CpE 319 Assignment 3

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1 Problem 2.15

We can relate bandwidth (W) and data rate (B) using the Nyquist theorem as follows:

$$W = \frac{B}{2log_2 M} \tag{1}$$

- NRZ: $W = \frac{B}{2log_2 2} = {}^1/_2 B$

  NRZ uses two symbols, and transitions at most once per bit, meaning that the baud rate and bit rate are the same.

- MLT-3: $W = \frac{2B}{2log_2 3} \approx 0.63B$

  MLT-3 uses three symbols and transitions at most twice per bit, meaning that the baud rate is twice the bit rate.

- Manchester: $W = \frac{2B}{2log_2 2} = B$

  Manchester Encoding uses two symbols but transitions at most twice per bit, meaning the baud rate is twice the bit rate.

2 Problem 2.16

We will consider 4B/5B encoding for an NRZ-I scheme, since for NRZ-L, 4B/5B does not guarantee a transition every four bits. With 4B/5B, we can examine the code and determine that at most there will be three consecutive 0 bits transmitted. This is due to the codes 10100 and 11100 terminating with two zeroes. If they are followed by a code beginning with a 0 bit, three 0s will be transmitted. Thus, the worst case for lack of transmissions is 1000 or 0001: a transition followed by 3 non-transitions, or vice versa. In either case, a transition occurs at least once in every four bits.

3 Problem 2.18

A 1 MHz line can support 200 simultaneous 4kHz connections with a 1kHz guard band between each 4kHz band. If each phone makes 4 calls over 8 hours, each lasting 6 minutes, each line can support $(8*60)/(6*4) = 20$ phones. If 10% of the usage of those phones is long-distance calls, the end office can support a maximum of $10 * 20 * 200 = 40000$ phones.

An end-office may choose to support far fewer phones because if resource demand increases or fluctuates (e.g. most long-distance calls are placed in the afternoon), they will be unable to serve the added demand.

4 Problem 2.22

$4 * 1200 = 4800$ bits/sec

5 Problem 2.25

We will have 10 signals at 4000Hz and nine guard bands at 400 Hz, so the total required bandwidth is $10 * 4000 + 9 * 400 = 43600$ kHz.

6 Problem 2.28

6.1 Part a

$C = 2 * 4kHz * 2\text{bits/symbol} = 16kbps$

6.2 Part b

With T1, we transmit 7 data bits per channel every 125 μsec.

Thus, for one channel, our data rate is $\frac{7}{8} \times \frac{1}{125 \times 10^{-6}} \approx 0.57kbps$.

7 Problem 2.31

SONET transfers bits at the rate of 51.84×10^6 bits/sec. If the clock takes 10×10^9 seconds to drift 1 second, it will take 51.84×10^3 seconds for it to drift the width of one bit. This means that the clock will need to be resyncrhonized at least every 14.4 hours.