units offers a powerful way of correcting the measured sampled values in real time. Specifically, the model of the instrumentation channel can be used in a dynamic state estimation procedure to provide the estimated values of the primary quantities from the secondary quantities. This task can be performed on each one of the instrumentation channels independently from any other channel, i.e.

it is a distributed computation process and it does not affect the operation of the relay other than a small latency that is only a fraction of the sampling period. The process provides the best estimate of the primary sampled values. The report describes the implementation of the method and demonstrates the method on an example test system. It is shown that the method performs remarkably well even in cases of severe saturation of instrument transformers.

Project Publications:

- [1] A. P. Sakis Meliopoulos, George Cokkinides, Jiahao Xie, and Yuan Kong, "Instrumentation Error Correction within Merging Units", *Proceedings of the 2018 Georgia Tech Fault and Disturbance Analysis Conference*, Atlanta, Georgia, April 30-May 1, 2018.
- [2] A. P. Sakis Meliopoulos, G. J. Cokkinides, Hussain Albinali, Paul Myrda and Evangelos Farantatos, "Integrated Centralized Substation Protection", *Proceedings of the of the 51th Annual Hawaii International Conference on System Sciences*, Hawaii, HI, January 3-6, 2018.

Student Theses:

- [1] Yuan Kong. *Instrumentation Error Correction and its Effects on Transmission*, PhD, Georgia Institute of Technology, 2019 (expected).
- [2] Jiahao Xie. *Centralized Substation Protection*, PhD, Georgia Institute of Technology, Expected Graduation: 2019 (expected).

