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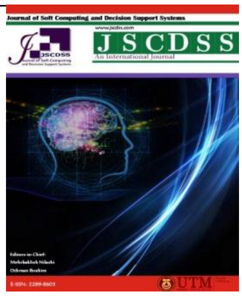

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4μW RMS-to-DC Converter in 180nm Technology Process for Biomedical Applications

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Abstract

This paper presents a low power RMS-to-DC converter for biomedical applications using CMOS transistors. This converter is designed by fewer number of transistors to reduce the power consumption as well as complexity so that only 18 transistors are included to build up the circuit. To make the circuit suitable for biomedical application, CMOS transistors operate in subthreshold region helping with reducing the power dissipation. This circuit takes the advantages of current-mode approach and translinear principle to make the circuit performance suitable for biomedical purposes and better than previous state-of-the-art works. Mathematical operations have been done for better understanding of the circuit operation. To verify the circuit performance, simulations have been done through H-spice in 180nm technology process to validate the analysis and topology of this converter. Based on the simulation results, the circuit has a low power of 4μW, low supply voltage of 0.9V, low relative error of 6%, bandwidth of 3 MHz, and input range of 50nA-450nA.

Keywords: RMS-to-DC converter, Subthreshold, MOS Translinear Loops (MTL)

1. Introduction

RMS-to-DC converter is an electronic circuit which is used for estimation of the average energy content in an electronic signal (Mulder et al., 1997; Mulder et al., 1996; Wey et al., 2000; Danesh et al., 2013). The converter is widely used in instrumentation devices (Haddad et al., 2003), biomedical ICs (Kafe et al., 2014), and syllabic companding systems (Frey et al., 200).

There are two approaches for designing RMS-to-DC converters: 1) current-mode approach, 2) voltage-mode approach. A current-mode circuit enables current processing and has certain essential advantages against a voltage-mode circuit such as wide bandwidth, high slew rate, low power consumption, and simple circuitry (Wilson, 1990; Toumazou et al., 1990), to name but a few. A squarer cell is an essential component in recent designed current-mode RMS-to-DC converters. The input range of two-quadrant squarer is wider than a one-quadrant one (Toumazou et al., 1990). The MOS translinear loops (MTL) derived by Seevinck and Wiegerink for the first time (Seevinck et al., 1991). MTL circuits are designed by applying the MTL principle and used in synthesizing many nonlinear signal processing functions (Mulder et al., 1996). The increasing demand for low-voltage/low-power integrated circuits has encouraged the conception of CMOS current-mode architectures. Up-down translinear loop in different computational circuits (Danesh et al., 2019; Lopez-Martin et al., 2003) and class-AB linear transconductors (Cruz-Blas et al., 2005) has been used. In (Danesh et al., 2019), the up-down structure of squarer cells uses no additional supply voltages and has less complexity. Also, the working region of transistors is weak inversion leading to less power consumption. From this point of view, the design process of low power actuators like reaction wheels (Izadi et al., 2015) is developed for reducing power consumption. In this paper, a two-quadrant low-power current-mode RMS-to-DC converter is presented which uses translinear principle with MOS transistors operating in weak inversion region. Due to the features of the current-mode structure used in this converter, the complexity and power consumption of the circuit are reduced. Power consumption and design simplicity are two significant features. The simplicity in the design process brings about more accurate fault detection model for sensors (Izadi et al., 2016; Izadi et al., 2019; Izadi et al., 2017). Therefore, circuit complexity should be considered in devices requiring low power consumption. For example, (Bellasi et al., 2013) proposes an Analog-to-Information Converter (AIC) based on compressive sensing which is more energy-efficient and faster than other state-of-the-art Analog-to-Digital Converters (ADC). Also, (Zanddizari et al., 2018) proposes a signal processing