

**FAST FOURIER TRANSFORM MODULE FOR IMPLEMENTATION IN  
NIOS II EMBEDDED PROCESSOR**

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FAST FOURIER TRANSFORM MODULE FOR IMPLEMENTATION IN NIOS II  
EMBEDDED PROCESSOR

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Specially dedicated to  
my beloved mother and father  
“Only those who dare to fail greatly, can ever achieve success greatly”

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## ABSTRACT

The Fast Fourier Transform is an indispensable algorithm in many digital signal processing applications but yet is deemed computationally expensive cost when designed it on hardware. This thesis proposes a design and implementation of Fast Fourier Transform algorithm in embedded system by utilize it in Nios II embedded processor and integrate with Nios II floating point custom instruction. The design is based on Decimation-In-Time and Decimation-In-Frequency radix-2 for the better performance and speed. Hardware implementation, the ALTERA CYCLONE II EP2C35F672C6 (DE2 board) is used. Hardware interfacing, Graphical User Interface (GUI) has been developed using MATLAB software; it's an original method for interfacing between ALTERA Field Programmable Gate Array (FPGA) and software in host PC. Input values are sent from MATLAB to ALTERA development board via serial port and the calculation data return back to MATLAB. The purpose of this technique is take advantages of the MATLAB in analysis and plot the result.

## ABSTRAK

Penukaran Pantas Fourier merupakan suatu algoritma yang mustahak dalam kebanyakan aplikasi pemprosesan isyarat digital dan hanya dianggap sebagai suatu kos pengiraan yang tinggi bila ia direka bentuk dalam sesuatu “hardware”. Tesis ini mencadangkan suatu corak dan implementasi algoritma Fast Fourier Transform dalam system yang terikat dan diaplikasikan di dalam prosessor Nios II dan dintegrasikan dengan arahan khas titik terapung Nios II. Corak tersebut adalah berasakan Decimation-In-Time dan Decimation-In-Frequency radix-2 untuk mendapatkan hasil yang lebih bermutu dan cepat. Dalam implementasi “hardware”, ALTERA CYCLONE II EP2C35F672C6 (DE2 board) digunakan. “Hardware interfacing “,Antaramuka Grafik Pengguna telah dikembangkan dengan menggunakan “software” MATLAB; ia adalah kaedah tulen untuk mewujudkan sesuatu ruang hubung kait antara ALTERA Field Programmable Gate Array (FPGA) dan “ hos software” dalam PC. Nilai input dihantar dari MATLAB ke ALTERA development board melalui port serial dan data pengiraan pula dihantar balik ke MATLAB. Tujuan teknik ini digunakan adalah untuk meggunakan faedah MATLAB dalam analisis dan untuk mengeplot hasil / keputusan yang diperoleh.

## TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	x
	LIST OF FIGURES	xi
	LIST OF APPENDIX	xiv
 1	 INTRODUCTION	 1
	1.1 Motivation	1
	1.2 Problem Statement	2
	1.3 Project Objectives	3
	1.4 Scope of Work	4
	1.5 Project Contribution	4
	1.6 Thesis Organization	5

<b>2</b>	<b>FAST FOURIER TRANSFORM</b>	<b>6</b>
2.1	Introduction	6
2.2	FFT Algorithms	7
2.2.1	Radix-2 FFT Algorithms	8
2.2.1.1	Decimation-In-Time FFT	9
2.2.1.2	Decimation-In-Frequency FFT	15
2.3	Algorithms Implementation	17
<b>3</b>	<b>EMBEDDED SYSTEM DESIGN</b>	<b>18</b>
3.1	Project Procedure	18
3.2	System Architecture	20
3.3	Features Embedded Systems	21
3.3.1	History and Future of Embedded System	23
3.3.2	Real Time System	24
3.4	Embedded Software of FFT Algorithm	24
3.4.1	The <i>Complex</i> Class	25
3.4.2	The Main Function	27
3.4.2.1	The System Inputs	28
3.4.2.2	The Earlier Stages	29
3.4.2.3	The Final Stage	32
3.5	Nios II based System on Chip Development Platform	33
3.5.1	Nios II Custom Instruction	34
3.5.2	Nios II Floating Point Custom Instruction	35
3.6	Application Software	36
3.7	ALTERA DE2 Development Kit	37



