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FPGA IMPLEMENTATION OF FOUR PHASE CODE DESIGN USING MODIFIED GENETIC ALGORITHM (MGA)

Kandarpa Srinivas, Bandi Sarada, Malijeddi Murali

Abstract— **The proposed architecture consists of an efficient VLSI hardware implementation of the Modified Genetic Algorithm for identifying the good pulse compression sequences based on Discrimination Factor. The main advantage of implementation using Hardware based Genetic Algorithm is its inherent speed over Software based methods. The speed advantage makes the hardware based Modified Genetic Algorithm (MGA) is a prime candidate for real time applications. This architecture provides the flexibility of generating Pulse compression sequences with variable frequencies. Radar signal processing applications require a set of sequences with individually peaky auto correlation and pair wise cross correlation. Obtaining such sequences is a combinatorial problem. If the auto correlation and cross correlation are taken in the aperiodic sense then there are hardly any theoretical aids available. Thus the problem of signal design referred to above are challenging problem for which many global optimization algorithms like genetic algorithm, simulated annealing, tunneling algorithm were reported in the literature. Higher performance systems using custom silicon cost too much for the typically small production volumes, and are not flexible enough for research applications. Field programmable gate arrays offer the performance of custom silicon while maintaining the economies and flexibility of the microprocessor based solutions. Recent FPGA devices possess the density and performance to realize Pulse compression sequences in a single FPGA. The Proposed VLSI architecture is implemented on the FPGA as it provides the flexibility of re-configurability and re-programmability. The Proposed architecture is a novel and efficient architecture as it generates the Pulse compression sequences at the clock rate of FPGA.**

Index Terms—**Discrimination Factor, FPGA, Modified Genetic Algorithm, Pulse Compression Sequences**

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I. INTRODUCTION TO SPREAD SPECTRUM

Early spark-gap wireless transmitters actually used spread spectrum, since their RF bandwidths were much wider than their information bandwidth. The first intentional use of spread spectrum was probably used by Armstrong in the late1920s or early 1930s with wide-band frequency modulation (FM). Global Positioning System (GPS) is now the world's single largest spread spectrum system. The term 'spread spectrum' describes a modulation technique that makes the sacrifice of bandwidth in order to gain signal-to-noise (S/N) performance. Because spread spectrum signals are noise-like, they are hard to detect. They are also hard to intercept or demodulate.

II. PULSE COMPRESSION

Pulse compression[2] techniques are usually applied in radar to increase the signal energy transmitted without sacrificing the range resolution. It allows radar to utilize a long pulse to achieve large radiated energy but simultaneously to obtain range resolution of short pulse. The increased detection capability of a long pulse radar system is achieved while retaining the range resolution capability of a narrow pulse system.

The concept of pulse compression is shown below figure where the short pulse, long pulse and compressed pulse waveforms are shown FIG 1

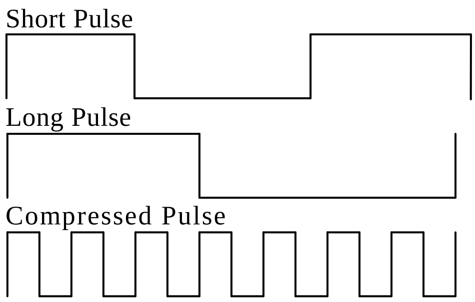

Fig1 : Pulse Wave Forms

Theoretically, in pulse compression, the code is modulated onto the pulsed waveform during transmission. At the receiver, the code is used to combine the signal to achieve a high range resolution.The pulse compression receiver compresses the long received signal of length T

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into a narrow signal of width l/B. It does this by delaying each sub-part of the input signal spectrum for different amounts so that each sub-part arrives at the output at the same instant. The pulse compression ratio is T/ (1/B) or B*T.

III. FUNCTIONALITY OF SYSTEM

This project consists of an efficient VLSI implementation of Modified Genetic Algorithm, for the identification of the good Pulse compression sequence based on Discrimination Factor. It is the main criteria for good Pulse compression sequence. The architecture has been authored in VHDL for four phase Pulse compression sequences and synthesis was done with Xilinx XST. Xilinx ISE Foundation 9.1i has been used for performing mapping, placing and routing. For Behavioral simulation and Place and route simulation Modelsim6.0 has been used. The Synthesis tool was configured to optimize for area and high effort considerations. The targeted device selected here is Spartan-3 xa3s5000fg900-5. The interest of the project work is an attempt to obtain a real time signal processing VLSI architecture for the identification of the four phase pulse compression sequences with good Discrimination for radar. Pulse compression sequences with low auto correlation functions with one main peak and very small side peaks are of interest in numerous practical applications in telecommunications, radar, and spread spectrum applications.

