A NEW APPROACH FOR PN-CODES GENERATION AND SYNCHRONIZATION IN CW MOBILE MULTISTATIC RADAR SYSTEMS

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Abstract

Bistatic radars and multistatic radars are often designed for operation on high altitude platforms such as satellites and airplanes. In these cases problems with pseudo-noise code generation, synchronization and isolation appear when continuous wave – phase modulation is used. This mode of operation gives the opportunity for coherent signal processing, precise distance and 3-D coordinates measurements, as well as targets resolution by means of their Doppler spectra.

The goal of this report is to propose a new approach for pseudo-noise code generation and synchronization, suitable for mobile multistatic radar networks.

The proposed new principle uses several space distributed sources of radio-signals, phase modulated by appropriate pseudo-noise codes. A particular radar transmitter site receives these signals by means of the well known CDMA technology. For this purpose the same codes are generated and synchronized in the site receiver. The ***mod2 sum*** *of these codes creates a new code, which we named Unique pseudo-noise code. It is used for spreading of the transmitted radar signal.*

The basic SC-CDMA geometry of a particular mobile multistatic radar system, as well as mathematical description of the proposed method of code generation and synchronization are given in the report. A proposal for a real system, using the satellites of the global positioning system GPS as sources of the pseudo-noise signals, is given too.

1. Introduction

Bistatic radars and Multistatic Radar Networks (MRN) are subject to problems and special requirements that are either not encountered or encountered in less serious form by monostatic radars [1]. In general, the implementation of a MRN is more easily accomplished when the positions of all transmitting and receiving elements are fixed with respect to each other, for example when located on the ground. Because of the Line Of Sight (LOS) restrictions, they are often designed for operation on high altitude platforms such as satellites and airplanes. Another particular application of satellite based global MRN is the protection of the Earth surface from meteors and asteroids. In these cases problems with Pseudo-Noise (PN)-code generation, synchronization and isolation appear when Continuous Wave - Phase Modulation (CW-PM) mode of operation is used. On the other hand CW-PM gives the opportunity for coherent signal processing, precise distance and 3-D coordinates measurements, as well as targets resolution by means of their Doppler spectra.

In fig. 1 the geometry associated with bistatic radars [2] is shown. It could be base configuration for a more sophisticated MRN. A synchronization link between the transmitter and receiver is necessary in order to maximize the receiver's knowledge of the transmitted signal so that it can extract maximum target information. The synchronization link may provide the receiver with the following information:

- The transmitted frequency in order to compute the Doppler shift;
- The transmit time or phase reference in order to measure the total scattered path $R_t + R_r$.

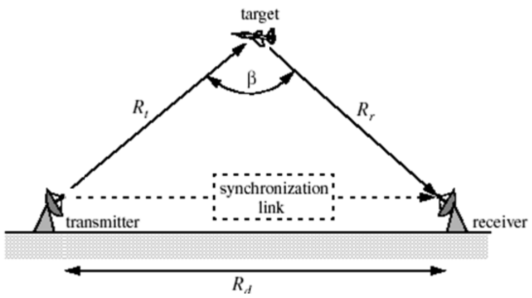

Figure 1. The basic bistatic radar geometry

Frequency and phase reference synchronization can be maintained through line-of-sight communications between the transmitter and receiver.

The goal of this report to propose a new approach for PN-code generation and synchronization in order to solve some of the problems of the future sophisticated fixed and mobile MRN,s. Similar approach was proposed by the author several years ago for a new s.c. Space Correlated (SC) CDMA method of access, used in satellite and terrestrial cellular networks for global mobile communications [3, 4].

2. SC-CDMA approach

The proposed SC-CDMA principle uses several space distributed sources of radio-signals, positioned at points O_1 and O_2 – fig. 2. The signals are phase modulated by appropriate PN-codes $C_1(t)$ and $C_2(t)$. The Mobile Stations (MS) receive these signals by means of the well known CDMA technology. For this purpose the same PN-codes are generated and synchronized in the MS receiver. The ***mod2 sum*** of these codes creates a new code, which we named U (Unique)-PN code. This code is used for spreading the transmitted by the MS information. Similar approach is used for generation of the Base Station (BS) U-PN codes.

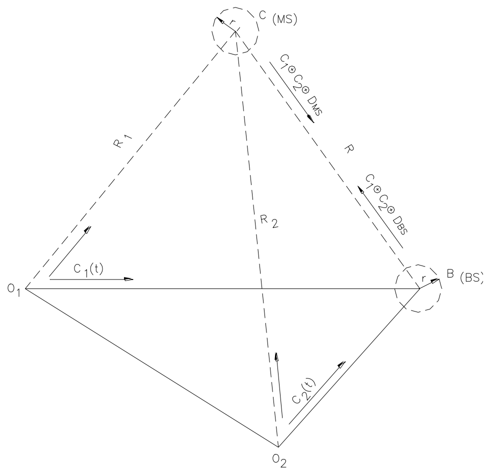

Figure 2. The basic SC-CDMA bistatic radar geometry

3. SC-MRN: the new approach to synthesize radar MRN-codes

The possible implementations of SC-CDMA approach in a bistatic radar geometry is shown in fig.3. BPSK modulated by PN-codes radiosignals are transmitted from the points O_1 and O_2 (both of them with known coordinates in a 2D coordinate system). These signals are received in the transmitter site and in the receiver site of a bistatic radar system, where the used PN-sequences $C_1(t)$ and $C_2(t)$ are recovered with their phases and used as follows:

- ***Transmitter site:***

$C_1(t)$ and $C_2(t)$ are ***mod2sum*** and the resulting U-PN code (eq.1) is used for BPSK modulation of the transmitted radio-signals. The phases of the received PN-codes are determined by the transmitter position. These coordinates are sent to the receiver with appropriate radio-communication link.

$$U - PN_{transmitter}(t) = C_1(\Omega_C t + \frac{2\pi}{\lambda_C} R_1) \oplus \oplus C_2(\Omega_C t + \frac{2\pi}{\lambda_C} R_2) \tag{1}$$

where λ_C is the wavelength and Ω_C is the angle frequency of the used PN-code.

