A New Pulse Compression Technique for Polyphase Codes in Radar Signals

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ABSTRACT
In this paper we have proposed a new pulse compression technique for polyphase codes. In the proposed technique amplitude weighting is applied to a combination of the incoming signal and one-bit shifted version of the incoming signal. This technique produces better peak side lobe ratio (PSL) and integrated side lobe ratio (ISL) than all other conventional sidelobe reduction techniques. In simulation results the performance of Woo filter, Asymmetrical weighting and Amplitude weighting Techniques are compared with the proposed technique. Main lobe splitting which is the main disadvantage in Woo filter is eliminated in this techniques and it is easy to implement and incurs a minimal signal to noise ratio SNR loss.

General Terms
Pulse compression; Woo filter; Range resolution.

Keywords
Peak sidelobe level (PSL); Integrated sidelobe level (ISL); Signal- to-noise ratio loss (SNR).

1. INTRODUCTION
Pulse compression (PC) is an important module in many of the modern radar systems. It is used to overcome major problem of a radar system that requires a long pulse to achieve large radiated energy but simultaneously a short pulse for range resolution [1].Range resolution is an ability of the receiver to detect nearby targets. The receiver matched filter output is the autocorrelation of the signal. If matched filter is not able to give satisfactory PSL, a mismatch filter can be used so as to reduce the sidelobes further at a cost of introducing SNR mismatch loss. Low autocorrelation sidelobes are required to prevent the masking of weak targets that occurs in the range sidelobe of strong target [2].The performance measures of PC techniques are PSL, ISL, SNR loss and Doppler shift. The major advantages of PC are resulting gain in SNR and relative tolerance to jammers.PC can also lift small target signals out of clutter. Lewis proposed sliding window two-sample subtractor to reduce the sidelobes for polyphase codes [3]. Woo and Griffiths developed a sidelobe canceller to reduce peak sidelobe level and integrated sidelobe level [4]. In this paper we propose a new technique to reduce the PSL and ISL significantly and it is free from the drawbacks of the conventional sidelobe reduction techniques.

2. POLYPHASE CODES
The codes that use any harmonically related phases on certain fundamental phase increments are called polyphase codes [3, 5]. Well know polyphase codes with better Doppler tolerant and low range sidelobes are Frank and P1 codes which are derived from step frequency, Bolter matrix derived P2 code and linear frequency derived P3 and P4 codes. The significant advantage of P1 and P2 codes over the Frank code and the P4 code over P3 is that they are tolerant to receiver band limitations. In this paper P4 code is used for simulation purpose and the phase sequence of this code is given by

$$\Phi_i = \frac{\pi}{N}(i-1)^2 - \pi(i-1) \qquad (1)$$

Where i=1, 2…N and N is the code length.

3. NEW PULSE COMPRESSION TECHNIQUE
In this proposed technique the incoming P4 signal and one-bit shifted version of the incoming signal are combined to which amplitude weighting is applied. Here matched filter is used as the cross correlation between the amplitude weighted signal and the combined signal. The structure of the proposed technique is shown in Fig. 1.

4. SIMULATION RESULTS
In this section we compare the merit factors of new technique with different sidelobe reduction techniques, using P4 code of length 1000. In the amplitude weighting technique the code signal is multiplied with the window coefficients and the weighted code and the transmitted signal are applied to correlation in the receiver side [6, 7].The tradeoff in reducing the PSL is spreading of the compressed pulse. The output of this technique using Blackman window is shown in Fig. 2. Woo filter technique is that which uses two correlation filters to produce a single discrete filter, It reduces PSL and ISL at sacrifice of mainlobe splitting and 3 [dB] SNR loss [4, 8, 9], and is shown in Fig. 3. The modified forms of Woo filter reduces the PSL further and also the mainlobe splitting present in Woo filter is removed [10]. This is depicted in Fig. 4. Asymmetrical weighting is a technique in which amplitude of the Woo filter is taken as the weighting function to the incoming signal. This method enables to suppress PSL beyond Barker codes levels while other performance degradations are minimized [11, 12]. Shown in Fig. 5. The proposed technique produces better PSL and ISL than all other conventional sidelobe reduction

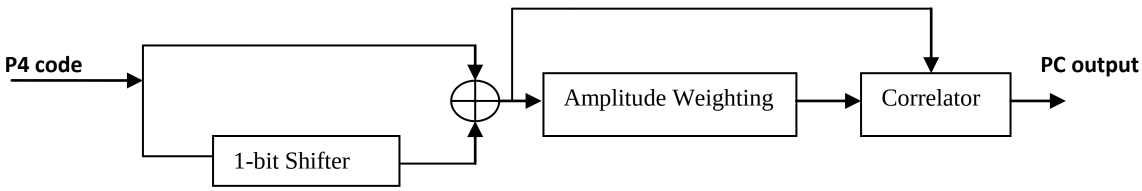

Fig 1: A schematic diagram of proposed pulse compression technique.