IV. PULSE COMPRESSION CODES AND ITS CHARACTERISTICS

A. *Binary codes*

Binary is a way of counting using two numbers. Binary codes are used to represent information in digital form. It can be represented by (1,-1) or (0,1) or (0,-1).

B. *Ternary Codes*

[9][6]Ternary Code is the code that can be used to represent information and data and uses 3 digits for representation. (i.e.,) this code consists of 1, 0, and -1.

C. *Four Phase codes*

Four phase code can also be applied to represent data. It uses four arguments to represent information. Four phase code uses the alphabet -1, 1, j, -j.

D. *Quinquenary codes*

Quinquenary code uses five arguments to represent information. Quinquenary code uses the alphabet -2, -1, +2, +1 and 0.

E. *Six Phase codes*

Six Phase code uses six arguments to represent information. Six Phase code uses the alphabet +1, -1, (0.5+j 0.866), (0.5-j 0.866), (-0.5+j 0.866) and (-0.5-j 0.866)

The criteria of goodness of pulse-compression sequences are evaluated by following methods.

E. *Merit Factor*

The Merit factor (F) of a sequence is defined as the ratio of the main lobe energy of the autocorrelation to the total energy in the side lobes. Merit factor is a measure of the quality of pulse compression.

Let S = [x0, x1, x2, x3 ……….xN-1] be a real sequence of length N.

Let
$$r(k) = \sum_{i=0}^{n-1-k} x_i x_{i+k}$$

Where k=0, 1, 2… (N-1) is its aperiodic autocorrelation. Now Merit Factor is written as

$$F = \frac{r^2(0)}{2\sum_{k \neq 1}^{N-1} r^2(k)}$$

The merit factor F must be as large as possible for good sequence. The merit factor is an indication of the quality of pulse compression and a higher merit factor is always desirable.

F. *Discrimination Factor*

The Discrimination factor is defined as the ratio of amplitude of main peak of the auto correlation to the absolute maximum amplitude in the side lobes.

$$D = \frac{r(0)}{Max_{k \neq 0} \, |r(k)|}$$

Discrimination Factor is used to measure weather a coded signal is Good or poor and also it measures how the main lobe signal is different form the peak side lobe level.

G. *Energy efficiency*

The energy efficiency is defined as the ratio of the actual energy in sequence to the energy if every element has the maximum amplitude in the sequence. Mathematically it is given as below,

$$E = \frac{\sum_{k=0}^{N-1} x^2(k)}{N}$$

For binary sequences the energy efficiency is unity. For ternary sequences it is merely proportional to the non zero elements in the sequence. of the For Four Phase sequences the Energy efficiency is better than ternary sequences.

H. Quality Factor

Quality factor is defined as the product of merit factor and energy efficiency.

Q=F x E.

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V. INTIAL DESIGN IMPLEMENTATION STEPS

A. Problem Formulation

Problem formulation is the selection of design variables, constraints, objective function(s), and models of the discipline/design.

B. Selection of design variables

Design variables can be continuous, discrete or Boolean. Design problems with continuous variables are normally solved more easily. Design variables are often bounded, that is, they have maximum and minimum values. Depending on the adopted method, these bounds can be treated as constraints or separately.

C. Selection of Constraints

A constraint is a condition that must be satisfied to render the design to be feasible. An example of a constraint in beam design is that the resistance offered by the beam at points of loading must be equal to or greater than the weight of structural member and the load supported. In addition to physical laws, constraints can reflect resource limitations, user requirements, or bounds on the validity of the analysis models. Constraints can be used explicitly by the solution algorithm or can be incorporated into the objective, by using Lagrange multipliers.

D. Objectives

An objective is a numerical value that is to be maximized or minimized. For example, a designer may wish to maximize profit or minimize weight. Many solution methods work only with single objectives. When using these methods, the designer normally weights the various objectives and sums them to form a single objective. Other methods allow multi-objective optimization such as the calculation of a Pareto front.

