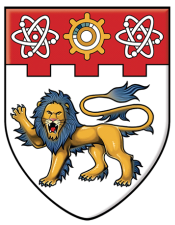

NANYANG
TECHNOLOGICAL
UNIVERSITY

POWER OPTIMISATION FOR ADAPTIVE EMBEDDED WIDEBAND RADIOS

A Thesis submitted to
the School of Computer Engineering
of Nanyang Technological University

by

Pham Hung Thinh

in fulfillment of the requirement for
the Degree of Doctor of Philosophy of
for Computer Engineering

September 22, 2014

Contents

List of Figures iv
List of Tables 1

1 Research Introduction **2**
1.1 Background 2
1.2 Research Motivation 2
1.3 Objective and Contributions 2
1.4 Organization 2

2 Background Literature **3**
2.1 Power Consumption 4
2.1.1 Power Dissipation on FPGA 4
2.1.2 Power Estimation 4
2.1.3 Low power design strategies 4
2.2 Orthogonal Frequency Division Multiplexing 4
2.2.1 Cyclic Prefix 4
2.2.2 OFDM-based system 4
2.2.3 Evaluating OFDM 4
2.3 Multiple Standard Cognitive Radios 4
2.4 OFDM Synchronisation 4
2.4.1 Timing Offsets 4
2.4.2 Frequency Offset 4
2.4.3 Phase Noise 4
2.5 Related Work on OFDM synchronisation 4
2.5.1 Coarse STO and Fractional CFO Estimation 4

2.5.2 Fractional CFO Compensation 4
2.5.3 Fine STO and Integer CFO Estimation 4
2.6 Shaping OFDM Spectral Leakage 4
2.6.1 Pulse Shaping 4
2.6.2 Image Spectrum Compression 4
2.7 Summary 4

3 Multiplierless Correlator Design for low-power systems 5
3.1 Introduction 5
3.2 Implementation of correlators 5
3.2.1 Design of DSP48E1 Based Correlator 5
3.2.2 Design of Multiplierless Correlator 5
3.2.3 Implementation Results 5
3.3 Simulation and discussion 5
3.4 Summary 5

4 Proposed Method for OFDM Synchronisation 6
4.1 Introduction 6
4.2 Proposed Technique for FFO and STO Estimation 6
4.3 Enhanced Synchronization Through Novel IFO Estimation Architecture 6
4.4 Summary 6

5 Proposed Method for Shaping OFDM Spectral Leakage 7
5.1 Introduction 7
5.2 Proposed Technique for Adaptive Shaping Spectral Leakage 7
5.3 Simulation Results and Discussion 7
5.4 Summary 7

6 A Novel Architecture for Multiple Standard Cognitive Radios 8
6.1 Introduction 8
6.2 Proposed OFDM-based baseband modulation for MSCR 8
6.3 Performance Analysis and Discussion 8
6.4 Summary 8

7 Conclusion and Future Work **9**

References **10**

List of Figures

List of Tables

Chapter 1

Research Introduction

1.1 Background

1.2 Research Motivation

1.3 Objective and Contributions

1.4 Organization

Chapter 2

Background Literature

2.1 Power Consumption

2.1.1 Power Dissipation on FPGA

2.1.2 Power Estimation

2.1.3 Low power design strategies

2.2 Orthogonal Frequency Division Multiplexing

2.2.1 Cyclic Prefix

2.2.2 OFDM-based system

2.2.3 Evaluating OFDM

2.3 Multiple Standard Cognitive Radios

2.4 OFDM Synchronisation

2.4.1 Timing Offsets

2.4.2 Frequency Offset

2.4.3 Phase Noise

2.5 Related Work on OFDM synchronisation

2.5.1 Coarse STO and Fractional CFO Estimation

2.5.2 Fractional CFO Compensation

2.5.3 Fine STO and Integer CFO Estimation

2.6 Shaping OFDM Spectral Leakage

2.6.1 Pulse Shaping

Chapter 3

Multiplierless Correlator Design for low-power systems

3.1 Introduction

3.2 Implementation of correlators

3.2.1 Design of DSP48E1 Based Correlator

3.2.2 Design of Multiplierless Correlator

3.2.3 Implementation Results

3.3 Simulation and discussion

3.4 Summary

Chapter 4

Proposed Method for OFDM Synchronisation

4.1 Introduction

4.2 Proposed Technique for FFO and STO Estimation

4.3 Enhanced Synchronization Through Novel IFO Estimation Architecture

4.4 Summary

Chapter 5

Proposed Method for Shaping OFDM Spectral Leakage

5.1 Introduction

5.2 Proposed Technique for Adaptive Shaping Spectral Leakage

5.3 Simulation Results and Discussion

5.4 Summary

Chapter 6

A Novel Architecture for Multiple Standard Cognitive Radios

6.1 Introduction

6.2 Proposed OFDM-based baseband modulation for MSCR

6.3 Performance Analysis and Discussion

6.4 Summary

Chapter 7

Conclusion and Future Work

References