IMPLEMENTATION OF POLYPHASE SEQUENCE DESIGN USING VERILOG

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Abstract:

In this paper Modified Genetic Algorithm (MGA) is implemented using Verilog. MGA is a combination of the Genetic Algorithm and Hamming Scan Algorithm. Proposed Algorithm is having fast convergence rate. MGA is use to synthesize Eight Phase Sequences with good correlation properties. Eight Phase Sequences can be used to improve the performance and flexibility in Radar signal design.

Keywords: **Autocorrelation, Polyphase Codes, Merit factor, Discrimination factor, Genetic Algorithm, Hamming Scan Algorithm, Radar signals .**

1.INTRODUCTION

The main function of the radar is to detect the moving /stationery object. It may be continue wave (CW) radar or pulse radar. CW radar transmits the continuous sinusoidal signal and generally it use to detect the speed of the object, but it requires two antennas. The Pulse radar require single antenna and act as transreceiver. Pulse radar may employ pulse compression technique to improve range resolution [1-5]. Pulse compression radar uses long duration pulse at transmitter to detect the target at longer distance and compress the pulse at the receiver to get high range resolution. Range resolution of radar is define as,

$$\Delta R = \frac{cT_R}{2}$$

ΔR denotes the range resolution, c is speed of light, T_R is transmitted pulse duration and the Doppler resolution is define as;

$$R_d = \frac{1}{T_R}$$

Matched filter is used to maximize the signal to noise ratio at receiver. The digital pulse compression techniques are of two types of methods i.e., Frequency Modulation (FM) and phase coding technique. In case FM technique it works on both linear and non linear FM. But FM base pulse compression has range Doppler coupling. In Phase coded pulse compression technique the signal of pulse of duration T_R is divided into N sub pulses each of width of t. The bandwidth of signal is increase by changing the phase of each pulse. When pulse compression radar use the Barker code peakside lobe is ≤ 1 and achieve good autocorrelation property.

2. Eight Phase Sequences design

The Eight Phase code of length N bits is indicated as:

$$\left\{ x(n) = e^{j\phi_m(n)} , \quad n = 1, 2, ..., N \right\} \qquad \ldots (1)$$

Where $\phi_m(n)$ is the phase of n^{th} bit in the sequence, which lies between 0 and 2π. The phase of any bit of sequence x(n) is selected from set of M phases, indicated in equation (2).

$$\phi_m(n) \in \left\{0, \frac{2\pi}{M}, 2\frac{2\pi}{M}, ..., (M-1)\frac{2\pi}{M}\right\} \qquad \ldots (2)$$
$$= \{\psi_1, \psi_2, ..., \psi_M\}.$$

For example M = 8, the values of $\{\psi_1,\psi_2,\psi_3.....\psi_8\}$ will be 0, π/4, π/2 and 7π/4 respectively.

Considering a Eight phase code x(n) with code length of N, one can indicate phase of x(n) by the 1 by N matrix shown below:

$$x(n) = [\phi_m(1), \quad \phi_m(2), \quad \phi_m(3), ... \quad \phi_m(N)] \ldots (3)$$

where the phase in the eq.(3) must be chosen from the phase value shown in eq.(2).

Autocorrelation of a sequence:

The aperiodic autocorrelation function (ACF) of sequence x of length N is given by,

$$A(k) = \begin{cases} \sum_{n=0}^{N-k-1} x_n x_{n+k}^* ; & 0 \le k \le N-1 \\ \sum_{n=0}^{N+k-1} x_n x_{n-k}^* ; & -N+1 \le k \le 0 \end{cases} \qquad .....(4)$$

For the generation of Eight phase codes utilized in communication and in the Radar, should have minimum cost function indicated in eq.(5),

$$E = 2\sum_{k=1}^{N-1} |A(k)|^2 \qquad \ldots \quad (5)$$

The minimization of cost function in (5) generates a Eight Phase sequences. In this optimization we have minimize the auto-correlation sidelobeenergy E. By this the autocorrelation of a sequence is calculated and sequence having minimum sidelobe energy is synthesized. These synthesized sequences can be used to detect the target and find out radar parameters.

