Oral presentation: 31

An enhanced amplitude estimation system for sinusoidal signals based on phase sensitive detection

A. M. Ajward

Department of Engineering Technology, Faculty of Technology, University of Ruhuna, Sri Lanka
ajwardma@gmail.com

Highly accurate estimations of the amplitudes of sinusoidal signals that are associated with huge noise levels have many practical applications especially in domains such as research, medicine, and industry. Under considerably large noise levels, particularly in microcontroller based discrete-time systems, Phase-Sensitive Detection (PSD) or lock-in detection is one of the typical techniques mostly used for estimating the small signal amplitudes with a greater accuracy. The typical PSD technique may be adequate enough for many noisy circumstances, yet higher estimation accuracy of the signal amplitudes are highly desirable in many extreme practical requirements, where the signals are considerably small compared to the associated high noise levels. In this paper, an enhanced PSD technique to reduce the measurement errors and thus increase the signal amplitude estimation accuracy is proposed and established. In the proposed novel discrete-time based amplitude estimation system for sinusoidal signals, the required out-of-phase intermediate signal for the estimation of the input signal amplitude is generated using a newly derived mathematical formula. An impulse-response-function is implemented and the required impulse responses for estimating the intermediate signal is evaluated by a convolution sum using the novel formula. In the formula all the desired individual impulse responses of the input signal are calculated and integrated together in order to calculate the net response for the required out-of-phase signal. We have used the properties of the specific convolution sums, sinusoidal functions and impulse-response functions to derive and propose the new, much more efficient out-of-phase intermediate signal estimation method than the typically used and implemented it in a novel PSD based measurement system. The increased accuracy of the amplitude estimations of the newly designed system is confirmed by means of experiments using input signals of Signal-to-Noise-Ratio (SNR) from 6.00 dB to 40.0 dB. The results indicate that despite the SNR of the input signals, based on the estimated errors of the amplitude measurements using the proposed technique, the measurements are at least 240% more accurate than the typical system, while consuming a similar amount of time for performing the estimations. Even at the worst SNR at 6.00 dB the proposed technique is more accurate at least by 240% and for 100 single averaged amplitude measurements, the percentage error is less than 0.6%. The technique can be implemented in microcontroller based high accuracy amplitude estimation systems.

Keywords: Accuracy, amplitude estimation, error, noise