

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

PTM Sequencing for Sidelobe Suppression in Radar

Mr.Ravi Kishore Singh¹, Maninder Kaur², Deepika Chowdary³, Ajith⁴

Department of ECE, Guru Nanak Institutions Technical Campus, Secunderabad, India

ABSTRACT: So far we were familiar with many radar waveforms constructing methods and sequencing pulse code transmission techniques for annihilation of side lobes. But all these various generalizations of complementary sequencing of codes suffer from the same problem of completely suppressing the side lobes over a Doppler interval. So in this project we present PTM sequencing of Golay complementary waveforms which is better solution than earlier methods. By PTM sequencing (i.e., using PTM pulse trains), locating the weak targets near a strong reflector is possible and by carefully choosing the order in which the Golay waveforms (complementary) transmitted in a pulse train we can clear out the range side lobes of the ambiguity function in an interval along zero Doppler axis. For sequencing we make use of two sequences X0 and X1 which controls range and size and forms a sequence X=[X0 X1 X1] which is Prouhet-Thue-Morse sequence.

KEYWORDS: Ambiguity, Golay Pairs, Doppler.

I. INTRODUCTION

Radar an EM device capable of transmitting an EM wave near 1-110 GHz and receive back a reflection from a target and based on the characteristic of returned signal determines the target.

A transmitter generates an EM signal that is radiated in space by antenna. A portion of transmitted energy is intercepted by target and reradiated in many directions. Now re-radiation is collected by radar antenna the received signal is processed to detect the presence of object. Modern radars are increasingly being equipped with arbitrary waveform generators which enable generation of different wave fields across space, time, frequency, polarization, wave number, or combination of these; we can modularize the design problem[7].

In sensing and communication it is often required to localize a received signal in time, e.g., to estimate the range of a target from a radar based on the delay in the radar return or to synchronize a mobile handset with a pilot signal sent from a base station. Typically, localization is performed by a match filtering the received signal with the transmitted waveform. The output of the matched filter would ideally be an impulse at the desired delay. Therefore, waveforms with impulse –like autocorrelation functions are of great value in these applications. Phase coding is a common technique in radar for generating waveforms with impulse like auto correlation functions. In this technique, a long pulse is phase coded with a uni-modular sequence and the autocorrelation function of the coded waveform is controlled through the autocorrelation function of the uni-modular sequence.

Famous class of complementary sequences is binary complementary sequence which was introduced by Marcel Golay [1].Golay complementary sequences have a property that the sum of their autocorrelation functions vanishes at all delays other than zero. When these sequences are transmitted separately and their auto correlation functions [4] are added together the sum will be a peak at the zero axis (impulse).

A major barrier exists in adoption of golay complementary sequences for radar and communications. Perfect autocorrelation of these sequences is highly sensitive to Doppler shift. Ambiguity function of complementary sequences is free of delay side lobes along zero- Doppler axis; off zero Doppler axis it will have large side lobes. Most of Golay complementary sequences include multiple complementary sequences and ploy-phase complementary



(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

sequences which has same problems. To solve these problems we can design a Doppler resilient sequence of golay complementary waveforms, for which the pulse train ambiguity is free range of side lobes at Doppler shifts. We have to determine sequence of Golay pairs that annihilates the range side lobes. Prouhet-Thue- Morse sequence [2]-[3] plays a key role in constructing the Doppler resilient sequence of Golay pairs.

II. GOLAY COMPLEMENTARY PAIRS

Consider two length-N unimodular sequences complex numbers x[n] and x1[n] are Golay complementary if for k=-(N-1)... (N-1) the sum of their auto correlation functions satisfies

Corr
$$x[k]$$
 + Corr $x1[k]$ =2L δk , 0

The discrete time index n from x (n) and x1(n) and simply use x and x1[6]. We use the notation (x, x1) whenever x and x1 are Golay complementary and call (x, x1) a Golay pair. It follows that if (x, x1) is a Golay pair then $(\pm \tilde{x}, \pm \tilde{x}, 1)$, and $(\pm \tilde{x}, \pm \tilde{x}, 1)$ are also Golay pairs, where is the time reversed complex conjugate of x[n] and x1[n]. The composite ambiguity function of a set of waveforms {x0(t), x1(t)... xN-1 (t)} is defined as

$$A(\tau, v) = \sum_{n=0}^{N-1} Axn(\tau, v)$$

Where Axn (τ, ν) is the (auto) ambiguity function of xn (t) in delay variable τ and Doppler variable ν . The composite Ambiguity function A (τ, ν) corresponds to the main lobe of the ambiguity function of the pulse train [x0(t) x1(t) ... xN-1 (t)], where consecutive pulses are separated by a pulse repetition interval (PRI). The discrete ambiguity function can be shown as

$$A(K, \theta) = \sum_{n=0}^{N} e^{jn\theta} Cxn(K)$$

 θ - Relative Doppler shift during a PRI.

Even a slight difference in Doppler results in large side lobes, at fine resolution we'll have to cover the possible Doppler ranges, which many Doppler filters. For this we have to design Doppler resilient Golay pairs(x0, x1)... (xN-2, xN-1) so that A (k, θ) \approx NL δ k, 0 for a reason- able range of Doppler shifts θ [5].

