5.20 From the text, $(SNR)_{db} = 6.02\ n + 1.76$, where n is the number of bits used for quantization. In this case, $(SNR)_{db} = 60.2 + 1.76 = 61.96$ dB.

5.21 **a.** $(SNR)_{db} = 6.02\ n + 1.76 = 30$ dB

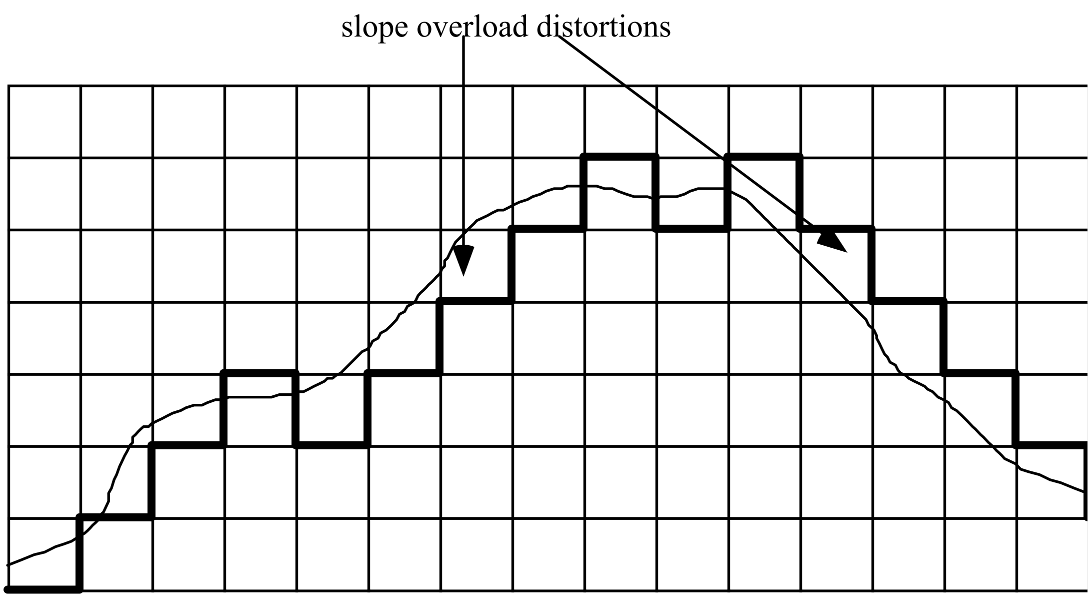
$n = (30 - 1.76)/6.02 = 4.69$

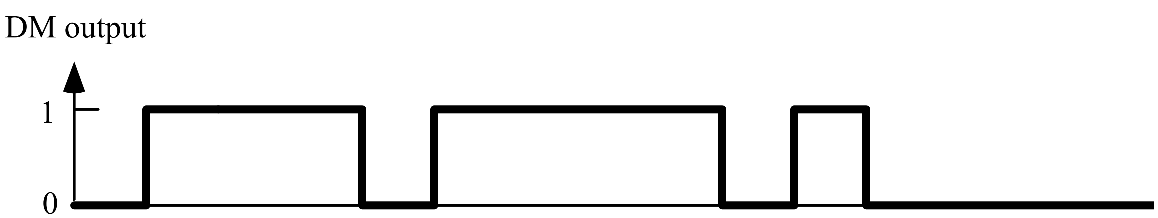
Rounded off, n = 5 bits

This yields $2^5 = 32$ quantization levels

b. R = 7000 samples/s × 5 bits/sample = 35 Kbps

5.24





6.1 **a.** Each character has 25% overhead. For 10,000 characters, there are 20,000 extra bits. This would take an extra 20,000/2400 = 8.33 seconds.

b. The file takes 10 frames or 480 additional bits. The transmission time for the additional bits is 480/2400 = 0.2 seconds.

c. Ten times as many extra bits and ten times as long for both.

d. The number of overhead bits would be the same, and the time would be decreased by a factor of 4 = 9600/2400.

