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Design and Development of Algorithms to Optimize MIMO Radar Waveforms: QPSO Technique

[1*]Sowmyashree M S, [2]Byrareddy C R
[1]Assistant Professor, [2] Professor
[1]Department of Electronics and Communication Engineering
Government Engineering College, Krishnaraja Pet -560026, Karnataka, India

Abstract: The performance of MIMO radar systems has to be evaluated through their response in terms of their waveforms. In order to obtain the suitable waveforms, the effect of influencing variables such pulse width and band width has to be designed properly in order to get the suitable waveforms for the evaluation of the multiple input and multiple output (MIMO) Radar systems. The development of suitable algorithms is very much important to optimize the design considerations of the MIMO Radar waveforms. In this work, design and development of algorithms for the optimization of MIMO Radar waveforms using Quantum Particle swarm Optimization (QPSO) technique is reported. The designed algorithms have been evaluated for the output of systems using simulation technique with the help of MATLAB tool. Three particles were considered for the analysis with the designation Code1, Code2 and Code3. The designed systems have been evaluated under the influence of different factors such as pulse width of 100 and 150µs through the different band width of 5 and 10 MHz. The development of algorithms using QPSO technique has been effectively implemented for the optimization of the MIMO Radar waveform. It is recommended from the technique that the obtained waveforms must have the maximum auto side lobe peak (ASP) and minimum cross correlation peak (CP) value. The range of values designed for the system is from 0 to 1. The distribution of data has been studied through normal distribution and uniform distribution. The simulation has been carried out by considering the combination of particles such as code1-code1, code1-code2 etc. It is observed from both the distribution that the value of ASP and CP were well within the accepted range of the experiment. It is suggested that the simulation results were acceptable and hence the designed algorithms using QPSO technique were recommended for the development of MIMO Radar systems. Further, the effect of pulse width and also the band width have suitable influence on the optimization of the designed waveforms.

***Index Terms* – MIMO, Optimization, QPSO, Pulse width, Band width, ASP, CP**

I. INTRODUCTION

MIMO scheme is used for enhancing the performance of single antenna system. MIMO utilizes multiple transferring waveforms and has a capability for procedure signals received by multiple receiving antennas that employs generally removed transmitters and receivers has been observed over several various feature for enhancing radar recognition with in spatial diversity. Since MIMO transfer diverse waveforms over dissimilar broadcast antenna elements, it utilizes spatial as well as waveform diversity for increasing numerous feature of system [1]. The transmitted signals were equally orthogonal for avoiding interference as well as gain autonomous data over different target proceeds. MIMO was employed for orthogonal waveforms transferred over various phase centres as well as N receive phase centres. Every phase centres receives the received signals that are filtered to be transferred. Transmitted signals are lower autocorrelation side lobe peaks levels (ASP) to the radars of higher resolution for target recognition. Polyphase and DFCW are various kind of waveform used for developing orthogonal waveforms [2]. The polyphase compression relation was comparatively minute compared to DFCW. Linear Frequency Modulation Pulses has lesser ASP with restoring fixed frequency pulse. In recent times, several techniques are developed for intending orthogonal sequences by lesser autocorrelation peak side lobe level as well as low a periodic cross-correlation. PSO-In and QPSO are used for proposing polyphase waveform, Discrete Fourier Coded Waveform (DFCW) – Frequency hopping (FH) and DFCW-LFM (Liner Frequency Modulation) to obtain good correlation properties. Quantum PSO achieves higher classical PSO of DFCW-FH and DFCW-LFM while performance remains same in the polyphase case. MIMO transfer moderately coherent or non-coherent waveforms to enhance spatial resolution. As waveform intend to SIMO for increasing delay, waveform design to MIMO engage delay, doppler as well as spatial resolution type [3]. MIMO transfer waveforms are considered by MIMO radar ambiguity task. In order to identify the range, velocity of required objects, Radar systems broadcast electromagnetic energy within free space as well as employs reflected energy over the objects.

A radar system utilizes multiple transfer antenna elements on broadcast as well as receives antenna elements. MIMO utilizes spatial as well as waveform diversity for enhancing several impact of system concert. MIMO is utilized extensively in spaced antennas [3] or collocated antennas [4]. To increase target identification capability, the latter configuration increases the spatial resolution, as the former arrangement provides increased spatial diversity metrics as well as interference rejection ability.

