1. A cable company uses one of the cable TV channels (with a bandwidth of 6 MHz) to provide digital communication for each resident. What is the available data rate for each resident if the company uses a 64-QAM technique?

$B = (1+d)S = S, \quad (d=0), \quad L = 64$

$B = \frac{N}{r} \Rightarrow N = Br$

$N = 6M * \log_2 64$

$= 6M * 6$

$= \boxed{36\,Mbps}$

Problem 2: Four channels , two with a bit rate of 200kbps and two with a bit rate 150 kbps are to be multiplexed using multiple slots TDM with no synchronization bits. Answer the following questions:

i. What is the size of a frame in bits?

ii. What is the frame rate?

iii. What is the duration of a frame?

iv. What is the date rate?

Data Rate Management:

Solution: The frame carries 4 bits from each of the first two sources and 3 bits from each of the second two sources.

a) Frame size = $4 \times 2 + 3 \times 2 = 14$ bits.

b) Each frame carries 4 bit from each 200-kbps source or 3 bits from each 150 kbps.

Frame rate = 200,000 / 4 = 150,000 /3 = 50,000 frames/s.

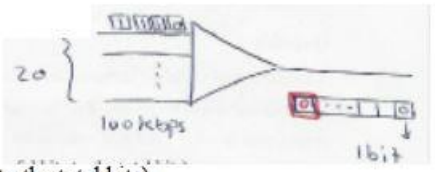
c) Frame duration = 1 /(frame rate) = 1 /50,000 = 20 **µs**.

d) Output data rate = (50,000 frames/s) × (14 bits/frame) = 700 kbps.

We can also calculate the output data rate as the sum of input data rates because there are no synchronization bits.

Output data rate = $2 \times 200 + 2 \times 150 = 700$ kbps.

3. We need to use synchronous TDM and combine 20 digital sources, each of 100 Kbps. Each output slot carries 1 bit from each digital sources, but one extra bit is added to each frame for synchronization. Answer the following questio



a. What is the size of an output frame in bits?
b. What is the output frame rate?
c. What is the duration of an output frame?
d. What is the output data rate?
e. What is the efficiency of the system (ratio of useful bits to the total bits).

a) frame size = 20 + 1 = **21 bit**

b) frame rate = $\frac{1}{\text{frame duration}} = \frac{1}{\text{input slot duration}}$

= **100,000 frame/sec**

c) frame duration = $\frac{1}{\text{frame rate}} = \frac{1}{100000} = 0.01 * 10^{-3}$

$= 0.01$ msec

= **10 Msec**

d) output data rate = frame rate * frame size

$= 100 * 10^3 * 21$

= 2100 kbps = **2.1 Mbps**

e) efficiency = $\frac{\text{useful bits}}{\text{total sent bits}} = \frac{20}{21}$ = **0.9523**

* 20 bit of each frame is useful
21 bit are actually sent per frame.

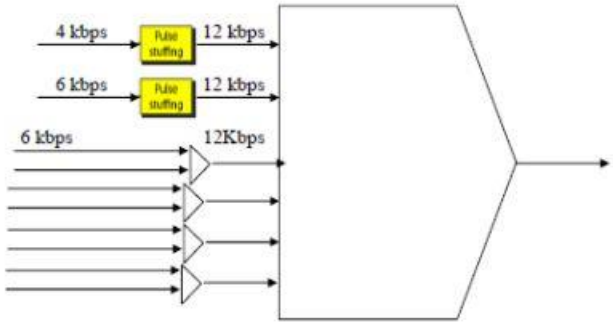
Percentage = $0.9523 * 100$

= **95.23 %** of the sent data is useful !!

