Ain Shams University
Faculty of Engineering
Electronics and Communications Department

DC-DC Converter for Low-Energy Wireless Applications

A Thesis submitted in partial fulfillment for the requirements of a Master of Science degree in Electrical Engineering Electronics and Communications Engineering Department

Mahmoud Abdelwahab Ahmed Ahmed Khalil
B.Sc. of Electrical Engineering
(Electronics and Communications Engineering Department)
Ain Shams University, 2013

Supervised by
Prof. Emad Eldin Mahmoud Hegazi
Assoc. Prof. Mohamed Ahmed Mohamed El-Nozahi

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Examiners' Committee

Title, Name and Affiliation	**Signature**
Prof. Serag ElDin Habib Faculty of Engineering, Cairo University, Electronics and Communications Engineering Dept.	....
Prof. Hani Fikry Ragai Faculty of Engineering, Ain Shams University, Electronics and Communications Engineering Dept.	....
Assoc. Prof. Mohamed Ahmed Mohamed El-Nozahi Faculty of Engineering, Ain Shams University, Electronics and Communications Engineering Dept.	....
Prof. Emad Eldin Mahmoud Hegazi Faculty of Engineering, Ain Shams University, Electronics and Communications Engineering Dept.	....

Date: 30/01/2019

Statement

This Thesis submitted in partial fulfillment for the requirements of a Master of Science degree in Electrical Engineering Electronics, and Communications Engineering Department.

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

No part of this thesis was submitted for a degree or a qualification at any other university or institution.

Name: Mahmoud Abdelwahab Ahmed Ahmed Khalil

Signature : ....

Date: 30/01/2019

Researcher Data

Name: Mahmoud Abdelwahab Ahmed Ahmed Khalil

Date of Birth: 10/05/1991

Place of Birth: Mecca Al-Mukarramah, Saudi Arabia

Last Academic Degree: B.Sc. in Electrical Engineering

Field of Specialization: Electronics and Communications

University issued the degree: Ain Shams University

Date of issued degree: 2013

Current job: Senior RF/AMS Design Engineer at Si-Vision

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Mahmoud Abdelwahab Ahmed Ahmed Khalil
Electronics and Communications Engineering Department
Ain Shams University, Cairo, Egypt
January 2019

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Abstract

Mahmoud Abdelwab Ahmed Ahmed Khalil "DC-DC Converter for Low-Energy Wireless Applications", Master of Science dissertation, Ain Shams University, 2019.

The demand on DC-DC converter increases as the scaling of CMOS technologies into the nanometer scale imposes lower supply voltage than the battery voltage which is defined by its electrochemical properties' limitations. High-efficiency DC-DC converters are needed to extend the battery life. This thesis aims to design a high efficiency and a low voltage ripple DC-DC Converter for low-energy wireless applications. The proposed converter is implemented using UMC130nm CMOS technology with a new design methodology and startup technique to reduce the power-up consumed energy and the startup time variations. The proposed buck inductor peak current is well-controlled at all inductance, input, and output voltage range using a simple replica circuit matched to the PMOS switch. An automatic background calibration is introduced to sustain converter stability and reduce the regulator voltage ripple across different load, supply and external components values. Simulation results show that the proposed converter minimizes ripple magnitude and variations especially at light loads while maintaining good efficiency results. Finally, a new FoM is introduced to compare all PFM buck designs.

Keywords: Low-Energy Transceivers, Inductor-based switching regulator, Pulse frequency modulation DC-DC converter, Adaptive on-time buck converter, Low-ripple DCM buck converter.

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Summary

This thesis is divided into six chapters including the lists of contents, tables, figures and references as follows:

Chapter 1 is an introduction highlighting the challenges and the main contributions of the thesis, followed by the outline of the thesis.

Chapter 2 includes a survey between all the switching regulators' topologies in terms of voltage ripples, load current and power efficiency. This chapter describes the selected buck converter in-detail.

Chapter 3 depicts the system design specifications resulting from supplying wide range of noise-sensitive loads and illustrates the voltage ripple briefly including its variations with load current, supply voltage and passives values. This chapter includes a survey for spurious noise reduction and different startup techniques. A new FoM is introduced to allow absolute comparison between PFM different designs through meaningful parameters.

Chapter 4 shows the proposed converter circuit implementation. This chapter starts with BIAS top design and then illustrates the main operation of the final circuits design. Also, a new technique is adopted to generate a constant inductor peak current at all inductance, input and output voltage ranges. The chapter ends with a new background calibration technique to reduce the regulator ripple variations across different load, supply and external components values while maintaining converter stability.

Chapter 5 shows all the simulation results for the proposed buck converter across different scenarios and PVT corners. It also depicts the achieved results summary, the proposed converter area estimate, and the initial floorplan.

Chapter 6 is the conclusion of this work and the possible future work that needs to be added.

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