Implementation of a robust complex extended Kalman filter with LabVIEW for detection in a distorted signal

Abstract This article proposes the PC-based LabVIEW as the software to develop the algorithm of the robust complex extended Kalman filter (RCEKF) to detect the parameters of the voltage signal in power systems. The hardware used is a sample-and-hold card and a data acquisition (DAQ) card to extract the data from an outside system to the PC, and the program will compute the amplitude, frequency, and phase of the voltage signal with RCEKF. To validate the performance of RCEKF, the voltage signal from a function generator was applied to check the feasibility of the algorithm. This application was also used in the Taiwan Power Company (TPC) secondary substation in Sijhou, Taiwan.

Key words Complex Kalman filter · Robust algorithm · Voltage distorted signal · LabVIEW

1 Introduction

The parameters of a voltage signal include amplitude, phase angle, and frequency. The accuracy of estimations of the parameters is a very important issue for the running of a power system. A literature review showed that the types of state variables used with the extended Kalman filter are the real type and the complex type in the application of signals estimation generally. However, in practical applications, the former method will result in only an estimated value if the signal is out of order. The pitch of the measured value and the estimated value will increase gradually throughout the tracking time. Therefore, in order to avoid these drawbacks, the complex extended Kalman filter was proposed, and was applied in the estimation of voltage distortion signal parameters. The complex extended Kalman filter is considered only in the linear part of the equation during the filtering process. When the parameter is not normal, the nonlinear part of the equation will sometimes have a great influence.

According to Huang and Shih, if there is an unusual signal in the system, the variation in quantity will result in errors between the estimated value and the optimal value. This condition will cause a variable state which does not lead to the optimal solution, and it will not be possible to estimate the parameter exactly.

In order to solve this problem, Huang and Shih proposed a robust calculation method modeling the extended Kalman filter. This can be a state estimation application of a power system, and results in a reasonably effective simulation. However, the robust calculation method is composed of an exponential function with innate characteristics, i.e., \( \exp(-|V_k - Hx_{\text{opt}}|) \). The meaning of this application is that the greater the difference between the measured value and the estimated value, the less effective the estimation filtering. Here we propose this robust calculation approach with a complex extended Kalman filter in signal estimation in order to improve the performance. In the literature, signal estimation is only applied at the simulation stage, but this approach is seldom used in practical measurements. Therefore, no individual algorithm is of use in practical verification tasks.

The PC-based LabVIEW is often applied in power systems. Therefore we used the graphic control software of LabVIEW to finalize a program using the robust complex extended Kalman filter. This program is used in practical measurements as follows. Firstly, the sine wave is given by

\[ z(t) = A \sin(2\pi f t + \phi) \]

where \( A \) is the amplitude, \( f \) is the frequency, and \( \phi \) is the phase angle.