III. PTM

The PTM pulse train clears out the Doppler induced range side lobes along modest Doppler shifts and brings out the weak targets. We denote by $t = (tn) n \ge 0$ the PROUHET-THUE- MORSE sequence over $\{0,1\}$ defined recursively by $t_0=0$ and $t_2n=tn, t_{2n+1}=t\bar{n}$ for all $n\ge 0$, where, for x $\mathcal{E} \{0,1\}$, we define $\bar{x} = 1-x$

IV. PTM SEQUENCING OF GOLAY PAIRS

Let x and y be golay sequences which form a complementary pair. Let (x, x1) is a golay pair. If [x, x1] is a golay pair then $[\pm x, \pm \tilde{x} 1]$, $[\pm \tilde{x}, \pm x1]$, and $[\pm \tilde{x}, \pm \tilde{x} 1]$ are also golay pairs, where \tilde{y} corresponds to the complex conjugate of y. Let us define pulse trains as X0=[x x1] and X1 = [- $\tilde{x}1 \ \tilde{x}$].where the frequency of separation of pulses is PRF. To construct a PTM sequence consisting golay pairs we need to start with X0 followed by X1 then again X0 and so on.

The PTM sequencing of golay complimentary waveforms [2] produces an impulse like ambiguity response in range across desired Doppler intervals.

For example, PTM sequence of golay pairs with length 4 is as shown

$$\chi_{\text{PTM}} = [X0 X1 X1 X0]$$
(4)

 $= [\mathbf{x} \ \mathbf{x}\mathbf{1} - \mathbf{\tilde{x}}\mathbf{1} \ \mathbf{\tilde{x}} - \mathbf{\tilde{x}}\mathbf{1} \ \mathbf{\tilde{x}} \ \mathbf{x} \ \mathbf{x}\mathbf{1}]$

The composite ambiguity function of X $\ P \ T \ M$ is given by

$$A_{\text{PTM}}(k, \theta) = (\sum_{n \in s_0} e^{jn\theta}) Cx(k) + (\sum_{n \in s_1} e^{jn\theta}) Cy(k)$$

Where S_0 gives all the indices corresponding to zeroes in the given sequence length. And S1 gives all the indices corresponding to ones in given sequence. We have assumed here that the auto correlation of both x and \tilde{x} are equal.



(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

V.EXPERIMENTAL RESULTS

Figures show the results of PTM Sequencing for side lobe suppression in radar.







Figure (2) 16 bit PTM sequence



(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015



Figure (3) PTM sequencing of Golay Pairs

VI. CONCLUSION

Through this paper we have explained that PTM sequencing of two complementary sequences produces suppressed side lobe waveform over a desired Doppler interval and traces weak targets which are masked by the side lobe of ambiguity function centered at the delay Doppler position of strong reflector. The magnitude of the range side lobes of the pulse train ambiguity function of the constructed pulse trains are proportional to the magnitude spectrum of PTM sequence, which have higher order nulls in a desired Doppler band so by properly designing (P,Q) we can trade-off between order of spectral null and SNR which is usually expected to be high.

REFERENCES

- [1] M. J. E. Golay, "Complementary series," IRE Trans. Inform. Theory, vol. 7, no. 2, pp. 82–87, April 1961.
- [2] J. P. Allouche and J. Shallit, "The ubiquitous ProuhetThue-Morse sequence," in Sequences and their applications, Proc. SETA'98, T. Helleseth C. Ding and H. Niederreiter, Eds. 1999, pp. 1–16, Springer Verlag.
- [3] E. Prouhet, "M'emoire sur quelques relations entre les puissances des nombres," C. R. Acad. Sci. Paris S'er., vol. I 33, p. 225, 1851.
- K. Gerlach and F. F. Kretschmer, "General forms and properties of zero cross-correlation radar waveforms," IEEE Trans. Aerosp. Electron. Syst., vol. 28, no. 1, pp. 98–104, Jan. 1998
- [5] R. Sivaswami, "Self-clutter cancellation and ambiguity properties of subcomplementary sequences," IEEE Trans. Aerosp. Electron. Syst., vol. AES-18, no. 2, pp. 163–181, Mar. 1982.
- [6] A. Pezeshki, A. R. Calderbank, W. Moran, and S. D. Howard, "Doppler resilient waveforms with perfect autocorrelation," IEEE Trans. Inform. Theory, submitted Mar. 2007, available at arXiv.org:cs/0703057.
- [7] N.Levanon and E. Mozeson Radar Signals, 2004 :Wiley
- [8] S. J. Searle and S. D. Howard "A novel polyphase code for sidelobe suppression", Proc. Int. Waveform Diversity and Design Conf., pp.377 -381 2007

BIOGRAPHY



Prof RK Singh received Masters of Engineering in Electrical Engineering from IIT Bombay. He is currently pursuing PhD from Gitam University in the area of Digital Signal Processing. His research areas include Radar Systems and Signal Processing.



(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015



Maninder Kaur received, B.Tech in 2006 from Guru Nanak Engineering College, Ibrahimpatnam and completed M.Tech in 2008 from the same college. Currently working as Associate.Professor in Dept., of E.C.E of GNITC specializing on Radar Systems and Digital Signal Processing.



Bandella.Deepika Chowdary,Pursuing B.tech in Dept., of E.C.E in Guru Nanak Engineering College, Ibrahimpatnam. Major Project in Radar Systems and Signal Processing under the guidance of Prof. RK Singh



Ajith Junneti, Pursuing B.Tech in Dept., of E.C.E in Guru Nanak Engineering College, Ibrahimpatnam. Major Project in Radar Systems and Signal Processing under the guidance of Prof. RK Singh