Chapter 2

1. If a binary signal is sent over a 3-kHz channel whose signal-to-noise ratio is 20 dB, what is the maximum achievable data rate?

Nyquist: $2 \times 3 \times \log_2 2 = 6$ kbps

Shannon: $10 \log_{10}(S/N) = 20$ dB $\therefore S/N = 100$ $\quad 3 \log_2 101 = 19.97$ kbps $\quad \therefore$ the maximum rate is 6 kbps.

2. What signal-to-noise ratio is needed to put a T1 carrier on a 50-kHz line?

T1 standard rate = 1.544 Mbps $\quad 1.544$ Mbps $= 50$ kHz $\log_2(1+S/N)$

$\therefore S/N = 1.976 \times 10^9 \quad 10\log_{10}(S/N) = 92.96$ dB

3. Ten signals, each requiring 4000 Hz, are multiplexed on to a signal channel using FDM. How much minimum bandwidth is required for the multiplexed channel? Assume that the guard bands are 400 Hz wide.

$4000 \times 10 + 400 \times 9 = 43600$ Hz

Chapter 3

1. A bit string, 0111101111101111110, needs to be

transmitted at the data link layer. What is the string actually transmitted after bit stuffing?

0111110111110011111010 blue char is added character

2. What is the remainder obtained by dividing x^7 + x^5+1 by the generator polynomial x^3 +1 ? (注：x^7 表示 x 的 7 次方，其它表述方式相同)

10100001

1001

过程见本文档最后，remainder is x^2+x+1

3 Data link protocols almost always put the CRC in a trailer rather than in a header. Why?

Sender's hardware circuitry can calculate CRC checksum as it sends and append it to trail, receiver can calculate the CRC checksum as it receives and compare it to trail.

4. Frames of 1000 bits are sent over a 1-Mbps channel using a geostationary satellite whose propagation time from the earth is 270 msec. Acknowledgements are always piggybacked onto data frames. The headers are very short. Three-bit sequence numbers are used. What is the maximum achievable channel utilization for

RTT = 540 ms

window size = 8

a) (a) Stop-and-wait. → 0.1845%
b) (b) Protocol 5 (GBN) → 1.2915%
c) (c) Protocol 6 (Selective Repeat) → 0.738%

5. What is the minimum overhead to send an IP packet using PPP? Count only the overhead introduced by PPP

itself, not the IP header overhead.

2 flag + 1 protocol + 2 checksum = 5 bytes

================ ============ ============

Char 3.

2.

```
          10110111
1001 ) 10100001000
       1001
       0110
       0000
        1100
        1001
         1010
         1001
          0111
          0000
           1110
           1001
            1110
            1001
             1110
             1001
              111
```

4, RTT = 540 ms window size = 8 Frame size = 1000 bits channel: 1 Mbps

(a) $\mu = \frac{1000 \div 10^6}{0.54 + 2 \times 1000 \div 10^6} = 0.1845\%$

(b) $\mu = \frac{7 \times \frac{1000}{10^6}}{0.54 + 2 \times 1000 \div 10^6} = 1.2915\%$

(c) receive window size = $(7+1)/2 = 4$.

$\mu = \frac{4 \times \frac{1000}{10^6}}{0.54 + 2 \times \frac{1000}{10^6}} = 0.738\%$.