E. Models

The designer has to also choose models to relate the constraints and the objectives to the design variables. These models are dependent on the discipline involved. They may be empirical models, such as a regression analysis of aircraft prices, theoretical models, such as from computational fluid dynamics, or reduced-order models of either of these. In choosing the models the designer must trade-off fidelity with the time required for analysis.

VI. FINAL DESIGN IMPLEMENTATION STEPS AND REPRESENTATION IN STANDARD FORM

Once the design variables, constraints, objectives, and the relationships between them have been chosen, Maximization problems can be converted to minimization problems by multiplying the objective by -1. Constraints can be reversed in a similar manner. Equality constraints can be replaced by two inequality constraints as follows.

A. Problem Solution

The problem is normally solved choosing the appropriate techniques from those available in the field of optimization. These include gradient-based algorithms, population-based algorithms, or others. Very simple problems can sometimes be expressed linearly; in that case the techniques of linear programming are applicable.[3]

1. **GRADIENT-BASED METHODS**
   - A. Newton's Method
   - B. Steepest Descent
   - C. Conjugate Gradient
   - D. Sequential Quadratic Programming

2. **POPULATION-BASED METHODS**
   - A. Genetic Algorithms
   - B. Particle Swarm Optimization

3. **OTHER METHODS**
   - A. Random Search
   - B. Grid Search
   - C. Simulated Annealing

B. Steps for the general procedure used to formulate and solve optimization problems.

1) Analyze the process itself to identify the process variables and specific characteristics of interest, i.e., make a list of all the variables.

2) Determine the criterion for optimization and specify the objective function in terms of the above variables together with coefficients.

3) Develop via mathematical expressions a valid process model that relates the input-output variables of the process and associated coefficients. Include both equality and inequality constraints. Use well known physical principles such as mass balances, energy balance, empirical relations, implicit concepts and external restrictions. Identify the independent and dependent variables to get the number of degrees of freedom.

4) If the problem formulation is too large in scope: break it up into manageable parts, or simplify the objective function and the model.

5) Apply a suitable optimization technique for mathematical statement of the problem.

6) Examine the sensitivity of the result, to changes in the values of the parameters in the problem and the assumptions.

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C. *Classical Optimization Techniques*

The classical optimization techniques are useful in finding the optimum solution or unconstrained maxima or minima of continuous and differentiable functions. These are analytical methods and make use of differential calculus in locating the optimum solution. The classical methods have limited scope in practical applications as some of them involve objective functions which are not continuous and/or differentiable. These methods lead to a set of nonlinear simultaneous equations that may be difficult to solve.

D. *Advanced Optimization Techniques*[5]

A. Genetic algorithm
B. Taboo search Algorithm
C. Simulated Annealing Algorithm
D. Hamming Scan Algorithm

VII. GENETIC ALGORITHM

[8]A genetic algorithm (GA) is a search technique used in computer science to find approximate solutions to optimization and search problems. Specifically it falls into the category of local search techniques and is therefore generally an incomplete search. Genetic algorithms are a particular class of evolutionary algorithms that use techniques inspired by evolutionary biology such as inheritance, mutation, selection, and crossover (also called recombination).

A. *Evolutionary Algorithms for Optimization and Search*

Most real world optimization problems involve complexities like discrete, continuous or mixed variables, multiple conflicting objectives, non-linearity, discontinuity and non-convex region. The search space (design space) may be so large that global optimum cannot be found in a reasonable time. The existing linear or nonlinear methods may not be efficient or computationally inexpensive for solving such problems. Various stochastic search methods like simulated annealing, evolutionary algorithms (EA) or hill climbing can be used in such situations. EAs have the advantage of being applicable to any combination of complexities (multi-objective, non-linearity etc) and also can be combined with any existing local search or other methods. Various techniques which make use of EA approach are Genetic Algorithms (GA), evolutionary programming, evolution strategy, learning classifier system etc. All these EA techniques operate mainly on a population search basis. In this project Genetic Algorithms, the most popular used EA technique, is explained as in below figure 2.

