Pulsed Range Imaging

A chirp-pulsed radar signal $p(t) = \exp[j(\beta t + \alpha t^2)]$ is used, with pulse duration $T_p = 10\mu s$, i.e. $p(t)$ is nonzero when $t \in [0, T_p]$ and is zero otherwise, carrier frequency is $f_c = 1 \times 10^3$ MHz, baseband bandwidth is $B_0 = 50$ MHz. Five targets are located at $X_c + x_n$, $n = 1, \cdots, 5$, $x_1 = 0$, $x_2 = 0.7X_0$, $x_3 = 0.8X_0$, $x_4 = -0.5X_0$, and $x_5 = 0.3X_0$. The corresponding reflectivity is $\sigma_1 = 1$, $\sigma_2 = 0.8$, $\sigma_3 = 1$, $\sigma_4 = 0.8$, $\sigma_5 = 0.7$, and the mean range of the target scene is $X_c = 2 \times 10^3$ meters. The range swath echo time period is $T_x = 0.67\mu s$. Consider pulse compression for target reconstruction. Since $T_x < T_p$, the Nyquist time-domain sampling space Δ_t for the echoed signal $s(t)$ is less than the Nyquist time-domain sampling space Δ_{tc} for the compressed signal $s_c(t)$. Hence, the measured samples are chosen based on Δ_{tc} which is less restrictive than Δ_t. This results in an aliased baseband-echoed signal. Perform sufficient up-sampling in the compressed signal to convert the time sample spacing from Δ_{tc} to Δ_t. Decompress the upsampled compressed signal to retrieve the alias-free echoed signal which is suitable for matched filtering.

Complete Matlab programming that generates the following results. Submit through UBLearns a report (**a single pdf file**) that includes 1. Figures of the results; 2. Analysis of the results (describe your observations and provide analysis of these observations); 3. Attach the Matlab code **at the end of the report** for all problems. In addition, submit the Matlab code that can be compiled to generate all the results in one .zip file to yl72@buffalo.edu.

Note: this is an individual project and please complete the project independently.

P1.1 Real part of the baseband echoed signal $s_b(t)$ versus the time array t.

P1.2 Real part of the baseband reference reference echoed signal $s_{0b}(t)$ versus t.

P1.3 Baseband-echoed signal spectrum $|S_b(\omega)|$ (i.e. the magnitude of $S_b(\omega)$) versus ω.

P1.4 Baseband reference echoed signal spectrum $|S_{0b}(\omega)|$ versus ω.

P1.5 Baseband matched filtered signal spectrum $|S_{Mb}(\omega)|$ versus ω. Also display $|F(k_x)|$ versus the spatial frequency k_x array.

P1.6 Range reconstruction via baseband matched filtering. Plot the real part of $s_{Mb}(t)$ versus the time t array, and plot the $|f(x)|$ array versus the range x array.

P1.7 Real part of the time domain baseband compressed signal $s_{cb}(t)$ versus t.

P1.8 Range reconstruction via time domain compression, i.e. plot $|S_{cb}(\omega)|$ versus the range x.