MIMO includes configuration of antennas configured while ULAs. Point target indicates target, transmitters with receivers positioned within same 2-D plane. Consider spacing among transmitters and receivers. Identify target, θ indicates target angle and λ

denotes carrier wavelength of target delay and Doppler frequency. Next, waveform on antenna was computed by DFCW comprises of L frequency hopping waveforms [5] is indicated by:

$$S_p = \sum_{n=0}^{N-1} A(t)\, e^{(j2\pi f^p{}_n t)}$$

$$(t) = \begin{cases} 1/T, \text{if } (n-1)T \leq t \leq nT \\ 0 \qquad \text{elsewhere} \end{cases}$$

p = 1, 2, 3....L where L denotes amount of transmitters. T indicates sub pulse time. N represents amount of sub pulse which are permanent by coefficient sequence (0, 1, 2,..., range) where range is decided by bandwidth used as well as $f_n^p = n.\Delta f$ indicates frequency of sub pulse n p within DFCW-FH and Δf denotes frequency.

From the research it was suggested that autocorrelation of DFCW as well as ASP indicates 0.21 [6]. It was difficult as well as changes particularly by various firing order of frequency within sequence. Thus, the aim is used for detecting frequency to reduce CP. The cost function was selected by the amount of the whole autocorrelation side lobe energies to every each waveform as well as every potential cross correlation. Therefore, cost purpose is shown by 'μ' indicates relative weight allocated towards autocorrelation. While reducing E, find the optimal firing frequency. To obtain the optimized values of the target range, it is required to design the system which employs the efficient algorithm for selecting the values. In this view, the MIMO Radar systems have been designed using classical and QPSO Technique for the development of the antenna system. Further, different distribution has been adopted in order to evaluate the performance of the different process variables such as pulse width and band width used in the system.

The development of MIMO RADAR system has been designed and developed in order to obtain optimized waveform using different techniques has been contributed by fellow researchers to research bench. Haimovich et al [7] studied and reported the MIMO radar systems and their ambiguity optimization using Phase Coded Pulse Waveforms. The resolution properties of MIMO radar transmit waveforms is studied using the MIMO radar ambiguity function. In this study, they derived MIMO radar ambiguity function of phased coded pulse waveforms. The study on the MIMO systems using widely separated antennas was reported by Haimovich et al [8]. In this study, they developed the algebraic solution for tracing a moving target in MIMO radar systems. They proposed the algorithm which is established on constructing a pseudo-linear set of equations and two-stage weighted least squares estimation. They showed that the numerical simulations promised the significant improvement in localization accuracy over the existing methods using Gaussian noise model. The study on MIMO Radar with Collocated Antennas and DOA estimation performance in case of narrowband and wideband signals has been reported by Jain Li and Stoica [9]. They analyzed the existing signal processing algorithms and proposed a new one in order to improve the DOA estimation performance in case of narrowband and wideband signals. They proposed the techniques under ideal and non-ideal conditions considering the punctual targets. The concept of multiple-input multiple-output (MIMO) radars ambiguity properties and their optimization using frequency hopping waveforms has been designed and reported by Chen and Vaidyanathan [10]. They derived some mathematical properties of the MIMO radar ambiguity function. They developed a new algorithm for designing the orthogonal frequency-hopping waveforms has been proposed.

