Chapter 37
Enhancement of Turbo-Generators Phase Backup Protection Using Adaptive Neuro Fuzzy Inference System

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ABSTRACT

This research work presents an advanced solution for the problem due to the current setting of Relay (21). This problem arises when it is set to provide thermal backup protection for the generator during two common system disturbances, namely a system fault and a sudden application of a large system load. These investigations are carried out using Adaptive Neuro Fuzzy Inference System (ANFIS). The results of the investigations have shown that the ANFIS has a promising tool when applied for turbo-generators phase backup protection. The effect of this tool varies according to the type of input data used for ANFIS testing and validation. The proposed method in this paper proposes the use of two different sets of inputs to the ANFIS, these inputs are the generator terminal impedance measurements (R and X) and the generator three phase terminal voltages and currents (V and I). The dynamic simulations of a test benchmark have been conducted using the PSCAD/EMTDC software. The results obtained from the ANFIS scheme are encouraging.

DOI: 10.4018/978-1-5225-1908-9.ch037

1. INTRODUCTION

Protective relaying provides important safeguard for power grid operation. Conventional backup protection depends on local electrical information to make relevant decisions, and cannot securely distinguish an internal fault from heavy load during flow transfer (Horowitz and Phadke 2006). This may cause cascading trip events and accelerate power system collapse. In addition, the complex setting principle of conventional backup protection may induce hidden failures caused by setting mistakes (Novosel et al. 2010), which would increase the risk of system instability during a disturbance (Patelet al. 2004; Tziouvaras 2007).

Consequently, some of the researchers have proved the existence of a potential problem due to the current setting of Relay (21) when it is set according to the present standards and recent related publications for generator thermal backup protection against transmission line uncleared faults, it is found that the current setting of the Relay (21) for generator thermal backup protection restricts the over excitation thermal capability of the generator (Elsamahy et al. 2012). Such a restriction does not allow the generator to supply its maximum reactive power during such events. Therefore, the necessity of modifying the Relay (21) reach to ensure a secure performance for the relay during major system disturbances was initiated, which would allow the generator to fulfill the system requirements during such events to ensure adequate level of voltage stability.

The Relay (21) element is typically set at the smallest of the following three criteria (Mozina 2006):

- 120% of the longest line with in-feeds.
- 50% to 67% of the generator load impedance (Z_{load}) at the rated power factor angle (RPFA) of the generator. This provides a 150% to 200% margin over generator full load.
- 80% to 90% of the generator load impedance at the maximum torque angle (MTA) of the relay setting (typically 85°) (Z_{GCC}).

In particular situations; when the generator distance phase backup protection relay is mainly required to provide thermal backup protection for the generator against transmission line faults; which are not cleared by transmission line relays; Relay(21) is set directly according to the second criterion (which is the setting considered during the investigations of this paper). The time delay for Relay (21) should be set longer than the transmission line backup protection (0.8 to 1 second) with appropriate margin for proper coordination.

Here in this paper, when applying this setting to the Relay (21) and when checking the "coordination of generator and transmission systems" requirements reported in the North Electric Reliability Council (NERC), where it is stated that the relay setting must be tested to assure that it will not respond incorrectly for system loading during extreme system conditions when the generator is not at risk of thermal damage. So, the loadability is validated against two operating points. These operating points were selected based on observed unit loading values during the August 14, 2003 blackout as well as other subsequent system events. These two load operating points shall not exceed the Relay (21) setting, and are believed to be a conservatively high level of reactive power out of the generator with a 0.85 per unit high side voltage, such that a relay set to be secure for these conservative operating points will be secure for the wide range of conditions that may challenge the apparent impedance characteristic of the phase distance protection.

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