Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Environmental Sciences 11 (2011) 655 – 661

Procedia
Environmental Sciences

Power System Dynamic State Estimation Based on a New Particle Filter

CHEN Huanyuan[a], LIU Xindong[b], SHE Caiqi, Yao Cheng

College of Electrical Information Engineering Jinan University Zhuhai, China
[a]chenhuanyuan1989@126.com ; [b] baiom@126.com

Abstract

In order to improve the performance of power system dynamic state estimation, a new particle filter for nonlinear filtering problems (Mixed Kalman Particle Filter, MKPF) is introduced. The MKPF method which based on the extended Kalman filter (EKF) and the unscented Kalman filter (UKF), can obtain a more accurate approximate expression of the true distribution. Combined with the real-time data of mixed measurement (WAMS/SCADA), a simulation of power system dynamic state estimation is established. Finally, the simulation results show that the method can quickly follow to the real value after the power system is disturbed and obtain higher estimated accuracy and robustness than the EKF and UKF methods.

Keywords: Power system；Dynamic state estimation； Mixed Kalman Particle Filter； mixed measurement； simulation

1. Introduction

Dynamic state estimation is a branch of state estimation. The actual power system is a complex, nonlinear and dynamic system. Dynamic state estimation is more in line with the nature of the power system than the static state estimation. Dynamic state estimation, which has forecasting capabilities, can provide the real-time operational status of the power system. Therefore, it is an important part of the energy management system (EMS)[1-2].

Currently, the power system dynamic state estimation method is based on extended Kalman filter (EKF) method. In normal operating conditions, it is comparatively accurate to use EKF method to obtain the power system dynamic state estimation. While in some specific cases, such as load or generator output power mutates, the limitation of EKF method will produce a large error. In order to improve its prediction and filtering performances, Chinese and overseas scholars had made some improvements: On the basis of load forecasting model, reference [3] used a dynamic method which was able to truly predict the trend of the system load. But this load model could not use the original Kalman filter model for iterating. Reference [4] used Adaptive Kalman filtering (AKF) to improve the filtering accuracy. But due to its online estimate

doi:10.1016/j.proenv.2011.12.102

model parameters and statistical characteristics of noise, the calculated amount was too large and was difficult to meet the online requirements. Reference [5] used the Unscented Kalman filter (UKF) method for power system dynamic state estimation, and achieved a more accurate estimation than traditional EKF method. However, UKF has certain restrictions on use. It applies only to ordinary Gaussian distribution model. While the actual power system is a nonlinear system, especially after the large disturbances. The load will change and the generators will also appear large oscillation. This change and oscillation are highly nonlinear, and the entire system is a time variant nonlinear system, that using UKF method for dynamic state estimation has certain defects.

Based on the above considerations, a new particle filter for nonlinear filtering problems proposed by reference [6] is introduced in this paper. This method, which mixes the EKF and UKF method as recommended distribution, can achieve a more accurate approximate expression to the real distribution and with more forecasting and filtering accuracy. Combined with the real-time data of mixed-measurement, a power system dynamic state estimation simulation is established. Finally, the simulation results verify the validity of this method.

2. EKF Dynamic State Estimation

The general transfer and measurement equations of the power system dynamic state estimation can be written as:

$$\begin{cases} x_{k+1} = f(x_k) + w_k \\ z_k = h(x_k) + v_k \end{cases} . \tag{1}$$

Where x_k and z_k are state and measurement vectors at moment k ; f and h are non-linear state transfer function and non-linear measurement function; w_k and v_k are model and measurement noise; $w_k \propto N(0, Q_k)$, $v_k \propto N(0, R_k)$, Q_k is the model errors variance, R_k is the measurement errors covariance.

Currently, the common power system dynamic state estimation method is the EKF method. Specifications of EKF method see reference [7]. While in practical application of power system, EFK method has certain disadvantages: When the load or generator output power mutates, the entire system is strongly nonlinear. That EKF ignores the second-order and higher-order entries will greatly affect the estimate accuracy, or even causes serious distortion. Moreover, the conditional distribution of the power system is strong non-Gaussian, that EKF method uses Gaussian distribution conditions will give rise to considerable error.

3. UKF Dynamic State Estimation

Unscented Kalman filter (UKF) is also a kind of recursive Bayesian estimation method[8], which applies unscented transform (UT) method to use a group determine sampling points to approximate a posterior probability. But it does not have to linearism the nonlinear state equation or measurement equation. It directly uses the nonlinear state equation to estimate the probability density function of state vectors. Specifications of UKF method see reference [8]. Reference [5] applied UKF method to the power system dynamic state estimation, which had solved the traditional EKF method's shortcomings such as slow convergence speed and poor robustness, but still not solved the nonlinear problems of power system.

4. Mixed Kalman Particle Filter Dynamic State Estimation

On the basis of EKF and UKF methods, preference [6] introduced a new type of particle filter, called mixed Kalman particle filter (MKPF). It mixed the EKF and UKF methods as the recommended distribution. At moment k, UKF method is used to produce the system state estimation first, and then EKF