DESIGN OF HIGH-PERFORMANCE VARIATION-TOLERANT DIFFERENTIAL VOLTAGE-TO-TIME CONVERTER (VTC) CIRCUITS

By

Abdullah Mohamed Ahmed El-Bayoumi

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Electronics and Communications Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2016

DESIGN OF HIGH-PERFORMANCE VARIATION-TOLERANT DIFFERENTIAL VOLTAGE-TO-TIME CONVERTER (VTC) CIRCUITS

By

Abdullah Mohamed Ahmed El-Bayoumi

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Electronics and Communications Engineering

Under the Supervision of

Prof. Dr. Ahmed M. Soliman

Emeritus Professor

Electronics and Communications
Engineering Department
Faculty of Engineering, Cairo University

Dr. Hassan Mostafa

Assistant Professor

Electronics and Communications
Engineering Department
Faculty of Engineering, Cairo University

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2016

DESIGN OF HIGH-PERFORMANCE VARIATION-TOLERANT DIFFERENTIAL VOLTAGE-TO-TIME CONVERTER (VTC) CIRCUITS

By

Abdullah Mohamed Ahmed El-Bayoumi

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Electronics and Communications Engineering

Approved by the
Examining Committee

_____
Prof. Dr. Ahmed M. Soliman, Thesis Main Advisor

_____
Prof. Mohamed Riad, Internal Examiner

_____
Prof. Hassanein H. Amer, External Examiner
(Electronics and Communications Engineering, The American University in Cairo)

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2016

Engineer's Name: Abdullah Mohamed Ahmed El-Bayoumi
Date of Birth: 05/11/1990
Nationality: Egyptian
E-mail: abdullah.elbayoumi@pg.cu.edu.eg
Phone: +20 100 380 7047
Address: Electronics and Communications Engineering Department, Cairo University, Giza 12613, Egypt

Registration Date: 01/10/2012
Awarding Date: --/--/2016
Degree: Master of Science
Department: Electronics and Communications Engineering

Supervisors:

Prof. Dr. Ahmed M. Soliman
Dr. Hassan Mostafa

Examiners:

Prof. Dr. Ahmed M. Soliman (Thesis main advisor)
Prof. Mohamed Riad (Internal examiner)
Prof. Hassanein H. Amer (External examiner)
(Electronics and Communications Engineering, The American University in Cairo)

Title of Thesis:

Design of Time-based Analog-to-Digital Converter (T-ADC): High-Performance Variation-Tolerant Differential Voltage-to-Time Converter (VTC) Circuits

Key Words:
Nanometer CMOS technology; voltage-to-time converter; time-based analog-to-digital converter; software-defined radio; biomedical applications; metal-insulator-metal capacitor; dynamic range.

Summary:

In this thesis, various metal-insulator-metal (MIM) capacitor-based differential Voltage-to-Time Converters (VTCs) including 2 novel proposed designs, which achieve a high performance at higher sampling frequency for a Software-Defined Radio (SDR) receiver at 65-nm CMOS technology, are presented and compared to their single-ended design. A study on tolerating the process-voltage-temperature (PVT) variations for the 1st proposed design with proposing a dynamic calibration technique based on a set of large-sized capacitor-based voltage dividers circuits is presented. Post-layout simulation results are provided for both designs at 130-nm CMOS technology for low-frequency low-power implantable biomedical systems.

Acknowledgments

To begin with, I would like to take this opportunity by expressing my deepest gratitude and appreciation towards my supervisors Prof. Dr. Ahmed M. Soliman and Dr. Hassan Mostafa. Their continuous support, guidance and enthusiasm have made my research instrumental, intellectually stimulating, enjoyable and very rewarding in successfully performing and completing my thesis. It is a great honor to be accepted as a masters' degree student under the supervision of Prof. Dr. Soliman. It is really remarkable to attend the IEEE International Conference on Electronics, Circuits and Systems (ICECS 2015) as an author and watch the honorary ceremony of Prof. Dr. Soliman for his amazing research contribution record in the cutting-edge technologies for academia and industry. His inspiration stories and his excellence dedication have guided me to finalize this work.

Also, I would like to specialize my thanks to Dr. Mostafa who has shaped my research direction with his ideas. His vision, mentorship, professional advices of technical and non-technical issues and friendship have advanced me through the thesis, although his lots of postgraduate and undergraduate students. These also encourage me to take the lead and participate in various international conferences. That helps me to get accepted of some of them. As we know the main aspect of any journey is to understand your failures, I have learnt from Dr. Mostafa to study well the review comments of my rejected papers and analyze them to start again. I really appreciate Dr. Mostafa's patience towards me regarding the work load of my industrial career. I am also thankful to Dr. Mohamed Refky for using his experience and knowledge to help me whenever I needed it. I would like to thank my fellow graduate students in the EECE department who have provided me with the tools and support needed to complete this dissertation.

Research is something when you change your way of thinking. This process of change may be slow. Thus, it could leave you completely unaware of the change you have made, and the progress that you are currently making. An instance of recollection, such as writing a summary of the progress you have been doing for the last years brings these things to your attention. This process of change is something that your environment is aware of, as one is thrown between despair and hope. Being a software engineer in a multinational company is stressful and at times it is emotionally challenging to struggle to manage your time between your industrial work background and your academic research. Although, they could fulfill a perfection background of how we innovate ideas till we can provide products to the market. Finally, I am also grateful to all my friends who have encouraged me to keep going on and brought social balance into my life.

Dedication

I have devoted this dissertation with a special thank you to my family for helping me to come this far and for being a continuous source of love, care, warmth and stability throughout my life. Collectively, they are an enormous pool of support for which I would not have succeeded without. I owe them every single achievement in my life.

Table of Contents

List of Tables

List of Figures