Merit Factor:

The merit factor is the measure of quality of the aperiodic autocorrelation of sequence in pulse compression[1,3,6]. The merit factor (MF) is defined as the ratio of main peak energy to the sidelobe energy,

$$MF = \frac{A(0)^2}{2\sum_{k=1}^{N-1}|A(k)|^2} \quad \ldots.(6)$$

For the values of k =1,2……N-1

Discrimination Factor(DF):

The discrimination factor can be defined as the ratio of the value of main peak lobe to the magnitude of the value of maximum side lobe of the autocorrelation function of a sequence[1,3,6].

$$DF = \frac{A(o)}{\max|A(k)|} \quad \ldots \quad (7)$$

Where k≠0. By this discrimination factor we can observe the difference between the main peak lobe to the peak side lobe.

3. OPTIMIZATION TECHNIQUES

Hamming Scan Algorithm(HSA):

Hamming scan algorithm is used to find local minima point and has high convergence rate in a limited region[7-8]. The hamming scan algorithm which search its entire neighbor and find the sequence which has high MF and DF value. The essential distinction between Genetic algorithm and Hamming scan algorithm is that Genetic calculation utilizes irregular possible numerous mutations but HSA calculates the mutations individually one by one .

For example, consider a two bit of a sequence [1 - 1] whose fitness is determined. The binary value of 1 is replaced with –1 and fitness function is calculated, if the fitness function which is calculated has an improvement over the first grouping sequence then the sequence is considered otherwise the original sequence is retained back. A similar strategy is performed for every one of the letter sets of sequences. This procedure is recursively applied until no more changes are recorded. The hamming scan algorithm has good convergence rate.

Genetic Algorithm:

Genetic Algorithm has the crossovers and mutations function on the sequence to reduce the cost function. GA is considered for getting optimum solutions of NL linear optimization problems. The GAs are mostly used for solving the complex problems compared to other algorithms, as they give solution but they are not only inefficient but also slower. The GA is used to solve the required problems with multiple solution from a single function this is considered as fitness function. GA uses the cross over and mutation operation, where the crossover module is used to create new generations of solution from single function. The mutation module is used to avoid the similarities between those generations.

Modified Genetic Algorithm (MGA):

The MGA is more effective and efficient algorithm which combine the Genetic algorithm and Hamming Scan Algorithm, Genetic algorithm is quite good at finding the global solution but not few last mutation to find the absolute optimum but HSA can find the absolute optimum at the last few mutation so it increases the rate of convergence where GA increase the robustness of MGA. The MGA also introduced adaptive systems. MGA combines the brilliant approaches of computations like global minimum converging property of Genetic algorithm and high convergence rate of Hamming scan algorithm[10-12]. The fitness function is used to determines best solution from the dynamic outputs and the reproduction output of minimum peak side lobe and best sequences varies with fitness function results.

4.VLSI ARCHITECTURE OF MGA

The block diagram of MGA is shown below which consists of random sequence generator, fitness function, crossover module, mutation module, hamming scan module.