The study on the orthogonal discrete frequency coding waveform design for MIMO Radar system has been conducted by H. Deng [11]. A modified Genetic Algorithm (GA) was proposed to design numerically orthogonal Discrete Frequency-Coding Waveforms (DFCWs) with good correlation properties for MIMO radar. They also investigated the effect of Doppler frequency shift on the performance of aforesaid signals. The simulated results and their comparison showed that the proposed algorithm is more effective for the design of DFCWs with superior aperiodic correlation properties. The ambiguity function and cross-ambiguity function for discrete frequency-coding waveform (DFCW) with arbitrary firing order for Netted Radar Systems have been developed and reported by Deng et al [12]. The results showed that the ambiguity function for DFCW shows that orthogonal DFCWs have comparatively large ASP and very low Doppler tolerance. The study on the performance analysis of MIMO Radar waveform using accelerated particle swarm optimization algorithm have been reported by Roja reddy and Uttara Kumari [13]. They adopted the accelerated particle swarm optimization algorithm for designing and developing the above system which will be the best in evaluating the performance. The designed and simulation results showed that the proposed algorithm is more effective in the design and analysis of DFCWs signal used in MIMO radar systems compared to others. The Polyphase code design for the orthogonal netted Radar system have been developed and analyzed by Deng [14]. They proposed the novel hybrid algorithm to numerically optimize orthogonal polyphase code sets. This algorithm integrates a statistical simulated annealing algorithm with the traditional iterative code selection method.

Design and development of Polyphase orthogonal code for MIMO Radar systems has been proposed by Liu et al [15]. The proposed novel approach includes the Genetic Algorithm (GA) and the traditional iterative code selection algorithm and provides a powerful tool for the design of multiple orthogonal Polyphase sequences satisfying the requirements imposed both on autocorrelation and cross-correlation. The designed results showed that the proposed model is best suited for the parameters selected for the analysis. Azmil et al [16] proposed a new model for optimizing the Polyphase coding waveform for multiple input and multiple output Radar system using evolutionary algorithms. They reported the effective approach to design an orthogonal code for these radar systems using four evolutionary algorithms, namely, PSO, NPSO, BA and ABC. The designed and the simulated results showed that the different algorithms have their own capability of proving themselves worth in the system. The power function for the numerical solution artificial bee colony (ABC) algorithm has been designed and developed by Karaboga et al [17]. Artificial Bee Colony (ABC) algorithm is an optimization algorithm based on the intelligent behavior of honey bee swarm. They used the ABC algorithm for optimizing multi variable functions. The designed results were compared with the other efficient algorithms such as Genetic Algorithm (GA), Particle Swarm Algorithm (PSO) and Particle Swarm Inspired Evolutionary Algorithm (PS - EA). They proved that ABC performance was outstanding compared to others.

From the above research work contributed by many researchers, it is clear that the design and development of algorithms using different techniques to design the waveform for MIMO Radar system have been available in plenty. But the design of algorithms using QPSO and also classical techniques were not reported. Further, the evaluation of the simulated results using normal and uniform distribution under the influence of different process variables requires critical study. Keeping this in view, an attempt has been made to develop the algorithms using QPSO and Classical Hybrid technique to optimize the MIMO Radar waveform. Further, the influence of different process variables such as band width, method of distribution, indicating factors and pulse width were also taken in to consideration for the analysis and hence for the investigation.

II. HYBRID QPSO: ENHANCEMENT OF UNAMBIGUOUS PCSO

Hybrid QPSO is subjected to double exponential distribution. Hybrid distribution may improve the QPSO which are multiplied with a factor depending on particle, particle best and its mean best. This technique uses normal distribution and standard normal distribution in one case and uniform distribution and standard normal distribution in other case for comparison.

2.1 Concept of QPSO

It is seen that proposed hybrid QPSO improve performance of designed waveforms. Considering the evolution equation of QPSO shown below,

$$X^{j}{}_{i,n+1} = p^{j}{}_{i,n} + A^{j}{}_{i,n+1} \qquad (1)$$

Where X stands for particle position to determine velocity and position.
Where $A^{j}{}_{i,n}$ indicates random sequence that converges towards zero where $X^{j}{}_{i,n}$ reaches to $p^{j}{}_{i,n}$ i.e. centre of δ potential well to jth component of ith element within nth iteration. Instead of considering $A^{j}{}_{i,n}$as the sum of two random sequences, in this proposed hybrid QPSO we consider it as product of two random sequences,

$$ {}^{j}{}_{i,n+1} = a^{j}{}_{i,n+1} * b^{j}{}_{i,n+1} \qquad (2)$$

Where $a^{j}{}_{i,n}$ and $b^{j}{}_{i,n}$ are the two probability distributions. In this paper we are selecting $a^{j}{}_{i,n}$ as normal distribution in one case and uniform distribution in other case. $b^{j}{}_{i,n}$ is selected to be standard normal distribution. It is expressed by,

$$A^{j}{}_{i,n+1} = \alpha\, |X^{j}{}_{i,n} - P^{j}{}_{n}|\, \ln\left(\frac{1}{u^{j}{}_{i,n+1}}\right) * \beta |X^{j}{}_{i,n} - C^{j}{}_{n}|\, \lambda^{j}{}_{i,n+1} \qquad (3)$$

