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Combinational Circuit Design Using Genetic Algorithms

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Abstract - In the paper an evolutionary techniques especially genetic algorithm is used to design and optimization of combinational digital circuits based on gate count is present. Combinational circuit with truth table chosen from literature is designed using proposed method. Obtained result is better optimization than human design method.

Keywords: *evolutionary techniques, genetic algorithm, combinational digital circuit, optimization.*

I. INTRODUCTION

Now-a-days enormous growth of smart electronics devices result digital circuit design becomes larger and larger. So it leads increase in cost and size. Combinational digital circuit design methods can be categorized into two optimization criteria, one is based on the gate count and another one is based on the transistor count. In both cases minimization leads to the decrease of physical implementation costs of a given circuit and also the power requirement of the circuit. The desired logic function has to be realized in FPGA circuit, the minimization of gate count and transistor count is especially recommended to miniaturization of circuits. In both criteria expanse of chip and production cost will be cheap.

Design methods of combinational digital circuits with traditional method became more complex when number of inputs in the desired circuits is becomes more than five. The proposed method uses Evolutionary technique to resolves complexity of inputs in circuits. The process of evolutionary circuit design is different from traditional design process; evolutionary circuit design is not based on designer knowledge and experience, but on the evolution process.

In The proposed algorithm, first the group of circuits (population) is initialized through pseudo random process. Then Genetic Algorithm is used to determine the fitness of each circuit (chromosome) [1].Fitness represent maximum matching of obtained solutions with excepted solutions. The Reproduction operator which looks for desirable fitness in the solution, then it updates the fitness function of all chromosomes, such that the search is encouraged to cut down undesirable circuits. The fitness is map to gene in a chromosome which is more susceptible to change during crossover and mutation. Single site crossover was implemented for creating new child. The fitness function is determined to each chromosome in every generation until optimal solution for circuit is obtained. By implementing the proposed method have obtained better solution for combinational circuit

synthesis. Results obtained using the proposed method is compared with the result obtained by human designed method.

II. OVERVIEW OF GENETIC ALGORITHMS

Genetic Algorithms are a class of techniques that are used to solve extremely complex search and optimization problems which are difficult to handle using analytic or simple enumerative methods. Along with a fewer similar approaches (such as Evolution Strategies, Evolutionary Programming) Genetic algorithms (GAs) are classified as a part of Evolutionary computation. Genetic algorithms are search algorithms based on the mechanics of natural selection and natural genetics [5].

A. Need for Ga

The most important goal of optimization is convergence. The conventional view of optimization is, man's longing for perfection finds expression in the theory of optimization. It studies how to describe and attain what is best, once one knows how to measure and alter what is good or bad. Optimization theory encompasses the quantitative study of optima and methods for finding them. Thus optimization seeks to improve performance toward some optimal point or points. To achieve the optimal solution some new optimization techniques are required. Practically, all optimization problems work in a similar manner, adapting simple Genetics to algorithmic solutions.

B. Genetic Representation

Each gene corresponds to a particular characteristic. Each of these characteristics should be independent to avoid interaction between the genes. Ideally there should be no correlation between gene values. Genes: Codes the character of an individual. Chromosome: Set of all genes of a specific species.

C. Fitness Function

The next operation is to associate to each chromosome a value corresponding to its fitness. The fitness function should not only indicate chromosome is how good, but also found to how close it is to the optimal one. However the Genetic Algorithm will concentrate on feasible or nearly feasible solutions.

D. Population

The first population should have a gene pool as large as possible so, it able to explore the whole search space. The initial population is generated randomly. The larger the population, the easier it is to explore the search space.

E. Reproduction

Reproduction is a process in which individual strings are copied according to their objective fitness function values. Objective function is important think in reproduction. Many selection operators are also used.

F. **Crossover**

Crossover is taken after reproduction. First good pair of individuals is selected from population. Then crossover site is selected according the string length. Inputs are given to child chromosomes then find fitness and repeat other procedure until optimum solution find.

III. PROPOSED SYSTEM USING GA

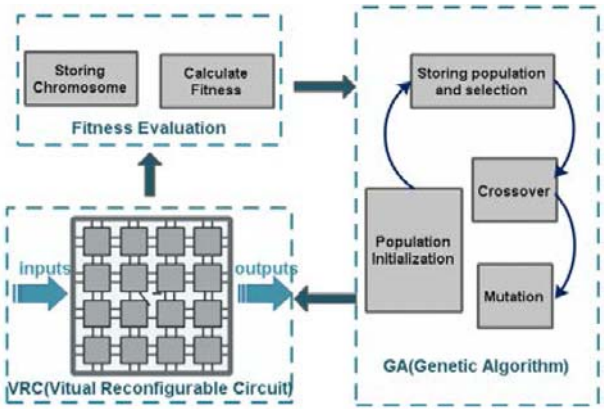
Genetic algorithm is used to Design and optimizations of combinational digital circuits based on minimum number of gates were the main goal of these algorithms. Here GA(genetic algorithm) taking large number of circuits initially by random and design optimal solution for our expected output thru search space and solution may not find in lifetime by using reproduction, fitness, crossover, mutation so, we can design optimal circuit than existing method.