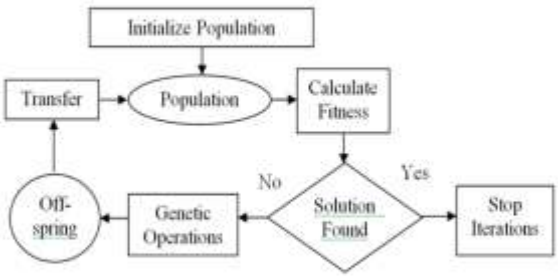

Fig 2 : A flowchart indicating the steps of a simple genetic algorithm

B. *The pseudo code for above simple EA is given below*

i = 0

Initialize population P0

Evaluate initial population

while (! termination condition)

{

i = i+1

Perform competitive selection

Create population Pi from Pi-1 by recombination and mutation

Evaluate population Pi }

The termination condition may be a desired fitness function, maximum number of generations etc. After fitness function evaluation, individuals are distinguished based on their quality. According to Darwin's evolution theory the best ones should survive and create new offspring for the next generation. There are many methods to select the best chromosomes, for example roulette wheel selection, Boltzman selection, tournament selection, rank selection, steady state selection and others. Two of these are briefly described, namely, roulette wheel selection and rank selection:

Roulette wheel is a very common selection method. Each individual is assigned a slice of a circular “Roulette wheel” and the size of slice is proportional to the individual’s fitness. The wheel is spun N times, where N is the number of individuals in the population. On each spin, the individual under the wheel’s marker is selected to be in the pool of parents for the next generation. Roulette wheel selection is easy to model and has been used in most studies, but problems will arise when there are big differences between the fitness values. For example, if the best chromosome fitness is 90% of the sum of all fitness, the other

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chromosomes will have very few chances to be selected. Parents are selected according to their fitness i.e., each individual is selected with a probability proportional to its fitness value. In other words, depending on the percentage contribution to the total population fitness, string is selected for mating to form the next generation. This way, weak solutions are eliminated and strong solutions survive to form the next generation.

Rank Selection The individuals in the population are ranked according to fitness first, and then every chromosome receives fitness value determined by this ranking. The expected value of each individual depends on its rank rather than on its absolute fitness. Its purpose is to prevent too-quick convergence.

Random Selection A selection operator randomly selects a chromosome from the population.

B. Genetic Operators

1. Crossover

Crossover is a genetic operator used to vary the programming of a chromosome or chromosomes from one generation to the next. Crossover module is used to perform the crossover operation on the 2 winner individuals. During crossover two parent strings from the mating pool combine to create two new child solution strings.

This happens as follows:

1) Randomly select two parent strings from mating pool.
2) Randomly select a crossover point in the solution string. This is the point between any two positions in the solution string.
3) Swap the ends of two parent strings, from the crossover point to end of the string to create two new child strings.

The process is illustrated below.

Parent strings	child strings
XXXX |XX	XXXXOO
OOOO |OO	OOOOXX

Crossover point ↑

Here X and O represent values in the solution strings. There are numerous variations in the basic crossover operator, for example randomly choosing two crossover points and swapping the string contents between those two crossover points. Of course it is possible that crossover may result in infeasible children, as for example:

We might see crossover such as

CDA|B ⟶ CDAC
BAD|C BADB

In this case both children are infeasible because they both contain repeated point. The best way to handle the infeasible child strings is to use a different variant of crossover that does not allow infeasible children to be created at all.

2. Mutation

Mutation occurs when a chromosome is changed in such a way as to alter the genetic message carried by that chromosome. It is used to randomly alter the values of some of the positions in some of the strings based on a parameter that determines the level of the mutation. In our example, the second position in the string [1 -1 j -j] might be chosen for mutation and randomly switched from a value of -1 to j. This is an improvement: [1 -1 j –j] has fitness of 6.0 while this has a fitness of 11. Of course it is just as possible that mutation could worsen the fitness function or even generate an infeasible solution. The motivation behind the mutation is to sample the solution space widely. So where crossover tries to concentrate the solutions that we already have into better solutions, mutation works instead to sample the solution space and to broaden the search. Mutation is a vital part of the solution process, and the mutation rate can have a big impact on the quality of the final solution. It is even possible (though vastly more inefficient) to solve the problems using only the mutation operator.

