

**Homework Assignment #6 (Rev 1)**  
Due Friday, December 9, 2022

*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  $\lambda \ll h$ .)
  - (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

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

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