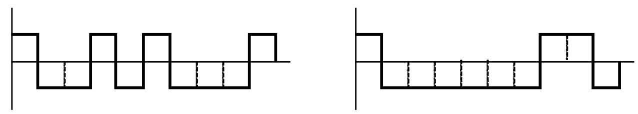
Session 37

Golay Complementary Sequences

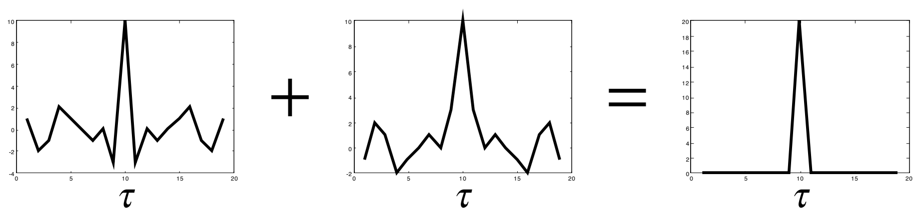
- *Complementary Sequences* are two (or more) phase coded sequences that can be used together to yield good range resolution results.
- Initially introduced by Marcel Golay for the design of optical spectrometers (see Harwit and Sloane, *Hadamard Transform Optics.)*
- One of the first examples of diversity waveform techniques.

Coherent Imaging Combining and Golay Sequences

≤ The Golay sequences provide an example of diversity waveform delay-only imaging.



1. Two complementary sequences are separated in time.
2. Their respective matched filters are time gated to range of interest.
3. Matched filter outputs with appropriate delay are coherently added; the sidelobes are canceled in the process.



Similarly, we will coherently add the individual delay-Doppler images obtained from the individual waveform measurements.

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There are many approaches to constructing Golay complementary pairs. For lengths $N = 2^n$, for $n = 1, 2, 3, \ldots$, the following approach works:

Let $S_0 = [+]$

$$S_1 = [S_0\ S_0] = [+\,+]$$
$$\hat{S}_1 = [S_0\ \bar{S}_0] = [+\,-]$$
} Comp. Pair

(n.b. $\bar{S}_0 = -[S_0]$)

$$S_2 = [S_1\ \hat{S}_1] = [+\,+\,+\,-]$$
$$\hat{S}_2 = [S_1\ \bar{\hat{S}}_1] = [+\,+\,-\,+]$$
} Comp. Pair

$\vdots \qquad \vdots$

$$S_n = [S_{n-1}\ \hat{S}_{n-1}]$$
$$\hat{S}_n = [S_{n-1}\ \bar{\hat{S}}_{n-1}]$$
} Comp. Pair

- Complementary sequences have been effectively used in a number of radar measurement problems where there is not significant motion between measurements. (e.g., sounding of the ionosphere.)

- For non-zero Dopplers, there can be significant sidelobes present (why?)

- Careful time-gating is required to make this work.

- Just separating the two waveforms and running a matched filter for the composite ambiguity function yields the following response:

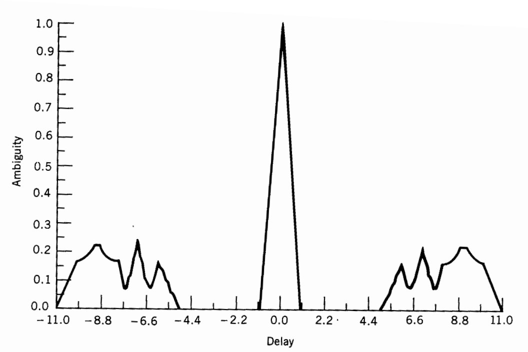


Figure 8.10 *A zero-Doppler cut of the ambiguity function of the complementary phase-coded pair [+ + − ; + j +].*

Figures from Levanon, *Radar Principles,*Chapter 8.

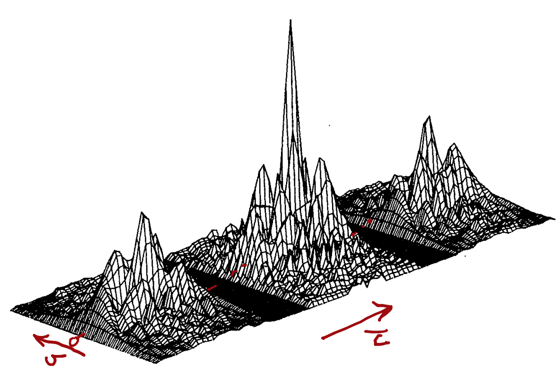


Figure 8.11 *The ambiguity function of the complementary phase-coded pair [+ + − ; + j +].*

Synthetic Aperture Radar

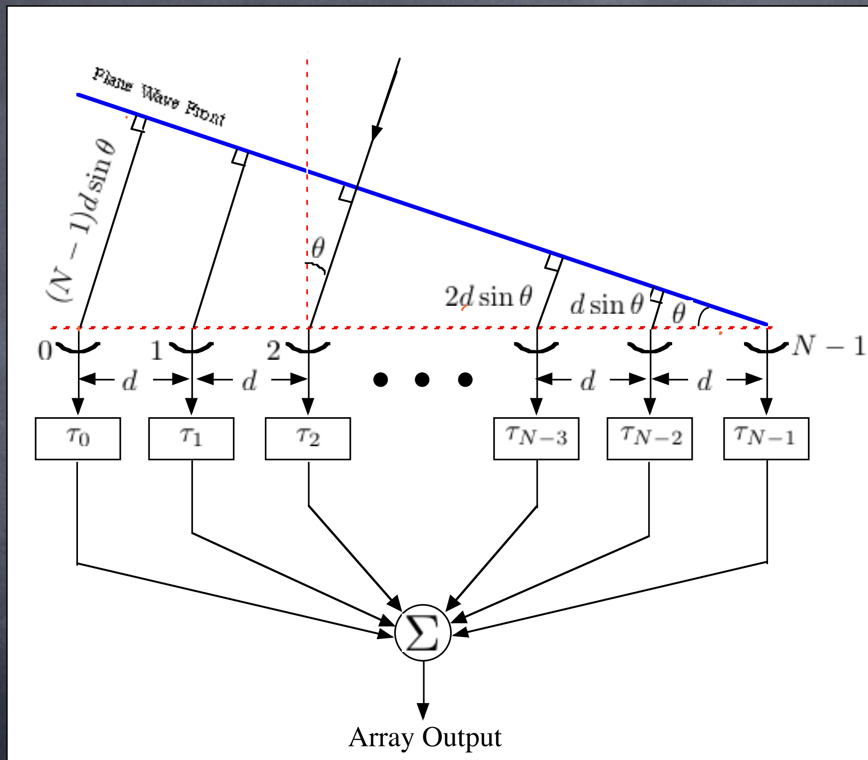
We will look at SAR from the point-of-view of Antenna Arrays

- Large antennas can be formed by arraying a number of smaller antennas.
- Three main benefits:
  1. Increased Gain
  2. Increased Directivity
  3. Electrically Steerable (Big advantage!)

Real Antenna Arrays

- Arrays can be formed in 1, 2, or 3 dimensions.
- An antenna aperture generated in this way is called an array antenna.
- The individual antennas making up the array are called array elements.

One-Dimensional Uniform Array



Linear Array Principle of Operation