Signal Design and Processing for Orthogonal Netted Radar System

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The netted radar systems through a central control unit will greatly improve the radar detecting and automatic tracking performances by information fusion. The conventional netted radar systems normally operate multistatic mode, i.e., one radar system operates as the transmitter and the rest operate as the receivers. If all radar stations in the netted system can transmit and receive simultaneously at the same carrier frequency, the netted radar system is coined as the orthogonal netted radar system. However, the waveforms used by the netted system must be carefully designed to avoid the self-interference and detection confusion. If the system transmits the waveforms from a special coding waveform set in which each of the waveforms has the nearly ideal aperiodic auto-correlation property and any two of them have no cross-correlation, it can adaptively operate, based on the environments, in regular monostatic mode or in bistatic or even multistatic mode with the same carrier frequency. The key to the feasibility of the orthogonal netted radar system is to design a set of the special coding waveforms of the unique properties as described above. The polyphase coding waveforms have increasingly become favorable alternatives to the traditional binary coding waveforms due to the maturity of digital signal processing and VLSI. Assuming that the waveform set used by an orthogonal netted radar system consists of L polyphase coding signals with each signal consisting of N complex numbers, we represent the frequency-hopping waveform set as: $\left\{s_l(n) = e^{j\phi_l(n)}, m = 1,2,..N\right\}, l = 1,2,..., L$ where $0 \le \phi_l(n) < 2\pi$ is the phase value of subpulse n of waveform l in the waveform set. For the orthogonal waveforms each of the waveforms has nearly ideal noise-like autocorrelation property and any two of them have no cross-correlation, therefore,

$$\frac{1}{N}\sum_{k=0}^{N-1-|m|} s_l^*(n)s_l(n+m)\begin{cases} = 1, & m = 0 \\ \approx 0, & m \ne 0 \end{cases} \quad l = 0,1,..., L-1 \tag{1}$$

and

$$\frac{1}{N}\sum_{k=0}^{N-1-|m|} s_p^*(n)s_q(n+m) \approx 0 \quad p \ne q, \quad p,q = 0,1,..., L-1 \tag{2}$$

The polyphase code set design with properties in (1) and (2) can be implemented with algebraic construction method or more practically, numerical methods. The following figure show the auto-correlation (a, b, c) and cross-correlation (d, e, f) properties for a designed polyphase code set by simulated annealing with L=3 and N=128. The processing of the polyphase coding signal is normally implemented with digital correlators. The processing results can be further improved by using CLEAN algorithms to remove the sidelobe and cross-correlation interferences..