

1) A systematic [10,6] block code has parity check equations $p_1 = m_1 + m_2 + m_6$, $p_2 = m_3 + m_4 + m_5$, $p_3 = m_2 + m_3 + m_6$, and $p_4 = m_1 + m_3 + m_4$.

1a) [10] Find a Generator Matrix of the form $\underline{\mathbf{G}} = [\underline{\mathbf{P}} | \underline{\mathbf{I}}]$

[Answer: $\underline{\mathbf{G}} =$ 1001 100000
1010 010000
0111 001000
0101 000100
0100 000010
1010 000001]

1b) [10] Find the Parity Check Matrix $\underline{\mathbf{H}}$.

[$\underline{\mathbf{H}} =$ 1000 110001
0100 001110
0010 011001
0001 101100]

1c) [10] If the vector [1110100110] is received, compute the syndrome vector \vec{s} . [0110]

1d) [5] Is the vector [1110100110] a legal code word? Explain. [No. The syndrome vector should be [0000] if legal.]

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2) A signal has an autocorrelation function $R_{XX}(\tau) = 4 + 4/(1 + 800\tau^2)$.

2a) [15] What percentage of the signal is DC power? [50%]

2b) [20] The signal $x(t)$ is input to an bandpass antenna with transfer function $H(f) = 1.0$, $10 \leq |f| \leq 20$ Hz. **Compute** the signal power at the antenna output. [Hint: Recall Duality states that if $x(t)$ and $X(f)$ form a Fourier Transform pair, then $x(-f)$ and $X(t)$ also form a Fourier Transform pair.] [0.3869 watts]

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3) A photo detector circuit (an active device), hereafter referred to as simply a photo detector, on a 10 Gbps fiber optic system has -26 dBW of optical signal power and -40 dBW of optical noise power as input, and a Noise Bandwidth of 10 GHz. The output is observed to have -28.2 dBW of electrical signal power and -40 dBW of electrical noise power. Note that the standard noise models discussed in Chapter 5 and in class apply here.

[10] **Compute** the Power Gain of the photo detector. [-2.2 dB = 0.6025]

[10] **Compute** the Noise Temperature of the photo detector. [119.6 M degrees K]

[10] The signal output of the photo detector is either a $T = 1/(10^{10})$ second Logic 1 pulse of the form $s_1(t) = A$ volts; or a T second Logic 0 of the form $s_0(t) = 0$ volts. **Compute** the value of A .

[0.05503 volts]

[10] The photo detector is followed by a *single sample* bit detector. **Compute** P(Bit Error).

[0.002962]

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4) A 19 Mbps High Definition TV signal is being transmitted using a center frequency of 1.91 GHz. The transmitter site has an EIRP of 1.8 watts. The receiver consists of an omni-directional antenna with an antenna gain of 1.13, a 30 foot cable run with a line loss of 4.0 dB per 100 feet, and a coherent Matched Filter detector with a noise figure of 16dB, attached in the order listed. Other losses are known to be 1.3 dB. The receiver antenna temperature is 360 degrees Kelvin. Suppose a $P(\text{Bit Error}) \leq 0.0001$ is required for successful operation. Note $Q(3.719) = 0.0001$.

[40] **Compute** the maximum possible transmission distance if coherent BPSK is being used.

[2.921 Km]

[10] *Extra Credit.* **Compute** the maximum possible transmission distance for coherent QPSK.

[2.921 Km]

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