6.2 For each case, compute the fraction g of transmitted bits that are data bits. Then the maximum effective data rate R is: R = gx, where x is the data rate on the line.

a. There are 7 data bits, 1 start bit, 1.5 stop bits, and 1 parity bit

$$g = 7/(1 + 7 + 1 + 1.5) = 7/10.5 = 0.67$$

$$R = 0.67\ x$$

b. Each frame contains 48 control bits + 128 information bits = 176 bits. The number of characters is 128/8 = 16, and the number of data bits is $16 \times 7 = 112$.

$$R = (112/176)B = 0.64x$$

c. Each frame contains 48 + 1024 = 1072 bits. The number of characters is 1024/8 = 128, and the number of data bits is $128 \times 7 = 896$.

$$R = (896/1072)B = 0.84x$$

6.11 a.

```
                                  1000100010011000
10001000000100001/10000000000000000000000000000000
                  10001000000100001
                      10000001000010000
                      10001000000100001
                          10010001100010000
                          10001000000100001
                             11001100110001000
                             10001000000100001
                              10001001101010010
                              10001000000100001
                  remainder =     0001101110011000
```

6.13

```
            10110110
110011/1110001100000
       110011
         101111
         110011
           111000
           110011
             101100
             110011
              111110
              110011
      CRC =    11010
```

6.15 **a.** Divide $X^{10} + X^7 + X^4 + X^3 + X + 1$ by $X^4 + X + 1$. The remainder is $X^3 + X^2$. The CRC bits are 1100. The string 100100110111100 is sent.

b. The string 000110110111100 is received, corresponding to $X^{11} + X^{10} + X^8 + X^7 + X^5 + X^4 + X^3 + X^2$. The remainder after division by $X^4 + X + 1$ is $X^3 + X^2 + X$, which is nonzero. The errors are detected.

c. The string 000010110111100 is received, corresponding to $X^{10} + X^8 + X^7 + X^5 + X^4 + X^3 + X^2$. The remainder after division by $X^4 + X + 1$ is zero. The errors are not detected.

7.3 Let L be the number of bits in a frame. Then, using Equation 7.5 of Appendix 7A:

$$a = \frac{\text{Propagation Delay}}{\text{Transmission Time}} = \frac{20 \times 10^{-3}}{L/\left(4 \times 10^3\right)} = \frac{80}{L}$$

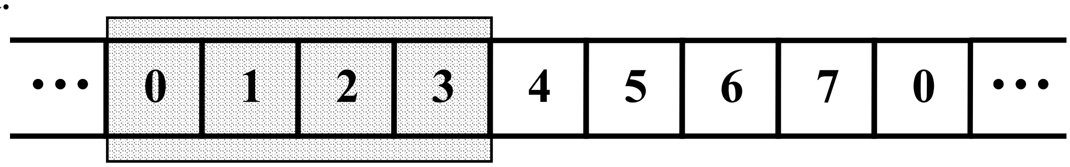
Given U=1/(1+2a)

$$U = \frac{1}{1+2a} = \frac{1}{1+\left(160/L\right)} \geq 0.5$$

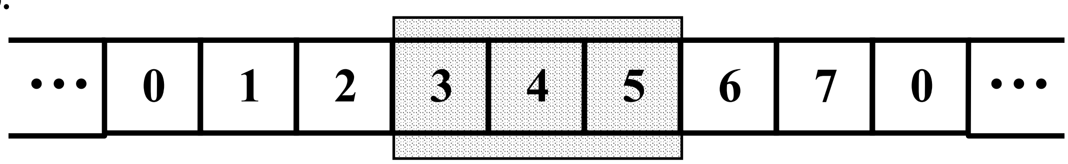
$$L \geq 160$$

Therefore, an efficiency of at least 50% requires a frame size of at least 160 bits.

7.10 **a.**



b.



c.