VIII. TABOO SEARCH ALGORITHM

In most cases of practical interest, global optimization is very difficult. This is because of the omnipresence of local minima, which tends to increase exponentially with size of the problem. The principal requirement before any global optimization method is that it must be able to avoid entrapment in local and continue the search to give a near optimal solution whatever the initial conditions are. The concept of the taboo search is based on a stochastic global optimization method originally developed by Glover for very large combinational optimization tasks. The concepts of “move” and “neighbourhood” are common to most heuristic and algorithmic procedures. In taboo search, a move is a transition from one trial solution to another. The move value is the difference of trial solutions. The move improves only if the move value is negative. In order to avoid a blind search, taboo search uses a prescribed problem specific set of contents, known as “taboo conditions” which must be satisfied for the move to be considered admissible. Otherwise, the move is taboo. A move remains taboo only during the “taboo period” a certain specified number of iterations. The “aspiration conditions” is defined to enable certain “interesting” moves. If this is satisfied, a taboo move becomes admissible. The

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taboo condition and the aspiration condition together are a heuristic device, a kind of learning procedure that benefits from information acquired during previous iterations. Thus taboo search performs an intelligent search of the solution space. From among the admissible moves at each iterative step, taboo search accepts the move with the lowest move values. This move might not lead to better solutions, but enables the algorithm to continue the search without becoming confounded by the absence of improving moves and to "climb out" of local minima.

IX. SIMULATED ANNEALING ALGORITHM (SAA)

[10][7][4]The name and inspiration come from annealing process in metallurgy, a technique involving heating and controlled cooling of a material to increase the size of its crystals and reduce their defects. The heat causes the atoms to become unstuck from their initial positions (a local minimum of the internal energy) and wander randomly through states of higher energy; the slow cooling gives them more chances of finding configurations with lower internal energy than the initial one. Simulated Annealing (statistical cooling) performs a computation that is analogous to a physical process. In the process a material is first heated up to a temperature that allows all its molecules to move freely around and is then cooled down slowly. The freedom of movement for the molecules decreases gradually until all the molecules take a fixed position. At the end of the process, the total energy is minimal provided that the cooling is very slow. The energy corresponds to the cost function. The movement of molecules corresponds to a sequence of moves in the set of feasible solutions. The temperature corresponds to a control parameter T. In the simulated annealing method, each point of the search space is compared to a state of some physical system, and the function to be minimized is interpreted as the internal energy of the system in that state. Therefore the goal is to bring the system, from an arbitrary initial state, to a state with the minimum possible energy.

X. HAMMING SCAN ALGORITHM

The Hamming scan algorithm is a traditional greedy optimization algorithm, which searches in the neighborhood of the point in all directions to reduce the cost function and has fast convergence rate. The basic difference between Genetic algorithm and Hamming scan algorithm is that Genetic algorithm uses random but possibly multiple mutations. This algorithm mutates elements of sequence one by one. The mutation is a term metaphorically used for a change in an element in the sequence. For example, consider a four-phase sequence [1 -1 j j] whose fitness is evaluated. The value 1 is replaced with –j and fitness is evaluated, if the fitness value has improvement over the original sequence the change is accepted otherwise the original sequence is retained. The same procedure is performed for all the elements of sequence. This process is recursively applied until no changes are required. A single mutation in a sequence results in a hamming distance of one from the original sequence. The Hamming scan algorithm mutates all the elements in the sequence one by one and looks at all the first order hamming neighbors of the given sequence. Thus hamming scan performs recursively local search among all the hamming-1 neighbors of the sequence and selects the one whose objective function value is minimum. The search time required for Hamming scan algorithm increases very fast with the length of sequence as the algorithm performs recursive search among the Hamming neighbors of the element in the sequence. Thus, Hamming scan also becomes unaffordable at larger lengths. The Hamming scan is expedited and hence made applicable at larger lengths.

XI. MODIFIED GENETIC ALGORITHM (MGA)

Modified Genetic Algorithm is proposed as a statistical technique for obtaining approximate solutions to combinatorial optimization problems. The proposed algorithm is a combination of Genetic algorithm (GA) and Hamming scan algorithm. MGA combines the good methodologies of two algorithms like global minimum converging property of GA algorithm and fast convergence rate of Hamming scan algorithm. The demerit of Hamming scan algorithm is that it gets stuck in the local minimum point because it has no way to distinguish between local minimum point and a global minimum point. Hence it is sub-optimal. The drawback in genetic algorithm is that it has a slow convergence rate because even though it may get closer to the global minimum point, it may skip it because of the methodology it employs. The MGA overcomes these drawbacks. Genetic algorithm (GA) is a class of search algorithm that have been used in many optimization problems. GA have an analogy with biological evolution. This evolution leads to efficient exchange of information between all models encountered, and allows the algorithm to rapidly assimilate and exploit the information gained to find better data fitting models. GA inherently superior to random search techniques and can also perform better than iterative matrix inversion which requires a good starting models The important ingredient of the Genetic approach is that large and complex models are represented by binary strings. These bit strings can be manipulated to produce more successful information by two main GA operations Crossover and Mutation