5. We need to use synchronous TDM and combine 10 digital sources; as follows: Source 1: 4 Kbps data rate. Sources 2-10: 6 Kbps data rate. Each output slot carries 1 bit from each digital source, but one extra bit is added to each frame for synchronization. Answer the following questions:

1. Draw the TDM block so that the data rate should be 12Kbps for each multiplexer input?

Solution:



2. What is the size of an output frame in bits?

Solution: Each output frame carries 1 bit from each source plus one extra bit for synchronization. Frame size = 6 × 1 + 1 = **7 bits.**

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Solution: Each output frame carries 1 bit from each source plus one extra bit for synchronization. Frame size = 6 × 1 + 1 = **7 bits.**

3. What is the output frame rate?

Solution:
12,000 frames/s

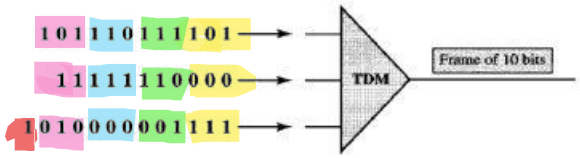
4. What is the duration of an output frame?

Solution:
Frame duration = 1 /(frame rate) = 1 /12,000 = **83.3 µs.**

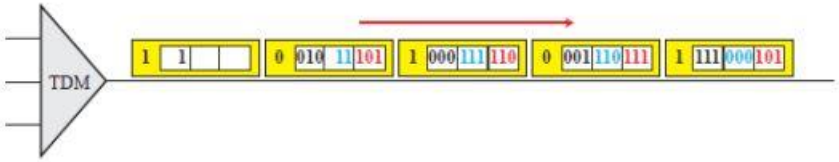
5. What is the output data rate?

Solution:
Data rate = (12,000 frames/s) × (7 bits/frame) = **84 Kbps**

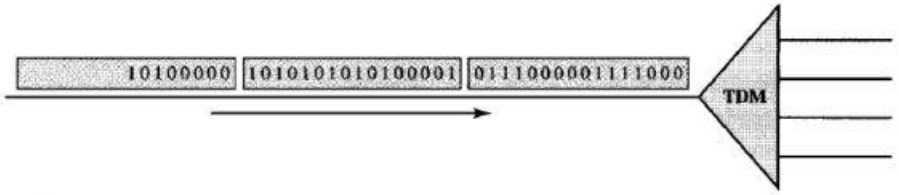
6. The figure below shows a multiplexer in a synchronous TDM system. Each output slot is only 10 bits long (3 bits taken from each input plus 1 framing bit). What is the output stream? The bits arrive at the multiplexer as shown by the arrows.



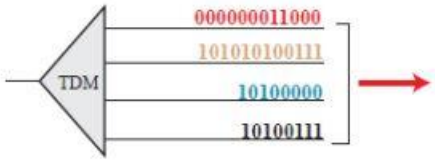
Sol:



7. The figure below shows a demultiplexer in a synchronous TDM. If the input slot is 16 bits long (no framing bits), what is the bit stream in each output? The bits arrive at the demultiplexer as shown by the arrows.



Sol:



8. Calculate the baud rate for the given bit rate and type of modulation.

a. 2000 bps, FSK

$r = \log_2 2 = 1 \rightarrow S = (1/1) \times (2000 \text{ bps}) = 2000 \text{ baud}$

b. 36,000 bps, 64-QAM

$r = \log_2 64 = 6 \rightarrow S = (1/6) \times (36{,}000 \text{ bps}) = 6000 \text{ baud}$

9. Find the bandwidth for the following situations if we need to modulate a 5-KHz voice.

a. AM

$B_{AM} = 2 \times B = 2 \times 5 = 10 \text{ KHz}$

b. PM (set $\beta = 5$)

$B_{PM} = 2 \times (1 + \beta) \times B = 2 \times (1 + 1) \times 5 = 20 \text{ KHz}$

10. What is the required bandwidth for the following cases if we need to send 4000 bps? Let $d = 1$.

a. ASK

$r = 1 \rightarrow B = (1 + 1) \times (1/1) \times (4000 \text{ bps}) = 8000 \text{ Hz}$

b. FSK with $2\Delta f = 4$ KHz

$r = 1 \rightarrow B = (1 + 1) \times (1/1) \times (4000 \text{ bps}) + 4 \text{ KHz} = 8000 \text{ Hz}$

c. QPSK

$r = 2 \rightarrow B = (1 + 1) \times (1/2) \times (4000 \text{ bps}) = 2000 \text{ Hz}$