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Department of Electronics and Communication Engineering

BEHAVIORAL MODELING AND VERIFICATION OF CHARGE PUMP DC-DC CONVERTERS

By

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A Thesis

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STATEMENT

This thesis "**Behavioral Modeling and Verification of Charge Pump DC-DC Converters**" is submitted to Ain Shams University for the degree of Master of Science in Electronics Engineering.

The work included in this thesis was carried out by the author in the Department of Communication and Electronics Engineering, Faculty of Engineering, Ain Shams University.

No part of this thesis has been submitted for a degree or a qualification at any other University or Institution.

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ABSTRACT

Complex systems today are becoming more and more mixed-signal, with the analog part being the design and verification bottle neck. Traditionally, the virtual verification for the analog part of the design was only available through transistor-level SPICE simulation. Lately, behavioral modeling has been proved to be the right methodology to cope with today's design and verification demands.

Some behavioral models of complex systems consume a lot of time during simulation due to reasons such as high switching rates or many operating frequencies. An example of such circuits is the family of switched-capacitor DC-DC converters, also known as charge pumps.

Our target is to study the different behavioral modeling techniques which, when deployed, enable the speed up of the simulation time of such circuits, while preserving accuracy. In this thesis we will also present an average modeling technique that concentrates on the information bearing signal of low frequency, instead of the detailed transient higher frequency signal, thereby greatly relaxing the simulation time-step, and gaining the same information in a shorter time. A real-life design is used to verify the presented methodology.

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CHAPTER 1
Introduction

1.1 Motivation

The growing competition among chip makers has made first time silicon success a key requirement. To achieve this, SoC designers are always in search for means to minimize risks and to verify their systems at less critical stages within their design cycle. Combining the complexity of digital verification with the increasing integration of more sophisticated analog circuits, the problem is getting exponentially worse. It is no longer wise to divide a design into analog and digital parts and make separate simulations for each. This is why mixed-signal simulation has become the solution adopted by many design houses to improve their verification methodologies. The complete system is simulated to verify the system functionality with respect to the target system specifications.

To succeed in simulating large and complex systems, some blocks need to be simplified using mixed-signal HDLs. An example of a typical sub-system that needs modeling is the Switched-capacitor or charge pump voltage converter circuit. This circuit is used in many applications that require multiple derived supply voltages, such as LCD drivers and many other portable applications. Its popularity stems from its low cost, small size and inductorless and fairly simple design. Complex systems such as LCD drivers are almost impossible to simulate at the system level due to their large size and complex functionality. The charge pump is one of the most active blocks in such systems, as it is