Where α and β were termed as CE as well as employed for balancing local and global search of particles. $C_n = (C^1{}_n, C^2{}_n, \dots \dots C^N{}_n)$ was termed as mean finest point given as,

$$C^{j}{}_{n} = \left(\frac{1}{M}\right) \sum_{i=1}^{M} P^{j}{}_{i,n} \quad (1 \le j \le N) \qquad (4)$$

2.2 Software Implementation

The following steps were involved while implementing the software:

- ➢ Initialize the array of particles by arbitrary points such as $X_j(0)$ $(j = 1,2, \dots \dots., N)$

- ➢ At first, every particles velocity is indicated by zero. Estimate the values equivalent by $f|X_1(0)|, f|X_2(0)|, \dots\dots\dots. f|X_N(0)|,$

- ➢ In i^{th} iteration, identify the next two significant parameters employed using representative particle j:

  - Historical finest value of $X_j(i)$, $P_{best,j}$, by highest value of object utility, encountered with particle j in every preceding iterations.
  - Historical finest value of $X_j(i)$,G_{best}, by highest value, encountered with preceding iterations with some of the N particles.

- ➢ Update velocity and position of particle j with in i^{th} iteration by,

$$A^{j}{}_{i,n+1} = \alpha\, |X^{j}{}_{i,n} - P^{j}{}_{n}|\, \ln\left(\frac{1}{u^{j}{}_{i,n+1}}\right) * \beta |X^{j}{}_{i,n} - C^{j}{}_{n}\, \lambda^{j}{}_{i,n+1} \qquad (5)$$

where α and β are two parameters employed for balancing local as well as global search of the particles. $C_n = (C^1{}_n, C^2{}_n, \dots \dots C^N{}_n)$ has the mean finest point given as,

$$C^{j}{}_{n} = \left(\frac{1}{M}\right) \sum_{i=1}^{M} P^{j}{}_{i,n} \quad (1 \le j \le N) \qquad (6)$$

In (6), M denotes amount of particles. $p^{j}{}_{i,n}$ may be obtained by

$$p^{j}{}_{i,n} = \phi^{j}{}_{i,n} P^{j}{}_{i,n} + (1 - \phi^{j}{}_{i,n}) G^{j}{}_{n}$$

Where ϕ was the random number and G stands for global best particle . $p^{j}{}_{i,n}$ gives the centre of δ potential well to jth component of i^{th} element within nth iteration.

- Calculate the standards by $f|X_1(i)|, f|X_2(i)|, \ldots. f|X_N(i)|$

- Step 2 was constant with updating iteration by $i = i + 1$, as well as detecting new values of P_{best} and G_{best}

III. RESULTS AND DISCUSSION

3.1 Optimized waveform for MIMO Radar systems for a Band width of 5 MHz and Pulse width of 100 and 150 µs

The simulation results of implemented technique using MATLAB is presented in the following section. The normal distribution and uniform distribution for different pulse width and band width is presented in the following section. The simulation has been carried out for a constant band width of 5 MHz for different pulse width of 100 µs and 150 µs.

