ECE678 Radar Engineering   Mark R. Bell
Fall 2024   MSEE 336

Homework Assignment #6
Due Friday, December 6, 2024

Reading Assignment: Coded waveform material in slides and Ch. 8 of Levanon.

1. *Levanon,* 8.1: The first three elements of a length $N = 6$ frequency hopping sequence 2, 4, 5, $*$, $*$, $*$ are 2, 4, 5. For the remaining three elements, find all possible combinations that will yield a Costas sequence.

2. *Levanon,* 8.2: Determine the sidelobe matrix of the Costas sequence

$$5, \ 3, \ 2, \ 7, \ 1, \ 8, \ 4, \ 6, \ 9.$$

3. Find a Costas sequence $\{a_n\}$ of length 16.

4. *Levanon,* 8.14: Learn about Frank codes on pp. 153–159 of Levanon. Then
   (a) Find the Frank code of length 9.
   (b) Calculate and draw its autocorrelation sequence.
5. Using the algorithm presented in class, find a binary complementary code pair of length 8. Calculate and draw its autocorrelation function, assuming that the two sequences are separated by an interval of 9 chip lengths.

6. An *unfocused SAR* is a synthetic aperture radar that forms its synthetic aperture by simply adding the received responses without applying any phase shifts to the returns. As a result, it has a relatively short synthetic aperture length $\mathcal{L}$, because if the aperture is too long, there can be a significant phase difference between the response at the middle and the end of the synthetic aperture. Suppose that the maximal allowed two-way phase difference across the aperture is $\pi/2$.
   (a) Find the maximum length $\mathcal{L}$ of the unfocused SAR aperture as a function of h, the height of the aperture above the surface being imaged. (You may assume $\lambda << h$.)
   (b) Show that the along-track resolution of the unfocused SAR is $\Delta x = (\lambda h)^{1/2}/2$.
7. In order to avoid Doppler ambiguity (aliasing), a SAR's pulse repetition frequency (PRF) must be higher than twice the highest Doppler shift. For a SAR staring broadside, show that the lower limit on the PRF is

$$\mathrm{PRF} \geq \frac{2V}{L},$$

where V is the platform velocity and L is the length of the real antenna aperture (along track).