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IMPORTANCE OF USING GOLD SEQUENCE IN RADAR SIGNAL PROCESSING

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ABSTRACT

In this paper we will discuss about the relevant topics of coding sequences. The coding sequences are used in designing the waveforms in the radar applications. By using different codes in generating the waveforms, there will be a decrease in the side lobes in the ambiguity function. More minor lobes in the ambiguity function represent the confusion in detecting the targets and another application is we can easily identify the minor targets. Gold sequences, having good cross correlation properties will help in managing the interference between successive pulses. The strong research objective is to show the significant improvement in radar clutter. Different lengths of barker codes are taken and its autocorrelation properties and ambiguity functions are compared by generating different lengths of gold sequence. All the results mentioned here are simulated in mat lab.

.**Keywords:**- *Gold Sequence, Pseudorandom Sequence*

1. INTRODUCTION

Radar as the name represents Radio Detection and Ranging. Mostly we are using in defence but now we are using even in commercial applications. In defence, it was used for detection of target. In commercial application also its use is detection only. In commercial we are using it in vehicular application. In this application the reduction in the minor lobe should be around -30db.By barker code the reduction is around -20.83 dB to -22.83db [4][5]. RADAR is used in vehicular application for the purpose of collision avoidance, increase security and saving of mankind. The performance of RADAR highly depends on the selection of input waveform .In the waveform designing we are mostly using frequency coding and phase coding for the better resolution of the targets.

The correct choice of waveform defines all the main characteristics of the radar as: Performance of target detection.- Resolution (angular, range and frequency). - Measurement (range, velocity & error).

Let the transmitted waveform is s(t),then the returned signal is represented as r(t)

$$r(t) = hs(t - \tau_0)e^{-j\ \ (t-\tau_0)+n(t)}$$

Where, h - target scattering coefficient if the target is present, then the value of h is not equal to zero.

$\tau_0 = \frac{2d_c}{c}$ Round trip time.

d_0 is used to find the target range.

$\omega = 2\pi f_0 \frac{2V_c}{c}$ Doppler frequency the velocity with which the target is moving is represented by v_0

n(t) is noise

The correlation is done to the transmitted signal s(t) and returned signal from the target is represented by r(t),

$$m(\tau - \tau_0, \omega) = hs(t - \tau_0)\bar{s}(t - \tau_0)e^{-j\ \ (t-\tau_c)} + N \qquad T$$

$$m(\tau, \omega) = hA(\tau, \omega) + N \qquad T$$

Where,

$$A(\tau, \omega) = \int s(t)\,\bar{s}(t - t_0)e^{-(j\ \ )}d$$

A(τ,ω) is the ambiguity function of the waveform s(t).

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2. AMBIGUITY FUNCTION

Ambiguity function is a two-dimensional function of delay and Doppler frequency that measures the correlation between a waveform and its Doppler distorted version.

$$A(\tau,\omega) = \int s(t)\,\bar{s}(t-t_0)e^{-(j\omega t)}d$$

The ambiguity function along the zero-Doppler axis is the autocorrelation function of the waveform:

$$A(\tau,0) = \int s(t)\,\bar{s}(t-t_0)d \;=\; R_s(\tau)$$

We have to maintain a good ambiguity function for the good waveform. A point target with delay and Doppler shift manifests as ambiguity function centered at $\tau_{0.}$When we have a multiple point targets we have a superposition of ambiguity functions. A weak target located near the strong target can be masked by the side lobes of the ambiguity function centred around the strong target. We have to minimise the minor lobes for the perfect detection of secondary targets [1][2][3].

Taking input array as 1, number of Doppler grid points and delay grid points are maintained at hundred, maximum Doppler shift is maintained at1.sparse matrix operations are used for the better calculation of results without using the loops

3. GOLD SEQUENCE

A GOLD code, also known as GOLD sequence, is one of the binary sequences used in telecommunications and satellite navigation. GOLD codes are named after Robert GOLD. GOLD codes having good autocorrelation and cross correlation properties which are useful in generation of phase coded sequence which is a part of radar waveform design. A set of gold code sequences consists of $2^n - 1$ sequences each one with a period of $2^n - 1$.

A set of Gold codes can be generated with the following steps. Take two maximum length sequences of the same length $2^n - 1$ such that their cross-correlation is less than or equal to $2^{(n+2)/2}$, where n is the size of the LFSR used to generate the maximum length sequence. The set of the $2^n - 1$ exclusive-ors of the two sequences in their various phases (i.e., translated into all relative positions) is a set of Gold codes. The cross-correlation in this set of codes is $2^{(n+2)/2} + 1$ for even n and $2^{(n+1)/2} + 1$ for odd n. Auto correlation function is used to calculate the delayed time of signal. Cross correlation function is used to calculate the level of distinction for the requirements of the codes

The exclusive or of two different Gold codes from the same set is another Gold code in some phase. Within a set of Gold codes about half of the codes are balanced – the number of ones and zeros differs by only one. The Hadamard matrix is an example of a binary orthogonal coding matrix, but it can be shown that the corresponding ambiguity function is useless for radar applications. **A** closer insight into the analytical expression of the ambiguity function reveals that their shapes strongly depends on the autocorrelation and inter correlation properties of the code. Nearly orthogonal binary codes, with good autocorrelation and inter correlation properties, are given by the so called Gold sequences [6].

