Preface

Wireless sensor networks (WSNs) are an emerging technology and certainly will be, without any doubt, a key technology in the future. To name a few, in 1999, the Business Week magazine included them as one of the most important technologies for the twenty-first century; in 2003, the Technology Review published by the MIT listed them as one of the top ten emerging technologies; and in 2006, Nature magazine dedicated a piece of news to them, entitled “2020 Computing: Everything, Everywhere,” where WSN was considered to cause a huge impact in the near future. Now, in 2012, a big progress has been made in the development of these networks, and there is a continuously accelerated advancement of this technology to satisfy the demands of the market.

A WSN consists of a set of spatially distributed sensor nodes that monitor different parameters, process the information using the embedded microcontroller (μC), and send measured data through a suitable RF module. Within the sensory field, a critical element in a WSN node is the electronic interface that conditions the signal coming from the set of low-cost sensors into a signal appropriate to be entered into the μC, task which usually consists in the amplification of the sensor output signal and the elimination of the offset, followed by its analog-to-digital conversion (ADC). Focusing in the ADC function, instead of conventional ADCs, the advantages of quasi-digital converters, such as voltage-to-frequency converters (VFCs), can be fully exploited offering a timely solution to perform signal digitalization.

A VFC is a data converter that codifies the information in frequency: the output signal is equivalent to a serial digital signal without the need of synchronization that can be directly interfaced to the μC using a single digital port, where the final digitalization is made thanks to the internal μC clocks. Thus VFCs combine the simplicity inherent to analog devices with the accuracy and noise immunity proper to digital converters. Besides noise immunity, VFCs usually need less integration area and power consumption compared with classical ADCs of equivalent accuracy and resolution used in smart sensor conditioning. In addition, due to cost reduction, low-cost μCs are used in WSN with the disadvantage of having the number of digital ports very limited, which prevents the use of conventional ADCs.

In this scenario, the main objective of this book is to develop VFC solutions integrated in standard CMOS technology to be used as a part of a microcontroller-based multisensor interface in the environment of portable applications, particularly within a WSN node. To use these converters in battery operated systems, stringent specifications to fulfil are low voltage, to be fed with the same batteries than the portable system and low power, to extend the batteries life. Thus, all through this book we offer a detailed study about VFC design—both at basic VFC cells and system level—their main characteristics and performances.

The starting point is the definition of the main VFC characteristic parameters, followed by a complete review of the most common types of VFCs existing in the literature, the multivibrator and the charge-balance VFC, and a brief analysis of the main frequency-to-code conversion methods, issues addressed in Chap. 2.

Next, as the multivibrator VFC is the one selected to be implanted for its use in a WSN node, its basic blocks, i.e., voltage-to-current converters, bidirectional current integrators, control and bias circuits are deeply examined. These basic blocks must be carefully designed as they will limit the full VFC performance, so their specifications have to guarantee those required by the corresponding application. Thus, the main challenges and solutions encountered during the design of such high performance cells are summarized in Chap. 3 and different high performance integrated proposals that will be next employed in specific VFCs are described and characterized considering low-voltage low-power constraints associated to portable systems. To achieve low-power consumption and easy any future scaled to shorter transistor channel length technologies, low-voltage power supplies have been employed: this requires greater effort in the design, but guarantees the validity of the achieved results in current submicron process technologies.

To close, the work is focused on the complete characterization of few different VFCs making use of some previously studied cells. Four complete VFC proposals are fully designed and evaluated in Chap. 4: a programmable VFC that includes an offset frequency and a sleep/mode enable terminal; a low-power rail-to-rail VFC; and two rail-to-rail differential VFCs. All of them are temperature compensated. These novel VFC contributions are more than competitive with those already presented in the literature and demonstrate their feasibility to be used in WSN interfaces as an alternative to conventional ADCs.

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