

# Quantum Computer Emulated on FPGA



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August 14, 2024

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A handwritten signature in black ink, appearing to read 'W. F. Amleh'.

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Date

# Acknowledgements

No man is an island entire of itself; every man is a piece of the continent,  
a part of the main.

—*John Donne*

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# Abstract

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# Abbreviations

# Chapter 1

## Introduction

Computational capabilities of classical computers that use binary to describe information are limited by physical constraints of power consumption and the amount of physical space that each element of information occupies. Moore's Law accurately predicted the exponential increase in transistors on integrated circuit chips, however, James R. Powell indicated that a persuasive argument from quantum mechanics based on the Heisenberg principle, defines an eventual limit to the miniaturization of transistors that can be achieved [1]. On the contrary, quantum mechanics also provides advantages that can be exploited to improve the computational capabilities by employing principles of superposition and quantum entanglement to represent different states of information.

Using the quantum state of particles to represent information forms the basis of quantum computing - a computing paradigm that uses the principles of quantum physics to represent and compute information as *qubits*. From the principle of superposition, qubits can be in a state of 0 and 1 simultaneously, unlike classical bits which can only be in a state of 0 or 1, and not both at the same time. Additionally, quantum entanglement allows qubits to be manipulated simultaneously, whereas classical bits can only be manipulated individually per operation. Exploiting these principles gives quantum computing a computational advantage where multiple instances of data can be manipulated simultaneously, thereby reducing the size of the instruction set as part of the architecture of a quantum computer. Another advantage of quantum computers is that, since qubits can exist in multiple states at the same time, the number of qubits required to perform a computation is exponentially smaller than the number of bits that would be required to perform the same operation using classical bits. These benefits account for the growing interest in quantum computing as means to overcome the limits of transistor growth as predicted by Moore's Law. Consequently, the use of quantum computer can reduce the time complexity of many processes that require exceptional performance to execute tasks. The following paper describes the design and emulation of a quantum computer on a field programmable logic gate array (FPGA) to simulate quantum acceleration of a classical computer.

Quantum acceleration

### 1.1 Background

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## 1.2 Objectives

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## 1.3 System Requirements

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## 1.4 Scope & Limitations

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## 1.5 Report Outline

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## Chapter 2

# Literature Review

If you wish to make an apple pie from scratch, you must first invent the universe.

—*Carl Sagan*

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## Chapter 3

# Conclusions

The same rule holds for us now, of course: we choose our next world through what we learn in this one. Learn nothing, and the next world is the same as this one.

—*Richard Bach, Jonathan Livingston Seagull*

The purpose of this project was to...

This report began with...

The literature review was followed in Chapter...

The bulk of the work for this project followed next, in Chapter...

In Chapter...

Finally, Chapter... attempted to...

In summary, the project achieved the goals that were set out, by designing and demonstrating...

## Chapter 4

# Recommendations

It is for us the living, rather, to be dedicated here to the unfinished work which they who fought here have thus far so nobly advanced.

—*Abraham Lincoln*

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# Bibliography

- [1] J. R. Powell, “The Quantum Limit to Moore’s Law,” *Proceedings of the IEEE*, vol. 96, no. 8, pp. 1247–1248, 2008.