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SIMPLE WIDE FREQUENCY RANGE IMPEDANCE METER BASED ON AD5933 INTEGRATED CIRCUIT

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Abstract

As it contains elements of complete digital impedance meter, the AD5933 integrated circuit is an interesting solution for impedance measurements. However, its use for measurements in a wide range of impedances and frequencies requires an additional digital and analogue circuitry. This paper presents the design and performance of a simple impedance meter based on the AD5933 IC. Apart from the AD5933 IC it consists of a clock generator with a programmable prescaler, a novel DC offset canceller for the excitation signal based on peak detectors and a current to voltage converter with switchable conversion ratios. The authors proposed a simple method for choosing the measurement frequency to minimalize errors resulting from the spectral leakage and distortion caused by a lack of an anti-aliasing filter in the DDS generator. Additionally, a novel method for the AD5933 IC calibration was proposed. It consists in a mathematical compensation of the systematic error occurring in the argument of the value returned from the AD5933 IC as a result. The performance of the whole system is demonstrated in an exemplary measurement.

Keywords: impedance, converter, AD5933, SoC, system on a chip, measurement.

1. Introduction

As per the AD5933 integrated circuit (IC) datasheet, "The AD5933 is a high precision impedance converter system solution that combines an on-board frequency generator with a 12-bit, 1 MSPS, analogue-to-digital converter (ADC). (…) The response signal from the impedance is sampled by the on-board ADC and a discrete Fourier transform (DFT)" [1]. The AD5933 output voltage and measurement frequency are fully programmable and the communication is provided by an I^2C interface.

An application of the AD5933 IC in biological diagnostics research has been reported by other authors. The AD5933 IC was used in the cell culture growth monitoring [2, 3], single cell measurement [4], blood coagulation detection [5], biosensor applications [6], general bio-impedance measurements [7–11], and was also used in technical object monitoring [12, 13]. It should be noted however, that in order to obtain the complete information about electrical properties of a measured object and to use a convenient method of the impedance spectra analysis (equivalent circuit modelling) the impedance has to be measured in a wide range of frequencies [14].

The technical data of exemplary impedance meters based on the AD5933 IC are listed in Table 1. Only three of the described devices allow to measure the impedance at more than three orders of magnitude of frequencies. The range of measured impedance is typically from 10 Ω to over 1 MΩ. However, in many cases the exact range is not given. Most of the mentioned impedance meters require additional analogue front-end circuits to provide a proper interface between the AD5933 IC and a measured sample.

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