PhD-Theme: Development of intelligent, robust, and non-linear Models in dynamic Equivalencing for interconnected Power Systems

Responsible: Dipl.-Ing. Oscar Clovis Yucra Lino

The stability analysis of interconnected power systems is a difficult key task on one hand because of the large number of network components, such as machines, governors, exciters, loads, and converters, among others, which can be considered in the calculation forming a complex dynamic system and on the other hand due to limited data exchange between energy utilities preserving economic interests in the increasingly liberalized power markets. Considering these reasons, it is suitable to describe the neighbor networks using equivalent models. Thus, an interconnected power system can be reduced to a simplified aggregated model by means of the dynamic equivalencing generating representative generators and governors, preserving the properties such as linear and non-linear characteristics of the original power system. These simplified power supply models can be utilized in the fields of network reliability, management, and planning, especially to manage blackouts situations and to affront new technical circumstances of the deregulated electricity market. The conventional dynamic equivalencing is based mainly on linear systems and consists of the following steps: (i) Coherency identification, (ii) Aggregation of generators, (iii) Static network reduction and (iv) Aggregation of control devices.
But, physically speaking, real characteristics of power system components are non-linear systems. To overcome this problem, following non-conventional approaches for forming dynamic equivalents as non-linear models using non-conventional intelligent systems are proposed:

- Instead of the coherency identification, an identity recognition analysis involving generators properties is proposed on the basis of standard clustering algorithms (K-mean, hierarchical clustering, Fuzzy clustering, and self organizing features maps (SOFM) by unsupervised neural networks). The aim of this approach is based upon the similarity recognition examination regarding the amplitude and phase behaviour of the external network generators. An important improvement in accuracy is reached by means of a proposed electromechanical distance. This aspect contributes to develop accurate dynamic equivalents incorporating more system parameters. The generated approach is the electromechanical-based identity recognition.
- Instead of the classical aggregation, an innovative splitting aggregation approach is presented generating "virtual" generator models and using principal component analysis (PCA) and Fuzzy theory. It involves a fictive splitting of generators. The objective is to develop representative aggregated machines with electromechanical system parameters and to consider essentially characteristics of the generators preserving their original electromechanical behavior within the power flow and disturbance process. This splitting strategy can be used for introducing mathematical reduction techniques in the area being equivalenced, which can be described by virtual aggregated machine models with physical properties.
- The aim of this ANN-based dynamic equivalencing approach is to construct an intelligent system using non-linear modelling and identification the complex power system. It is based upon a knowledge-and signal based robust dynamic artificial neural network (DANN) as global external equivalent which captures and describes essentially non-linear characteristics of the power system components, such as generators, transmission lines, converters, voltage and turbine controllers, among others considering different power flow conditions. The conventional steps to dynamic equivalencing are replaced by the properly chosen DANN taking into consideration a suitable off-line training process, in which the effect of the disturbance influence of the internal area on the external area has to be considered globally.

The applicability, accuracy, and robustness of the proposed approaches and its implementations are demonstrated at practical examples of a test networks and on the large interconnected European power system (UCTE/CENTREL) consisting of 496 generators.