WEEK 15

7.2 Figure P7.2 shows a four-stage feedback shift register. The initial state of the register is 1000. Find the output sequence of the shift register.

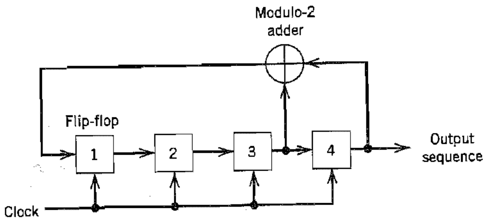

FIGURE P7.2

7.3 For the feedback shift register given in Problem 7.2, demonstrate the balance property and run property of a PN sequence. Also, calculate and plot the autocorrelation function of the PN sequence produced by this shift register.

7.4 Referring to Table 7.1, develop the maximal-length codes for the three feedback configurations [6, 1], [6, 5, 2, 1], and [6, 5, 3, 2], whose period is $N = 63$.

7.5 Figure P7.5 shows the modular multitap version of the linear feedback shift-register shown in Figure 7.4*b*. Demonstrate that the PN sequence generated by this scheme is exactly the same as that described in Table 7.2*b*.

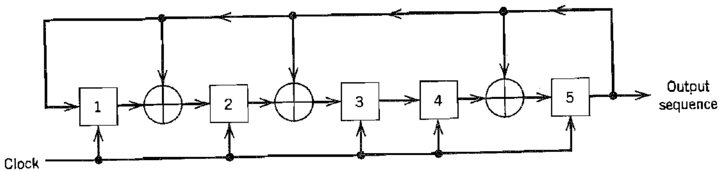

FIGURE P7.5

Direct Sequence/Phase-Shift Keying System

7.6 Show that the truth table given in Table 7.3 can be constructed by combining the following two steps:

(a) The message signal $b(t)$ and PN signal $c(t)$ are added modulo-2.

(b) Symbols 0 and 1 at the modulo-2 adder output are represented by phase shifts of 0 and 180 degrees, respectively.

7.7 A single-tone jammer

$$j(t) = \sqrt{2J}\cos(2\pi f_c t + \theta)$$

is applied to a DS/BPSK system. The N-dimensional transmitted signal $x(t)$ is described by Equation (7.16). Find the 2N coordinates of the jammer $j(t)$.

7.8 The processing gain of a spread-spectrum system may be expressed as the ratio of the spread bandwidth of the transmitted signal to the despread bandwidth of the received signal. Justify this statement for the DS/BPSK system.

7.9 A direct-sequence spread binary phase-shift keying system uses a feedback shift register of length 19 for the generation of the PN sequence. Calculate the processing gain of the system.

7.10 In a DS/BPSK system, the feedback shift register used to generate the PN sequence has length $m = 19$. The system is required to have an average probability of symbol error due to externally generated interfering signals that does not exceed 10^{-5}. Calculate the following system parameters in decibels:

(a) Processing gain.

(b) Antijam margin.

7.11 In Section 7.5, we presented an analysis on the signal-space dimensionality and processing gain of a direct sequence spread-spectrum system using binary phase-shift keying. Extend the analysis presented therein to the case of such a system using quadriphase-shift keying.

Frequency-Hop Spread Spectrum

7.12 A slow FH/MFSK system has the following parameters:

Number of bits per MFSK symbol = 4

Number of MFSK symbols per hop = 5

Calculate the processing gain of the system.

7.13 A fast FH/MFSK system has the following parameters:

Number of bits per MFSK symbol = 4

Number of hops per MFSK symbol = 4

Calculate the processing gain of the system.

Computer Experiments

7.14 Consider two PN sequences of period $N = 63$. One sequence has the feedback taps [6, 1] and the other sequence has the feedback taps [6, 5, 2, 1], which are picked in accordance with Table 7.1.

(a) Compute the autocorrelation function of these two sequences, and their cross-correlation function.

(b) Compare the cross-correlation function computed in part (a) with the cross-correlation function between the sequence [6, 5 2, 1] and its mirror image [6, 5, 4, 1].

Comment on your results.

7.15 (a) Compute the partial cross-correlation function of a PN sequence with feedback taps [5, 2] and its image sequence defined by the feedback taps [5, 3].

(b) Repeat the computation for the PN sequence with feedback taps [5, 2] and the PN sequence with feedback taps [5, 4, 2, 1].

(c) Repeat the computation for the PN sequence with feedback taps [5, 4, 3, 2] and the PN sequence with feedback taps [5, 4, 2, 1].

The feedback taps [5, 2], [5, 4, 3, 2], and [5, 4, 2, 1] are possible taps for a maximal-length sequence of period 31, in accordance with Table 7.1.