THE SUMMARY OF Ph. D. DISSERTATION

Major Information and Computer Science		SURNAME, First name SATO, Reiji

Title

Study of Time Sidelobe Reduction for Coded Pulse Compression

Abstract

Almost all of various performances requested for the modern radar can be improved in proportion to the transmitting energy and the resolution of the radar. So it is necessary for the radar using a common non-modulated pulse to decrease the pulse-width and increase the peak power to obtain the large transmitting energy and high resolution at the same time. However, there is the limit of the peak power derived from the hardware and others. Especially the limit is serious for the active phased-array radar using semi-conductor devices or high frequency radar. Therefore the pulse compression, which makes it possible to obtain the high range-resolution and large transmitting energy simultaneously without high peak power, is the very important technique for the radar. However, the unwelcome TSL (Time Side-Lobe) produced by the pulse compression has a bad influence on the detection performance. So, it is the most important issue for the pulse compression to reduce the TSL.

The pulse compression employs the long transmitting pulse that is frequency or phase modulated to widen the spectrum bandwidth. Generally, the wide bandwidth implies the high resolution. So, the signal is compressed to the short pulse by the matched filter. The pulse compression can be classified mainly into two categories according to the modulation type. One is the chirp pulse compression of FM modulation. The other is the coded pulse compression.

The coded pulse compression has an excellent characteristic of tolerability to the interference. So, it has been used in many radar systems and there have been various studies to reduce the TSL of the coded pulse compression. It should be, however, noted that almost all of those studies consider that the signal is compressed to a single sub-pulse width. In other words, it is originally assumed that the signal is compressed to a single sub-pulse width. On the other hand, there is the technique that can drastically reduce the TSL of the chirp method by the cost to widen the compressed pulse width. On the analogy of such technique used for the chirp method, it is then expected that the TSL of the coded pulse compression might be also reduced by the cost to widen the compressed pulse width.

In this research, the new technique to compresses a signal to a width of several sub-pulses is proposed in order to reduce TSL for the coded pulse compression.

In chapter 1, the background, meaning and others of this study are described.

In chapter 2,3, and 4, it is shown that a signal can be compressed to a width of several sub-pulses, by making the spectrum bandwidth narrow. This study focuses on the fact that the spectrum bandwidth is very narrow when the phase difference $\Delta a_n(=a_{n+1}-a_n)$ is constant. However, the spectrum becomes so narrow by this modulation that the signal cannot be compressed. It is then investigated to disarrange this modulation a little by introducing several phases nearby each other which Δa_n can be, in order to widen the

spectrum a little.

In chapter 2, it is proposed to introduce 2 phases, 0 and $\pi/2$ for Δa_n in the modulation described above. It is shown that the PSL (Peak Sidelobe Ratio) can be reduced compared to the conventional when the compression ratio is from 4 to 5.

In chapter 3, it is proposed to introduce more various phases and make the range of phase change larger than $\pi/2$. Then, the spectrum bandwidth becomes wider and the compression ratio becomes larger because the modulation is more like to the random modulation. It is also expected to have the higher possibility of finding codes of small PSL by introducing more various phases. It is shown that the PSL can be reduced compared to the conventional when the compression ratio is from 8 to 11.

In chapter 4, it is proposed to change the sign of Δa_n once. The spectrum bandwidth becomes wider than that of chapter 3. It is shown that, when the compression ratio is about 11, the PSL can be reduced compared to the codes obtained in chapter 3.

In chapter 5, The TSSWA (Two-Sample Sliding Window Adder) is applied to the binary code in order to reduce the TSL by a simple way. The function of the TSSWA, which was originally proposed for the P1 sequence and others resembling the chirp modulation in order to reduce their TSL, is simply to divide the signal into two same copy signals after the auto-correlation process, then delay one of them by sub-pulse width and add them again. From the spectrum point of view, the function of a TSSWA is to multiply the spectrum by the weighting function, which resembles the TSL reduction technique used for the chirp method. The TSL generally tends to be small as the spectrum bandwidth decreases in the chirp method. On the other hand, as the number of times when the TSSWA is applied increases, the spectrum bandwidth decreases. So, applying TSSWAs two times is expected more effective than applying only once in order to reduce the TSL of the binary code. In this chapter, it is shown that TSSWAs have an effect also on the TSL reduction of the binary code and especially double TSSWAs are significantly effective when the compression ratio is under 15.

In chapter 6, the new TSL reduction method including the TSSWA is proposed. The difference from the TSSWA is to multiply the one side of the divided signal by a constant whose absolute value is 1 before they is added again. The phase of the constant is supposed to be a parameter that should be optimized for the TSL reduction. Applying the new method two times is expected more effective than applying only once in order to reduce the TSL of the binary code similar to TSSWAs. It is then shown that the TSL of the P1 sequence and others can be improved by 0.5dB to 6.0dB compared to the conventional TSL reduction method.

In chapter 7, the S/N loss induced by double TSSWAs proposed in chapter 5 is estimated. It is then shown that, with less S/N loss than the conventional, the TSL can be reduced.

In chapter 8, the result of this research is concluded.