<b>4</b>	<b>MATLAB GRAPHICAL USER INTERFACE</b>	<b>40</b>
4.1	Introduction	40
4.2	Communication Interface	41
4.3	Serial Port Overview	42
4.3.1	Serial Communication	43
4.3.2	The Serial Port Interface Standard	43
4.3.3	Connecting Two Devices with a Serial Cable	44
4.4	MATLAB Software	45
4.5	Integration MATLAB with DE2 Board	45
<b>5</b>	<b>RESULTS AND PERFORMANCE EVALUATION</b>	<b>48</b>
5.1	Introduction	48
5.2	System Results	49
5.3	Performance Evaluation	53
5.4	Spectral Analysis	55
<b>6</b>	<b>CONCLUSION</b>	<b>57</b>
6.1	Concluding Remarks	57
6.2	Recommendation for Future Work	58
6.2.1	Higher N-Point FFT Computation	58
6.2.2	The Algorithm Architecture In The Decimation-In-Frequency	59
6.2.3	High Radix Used	61
6.2.4	Use of the System in Other Application	62
	<b>REFERENCES</b>	<b>63</b>
	Appendix A - C	66-81

**LIST OF TABLES**

<b>TABLE NO.</b>	<b>TITLE</b>	<b>PAGE</b>
3.1	Main design steps in the project	19
3.2	Math library floating-point usage	36
5.1	Comparison between the systems that includes floating point custom instruction and the system not including floating point custom instruction for several function	55

## LISTS OF FIGURES

<b>FIGURE NO.</b>	<b>TITLE</b>	<b>PAGE</b>
2.1	Radix-2 for an N point FFT.	8
2.2	First step in the decimation-in-time algorithm.	10
2.3	Five stages in the computation of an $n = 32$ -point DFT.	12
2.4	Thirty two-point decimation-in-time FFT algorithm.	13
2.5	Basic butterfly computation in the decimation-in-time FFT algorithm.	13
2.6	Shuffling of the data and bit reversal.	14
2.7	Thirty two-point decimation-in-frequency FFT algorithm	16
3.1	Project workflow	19
3.2	System architecture of the design	20
3.3	A Generic embedded system	22
3.4	Nios II processor system	34
3.5	Custom instruction logic connects to the Nios II ALU	35
3.6	ALTERA DE2 board	38
3.7	Block diagram of the DE2 board.	39
4.1	Communication interface between FFT module and MATLAB software	40
4.2	A male DE-9 connector used for a serial port on a PC style computer.	42
4.3	Connecting two devices with a serial cable	43

4.4	Integration MATLAB with DE2 board	45
5.1	Ramp function	49
5.2	Output in MATLAB command window	50
5.3	The final output of ramp function	51
5.4	Step function	52
5.5	Final output of step function	52
5.6	Console view displaying Nios II hardware output using floating point custom instruction for step function	53
5.7	Console view displaying Nios II hardware output without floating point custom instruction for step function	54
5.8	Sinusoidal Signal	56
5.8	Result of Sinusoidal signal	56
6.1a)	FFT for ramp discrete time signal $N=32$	59
6.1b)	FFT for ramp discrete time signal $N=1024$	59
6.2a)	Butterfly algorithms for DIF	59
6.2b)	Butterfly algorithms for DIT	60
6.3	Thirty two-point Decimation-In-Frequency FFT algorithms	60
6.4	Basic butterfly computations in a radix-4 FFT algorithm	61
6.5	Radix-4 for a 16 point FFT	61
B.1	CPU window	69
B.2	JTAG UART window	70
B.3	Timer window	71
B.4	The system components	72
B.5	Floating point custom instruction location in Nios II embedded processor	72
B.6	Floating point hardware	73
B.7	Complete configuration of the floating point custom instruction	73

B.8	The entire components system in Quartus II	75
B.9	Interface Protocols	76
B.10	System library properties	77
B.11	Run the setting	78
B.12	Complete configuration of the serial connection	79

**LIST OF APPENDIX**

<b>APPENDIX</b>	<b>TITLE</b>	<b>PAGE</b>
A	FFT code in C++	66
B	Building and configuration of the embedded system into Nios II embedded processor	69
C	MATLAB code for connection with DE2 board	80

## **CHAPTER 1**

### **INTRODUCTION**

This thesis proposes a design of Fast Fourier Transform and applies it into Nios II Embedded Processor. This chapter covers the motivation, problem statement, project objectives, scope of work, project contributions and finally thesis organization.