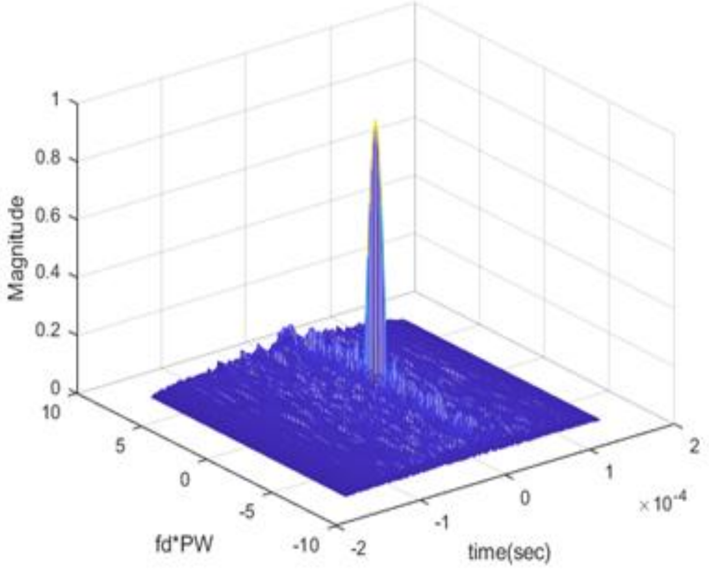


Figure 1: MIMO Radar Partial Ambiguity Function of DFCW – FH with code length N = 128, BW = 5 MHz and PW = 150 µs

Figure 1 shows the MIMO Radar ambiguity function of DFCW – FH with code length N = 128 for a band width of 5 MHz under the effect of 150µs (Uniform distribution). The uniform distribution of all the data has been scattered across the mean values. It is suggested from the figure that the effect of pulse width also one of the variable affecting the wave form. Here, the particles are distributed across the system. The steep waveform has been exhibited in the figure which is the result of optimized value for which the function is most effective for the design of MIMO Radar systems. The response of the all the particles considered for the analysis is also shown in the figure. The steep and well defined width of the pulse has been observed in the figure. This showed that the designed algorithm is well within the acceptable waveform of the system. Further the delay cut of the MIMO Radar partial ambiguity function of DFCW-FH for one designed sequence with code N = 128, band width = 5 MHz under the influence of 150 µs is shown in figure 2 (Normal distribution). The normal distribution of the response of the particles for different pulse width also presented in the figure. The different waveforms have been responded by the different particles under the influence of different pulse width. For the designed pulse width of 150 µs, the steep band has been exhibited by the system indicating that the optimum designed value of the system variable is suitable to obtain the proper wave form [15, 17].

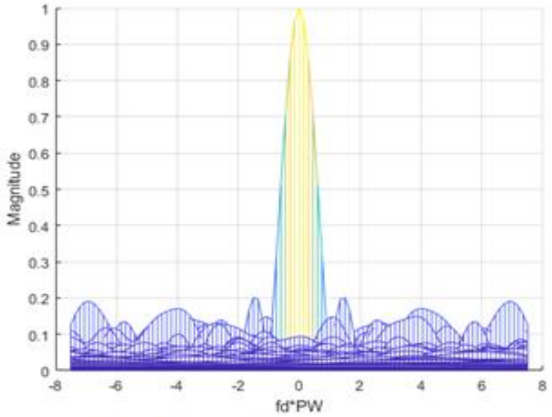


Figure 2: Delay cut of the MIMO Radar Partial Ambiguity Function of DFCW – FH for one designed sequence with code N = 128, BW = 5 MHz and PW = 150 µs

Table 1: Maximum ASP and CP of the designed DFCW – LFM set at 5 MHz Band width using hybrid QPSO

	Pulse width = 150 µs		
	Code1	Code2	Code3
Code1	0.9858	0.0478	0.0377
Code2	0.0478	0.9981	0.0516
Code3	0.0377	0.0516	0.0920

The maximum ASP and CP value of the designed DFCW – LFM set at 5 MHz band width for PW = 150 µs using hybrid QPSO is tabulated in the table I. The different combination of particles such as code1-code1, code1-code2 has been trained and the results are tabulated. It is designed the technique system in such a way that the maximum ASP and minimum CP value has to be exhibited by the system. It is observed from the table that the least value of the same parameters were obtained for the particle combination of code3-code3 and the maximum value of the same has been responded by the hybrid combination of code2-code2 which is 0.9858. The value obtained from the simulation is well within the acceptable limit which is designed to be the optimized value for the designed functions [18].

