A Digitally Programmable A/D Converter for Smart Sensors Applications

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Abstract:
Nonlinear analog-to-digital conversion in smart sensor applications is an important topic since signal digitization and linearization can be performed in a single step near the transducer. In this paper a double pulsewidth modulated (PWM) scheme for nonlinear analog-to-digital conversion is presented. Calibration or auto-calibration data stored in the smart sensor's memory define the nonlinear profile characteristic of the transducer and provide the required data to obtain the inverse function of the analog-to-digital converter (ADC) transfer curve. Basically, as a function of the transducer's nonlinearity degree, the input voltage range of the ADC is segmented in a continuous set of subintervals and, for each of these subintervals, a second-order correction term based on a PWM A/D conversion is used to obtain a linear characteristic for the smart sensor. Additional advantages of this method result from its easy implementation in low-cost microcontrollers that include generally comparator inputs and PWM outputs. A flexible and programmable A/D conversion solution can be dynamically adapted to variations of the transducer's nonlinearity profile, and an increased resolution can be achieved at the expense of a lower conversion rate. Some MATLAB simulations and experimental results obtained with a square-root airflow transducer will be presented in the final part of the paper

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I. Introduction

The advent of smart sensor instrumentation [1]–[3] led to a generalized demand of analog-to-digital conversion solutions involving simple hardware and software components. Application requirements, mainly related with measurement resolution and data acquisition rate, are used to select the approach that best meets those requirements in a cost effective way. Compromises between resolution, accuracy and speed must be established considering the main requirements of each application [4], [5]. For example, controlling the temperature of a boiler can demand a high accuracy but a very low data acquisition rate due to the large time constants associated with temperature variations. Otherwise, mass flow measurements based on the Coriolis effect usually demand a medium level accuracy (8–10 bits), but the data acquisition rate must be much higher than the one of the previous example.

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