Date assigned: $\quad 2 / 14 / 2008$
Date due: $\quad 2 / 21 / 2008$

## Solution 4.1

|  | 011010000100011000000010 |
| :--- | :--- |
| (a) | $0-+0-0000+000-+0000000-0$ |
| (b) | $0+-0+0000-000+-0000000+0$ |
| (c) | $(+0+) 0-+0-(00-) 0+(00+)-+(-0-)(+0+) 0-0$ |
| (d) | $0-+0-0000+000-+(0+-0-+) 0-0$ |

## Solution 4.2

The average pulse density of bipolar line coding before the substitution is $50 \%$ if we assume that 1 's and 0's in message are equally likely. Since B3ZS replaces 3 consecutive zeros, we make the following table to see how often we see at least three consecutive zeros:

| First 3 <br> bit <br> string | Second 3 bit string to <br> make consecutive zeros | Possibility <br> Of seeing three <br> consecutive <br> zeros <br> combination |
| :--- | :--- | :--- |
| 000 | All combinations | $1 / 8$ |
| 001 | none | 0 |
| $01 \underline{0}$ | $\underline{001}$ | $(1 / 8)(1 / 8)$ |
| 011 | none | 0 |
| $1 \underline{00}$ | $\underline{\underline{00} 1, \underline{0} 10, \underline{0} 11}$ | $3(1 / 8)(1 / 8)$ |
| 101 | none | 0 |
| $1 \underline{1} \underline{0}$ | $\underline{001}$ | $(1 / 8)(1 / 8)$ |
| 111 | none | 0 |

From the last column of the above table, on average we see at least three consecutive zeros $=$ $1 / 8+5^{*}(1 / 8)(1 / 8)=0.2031$.
Since every three consecutive zeros are replaced either by two zero single pulse sequence or single two pulse sequence, on average, three zeros are replaced by 1.5 pulses 1.5 zeros.
Therefore, the new pulse density after B3ZS encoding is
New Pulse density $=0.5+0.2031 * 0.5=0.6016$

## Solution 4.3

Using the probability of error formula for polar signals

$$
P_{b}=Q\left(\frac{A}{\sigma}\right)=10^{-6} \quad \frac{A}{\sigma}=Q^{-1}\left(10^{-6}\right)=4.7534 \quad S N R=\frac{A^{2}}{\sigma^{2}}=13.6 \mathrm{~dB}
$$

Thus, the SNR requirement for a BER of $10^{-6}$ is determined to be 13.6 dB . Using a 1 Watt signal power for convenience, the noise power for 13.6 dB SNR is 0.043 . Similarly, crosstalk power that is 16 dB below 1 Watt is 0.025 W . The transmit power required to overcome the effects of the crosstalk is determined from the ratios:
(a) $(1 / .043)=\mathrm{PT} /(0.043+0.025), \mathrm{PT}=1.48 \mathrm{~W}=1.99 \mathrm{~dB}$ penalty.
(b) $(1 / .043)=\mathrm{PT} /(0.043+0.025 \mathrm{PT}), \mathrm{PT}=2.39 \mathrm{~W}=3.78 \mathrm{~dB}$ penalty

