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Testing and Evaluation of Wind Power Plant Protection System

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Abstract. This paper discusses methodology and test set up which may be used for Wind Power Plant (WPP) planning and protection system evaluation. The test set up consists of a digital simulator, as well as a number of physical relays, recorders, software for system and relay modeling, signal editing, etc. Minimizing economic loss, in terms of using maximum output of wind generated power without interruption and causing minimum equipment damage due to faults, is the main benefit of having protection system that operates correctly. The correctness of operation is crucial during grid disturbances in preventing unwanted power plant disconnection and further system stability violation. Since there are no standardized requirements or methodology for WPP protection system testing, its evaluation is challenging and manly customized to fit a given solution. This paper discusses test requirements and test methodology to perform the evaluation in a comprehensive manner.

Key words

Wind Power Plant, Protection System, Testing, Digital Simulator, Relaying.

1. Introduction

The Department of Energy (DOE) estimated that by 2030 20% of total generation in the US will be from the wind [1]. In such a high penetration scenario the WPP will need to stay connected to the grid during grid disturbances to avoid severe effects on the power system due to lack of generation. This makes technical challenges due to requirements for dependability and security of protection operation. Regulators and system operators in many countries have established grid codes for operation and connection of WPP [2, 3, 4]. The objective is to guarantee WPPs can offer the system support as close as possible to what is expected from the conventional power plants. In the past, it was the common practice to disconnect the WPP during a grid disturbance. However, disconnecting large scale WPPs could cause instability of the power system. For this reason, WPPs are required to remain connected for an extended time period during a grid faults to allow fault clearing and to provide reactive support to the network and voltage restoration. The Federal Energy Regulatory Commission (FERC) in the USA proposed requirements for WPP fault ride-through (FRT) for specific time period and for particular voltage levels. FERC Order No. 661-A [5] specifies requirements that wind generating facility must remain operational during voltage disturbances on the grid. Fast active and reactive power restoration to the pre-fault values after the grid voltage recovery is included into WPP interface requirements. Beside this, the supervisory control and data acquisition (SCADA) needs to ensure appropriate real-time communications and data exchanges between the wind power producer and the grid operator.

The effect of WPP on the grid protection system cannot be ignored. The WPP sort circuit contribution must be taken into account in setting calculation for the grid protection system. The impact of the grid disturbances on WPP protection cannot be neglected either. As regulators are placing rules regarding WPP behavior during and after grid disturbance, correct operation of the WPP protection system is becoming the study focus and it requires comprehensive testing. Furthermore, the new questions arise such as can the same principles used for distribution system be used for WPP protection or should new protection schemes need to be designed.

In the literature there have not been significant work reported in this area. The IEEE 1547 standard [6] for interconnecting distribution resources in electric power systems is an attempt to providing technical specifications for testing of the WPP interconnection. The document is mainly focused on general technical requirements for grid system interconnection with WPP and provides general testing requirements applicable on WPP that will be disconnected during a grid disturbance. Beside this, the only work on testing reported in the literature relates to evaluation of new protection algorithms for WPP systems. So far there has not been standardized procedures or requirements proposed for WPP protection system testing.