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Prevention of transient instability employing rules based on back propagation based ANN for series compensation

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ABSTRACT

Power system preventive control is dominated by generation rescheduling. Other preventive control actions are rarely mentioned in the literature. This paper presents a transient stability preventive control design that takes series compensation into account. The design methodology is aided with the 'IF–THEN' rules extracted from a trained multilayer perceptron (MLP) artificial neural network (ANN). The proposed method can add more degrees of freedom by incorporation of series compensation, and have additional flexibility in deploying preventive control actions. Two preventive control schemes are presented and applied to 39-bus power systems. Extensive computational studies have demonstrated the effectiveness of the proposal.

1. Introduction

Transient stability refers to the ability of the power systems to retain synchronism after a contingency. It depends upon the severity of the contingency and the initial operating state of the power systems [1]. Here the term of contingency, also called disturbance or fault, indicates an event like three-phase short-circuit in the grid that will cause large changes in power system [2]. Operating power system will first encounter the hurdle of transient stability before apparatuses thermal limits [3]. This is particularly true for many power systems nowadays as being forced to squeeze the last drop from the infrastructure due to increasing demands but limited electrical apparatus capacity. In such a circumstance when a contingency occurred in the electrical network, the power system is likely to lose stability, or may be even worse to trigger large scale blackouts [4].

In order to avoid catastrophic outages, power utilities resort to various planning, protection and control schemes. Preventive control is summoned up when the power system is still in normal status. It encompasses many types of control actions, including generation rescheduling, load curtailment and network switching reactive compensation [5,6]. Those preventive control actions reallocate power system operating state so that can guarantee satisfactory behaviour after a contingency occurred in the grid. A number of studies have performed on the development of preventive control.

In [7], a hybrid neural network-optimisation approach has been used to develop preventive control scheme. The similar methodology was applied to design the preventive control for an isolated power system but with different stability index [8]. Decision trees (DTs) has been considered to design preventive control. In [9], the power system's frequency and its derivative were considered stability criteria. Rules were extracted from the DTs and concerned about various generation active powers and corresponding system dynamic security. A linear relationship between the critical clearing time (CCT), an index for measuring power system transient stability, and generator power generation was deduced in [10]. According to the linear relationship, that research deployed the preventive control by rescheduling generator output and regulating terminal voltages. In [11], transforming the investigated power systems consecutively into a single machine equivalent yielded the stability margin of the multi-machine power systems. The preventive control was determined iteratively on the basis of the equivalent circuit transient stability margin. Ref. [12] investigated the load angle trajectories of all generators, regarded the trajectories as the stability criterion, and presented a hybrid approach of ANN-DT for preventive control of power systems. A heuristic stability performance index was proposed to evaluate the gradient of the performance index and determine the preventive control accordingly [13]. DTs were employed in [14] to find the thresholds in order to determine the boundaries for secure and insecure operating regions. In [15] the DTs were used to determine transient stability related security regions and their boundaries, and established preventive control. Ref. [16] used trajectory sensitivities were to coordinate multi-contingency preventive control.

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