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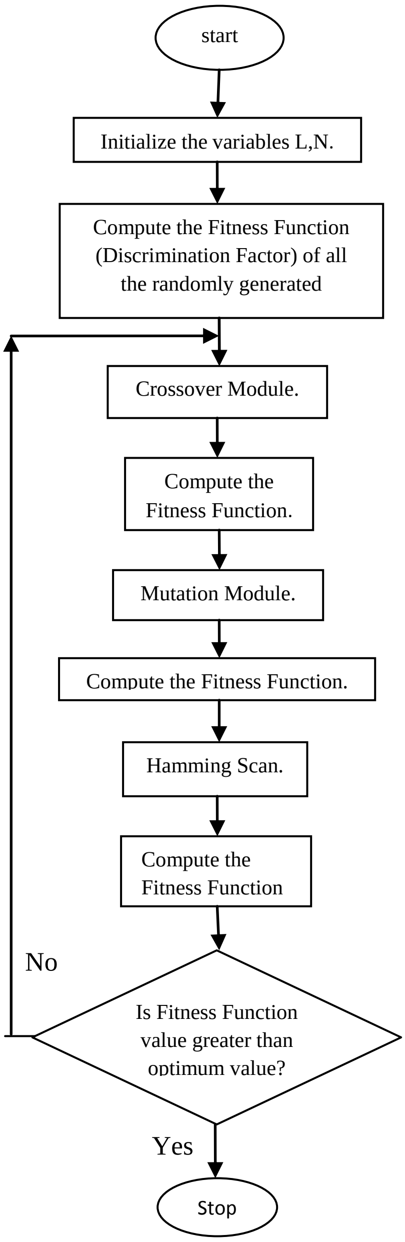


Fig 3 : MGA Flow Chart

The three main steps involved in GA are

1First the initial sequence is generated.

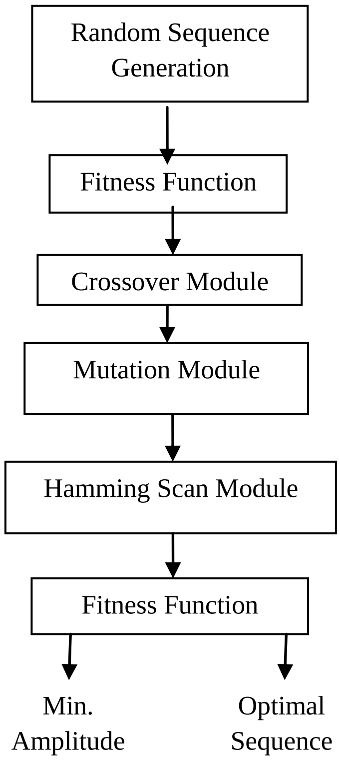
2The evaluation values of the fitness function for the current sequence is calculated.

3. The termination criteria is checked. The whole GA procedure stops if the termination criteria is reached otherwise selection ,crossover , mutation and Hamming scan operations are performed.

XII. FOUR PHASE CODE DESIGN USING MODIFIED GENETIC ALGORITHM

Since Discrimination Factor is the main criterion for good pulse compression sequences, therefore the Four Phase sequence having minimum side lobe amplitude can be considered as the best Four Phase Pulse compression sequence. The Block Diagram of a Modified Genetic Algorithm for the Design of Four Phase pulse Compression Sequence is shown below figure 4.

FIG 4 : BLOCK DIAGRAM OF MGA

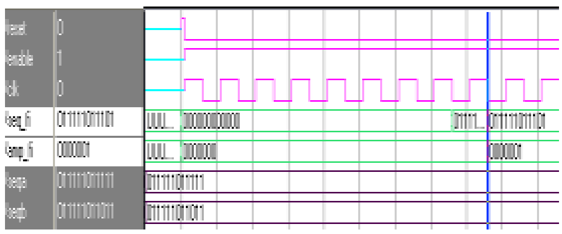


XIII. RESULTS AND ANALYSIS

A. Simulation Waveforms

Four phase sequences are designed using the proposed novel and efficient VLSI architecture. The synthesized results are single realizations obtained using Spartan-3.