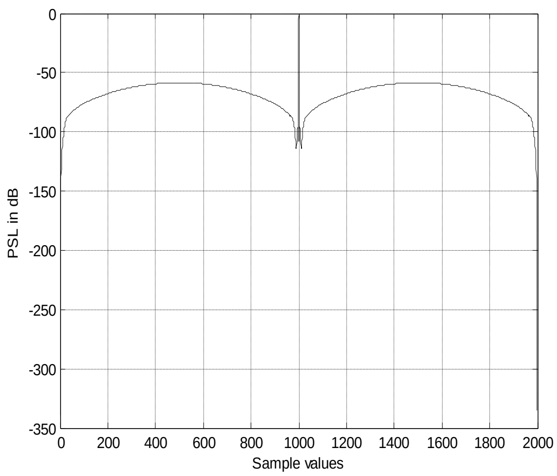

Fig 2: PSL of Amplitude weighting (Blackman)

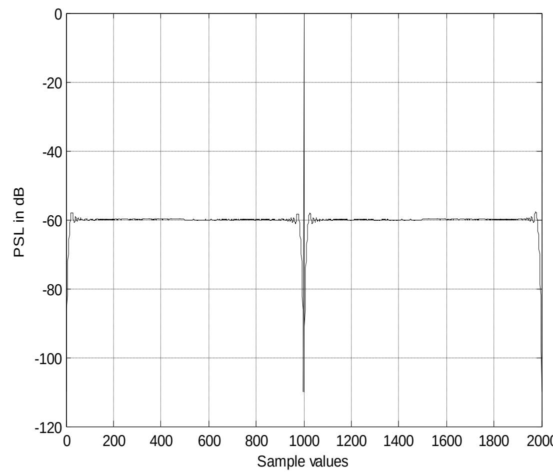

Fig 3: PSL of Woo Filter

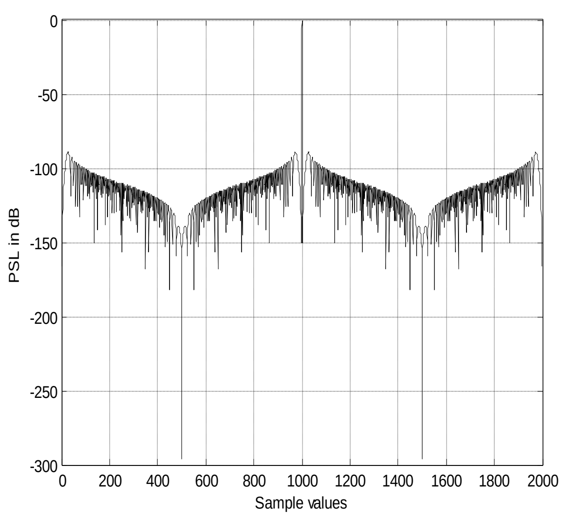

Fig 4: Woo Filter form 2

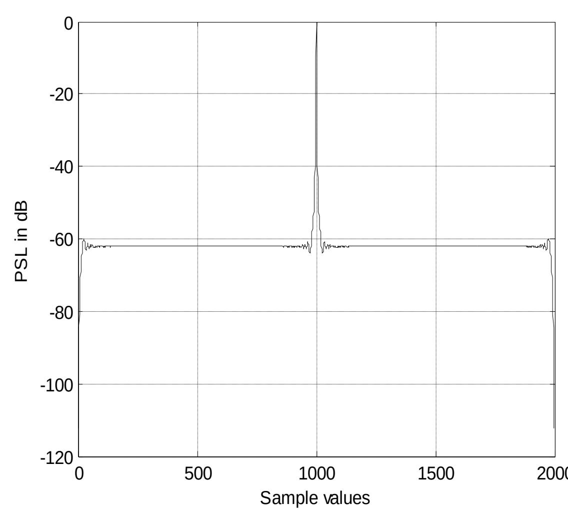

Fig 5: PSL of Asymmetrical weighting

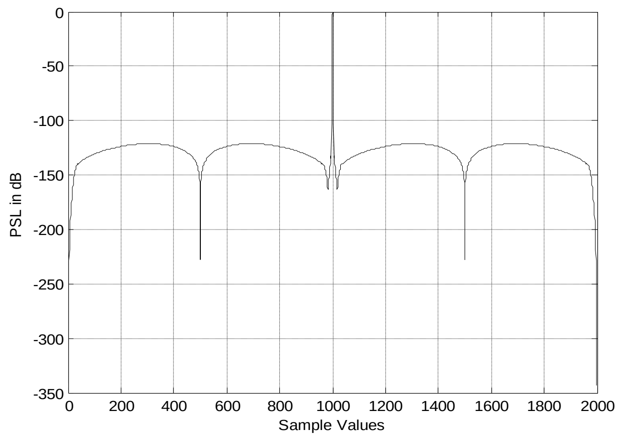

Fig 6: PSL of Proposed pulse compression technique

Table 1: PSL and ISL comparison of various Pulse compression schemes

PC Techniques	PSL[dB]	ISL[dB]	SNR Loss [dB]
New Technique (Blackman)	121.2	95.07	1.268
Amplitude Weighting (Blackman)	58.47	33.21	2.37
Woo Filter	59.83	30.09	3
Woo Filter Form-2	88.67	70.06	3
Asymmetrical weighting	61	30	0.912

techniques and is shown in Fig .6. Tab. 1 shows the comparison of all these techniques. From the table it is clear that the proposed technique with Blackman window yields better PSL and ISL values but the SNR loss is worse than asymmetrical weighing.

4. CONCLUSION

The analysis and simulation in this paper have demonstrated a new pulse compression technique which produces better peak sidelobe and integrated sidelobe ratios while avoiding the mainlobe splitting and maintaining desirable SNR-Loss levels.

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