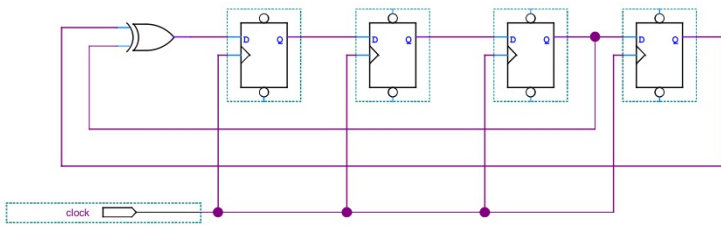# PN Sequences and Spread-Spectrum

Exercise 1: How many bits are there in an m-sequence for $m = 6$? How many are 1's? How many are 0's?

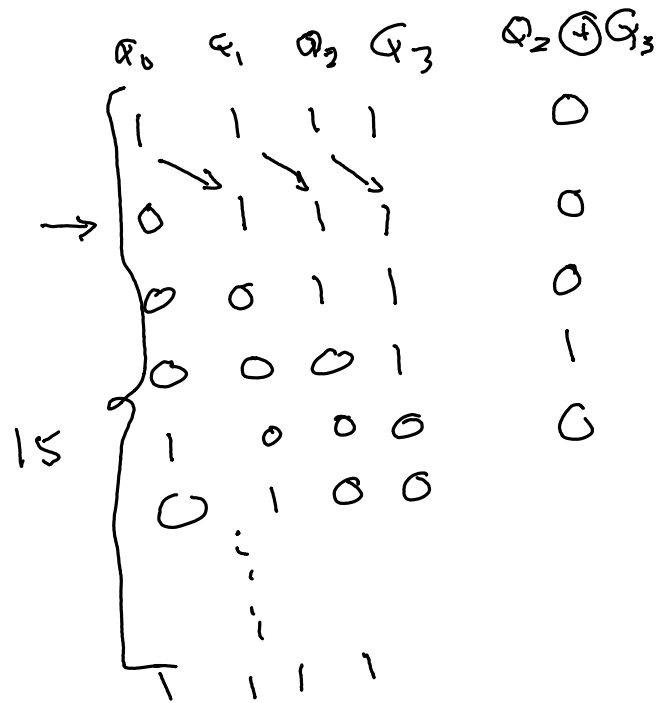$$\text{period} = 2^6 - 1 = 63$$

$$2^{m-1} = 32 \quad 1's$$

$$2^{m-1} - 1 = 31 \quad 0's$$

Exercise 2: If the initial value of each flip-flop is 1, what are the values of the next 4 bits output by the right-most flip-flop?

$$m = 4$$

$$\text{period} = 2^4 - 1 = 15$$

Q_0	Q_1	Q_2	Q_3	$Q_2 \oplus Q_3$
1	1	1	1	0
0	1	1	1	0
0	0	1	1	0
0	0	0	1	1
1	0	0	0	0
0	1	0	0	0
⋮				
1	1	1	1	

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Exercise 3: How many flip-flops would be required to generate a ML PRBS of period 8191? How many ones would the sequence have? What is the longest sequence of 0's?

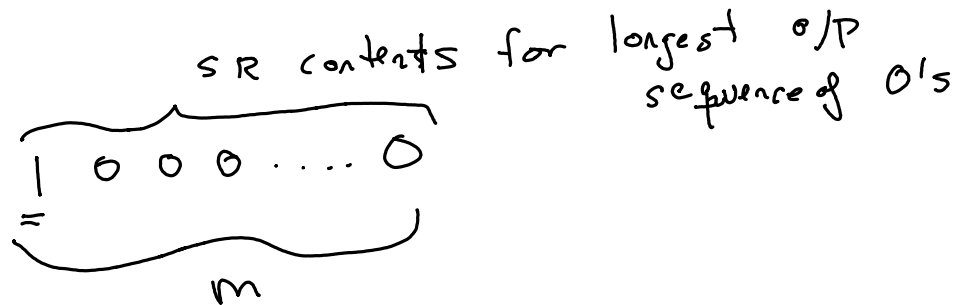$$\text{period} = 8191 = 2^m - 1$$

$$m = \log_2(8191 + 1)$$

$$8k = 2^3 \cdot 2^{10}$$

$$1s = \frac{8192}{2} = 4096 \qquad = 13$$

$$0's \qquad = 4095$$

SR contents for longest o/p sequence of 0's

$$= \underbrace{\begin{array}{ccccc} 1 & 0 & 0 & 0 \cdots \cdots & 0 \end{array}}_{m}$$

$$m - 1 = 12$$

Exercise 4: Derive H_2 and H_4. Show that the first two rows and last two columns of each matrix are orthogonal.

$$H_1 = [1]$$

$$H_2 = \begin{bmatrix} 1 & 1 \\ 1 & \sim1 \end{bmatrix} \leftarrow$$

$$H_4 = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & \sim1 & 1 & \sim1 \\ 1 & 1 & -1 & -1 \\ 1 & \sim1 & -1 & +1 \end{bmatrix} \Big\}$$

$$1\cdot1 + 1\cdot(-1) + 1\cdot1 + 1\cdot(-1)$$

$$= 1 - 1 + 1 - 1 = 0$$

$$1 - 1 + 1 - 1 = 0$$

Exercise 5: Show this.

$$\underline{a} = \begin{array}{cccc} 1 & 1 & 1 & 1 \end{array}$$

$$\underline{b} = \begin{array}{cccc} 1 & -1 & -1 & 1 \end{array}$$

$$\begin{array}{cccc} a & a & a & a \\ b & -b & -b & b \end{array}$$

first user:

$$\begin{array}{cccc} \underline{a+b} & \underline{a-b} & \underline{a-b} & \underline{a+b} \\ 1 & 1 & 1 & 1 \end{array}$$

$$\sum \quad a+b \quad a-b \quad a-b \quad a+b$$

$$4a + 0b$$

Second user:

$$\begin{array}{cccc} 1 & -1 & -1 & 1 \end{array}$$

$$\sum \quad a+b \quad -a+b \quad -a+b \quad a+b$$

$$0a + 4b$$

Exercise 6: Consider a 30 kHz signal. What is the SIR if a jammer is transmitting on the same frequency with equal received power? If the jammer is on a different frequency? What is the SIR if DSSS with a spreading factor of 100 is used? Does the SIR depend on the jammer's frequency?

Exercise 7: Why do all the downlink codes have the same delay? Why do different user's uplink signals have different delays?

Exercise 8: Is BT FFH or SFH?

not covered (not enough time) See solutions from 2019 if interested.