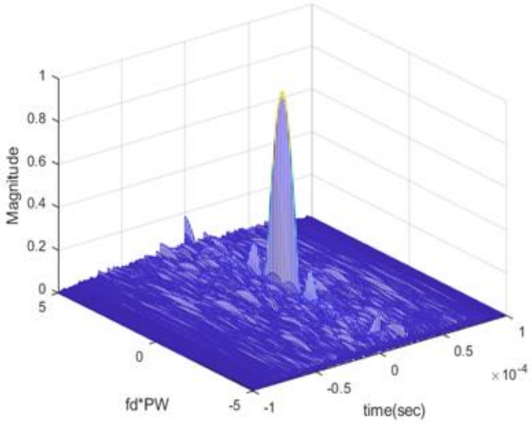


Figure 3: MIMO Radar Partial Ambiguity Function of DFCW – FH
with code length N = 128, BW = 5 MHz and PW = 100 µs

Figure 3 shows the MIMO Radar ambiguity function of DFCW – FH with code length N = 128 for a band width of 5 MHz under the effect of 100µs (Uniform distribution). The uniform distribution of all the data has been scattered across the mean values. When compared to the pulse width of 150 µs, the random response has been observed from the analysis. Here different peaks of suitable magnitude have been exhibited for the different pulse width which is reflected in the figure. The variations of the width and the peaks are not likely to be smooth. The steep waveform exhibited has lesser magnitude with more wide in nature. The response of all the particles considered for the analysis is also shown in figure. The steep and wide well defined width of the pulse has been observed in the figure. This showed that the designed algorithm is well within the acceptable waveform of the system [12, 13]

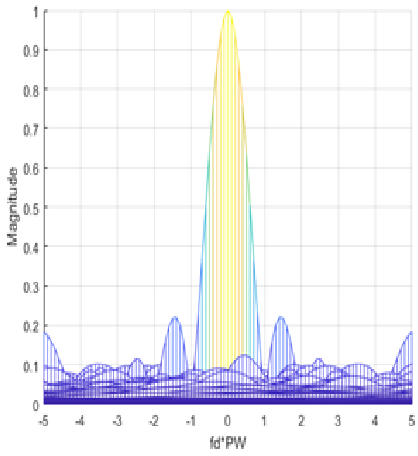


Figure 4: Delay cut of the MIMO Radar Partial Ambiguity Function of DFCW – FH for one designed sequence with code N = 128, BW = 5 MHz and PW = 100 µs

The delay cut of the MIMO Radar partial ambiguity function of DFCW-FH for one designed sequence with code N = 128, band width = 5 MHz under the influence of 100 µs is shown in figure 4 (Normal distribution). It is observed from the figure that the tiny waveforms of different magnitudes were the neighbors of the designed wave form obtained from the optimized function. It is clear that the varying wave forms design has been exhibited by the different value of the pulse width tested for the analysis. It is indicated from the figure that the waveform of highest magnitude having designed shape has been obtained. Comparing the same design with 150 µs, the width of the waveform is high and also the steep edged curve has been formed to indicate the effect of pulse width on the designed waveform [17, 19]. It is indicated that the obtained values from the graph showed that the designed function is effectively optimized one for the systematic evaluation of MIMO Radar Systems for the applications.

Table 2: Maximum ASP and CP of the designed DFCW – LFM set at 5 MHz Band width using hybrid QPSO

	Pulse width = 100 µs		
	Code1	Code2	Code3
Code1	0.0858	0.0278	0.0277
Code2	0.0278	0.0881	0.0216
Code3	0.0277	0.0216	0.0820

The maximum ASP and CP value of the designed DFCW – LFM set at 5 MHz band width for PW = 100 µs using hybrid QPSO is tabulated in the table II. The different combination of particles such as code1-code1, code1-code2 has been trained and the results are tabulated. The system has been designed in such a way that the maximum ASP and minimum CP value has to be exhibited by the system. It is observed from the table that the least value of the same parameters were obtained for the particle combination of code3-code3 and the maximum value of the same has been responded by the hybrid combination of code2-code2 which is 0.0881. The value obtained from the simulation is well within the acceptable limit which is designed to be the optimized value for the designed functions. The results revealed that the range of values designed for the functions is well within 0 and 1. Further, it is observed that the combination of particles exhibiting the maximum and minimum values of ASP and CP respectively were matching for the both the pulse width of 100 and 150 µs. This study suggested that the designed algorithm using QPSO technique is most significant in designing the MIMO Radar waveform best suitable for the applications.