A.CIRCUIT SYNTHESIS USING GA

Combinational circuit design methods that can be completely implement using genetic algorithm. For faster evolution in evolutionary circuit design, a subpopulation based multiobjective evolutionary algorithm is used. It shows MOEA is most proficient in the feature of speeding up the convergence of evolution [1-3].

Evolvable hardware approach is a lately urbanized technique to synthesize electronic circuits using Evolutionary Algorithms. Typically programmable logic devices are used for EHW. Its inner architecture can be tainted and optimized imminent of evolutionary algorithm. EA searches enormous number of candidate solutions (individuals) to attain final goal that satisfy the intended criterion. Multi objective is more natural and which can move toward to more real circumstances. Multi-VRC adopt MOEA concept. The goal of this scheme is to evolve a combinational circuit by employ the sub-population based MOEA modules.

B. Block Diagram



C. Reconfigurable Unit

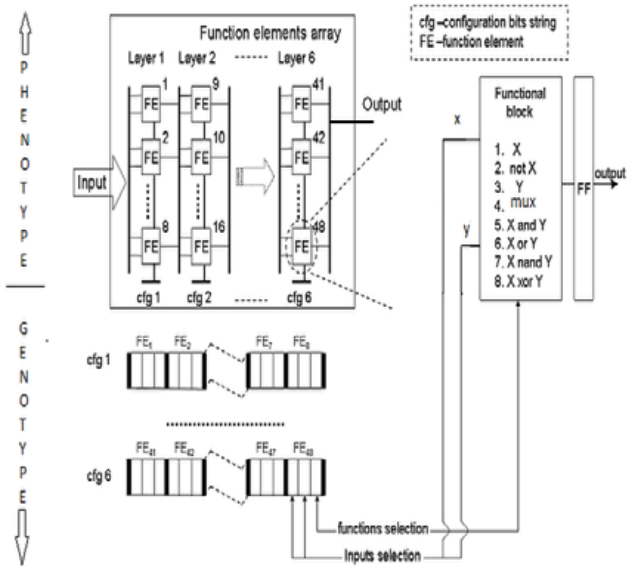


Figure 1: Reconfigurable Unit

The RC unit is a most important unit in evolvable hardware system. According to GA, the system phenotype is obtainable as an 8×6 array of 2-inputs function elements (FE). The system genotype is a linear binary bits string that gives the connections and functions of the FEs array. The genotype and the mapping process of the genotype to phenotype are important. In our proposed project, the FEs array consists of 6 FE layers, and 8 uniforms FEs are placed in each layer. The input connections of each FE are selected by its selection function. Each Functional block has 7 functions for given input then any one of function output is selected according their functional selection.

Each FE is operational with a Flip-flop to support pipeline processing. A layer of FEs is measured as a single stage of the pipeline [4]. This means 8 FEs in the same layer are configured at the same time. Hence, each chromosome is divided into 6 configuration bit strings. For example elements in functional block is

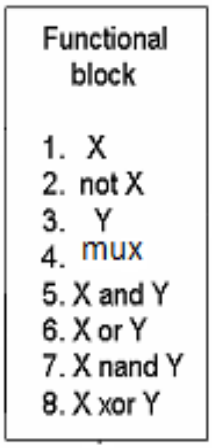


Figure 2: Functional Block

D. Evolutionary Algorithm Unit

In our project, evolution is based only on the crossover and selection operators; crossover is take place in simulation itself [5]. As the FEs array has to be configured layer by layer, the chromosome is separated into 6 individual configuration bit strings. Genotype-phenotype mapping done from first to last by RNG. Fitness value is finding for each chromosome and goes over until get optimal solution.