The behavioral simulation waveforms for the good Four Phase Pulse compression sequence of length 4 are shown in Fig.5.



After the synthesis ,the synthesis tool generates a complete net-list of target hardware components

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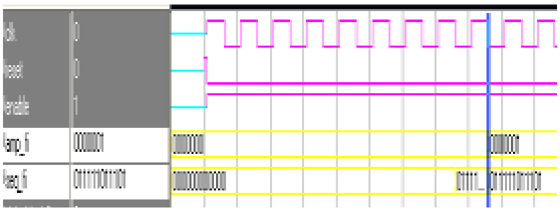
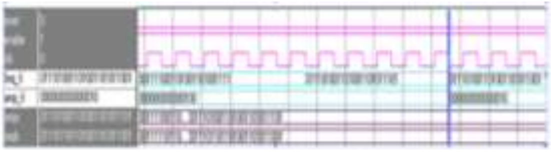
and their timings. The details of gates used for the implementation of the design are described in this netlist

The Post-Route simulation waveforms for the good Four phase Pulse compression sequence of length 4 are shown in Fig.6

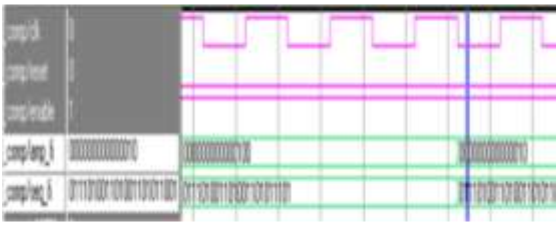


The netlist also includes wiring delays and load effects on gates used in the post-synthesis design. The netlist output is made available in various netlist formats including VHDL. Such a description can be simulated and its simulation is referred as Post Synthesis simulation. Timing issue , Determination of proper clock Frequency and race and hazard considerations can only be checked by a post synthesis simulation run after a design is synthesized.

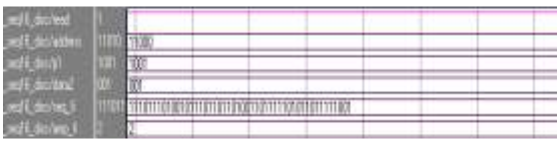
The behavioral simulation waveforms for the good Four phase Pulse compression sequence of length 8 is shown in Fig.7



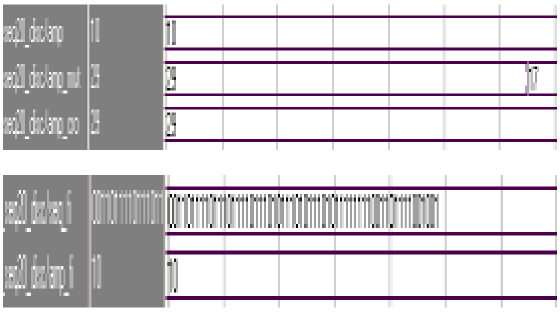
The Post-Route simulation waveforms for the good Four phase Pulse compression sequence of length 8 are shown in Fig.8



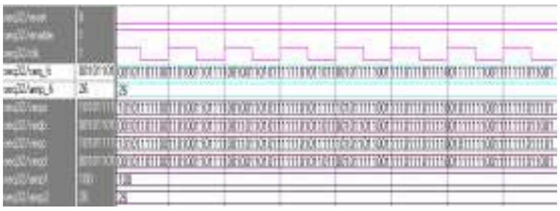
The behavioral simulation waveforms for the good Fourphase Pulse compression sequence of length 16 are shown in Fig.9 It can be seen that Fourphase sequence based on the lowest sidelobe amplitude is 2 among all the sidelobes is 111 011 101 001 011 101 101 101 001 101 111 101 0111 011 111 001(-j -1 j 1 -1 j j j 1 j –j j -1 -1 –j 1). Therefore Discrimination Factor of this sequence is 11.3137.