An example of ambiguity function corresponding to such sequences is depicted. It can be observed that this waveform gives good angular and time-delay resolutions. and that there is no coupling between direction and time-delay. Note however that the average delobe level is higher than in previously considered cases (I/M on average). Moreover this level cannot be reduced by any windowing. It is thus preferable to use this kind of waveform when the number of sub pulses is high (with the restriction that Gold sequences exist only for M being a power of two minus one). In it has been shown that other binary sequences can be found by numerical optimization methods, and that they lead to interesting properties for spatio-temporal applications.

4. RESULTS

Autocorrelation of gold sequence and barker sequence

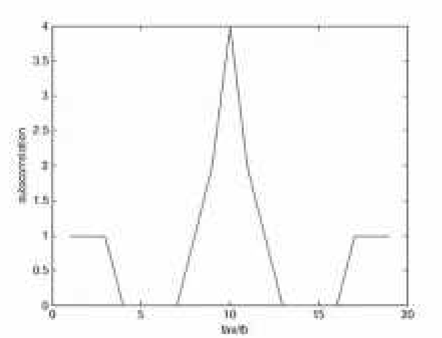

Figure 1.1: Autocorrelation Of Gold Sequence

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The gold sequence is generated by taking the following inputs. Initially the first polynomial is taken as [5 2 0], and the second polynomial is[5 4 3 2 0],initial conditions are [0 0 0 0 1],and the second initial conditions [0 0 0 0 1].by this ,generating the 10 sample sequence given by [1 1 1 0 0 0 0 0 0 1].the autocorrelation of the 10 sample gold sequence is represented in result. On calculation of peak to side lobe ratio result shown as per fig 1.1,(result is 4). Peak to side lobe ratio(psr) = amplitude of main lobe/amplitude of first side lobe.

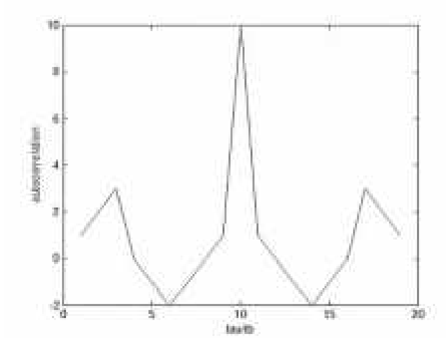

Figure 1.2: Autocorrelation Of Barker Sequence

The barker code generation conditions are given

For any binary code x:

I PSLxis a positive integer.

I PSLx ≥ 1.

A binary code x for which PSLx = 1 is a Barker Code

After generating of 10 samples of barker code, it is represented as [-1 -1 -1 1 1 -1 1 -1 -1 -1]. On calculation of peak to side lobe ratio result shown as per figure 1.2.(result is 3.33)

Ambiguity function for Normal Sequence:

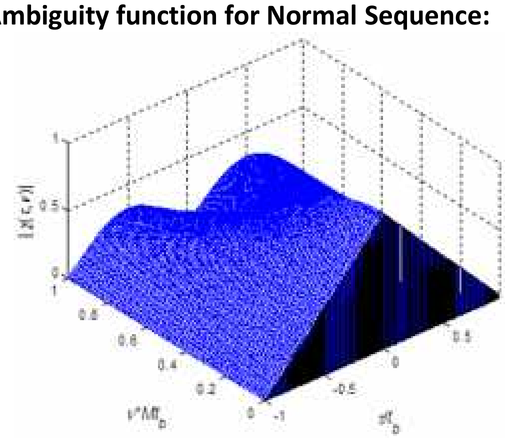

Figure: 1.3 Ambiguity Function When The Signal Element Is Taken As 1.

The result is generated by taking the parameters as input signal1, maximum Doppler shift F as 1 , maximum delay for ambiguity plot is 1 and maintaining the Doppler grid points and delay grid points are 100

Ambiguity functions for Gold Sequence:

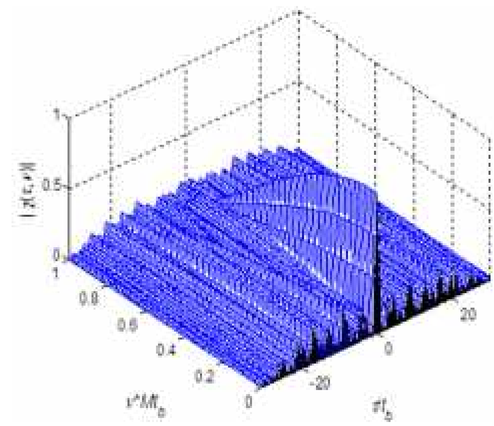

Figure 1.4: Ambiguity Function Of Gold Sequence

The result is generated by taking Gold sequence, maximum Doppler shift F 1, maximum delay for ambiguity plot is 1 and maintaining the Doppler grid points and delay grid points are 100.

5. CONCLUSION

The results shows that the cross correlation of Gold code autocorrelation results are better than cross correlation Barker codes. We can justify it as we have calculated the values of peak to side lobe ratio. The main lobe of the ambiguity function represents the resolution of the system interms of range and Doppler shift. The velocity and range of the target are not constant with respect to the time. From the results the additional lobes corresponds to potential ambiguities results in confusion of choosing correct range of the target and its velocity. So, it is necessary to reduce the side lobes for the perfect resolution of the target. So by using the specified code like Gold sequence, we can estimate the targets easily when compared to other codes. From the results we can say there is an improvement in the suppression and resolution. So there is so much scope in generating the ambiguity function with different codes and the suppression limits are implemented according to the application of using the radar system

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