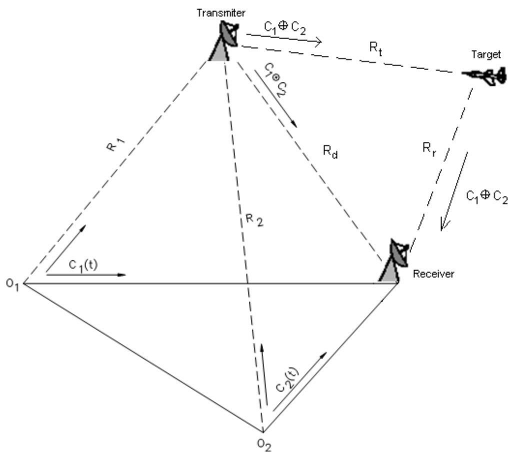

Figure 3. The basic SC-MRN geometry

- ***Receiver site:***

The phases of the received PN-codes are determined by the receiver position in the same 2D-coordinate system. Receiver processor computes the distances R_1, R_2, R_d in order to recovery the transmitted U-PN code in the receiver with phase, given with eq. 2. The recovered U-PN code is used for acquisition and tracking of the synchronization link and with introducing the suitable time delay – for measuring the distance $R_t + R_r$ by means of eq.3.

$$U - PN_{receiver}^{synchronization}(t) =$$

$$= C_1\left[\Omega_C t + \frac{2\pi}{\lambda_C}(R_1 + R_d) \oplus\right] \tag{2}$$

$$\oplus C_2\left[\Omega_C t + \frac{2\pi}{\lambda_C}(R_2 + R_d)\right]$$

$$U - PN_{receiver}^{target-reflected}(t) =$$

$$= C_1\left[\Omega_C t + \frac{2\pi}{\lambda_C}(R_1 + R_t + R_r)\right] \oplus \tag{3}$$

$$\oplus C_2\left[\Omega_C t + \frac{2\pi}{\lambda_C}(R_2 + R_t + R_r)\right]$$

4. Matrix presentation of SC-MRN codes

Bearing in mind the equations (1-3) it is possible to represent the U-PN codes phases of a SC-MRN, based on N primary sources, in matrix form as follows:

- ***U-PN code*** in the transmitter site:

$$\left[U - PN_{transmitter}\right] = \begin{vmatrix} \frac{2\pi}{\lambda_C} \times R_1 \\ \frac{2\pi}{\lambda_C} \times R_2 \\ \cdots\cdots\cdots \\ \frac{2\pi}{\lambda_C} \times Rn \end{vmatrix} \tag{4}$$

- ***U-PN code*** of the synchronization link in the receiver site :

$$\left[U - PN_{receiver}^{synchronisation}\right] = \begin{vmatrix} \frac{2\pi}{\lambda_C} \times (R_1 + R_d) \\ \frac{2\pi}{\lambda_C} \times (R_2 + R_d) \\ \cdots\cdots\cdots \\ \frac{2\pi}{\lambda_C} \times (R_N + R_d) \end{vmatrix} \tag{5}$$

- ***U-PN code*** of the target reflected wave in the receiver site :

$$\left[U - PN_{receiver}^{target-reflected}\right] = \begin{vmatrix} \frac{2\pi}{\lambda_C} \times (R_1 + R_t + R_r) \\ \frac{2\pi}{\lambda_C} \times (R_2 + R_t + R_r) \\ \cdots\cdots\cdots \\ \frac{2\pi}{\lambda_C} \times (R_N + R_t + R_r) \end{vmatrix} \tag{6}$$

4. SC-MRN based on global navigation system GPS

An attractive application of the SC-CDMA technology is the use of the satellites of the global positioning system GPS as sources of the PN-modulated signals. In this particular case the U-PN code is ***mod2 sum*** of the recovered in the transmitter site GPS receiver C/A codes of the visible satellites. Because of the very fast relative satellite motion the created in this case U-PN code changes very fast – it looks like a pure random signal. U-PN code acquisition and tracking is based on the exchanged between transmitter site and receiver site information about their positions in ECEF geographic coordinate system, used by GPS.

5. Conclusions

A new approach for pseudo-noise code generation and synchronization, suitable for mobile multistatic radar networks, is proposed in the report.

The basic SC-CDMA geometry of a particular mobile multistatic radar system, as well as mathematical description of the proposed method of code generation and synchronization are explained in details. A proposal for a real system, using the satellites of the global positioning system GPS as sources of the pseudo-noise signals, is given too.

The implementation of the proposed new SC-MRN approach for PN – code generation and synchronization will give new chance of the future sophisticated mobile defense radar systems.

References

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