Determination of Steady State Stability Margin Using Extreme Learning Machine

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Abstract: - Power systems have increased in size and complexity due to rapid growth of widespread interconnection. This situation will make power system operated closer to steady-state stability limit (SSSL) resulting in higher probability voltage instability or voltage collapse. This paper presents SSSL assessment in power system using Extreme Learning Machine (ELM) model based on REI-Dimo method. The equivalent REI-Dimo is used to determine SSSL index of the power systems. Then, the result of REI-Dimo will be taught on ELM method via online. The results of ELM will compared with Artificial Neural Network (ANN) method. Studies were carried out on a Java-Bali 500kV system. The simulation showed that the proposed method could accurately predict the proximity to SSSL in power system. The proposed method was computationally efficient and suitable for online monitoring of steady-state stability condition in the power systems.

Key-Words: - Extreme Learning Machine, ANN, REI-Dimo Equivalent, SSSL, Voltage Collapse

1 Introduction

Load growth without a corresponding increase in transmission capacity has brought power systems operate near to steady state stability limit (SSSL). When a power system approaches the SSSL, the voltage of some buses reduces rapidly for small increments in load and the controls or operators may not able to prevent the voltage decay or collapse. Voltage collapse has become an increasing threat to power system security and reliability. To operate the system with an adequate security margin, it is essential to estimate the voltage stability margin corresponding to the given operating point. The main problem here is that the maximum permissible loading of the transmission system is not a fixed quantity. It depends on various factors such as network topology, availability of reactive power support, generation and load patterns etc. All these factors continuously vary with time. Voltage magnitude alone cannot be used as an indicator of instability [1-3].

The steady-state stability limit (SSSL) of a power system is “a steady-state operating condition for which the power system is steady-state stable but an arbitrarily small change in any of the operating quantities in an unfavorable direction causes the power system to loose the stability". An earlier definition refers to this concept as “the stability of the system under the conditions of gradually or relatively slow changes in the load". Voltage collapse, units getting out of synchronism, and instability caused by self amplifying small-signal oscillations are all forms of steady-state instability [3].

Empirically, the risk of steady-state instability is associated with low real or reactive power reserves, low voltage levels, and large bus voltage variations for small load or generated power changes. Recurring "temporary faults”, i.e. where breakers trip without apparent reason and which is disconnected by a protection without being able to identify the fault, might also be an indication of steady-state instability. Breaker trips can happen when loads increase due to "balancing rotors" of generators that are operated near instability trip and then get back in synchronism[1-5].

Equivalent REI (Radial, Equivalent and independent) has also been used to speed up and simplify the complex computational algorithms. For example, the rigorous solution of the steady-state stability problem is predicated on detailed machine model and entails an alternate sequence of load flow and eigenvalues calculating until the point of instability is found. However, determining eigenvalues for successively deteriorated load-flow cases is computationally intensive and has the