

### Solution to HW3

#### 8.18 (18pts)

a. Assume a continuous stream of STDM frames. Then:

Bit rate for data portion of frame =  $L$  bits/second

Frame rate in frames per second =  $(C \text{ bits/second}) / (F \text{ bits/frame})$

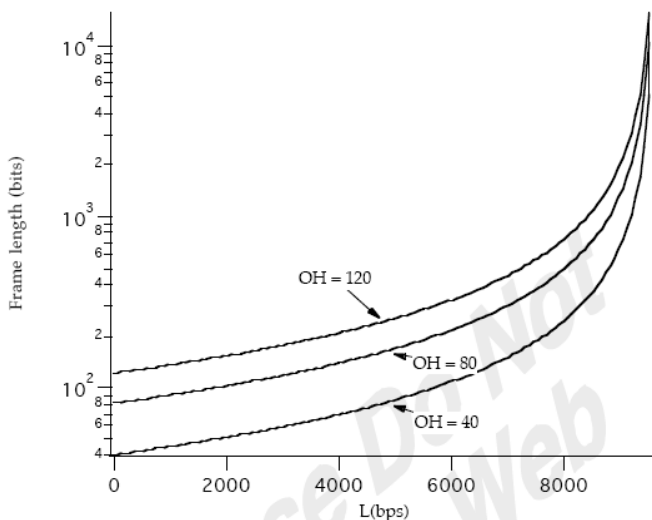
Bit rate for overhead =  $(OH \text{ bits/frame}) \times (C/F \text{ frames/second})$

Total data rate =  $C = L + ((C \times OH) / F) \text{ bits/second}$

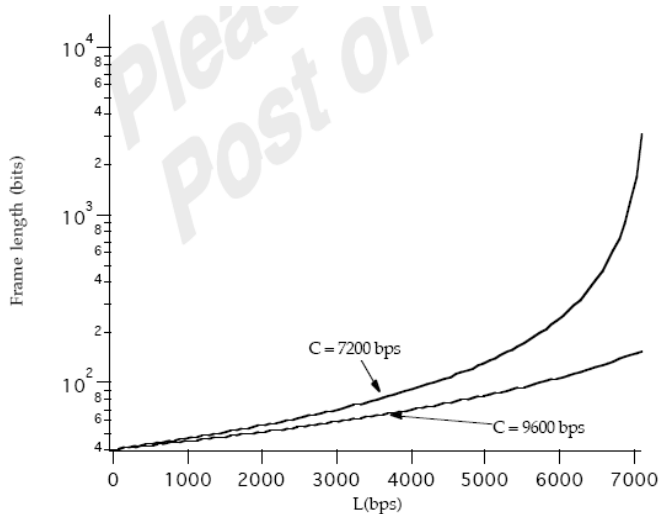
$F = (C \times OH) / (C - L) \text{ bits}$

If we fix the number of overhead bits (OH), we can vary the percent of overhead by varying  $F$ .

b.



c.



#### 6.2 (15 pts)

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

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

$$R = 0.67x$$

**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  $128 \times 7 = 896$ .

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

### 6.5 & 6.6 (12 pts)

**1)** Let the bit duration be  $T$ . Then a frame is  $12T$  long. Let a clock period be  $T'$ . The last bit (bit 12) is sampled at  $11.5T'$ . For a fast running clock, the condition to satisfy is

$$11.5T' > 11T \Rightarrow \frac{T}{T'} < \frac{11.5}{11} = 1.045 \Rightarrow f_{clock} < 1.045 f_{bit}$$

For a slow running clock, the condition to satisfy is

$$11.5T' < 12T \Rightarrow \frac{T}{T'} > \frac{11.5}{12} = 0.958 \Rightarrow f_{clock} > 0.958 f_{bit}$$

