COMMENT

COMMENT ON ‘MULTI-RANGE-RESOLUTION RADAR USING SIDEBAND SPECTRUM ENERGY’

The prevailing pulse compression technique utilises a matched filter receiver in order to achieve the highest attainable output signal-to-noise ratio (SNR), and relies on a judicious choice of transmitted waveform to achieve range response with narrow mainlobe and low sidelobes. As is well known, the magnitude of the frequency response of the matched filter is identical to the magnitude of the spectrum of the transmitted waveform. The logic is to amplify those frequencies where the signal’s power spectral density is high and attenuate frequencies dominated by noise.

A recently published paper [1] suggests a new pulse compression approach that is the antithesis of the matched filter. Rather than utilising the power in the spectral mainlobe of the transmitted waveform, the suggested mismatched filter attenuates the frequencies occupied by the waveform’s spectral mainlobe and enhances the sidelobe frequencies. In this way, the suggested approach squeezes a 1 ms delay resolution out of an unmodulated 5 ms pulse.

Obviously, the method in [1] throws away most of the power in the transmitted waveform. We will demonstrate it using the example in [1]. In that example, the transmitted sequence s and the mismatched filter h (taken from Table 1 of [1]) are

$$s = [11111]$$

$$\begin{aligned} h = [&212 - 1111\ \ 1111\ \ 26\ \ 0\ \ 185\\ &- 2222\ \ 2222 - 53\ \ 0\ \ 159\\ &- 3333\ \ 3333\ \ 79\ \ 0\ \ 132\\ &- 4444\ \ 4444\ \ 106\ \ 0\ \ 106\ \ 4444\\ &- 4444\ \ 132\ \ 0\ \ 79\ \ 3333 - 3333\ \ 159\ \ 0 - 53\ \ 2222\\ &- 2222\ \ 185\ \ 0\ \ 26\ \ 1111 - 1111\ \ 212]0.0001 \end{aligned}$$

Fig. 1 displays the spectrum of the signal (top) and the frequency response of the filter (bottom). The mismatch between the two is apparent. (The frequency scale is normalised with respect to the duration of a sequence element t_b.)

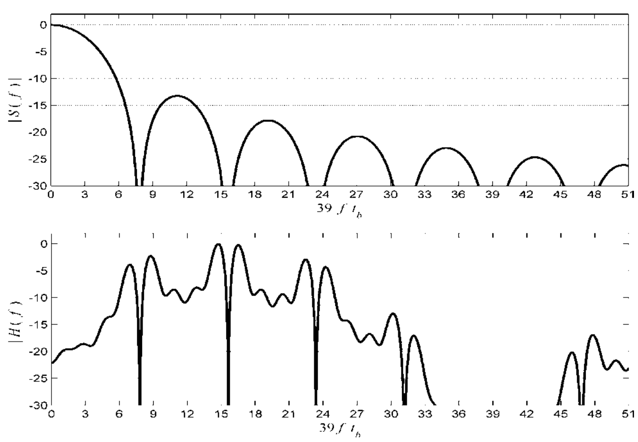

Fig. 1 *Spectrum of signal (top) and frequency response of mismatched filter (bottom)*

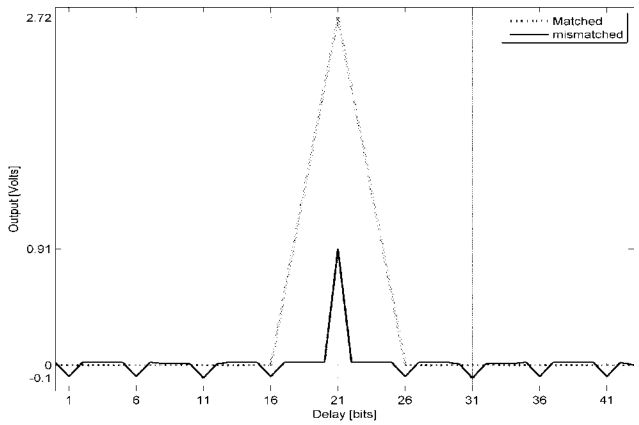

Fig. 2 *Signal response of the matched and mismatched filters having equal noise outputs*

In order to calculate the SNR loss, we will compare the performance of the mismatched filter with that of a matched filter

$$\begin{aligned} h_m = [&0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\\ &1\ 1\ 1\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\\ &0\ 0\ 0\ 0\ 0]0.5448 \end{aligned}$$

The coefficient 0.5448, which multiplies the matched filter sequence, was chosen to obtain the same average noise at the outputs of both processors (assuming white noise at the input), because with this coefficient we obtain

$$hh' = h_m h'_m$$

where h' is the transpose of h. Having set the mean noise output to be equal in both processors, we can now compare the signal outputs. This is obtained by cross-correlating s with h and s with h_m. The results are plotted in Fig. 2. Indeed, the mainlobe was narrowed by a factor of 5. However, the ratio between the two output peaks is 20 $\log_{10}$ (2.724/0.91) = 9.523 dB. Namely, the SNR loss of the proposed mismatched processor is almost 10 dB. To be fair to the paper, the last sentence of its Section 5 states ‘It is indicated that the proposed method improves range resolution at the expense of the output SNR’. The extent of that loss can be further deduced from its Fig. 10, where an ‘Improvement factor’ of 0.1 can be noticed. However, the casual reader may miss the point that such a processor throws away 90% of the received signal power. It is hard to believe that practical radar can tolerate such a loss.

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Reference

1 Shinriki, M., Takase, H., Sato, R., and Susaki, H.: ‘Multi-range-resolution radar using sideband spectrum energy’, *IEE Proc., Radar Sonar Navig.*, 2006, **153**, (5), p. 396-402