3.2 Optimized waveform for MIMO Radar systems for a Band width of 10 MHz and Pulse width of 100 and 150 µs

The simulation results of implemented technique using MATLAB is presented in the following section. The normal distribution and uniform distribution for different pulse width and band width presents the behavior of the waveform under the influence of different processing variables. The simulation has been carried out for a constant band width of 10 MHz for different pulse width of 100 µs and 150 µs. It is observed from both normal and uniform distribution that the pulse width and band width influenced the MIMO Radar waveform. Further, the sharp peak indicates that the suitability of all types of particles under consideration.

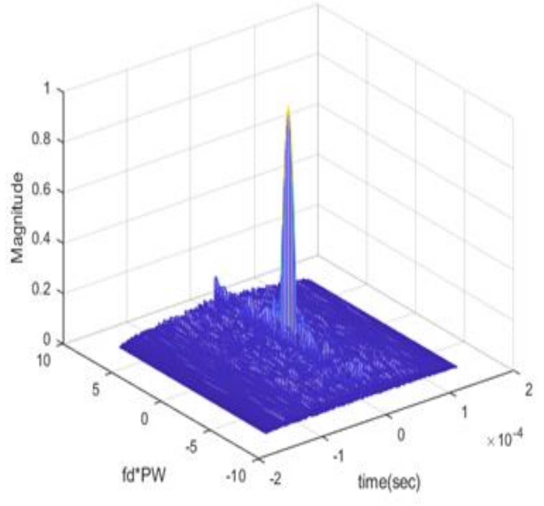


Figure 5: MIMO Radar Partial Ambiguity Function of DFCW – FH with code length N =128, BW = 10 MHz and PW = 150 µs

The effect of process parameters such as pulse width and band width on the radar waveform is shown in the figure 5. It shows the reflection of the optimized function designed using QPSO Technique. The MIMO Radar ambiguity function of DFCW – FH with code length N = 128 for a band width of 10 MHz under the effect of 150µs (Uniform distribution) clearly showed that the different particles considered for the analysis exhibits the similar behavior as that of the normal distribution. The steep waveform has been exhibited in the figure which is the result of optimized value for which the function is most effective for the design of MIMO Radar systems. The particles response with the system seemed to sharp and uniform across the width of pulse shown. This showed that the designed algorithm is well within the acceptable waveform of the system. But is is obser4ved that the response of the peak of the wave from is lower compared to 5 MHz for the same pulse width. Further the delay cut of MIMO Radar partial ambiguity function of DFCW-FH for one designed sequence with code N = 128, band width = 10 MHz under the influence of 150 µs is shown in figure 5 (Normal distribution). For the designed pulse width of 150 µs, the width of pulse is varying across the system depending up on the particle type and size of the system. Here, normal distribution showed that the response of the waveform is uniform and also reached the peak value of the consideration [15, 17].

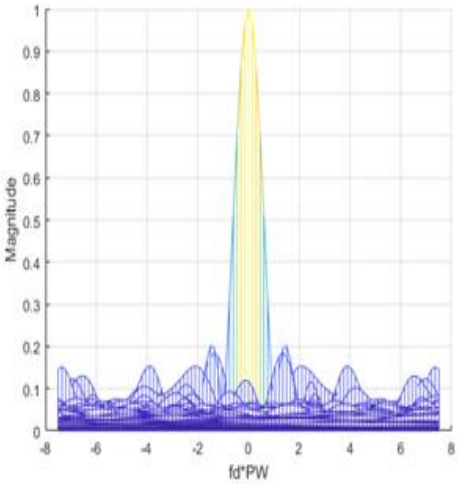
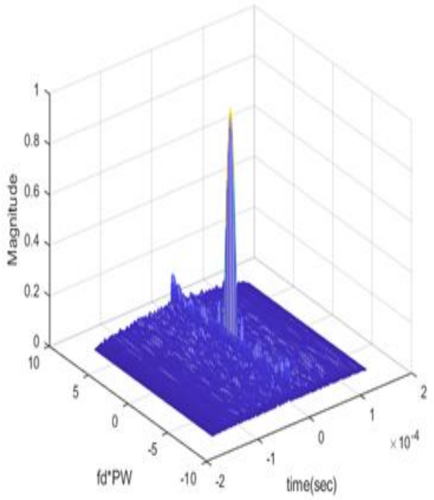


