Abstract

Traditionally, monitoring and control functions in large power systems were based on measurements obtained locally. While small disturbances have their impact confined locally to the area of disturbance, large disturbances impact the system performance on a larger geographical scale. Preventive / Control actions based on local measurements may not be completely effective in detecting/ preventing impinging wide scale disturbances leading to blackouts. This brought about the need to monitor the state of the system through measurements made at various locations which led to the development of Wide Area Monitoring, Protection and Control (WAMPAC). Compared to traditional Supervisory Control and Data Acquisition (SCADA), WAMPAC is expected to improve both accuracy and reporting rates of the measurements. In addition, the measurements in WAMPAC are time stamped which can aid in post disturbance processing. At the heart of the WAMPAC, is the Phasor Measurement Unit (PMU).

Phasor Measurement Units are devices that measure synchronized phasor, frequency and rate of change of frequency from voltage/current signals. This work focuses on two key computational aspects in PMU i.e. frequency and phasor estimation. The benchmarks required in terms of accuracy and other specifications under quasi steady state and dynamic conditions are outlined by the IEEE C37.118.1-2011 standard for synchrophasor measurements. Discrete Fourier Transform (DFT) with moving window is traditionally used for the estimation of fundamental frequency phasor. This method provides a good estimate even in the presence of harmonics, but tends to be inaccurate due to the presence of noise in measurements and the decaying DC component which occur during faults. Although, several improved algorithms to estimate the phasor and frequency in compliance with the IEEE C37.118.1-2011 standard are proposed in literature, further improvements are possible. In this thesis, algorithms to accurately estimate frequency and phasor particularly under dynamic conditions are proposed.

In the first part of this work, a frequency estimation algorithm based on interpolation of coefficients of Discrete Fourier Transform (DFT) is proposed. In particular, the magnitude of DFT coefficients corresponding to the fundamental frequency along with DC and second harmonic are used to accurately estimate the frequency of the voltage/current signal.

Subsequently, the second part of the work focuses on phasor estimation under transient conditions and at off nominal frequencies. With this objective, two algorithms which offer advantages over the existing approaches are proposed in this thesis. The first algorithm is based on interpolation of DFT coefficients while the second algorithm is based on time domain interpolation with resampling.

The frequency and phasor estimation algorithms proposed in this work are extensively tested using standard test signals and simulated voltages/currents of real life systems. For testing the accuracy of the proposed algorithm for real life systems, voltage and current signals obtained using Electromagnetic Transients Program (EMTP) for a 765 kV system and a 24 bus EHV equivalent system of a part of Indian Southern grid are considered. The estimated frequency and phasor of these signals are found to be in compliance with the IEEE C37.118.1-2011 standard.