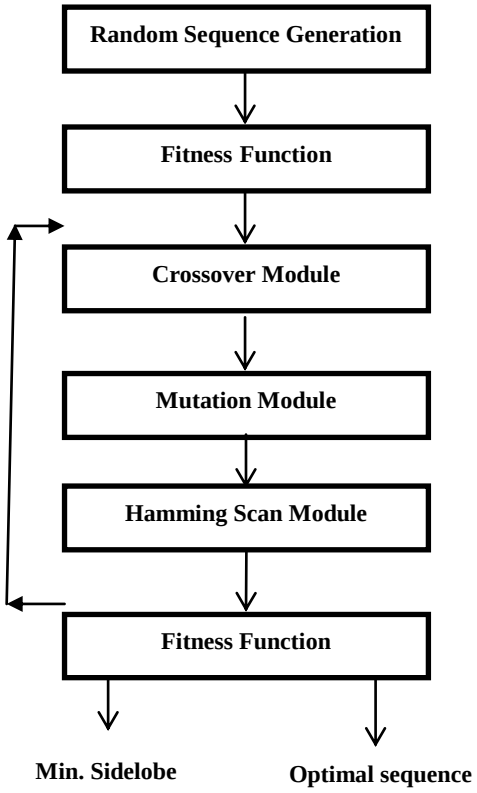

Fig1.block diagram of MGA

Fig2. Shows the VLSI Architecture for MGA
RTL SCHEMATIC

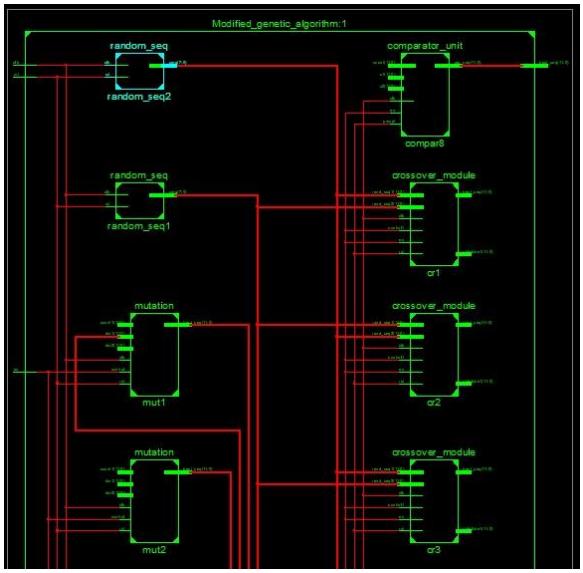

Fig.2. RTL Schematic of the MGA.

5. SIMUTION RESULTS

The different Length sequences of the Eight-phase codes are synthesized. The MF and DF is calculated and tabulated in below table 1. The fig. 2 shows the RTL Schematic of the MGA. The fig. 3 shows graphical representation of DF and MF values of synthesized sequences. The fig. 4 shows the autocorrelation of synthesized sequence of length 100. Fig.5 shows the Behavioral simulation of S1 sequence. The synthesized Eight-phase sequences can be used in pulse compression radar to improve the radar range resolution and detection capability.

Table 1.Performance of the 8- Phase designed sequence:

s.no	Sequence length	MF	DF
1	3	4.5000	3
2	4	4.5523	4
3	7	8.5730	7
4	8	9.1046	8
5	16	12.5993	16.0001
6	25	13.6518	21.4337

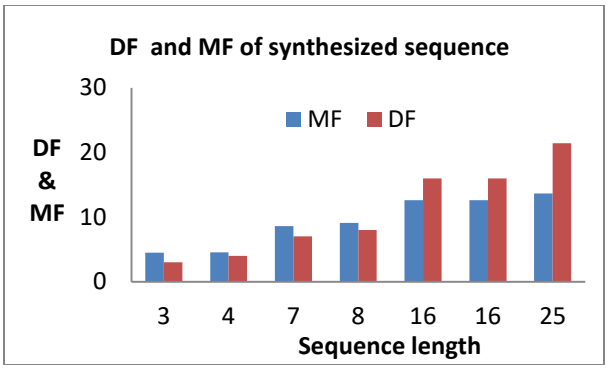

Fig 3. Comparison of MF and DF of the 8-Phase designed sequence.

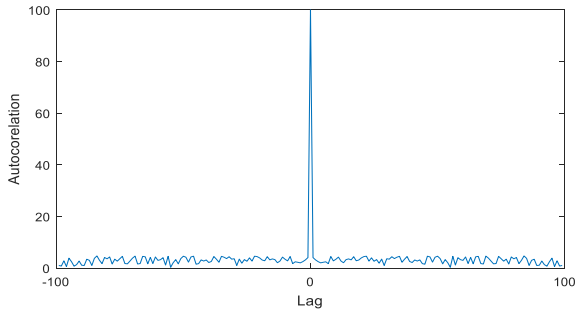

Fig4. Autocorrelation output of 8 phase sequence of length 100.

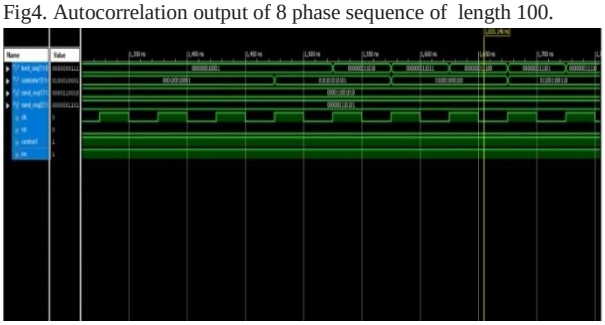

Fig.5 Behavioral simulation of S1 sequence The simulation of the Eight-phase sequence.

6. CONCLUSION

An Verilog architecture for designing the Eight phase sequences using MGA is implemented. It is an efficient architecture as it take less time compare to MATLAB to synthesized optimum sequence with good correlation properties. Design sequences have complex signal structure which is difficult to analyze by enemy electronics support measure and also difficult to jam. As the length of sequence increases the complexity increases to implement the algorithm using Verilog.

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