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Statistical modeling of fiber optic current transducer

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Abstract: Fiber optic current transducer (FOCT) is a new type of current measurement instrument with high accuracy, large dynamic range, wide frequency range and excellent insulating property. Thus, it has been highly concerned for using in high voltage grid. Although these FOCTs have such crucial advantages, the stochastic errors, mainly including random walk, bias instability, quantization noise, may suddenly degrade the system performance in a short period of time. To evaluate the stochastic error characteristics of fiber optic current transducer (FOCT), traditional solution adopts Allan variance method to plot the curve on the log-log scale. Considering the deficiency of severe shock in Allan variance, total variance methodology is proposed to analyze the stochastic error characteristics of FOCT with the aim of overcoming the deficiency. Total variance method transforms time-offset data to frequency-offset data and extends the data to be a virtual sequence nearly as three times long as the initial data by mapping. Additionally, the least square fitting (LSF) is applied to identify and obtain each coefficient of FOCT stochastic error, which helps to evaluate the stochastic error characteristics of FOCT excellently. Simulation results demonstrate that both Allan variance result and total variance result are nearly equivalent, when correlation time is short. However, when correlation time exceeds half total duration of the measurement, Allan variance estimation values tend to shock increasingly severely and total variance curve always extends steadily. Besides, every stochastic error coefficient is decreased effectively by Total variance method, comparing with Allan variance method. Total variance methodology overcomes the deficiency of severe shock in Allan variance successfully, and then optimizes evaluation method of FOCT stochastic error characteristics.

Key Words: fiber optic current transducer (FOCT); stochastic error; Allan variance; total variance; least square fitting (LSF)

1. Introduction

Fiber optic current transducer has higher accuracy, larger dynamic range, wider frequency range and more excellent insulating property, compared with electromagnetic current transducer. However, the stochastic errors in FOCT become one of the major restricting factors in the large quantity of power engineering applications [1-2]. Besides, optical current transducers based on the Faraday effect – now emerging counterparts for HV current transformers—are not suitable in these applications as they are vulnerable to external influences, such as vibration and temperature variations [3]. Stochastic errors in FOCT usually derive from light source, detection circuit, fiber optic ring and optical devices, and the stochastic error features of output current data behave as angle random walk noise, bias instability noise, rate random walk noise, rate ramp noise, quantization noise and sinusoidal noise, et al [4].

Allan variance noise modeling theory has been proved successfully in analyzing FOCT stochastic error characteristics, however, it cannot model itself or identified each noise coefficient in FOCT [5]. In

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