Figure 5: Delay cut of the MIMO Radar Partial Ambiguity Function of DFCW – FH for one designed sequence with code N = 128, BW = 10 MHz and PW = 150 µs

The maximum ASP and CP value of the designed DFCW – LFM set at 10 MHz band width for PW = 150 µs using hybrid QPSO is tabulated in the table 3. The different combination of particles such as code1-code1, code1-code2 has been trained and the results are tabulated. It is designed the technique system in such a way that maximum ASP and minimum CP value has to be exhibited by the system. It is observed from the table that the least value of the same parameters were obtained for the particle combination of code2-code2 and the maximum value of the same has been responded by the hybrid combination of code3-code3 which is 0.0985. It is observed from the value that the higher the pulse width, lower will be the critical Value of CP and ASP which are the deciding factors for the design of optimized waveform. It is indicated from the figure that the designed function has been optimized using QPSO Technique exhibits the better acceptable variables for the output of the system [18].

Table 3: Maximum ASP and CP of the designed DFCW – LFM set at 10 MHz Band width using hybrid QPSO

	Pulse width = 150 µs		
	Code1	Code2	Code3
Code1	0.0863	0.0218	0.0221
Code2	0.0218	0.0811	0.0265
Code3	0.0221	0.0265	0.0985



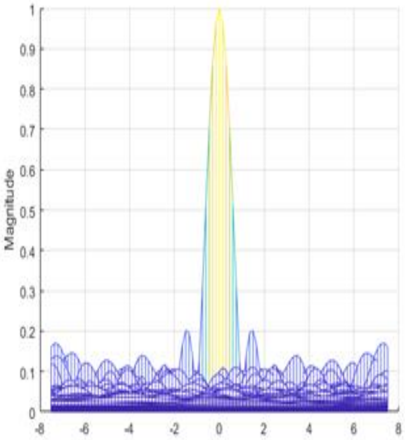


Table 4: Maximum ASP and CP of the designed DFCW – LFM set at 10 MHz Band width using hybrid QPSO

	Pulse width = 100 µs		
	Code1	Code2	Code3
Code1	0.0804	0.0006	0.0286
Code2	0.0006	0.0840	0.0374
Code3	0.0286	0.0374	0.0586

Figure 6 show the reflection of the optimized function designed using QPSO Technique. The MIMO Radar ambiguity function of DFCW – FH with code length N = 128 for a band width of 10 MHz under the effect of 150 and µs (Uniform distribution) clearly showed that the different particles considered for the analysis exhibits the similar behavior as that of the normal distribution for a pulse width of 100 µs. The behavior of the system followed the same trend both for 100 and 150. The slight variation in waveform has been observed due to the effect of disturbances experienced by the particles considered for the analysis.

IV. CONCLUSION

In the design and development of algorithms for the optimization of MIMO Radar wave from using QPSO Technique has been studied and reported. The following conclusion was drawn during the investigation:

1. The optimization of MIMO Radar waveform using classical and QPSO Hybrid technique was effectively implemented in designing the system
2. The analysis has been carried out using MATLAB tool through simulation
3. The simulation process has been carried for the MIMO Radar Partial Ambiguity Function of DFCW – FH with code length N = 128, BW = 5 and 10 MHz using different pulse width of 100 and 150 µs
4. The study has been exposed to both uniform and normal distribution
5. The simulation has been carried out for different particles code1, code2 etc.,
6. The optimized system has been designed in such way that the maximum value of ASP and Minimum value of CP has to obtained from the system
7. It is observed from the simulated results that the waveforms are uniform, steep and the suitable designed values are well within the acceptable optimized limits of the designed function
8. It is concluded that the QPSO technique is the most significant method for obtaining the MIMO Radar waveform which were optimized and suitable for the development of system
9. The algorithms designed and developed using this technique played the significant role in designing the MIMO Radar systems
10. It is concluded that the pulse width and band width are also the influencing design factors to be considered for the analysis during the optimization of wave forms using algorithms

V. ACKNOWLEDGEMENT

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