Therefore, the overall condition:  $0.958 f_{bit} < f_{clock} < 1.045 f_{bit}$

**2)** In worst-case conditions, the two clocks will drift in opposite directions. The resultant accuracy is 2 minutes in 1 year or:

$$2/(60 \times 24 \times 365) = 0.0000038$$

The allowable error is 0.4

Therefore, number of bits is  $0.4/0.0000038 = 105,000$  bits

### 6.10 (12 pts)

**a.** We have:

$$\text{Pr [single bit in error]} = 10^{-3}$$

$$\text{Pr [single bit not in error]} = 1 - 10^{-3} = 0.999$$

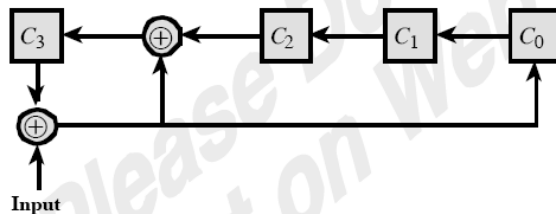
$$\text{Pr [8 bits not in error]} = (1 - 10^{-3})^8 = (0.999)^8 = 0.992$$

$$\text{Pr [at least one error in frame]} = 1 - (1 - 10^{-3})^8 = 0.008$$

**b.** Pr [at least one error in frame] =  $1 - (1 - 10^{-3})^{10} = 1 - (0.999)^{10} = 0.01$

### 6.14 (18 pts)

**a.**



b. Data = 10011011100

$$M(X) = 1 + X^3 + X^4 + X^6 + X^7 + X^8$$

$$X^4M(X) = X^{12} + X^{11} + X^{10} + X^8 + X^7 + X^4$$

$$\frac{X^4M(X)}{P(X)} = X^{12} + X^{11} + X^{10} + X^8 + X^7 + \frac{X^2}{P(X)}$$

$$R(X) = X^2$$

$$T(X) = X^4M(X) + R(X) = X^{12} + X^{11} + X^{10} + X^8 + X^7 + X^4 + X^2$$

$$\text{Code} = 001010011011100$$

For binary division steps, follow the example on pp.191 to obtain the remainder.

c. Code = 001010001011100

$$\frac{T(X)}{P(X)} \text{ yields a nonzero remainder}$$

**6.17(15 pts)**

a.

	00000	10101	01010
00000	0	3	2
10101	3	0	5
01010	2	5	0

b.

	000000	010101	101010	110110
000000	0	3	3	4
010101	3	0	6	3
101010	3	6	0	3
110110	4	3	3	0

**7.1 (12 pts)**

- a. Because only one frame can be sent at a time, and transmission must stop until an acknowledgment is received, there is little effect in increasing the size of the message if the frame size remains the same. All that this would affect is connect and disconnect time.
- b. Increasing the number of frames would decrease frame size (number of bits/frame). This would lower line efficiency, because the propagation time is unchanged but more acknowledgments would be needed.
- c. For a given message size, increasing the frame size decreases the number of frames. This is the reverse of (b).

**7.5 (10 pts)**

A → B: Propagation time =  $4000 \times 5 \mu\text{sec} = 20 \text{ msec}$

Transmission time per frame =  $1000 / (100 \times 10^3) = 10 \text{ msec}$

B → C: Propagation time =  $1000 \times 5 \mu\text{sec} = 5 \text{ msec}$

Transmission time per frame =  $x = 1000/R$

$R$  = data rate between B and C (unknown)

A can transmit three frames to B and then must wait for the acknowledgment of the first frame before transmitting additional frames. The first frame takes 10 msec to transmit; the last bit of the first frame arrives at B 20 msec after it was transmitted, and therefore 30 msec after the frame transmission began. It will take an additional 20 msec for B's acknowledgment to return to A. Thus, A can transmit 3 frames in 50 msec.

B can transmit one frame to C at a time. It takes  $5 + x$  msec for the frame to be received at C and an additional 5 msec for C's acknowledgment to return to A. Thus, B can transmit one frame every  $10 + x$  msec, or 3 frames every  $30 + 3x$  msec. Thus:

$$30 + 3x = 50$$

$$x = 6.66 \text{ msec}$$

$$R = 1000/x = 150 \text{ kbps}$$