#### **1.1 Motivation**

The Fast Fourier transform is a critical tool in digital signal processing where its value in analyzing the spectral content of signals has found application in a wide variety of applications. The most prevalent of these applications is being in the field of communications where the ever increasing demand on signal processing capabilities have given rise to the importance of the Fourier transform to the field. However, the Fourier transform is a part of many systems in a wide variety of industrial and research fields. Its uses range from signal processing for the analysis of physical phenomena to analysis of data in mathematical and financial systems.

The majority of systems requiring Fourier transforms are real time systems which necessitate high speed processing of data. Given the complexity in performing The Discrete Fourier, the implementation of high speed Fast Fourier transform has required the use of dedicated hardware processors. The majority of high performance Fourier transforms has required the use of full custom integrated circuits and has typically been in the form of an application, specifically integrated circuit. Although much work has been put into raising performance while reducing hardware requirements, and also cost, the cost of full custom hardware still limits the availability of Fourier transform hardware to low volume production.

Nevertheless the development of programmable logic hardware has produced devices that are increasingly capable of handling large scale hardware. High density field programmable gate arrays (FPGA) that are already available in the market can boast upwards of 180,000 logic elements, nine megabits of memory, and on board processors.

The use of FPGA in implementing hardware eliminates the need for the long and costly process of creating a full custom integrated circuit and the time and cost of testing and verification. Saving cost in designing, testing, and time from design to a functional device.

These features of the FPGA make it especially attractive for the purpose of creating embedded processors for research and development purposes.

However the design of any of embedded processors must consider two important factors efficiency and flexibility for reaching an ideal design.

## **1.2 Problem Statement**

Efficiency and flexibility are two of the most important driving factors in embedded system design. Efficient implementations are required to meet the tight cost, timing, and power constraints present in embedded systems. Flexibility, albeit



tough to quantify, is equally important; it allows system designs to be easily modified or enhanced in response to bugs, evolution of standards, market shifts, or user requirements, during the design cycle and even after production.

Various implementation alternatives for a given function, ranging from custom-designed hardware to software running on embedded processors, provide a system designer with differing degrees of efficiency and flexibility. Unfortunately, it is often the case that these are conflicting design goals. While efficiency is obtained through custom hardwired implementations, flexibility is best provided through programmable implementations.

Hardware/software partitioning separating a system's functionality into embedded software (running on programmable processors) and custom hardware (implemented as coprocessors or peripheral units) is one approach to achieve a good balance between flexibility and efficiency.

### **1.3 Project Objectives**

The aims of this project are as follow:

1. Design and implementation of Fast Fourier Transform (FFT) algorithm into embedded system by:
  - a) Utilizing Nios II embedded processor.
  - b) Integrating it with Nios II Floating Point Custom Instruction.
2. Developing MATLAB user interface to verify the proposed FFT system.

## **1.4 Scope of Work**

Taking into account the resources and time available, this project is narrowed down to the following scope of work.

1. This project only considers 32 point FFT floating point. The Decimation-In-Time (DIT) algorithm is chosen.
2. The algorithm is implemented in C++ language.
3. Floating Point Custom Instruction is targeted for Nios II platform and implemented in ALTERA Cyclone II DE2 board.
4. MATLAB Graphical User Interface (GUI) has been used for the purpose of interfacing with FPGA hardware to provide inputs and display outputs.
5. Serial port (RS232) is used for transmitting and receiving data between FPGA board and MATLAB.
6. This Embedded system is applied in Spectral Analysis as an application.

## **1.5 Project Contributions**

The most important contributions of this project are:

1. Integration framework of MATLAB and ALTERA development kit platform.
2. Utilizing Nios II Floating Point Custom Instruction in the design to increase performance and accelerate speed.
3. Created a simple protocol that is used for interaction with and communication between hardware and software via computer serial port.

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