IV. RESULTS

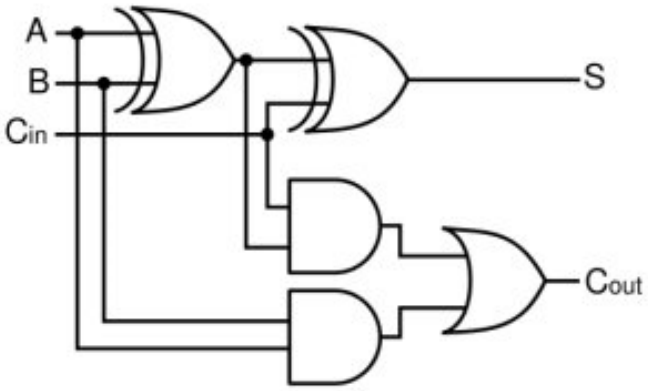
To analysis the performance of genetic algorithm for designing combinational circuits. Here full adder is used.

x	y	z	sum	carry
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	0	1	1

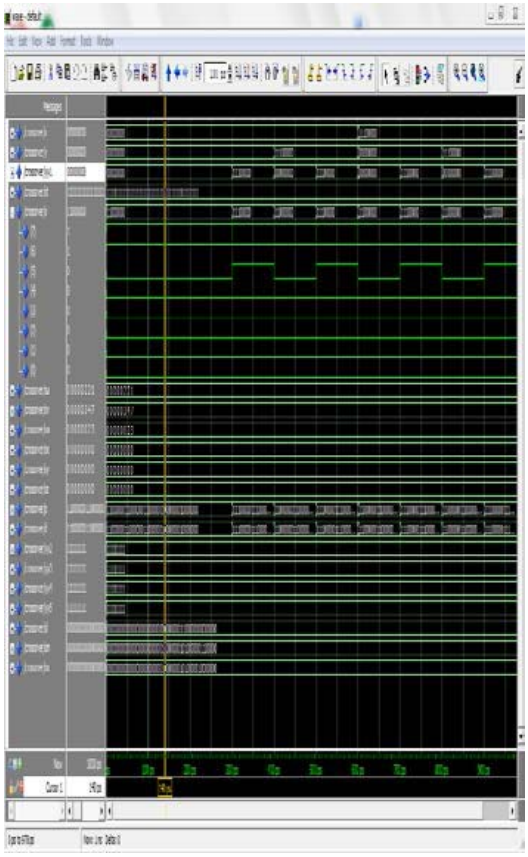
Truth Table of Half Adder

D.EVOLUTIONARY ALGORITHM UNIT

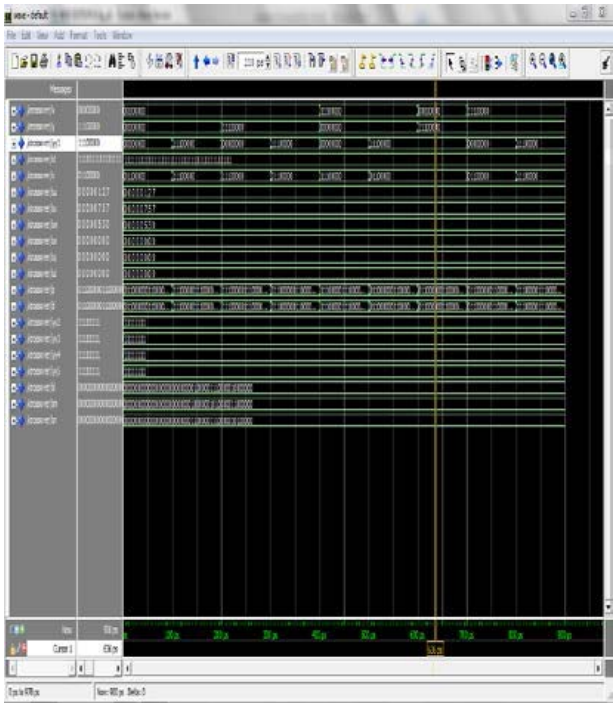
Full Adder Designed by Human Design



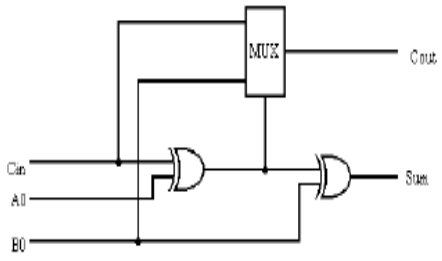
Carry Output of FA by Crossover



Sum Output of FA by Crossover



Full Adder Designed by GA



Comparison Between HD and GA

Design method	Number of gates
Human design	2 XOR,2 AND, OR gates required
Genetic algorithm	2 XOR, 1 MUX required

V. CONCULSION

The proposed system using genetic algorithm is to optimize the performance and area of given circuit. For Experimental result Full adder circuit is taken to demonstrate which provide evolution circuit with two XOR gate and one MUX have been presented. But in human design methods it take two XOR gate, two AND gate and one OR gate. For simple circuit itself number of gate gets reduced when inputs of circuit get increased. From this GA has better optimization. So proposed method minimize number of gate count and cost. This approach is flexible for designing combinational circuits.

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