Abstract

Ensuring secure operation has paramount importance in safe and economic operation of power systems, especially in this era of deregulation where multiple parties are responsible for delivery of power to customers. Deregulation introduced new mechanisms of system disturbances, reduced system robustness and predictability of operations. Growing consensus towards using probabilistic security assessment approaches is observed due to its large potential in improving decision making. A quantitative measurement for security assessment is helpful, as a consistent numeric index would help operators implement appropriate deterrent actions. Deregulation also raised need for power quality monitoring to improve understanding of system performance and achieve better control on system operation.

In view of the above, this thesis proposes security assessment of electrical power systems including voltage and thermal overload security risk assessment. Also the complex wavelet technique is presented for power quality monitoring (PQM) and the advantages of PQM is illustrated through a case study on a 220/33 kV Gas insulated (GIS) substation.

The application of the probabilistic load flow (PLF) in different areas of power system either by a numerical or analytical approach is well documented. A modified PLF based on the method of cumulants for assessment of the bus voltages and line flows of electric systems is proposed. All input quantities are modeled as complex random variables to take into account the real and imaginary input components of loads, injected power at buses, bus voltages and line parameters. The outputs of the PLF are obtained in terms of the first four cumulants, which define the mean, deviation, skewness and kurtosis. The density and distribution plots of these outputs are approximated using the rearranged Edgeworths' expansion for security assessment purpose.

Need for operational security requires an understanding of problems associated with thermal overload of lines, in order to assess potential impacts of thermal overload. An approach is proposed to assess thermal capacity of existing lines and the associated risks, considering effect of environmental condition on line temperature. The proposed overload risk index takes into account both the percent of overloading on the line, as well as the impact on the system caused by outage of the line due to its loading condition. This index helps prioritize insecure lines and provides degree of their insecurity. The plot of allowable safe operation time under transient conditions of load and existing environmental conditions, indicates time available until line temperature exceeds safe limits. This knowledge can be used for allowing short time increase in transmission capacity without compromising operational security.

In order to facilitate power quality monitoring to characterize performance and identify specific problems of the system, an approach combining the dual tree discrete wavelet transform (DT-DWT) based CWT and artificial neural network is proposed. Here energy deviation from the ideal condition is used as a discriminative feature for detection and classification of the disturbances. The use of CWT is studied as it helps in removing several limitations of DWT, like shift sensitivity, poor directionality and lack of phase information. It is observed that the DT-DWT based CWT approach is a more effective and accurate tool for PQM in comparison with the commonly used discrete wavelet transform (DWT).

All the work in this thesis has been either compared with previous results or validated by case studies and experimental results wherever possible and necessary.

Keywords: Probabilistic load flow, voltage security, thermal overload risk assessment, power quality monitoring.