The behavioral simulation waveforms for the good Fourphase Pulse compression sequence of length 20 are shown in Fig10. It can be seen that Fourphase sequence based on the lowest sidelobe amplitude is 10 among all the sidelobes is 001 101 111 011 101 111 011 101 011 101 011 101 011 111 111 001 101 111 001 001(1 j –j -1 j –j -1 j -1 j -1 j -1 –j –j 1 j –j 1 1). Therefore Discrimination Factor of this sequence is 6.3245



The behavioral simulation waveforms for the good Fourphase Pulse compression sequence of length 32 are shown in Fig.11. It can be seen that Fourphase sequence based on the lowest sidelobe amplitude is 26 among all the sidelobe amplitudes is 001 011 011 001 101 001 101 111 001 001 101 011 111 101 011 011 001 011 111 001 111 011 101 111 001 111 111 001 111 111 011 001 (1 -1 -1 1 j 1 j –j 1 1 j -1 –j j -1 -1 1 -1 –j 1 –j -1 j –j 1 –j –j 1 –j –j -1 1). Therefore Discrimination Factor of this sequence is 6.2757.



B. FPGA Editor Routed Design

The FPGA Editor is a graphical application for displaying and configuring Field Programmable Gate Arrays (FPGAs). The FPGA Editor requires a Native Circuit Description (.ncd) file. This file contains the logic of our design mapped to components (such as CLBs and IOBs). In addition, the FPGA Editor reads from and writes to a Physical Constraints File (PCF).The following is a list of a few of the functions you can perform on your designs in the FPGA Editor.

1 Place and route critical components before running the automatic place and route tools.

2 Finish placement and routing if the routing program does not completely route your design.

3 Add probes to your design to examine the signal states of the targeted device. Probes are

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used to route the value of internal nets to an IOB for analysis during the debugging of a device.

4 Run the BitGen program and download the resulting BIT file to the targeted device.

5 View and change the nets connected to the capture units of an ILA core in your design.

6 Use the ILA command to write a .cdc file

7 Create an entire design by hand (advanced users).

7 Discrimination Factor and Merit Factor of Fourphase pulse Compression Codes

The Fourphase sequences have superior Discrimination factors when compared to the merit factors of Fourphase sequences. These can be represented in the form of a graph as shown in Fig 5.12. Here blue color line represents Discrimination factor and pink color line represents Merit factor. Sequence lengths on X-axis , Discrimination and Merit factors are indicated on the Y-axis. Sequence lengths ,Discrimination Factor values and the Merit Factor values are shown in Table 12

Table 13 Graphical representation of comparing Discrimination Factor and Merit Factor of fourphase codes using MGA.

Table 12

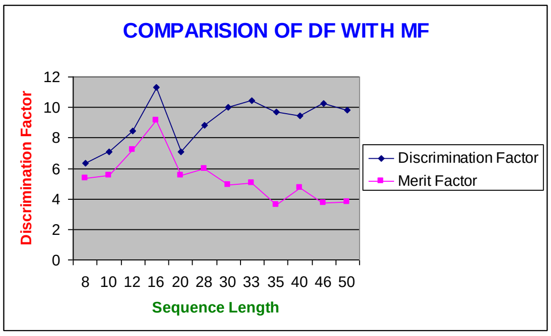

Table 13

Sequence Length	Discrimination Factor	Merit Factor
8	6.364	5.33
10	7.0711	5.55
12	8.4853	7.2
16	11.3137	9.142
20	7.0711	5.556
28	8.8544	5.9394
30	10	4.94
33	10.4355	5.0417
35	9.7073	3.5819
40	9.4281	4.7059
46	10.2859	3.7385
50	9.8058	3.7994

XII. CONCLUSION

The proposed VLSI System is a unique real-time signal processing solution for synthesis of optimal Four phase codes which has the following advantages. It has high efficiency as it identifies the optimal sequences within a short time, but exhaustive search consumes more time as the length of the sequence increases. The proposed VLSI System is a single chip solution for both identification and generation of pulse compression sequences with a little addition to the proposed architecture. The most computational intensive part of MGA is the fitness evaluation, each individual population evaluates efficiently in MGA. These improved FPGA technologies could be exploited to improve the MGA s capabilities. The parallelism through the FPGA pipelining contributed the majority of the hardware's speed up in this application. The concurrent execution of the FPGA, the hardware memory access efficiency, and its efficiency in generating random numbers are also noticeable factors in identifying four phase pulse compression codes. The synthesized Four phase sequences have good Discrimination Factor and less cross correlation energy values. Hence they are promising for practical applications such as Spread Spectrum and Multimedia Applications. It was also observed that the proposed architecture is giving good Discrimination Factor values even for higher sequence lengths. This shows the superiority of the architecture.

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