UNIVERSITI PUTRA MALAYSIA

DESIGN OF RADIX-4 SINGLE PATH DELAY FAST FOURIER TRANSFORM PROCESSOR WITH GENETIC ALGORITHMS OPTIMIZATION

PANG JIA HONG

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By

PANG JIA HONG

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirement for the Degree of Master Science

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This work is dedicated to my dearest family for their extraordinary love and endless care. Thank you

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the Degree of Master Science

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Chairman: **Nasri b. Sulaiman, PhD**

Faculty: **Engineering**

This research work involves the implementation of Single Objective Genetic Algorithm (SOGA) and Multi-objectives Genetic Algorithm (MOGA) in a 16-point Radix-4 Single Path Delay Feedback (R4SDF) pipelined Fast Fourier Transform (FFT) processor. The FFT processor is a critical block widely used in digital processing, which is considered as a very power consuming block in a device as many data are inputted for the FFT computation. Nowadays, the portability of the electronic devices which uses FFT processor requires being smaller size and low power consumption. One of the methods is to reduce the word length of FFT during its usage. However, the reduction of word length of FFT processor will degrade its Signal to Noise Ratio (SNR) value.

The SNR value represents the accuracy of the FFT processor. The larger the word length of the FFT processor, the higher the SNR value, leading to higher Switching Activity (SA), thus increases the power consumption of the FFT processor. In this research, the Genetic Algorithms (GA) is used to optimize the word length of FFT coefficients to maintain the SNR value and reduce the SA at the same time. The

genetic algorithms is proven to be a very effective method in optimization by using the way imitating natural process of living beings such as crossover, mutation and selection. The Multi Objective Genetic Algorithms (MOGA) is capable of optimizing the problem which has more than one criterion and both criterions must be treated simultaneously.

In this work, the GA optimization is implemented in the twiddle factor of FFT processor. The output solutions performance of the GA optimized FFT is compared to the non-GA solutions. The target of the optimization is to reduce the FFT word length and at the same time the solutions must fulfil the requirement of SNR higher than 63 dB and SA lower the conventional FFT which is 192 times. The results show that, the SOGA capable to optimize the FFT SNR without considering the word length. The MOGA can successfully optimize the performance of FFT by maintaining the SNR and reducing the word length to 13 bits. Two MOGA methods are used; they are Weighted Sum approach and Non-dominated Sorting Approach. The Weighted Sum approach is more suitable to be implemented in the optimization as it is simpler compared to Non-dominated Sorting Approach.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

REKABENTUK PEMPROSES SUAP BALIK LENGAH LALUAN TUNGGAL RADIX-4 PENJELMAAN FOURIER CEPAT DENGAN OPTIMISASI ALGORITMA GENETIK

Oleh

PANG JIA HONG

Ogos 2011

Pengerusi: **Nasri b. Sulaiman, PhD**

Fakulti: **Kejuruteraan**

Kajian ini merangkumi implementasi Multi-Objektif Algoritma Genetik (MOGA) pada 16 titik R4SDF (*Radix-4 Single Path Delay Feedback*) pemproses FFT (*Fast Fourier Transform*). Pemproses FFT merupakan stuktur penting yang banyak digunakan dalam telekomunikasi. Ia merupakan struktur yang banyak memerlukan kuasa disebabkan banyak data dimasukkan untuk proses pengiraan FFT. Kini, kebanyakan alat elektronik yang menggunakan pemproses FFT memerlukan saiz kecil dan hayat masa penggunaan yang lebih panjang. Salah satu cara untuk mengurangkan penggunaan kuasa FFT ialah mengurangkan panjang kata factor pekali FFT dalam rekabentuknya. Namun, pegurangan panjang kata akan mengurangkan prestasi SNR (Signal to Noise Ratio) FFT.

Tahap SNR mewakili ketepatan pemproses FFT. Panjang kata yang lebih panjang dalam rekabentuk pemproses FFT akan memberi ketepatan yang lebih tinggi, namun ia akan meningkatkan aktiviti pensuisan lalu mengakibatkan penggunaan kuasa berlebihan. Dalam kajian ini, MOGA digunakan untuk mengoptimumkan panjang kata pekali pemproses FFT supaya ia dapat mengekalkan tahap SNR yang sama

tinggi dan kegiatan switching aktiviti (SA) yang lebih rendah. Algoritma Genetik dibuktikan efektif dalam proses optimisasi dengan meniru process cara hidup semulajadi benda hidup seperti penyeberangan, mutasi dan seleksi. MOGA merupakan algoritma yang mampu mengoptimakan lebih daripada satu masalah objektif dalam satu masa.

Dalam kajian ini, optimisasi GA dijalankan dalam factor pekali FFT. Prestasi FFT dengan optimisasi GA dibandingkan dengan FFT bukan optimisasi GA. Target optimisasi ialah mencari penyelesaian yang memenuhi tahap SNR minima 63 dB dan SA kurang daripada 192 kali berbanding dengan FFT konvensional. Keputusan menunjukkan SOGA berupaya mencari penyelesaian yang mempunyai tahap SNR yang lebih tinggi tetapi SA diabaikan. Namun, MOGA dapat mengekalkan nilai SNR dan memberi SA yang lebih rendah hingga panjang kata 13 bits. Dua cara MOGA digunakan, iaitu Jumlah Pendekatan berwajaran (*Weighted Sum approach*) dan Non-dominasi (*Non-dominated Sorting Approach*). Cara Jumlah Pendekatan berwajaran lebih sesuai digunakan dalam optimisasi ini kerana ia lebih senang diimplementasi berbanding dengan Non-dominasi (*Non-dominated Sorting Approach*).

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I certify that a Thesis Examination Committee has met on 22 August 2011 to conduct the final examination of Pang Jia Hong on his thesis entitled "Design of Reconfigurable Fast Fourier Transform Processor Using Genetic Algorithms" in accordance with the Universities and University College Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The committee recommends that the student be awarded the Master of Science.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master Science. The members of Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or other institutions.

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PANG JIA HONG

Date: 22 August 2011

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