AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Electronics Engineering and Electrical Communications

On-Chip Timing Control

A Thesis submitted in partial fulfillment of the requirements of
Master of Science in Electrical Engineering
(Electronics Engineering and Electrical Communications)

by

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Bachelor of Science in Electrical Engineering
(Electronics Engineering and Electrical Communications)
Faculty of Engineering, Ain Shams University, 2012

Supervised By

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Cairo, 2016

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Statement

This thesis is submitted as a partial fulfillment of Master of Science in Electrical Engineering, Faculty of Engineering, Ain shams University. The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Thesis Summary

Oscillators represent an essential building block for many electronic, communication, and optical systems. They are used in digital electronic systems to provide them with the reference clock signal required for synchronizing their operation. Thus, oscillators must work with high accuracy and temperature stability in order not to affect the correct operation of these applications. However, different variations like supply, process, and temperature variations greatly affect the output frequency of oscillators. Supply and process variations can be calibrated at the beginning of the oscillator operation. Temperature variations represent the bottleneck for improving the oscillator stability. Therefore, many oscillators are developed over years to enhance their temperature stability. Some of them can achieve very low temperature variations like crystal oscillators; however, they are not suitable for full integration and have large area and cost.

Thus, this thesis focuses on the design of a new frequency control loop that adjusts the output frequency of an oscillator regardless of its temperature variations. A new technique that utilizes a switched-capacitor circuit is proposed for controlling the oscillator frequency. Also, a bandgap reference circuit is used to adjust the oscillator frequency to the desired value so that there is no need for an external reference oscillator. The proposed switched-capacitor-based frequency control loop can achieve very high temperature stability with low power. Also, it is suitable for on-chip integration.

The thesis is divided into six chapters as listed below:

Chapter 1

It is an introduction to the proposed work including the motivations, objective, and main contributions of this thesis.

Chapter 2

It gives an overview of the different types of oscillators, focusing on the advantages and disadvantage of each type and making a brief comparison between them. Also, it presents the factors that affect the output frequency of an oscillator.

Chapter 3

In chapter 3, the proposed switched-capacitor-based frequency control loop is presented. The principle of its operation along with its building blocks are introduced. System

modeling is developed to analyze the system performance. In addition, the concepts of composite-resistor temperature compensation and oven-controlled components are introduced.

Chapter 4

It deals with the circuit implementation of the different building blocks of the proposed frequency control loop. Six blocks are implemented using CMOS technology: (1) bandgap-reference circuit, (2) switched-capacitor circuit, (3) low-dropout regulator, (4) operational amplifier, (5) buffer, and (6) low-pass filter.

Chapter 5

It presents the full integration of the proposed system along with its simulation results using circuit-level simulation.

Chapter 6

It ends with a conclusion of the proposed work and possible directions for future work.

Key words: frequency control loop, oscillator frequency, temperature stability, switched-capacitor circuit, bandgap-reference circuit, low-dropout regulator, composite-resistor temperature compensation, heating components

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