Integrated Waveform Design via Pilot-Based OFDM for Joint Radar and Communication System

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Introduction

Nowadays, the trend of developing integrated radar and communication system has attracted more and more attention. In the existing OFDM-based integration schemes, phase-coded OFDM signals have been widely used. However, in most of the current research, in order to reduce the influence of the correlation of communication signal on the performance of the radar, the communication baseband signals are directly mapped into a phase encoding sequence and then transmitted. This reduces the ability of carrying information to a certain extent. Otherwise, the general phase encoding sequence such as m-sequence, Barker code and other forms are relatively fixed, which are easy to be intercepted and captured.

For the above two problems, we propose a method that utilizes the pilot in communication system to realize radar detection. The communication sub-carriers keep the original form, and the pilot sub-carriers carry the phase encoding sequence. In this way, the performance of the communication system will not degrade and the communication function will not affect the radar detection performance. Meanwhile, the chaotic sequence is adopted as the phase coding sequence in pilot, which is sensitive to the initial value. This character means that the chaotic sequence reduces the probability of being intercepted, and therefore it can improve the anti-interference ability of the integrated signal. The feasibility of the proposed integrated signal is verified by simulations.

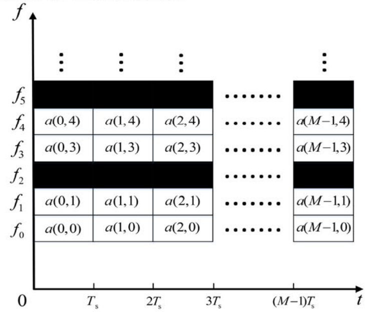

Figure 1: Time-frequency diagram of pilot-based integrated signal

Methods

- Make full use of the pilots in communication system
- Phase-coded pilot sequences are replaced with chaotic sequences
- Matched filtering and pulse compression processing at the receiver

Results and Discussion

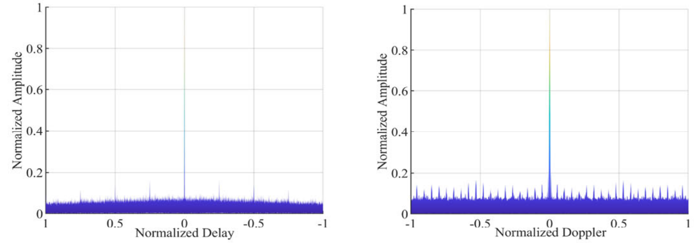

Figure 2: Ambiguity function slices

The ambiguity function graph of the integrated signal is a sharp pushpin shape, and the side lobe value is much lower than the main lobe value. The maximum values of the small peaks in these two graphs do not exceed 0.2, which still illustrates the good range and velocity resolution of the integrated signal

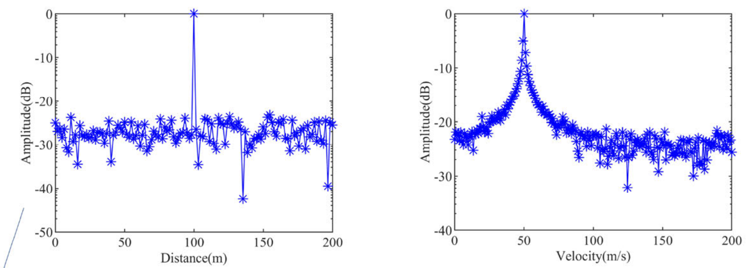

Figure 3: Velocity-resolved and Distance-resolved performance

In the left sub-figure, the curve has a very sharp peak, and the sidelobe values are all lower than -20dB, which shows that the processing algorithm in this paper has perfect distance-resolved performance. In the right sub-figure , the curve also has a peak, but it is not as sharp as in the left sub-figure, which means that velocity estimates may be more susceptible to noises.

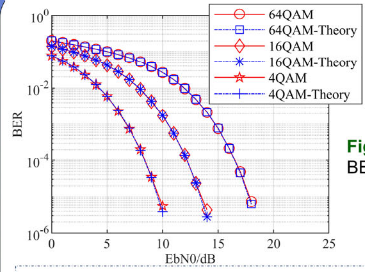

Figure 4: BER in AWGN channel

In AWGN channel, BER of the integrated signal in each modulation mode is very close to the theoretical value, which shows that the communication performance of the integrated signal will not be greatly affected by the addition of the radar

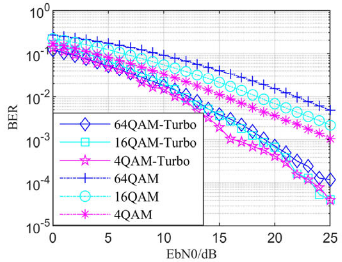

Figure 5: BER in Rayleigh channel

With the use of turbo channel coding and decoding algorithm, BER achieves a certain decline, which can already be reduced to the order of 10-5 at 25dB. Some reasons for the smaller degree of decline may be the inaccurate channel estimation at the receiving end, imperfect channel equalization algorithm, and insufficient turbo code length and decoding algorithm

Conclusion

The improved waveform design method we proposed makes full use of the pilot sequence of the communication system for radar sensing. In order to improve the randomness of the pilot sequence, the method introduced the chaotic sequence, and used the characteristics of the initial value sensitivity of the chaotic sequence to improve the anti-interception and anti-interference ability of radar detection. The simulation results showed that this integrated signal has good radar detection resolution, high communication rate and low bit error rate.