Chapter 4
PMU Phasor Estimation Using Different Techniques

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ABSTRACT

Many models of phasor measurement units (PMU) have been implemented; however, few dynamic models have been developed when the power system parameters change. It is necessary to use a method that can somehow estimate the frequency and correct the phasors. The conventional way to determine frequency is to detect zero crossings per unit time. However, this method has many drawbacks such as high cost and low accuracy. Also, after the frequency determination, the phasor should be corrected by suitably modifying the algorithm without omitting any data. This chapter presents different estimation techniques such as discrete Fourier transform (DFT), smart discrete Fourier transform (SDFT) that may be used to estimate the phasors. These estimated values would be incorrect if the input signals are at an off-nominal frequency and the phase angles would drift away from the true values. To correct this issue, first of all, the off-nominal frequency has been estimated using different techniques such as least error squares and phasor measurement angle changing, and then it is used to correct the phasors.

INTRODUCTION

Power systems are the largest manmade dynamic system. They are highly nonlinear and involve complicated electromagnetic and electromechanical phenomena. To operate the system reliably and economically, system conditions may be monitored using voltages and currents phasors. Conventionally, static state estimation has been used to estimate the steady-state power and voltage magnitudes. However, for dynamic applications, measurements are time-skewed without a time reference.

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Digital computer based measurements; protection and control have become common features of electric power substations. These systems use sampled data to compute various quantities such as voltage and current phasors.

The advent of satellite-based time-keeping system, such as high accurate atomic clocks used in global position system (GPS), with lowest cost GPS receiver providing high precision timing sources, measurements are made with a common time reference, usually GPS clock. The advances of computer, synchronization and communication technologies have made synchronized phasor measurement in power system applications such as protective relay and phasor measurement unit (PMU) within 1µs. Even the measurements accomplished at various sites, are synchronized to each other using the same common time base. Synchronized phasors measurement set provides a vastly improved method for tracking power system dynamic phenomena. They facilitate a number of wide area applications including wide area measurement systems. (WAMS), a power system protection, monitoring and control applications such as wide-area measurement protection and control system (WAMPAC) utilize these measurements.

Stand alone phasor measurement units (PMU) have been used on critical systems, for providing synchronized phasor measurement data. They are only in developed countries because they are relatively expensive, this has conveyed some manufacturers to design modern protective relay includes phasor measurement function and capabilities. The addition of synchrophasor measurement in a protective relay results in increased power system reliability and provides easier disturbance analysis, protection, and control capabilities.

LITERATURE REVIEW

In the power system phasor, amplitude, phase angle and frequency are variables which may be critical and used by many power system control and protection applications. The fast and accurate measurements of these variables are still considered in a contemporary topic of research interest. Many phasor estimation algorithms as the Newton method, Kalman filtering and level tracking, least square algorithm (Giray, M.M., & Sachdev, M.S.,1989; Girgis, A.A., & Brown, R.G., 1981) techniques have also been proposed for synchrophasor computations in (Phadke, A. G., & Thorp, J. S., 1988), a raised cosine filter (RCF) is used to compute phasors during power oscillations and dynamics. The RCF filter needs a comparatively large (4cycles) computational time windows. This algorithm has a very slow time response.

Discrete Fourier Transform (DFT) is widely used as phasor estimation algorithm of fundamental frequency (Nguyen, C.T., & Srinivasan, K., 1984; Sachdev, M.S., & Giray, M.M., 1985; Ouadi, A., Bentarzi H., 2009). Due to their good harmonic rejection property conventional DFT algorithm achieve excellent performance when the signal contains only fundamental frequency and integer harmonic frequency components.

Performance of the DFT algorithms deteriorates at off nominal frequencies and in the presence of DC decaying components as will be exposed in chapter 3. The smart DFT algorithm (Gurusinghe, D.R., Rajapakse, A. D., & Narendra, K., 2012, Ouadi, A. et al., 2010), where the sampling approach is maintained at fixed frequency and fixed window length. The power system frequency is estimated then the estimated phasors are compensated as a function of the estimated frequency. The used technique can be extended for accurate phasor of any harmonic (Girgis, A.A., & Brown, R.G., 1981). The lower frequency components, as the DC decaying which may introduce fairly large error in the phasor estimation (Johns, A.T., & Salman S.K., 1995; Phadke, A. G., & Thorp, J. S., 1988). For improving the DFT

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