AMERICAN INTERNATIONAL UNIVERSITY – BANGLADESH
Faculty of Engineering

Course/Lab Name:	Data Communication	
Semester: Spring 2023-24	**Term**: Final	**Assignment-2**

Question Mapping with Course Outcomes:

Item	COs	POIs	K	P	A	Marks	Obtained Marks
All Problems	**CO4**	**P.f.2.C6**	**K7**	**.**	**.**	**30**	
					Total:	**30**	

Student Information:

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Section: H	**Department: CSE**

Instructions for submission:

1. Use this page as a cover page.
2. Take pictures of your written answer and paste under each problem given below.
3. Give the file name using the middle 5 digits of your student ID.

For instance: if your ID is 20-40708-3 your file name will be 40708.pdf

4. Upload the pdf file to MS Teams under the assignment section. **Not through direct message to me.**
5. The submission will not be considered if the instructions are not followed.

Answer the following Questions:

Problem 01: For the available bandwidth of 200 kHz, which spans from 200 to 400 kHz. **Compute** followings:

(a) the carrier frequency for half duplex mode,

(b) the bit rate, if modulation is done by using ASK in half-duplex mode with d = 1?. **Sketch** the frequency spectrum for ASK in half-duplex.

(c) the bit rate, if modulation is done by using BFSK with d = 1. **Sketch** the frequency spectrum for BFSK.

Answer:

ANSWER TO THE QUESTION NO-01

(a)

The middle of the bandwidth is located at 300 KHz. This means that our carrier frequency can be at, $f_c = 300$ KHz.

(b)

Here, bandwidth, $B = 200$ KHz

$d = 1$, $r = 1$

We know, $B = (1+d) \times S$

$\Rightarrow B = 2S \Rightarrow B = 2 \times N \times \frac{1}{n} \Rightarrow N = \frac{B}{2} = \frac{200 \text{ KHz}}{2}$

$= 100$ Kbps

So, data rate, $N = 100$ kbps

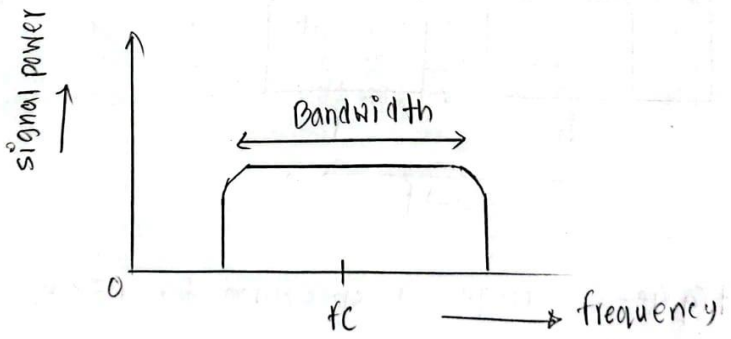


Figure1: Frequency Spectrum for Ask in half-duplex

(c)

For BFSK,

We choose to be 100 KHz,

Now,

$$B = (1+d) \times S + 2\Delta f$$

$$\Rightarrow B = 2 \times S + 2\Delta f$$

$$\Rightarrow B = 2 \times N + 2\Delta f$$

$$\Rightarrow N = \frac{B - 2\Delta f}{2} = \frac{200 - 100}{2} = 50 \text{ kbps}$$

So, **Bit rate, N = 50 kbps**

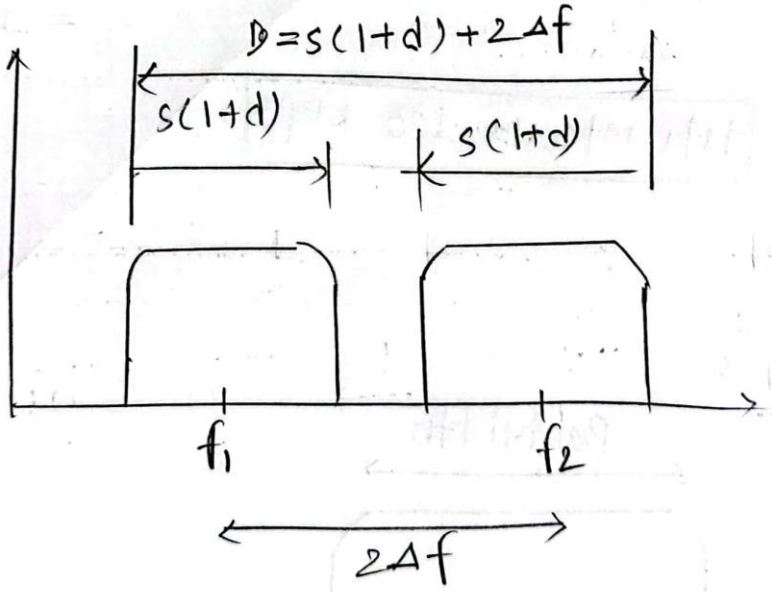


Figure-2: frequency specturm for BFSK

Problem 02*:* We need to send 3 bits of data at a time at a bit rate of 3 Mbps. The carrier frequency is 12 MHz. **Compute** the number of levels (different carrier frequencies), the baud rate, and the bandwidth. **Illustrate** the frequency spectrum showing the bandgap between the required carrier frequencies.

Answer:

ANSWER TO THE QUESTION NO-02

Here, $r = 3$,

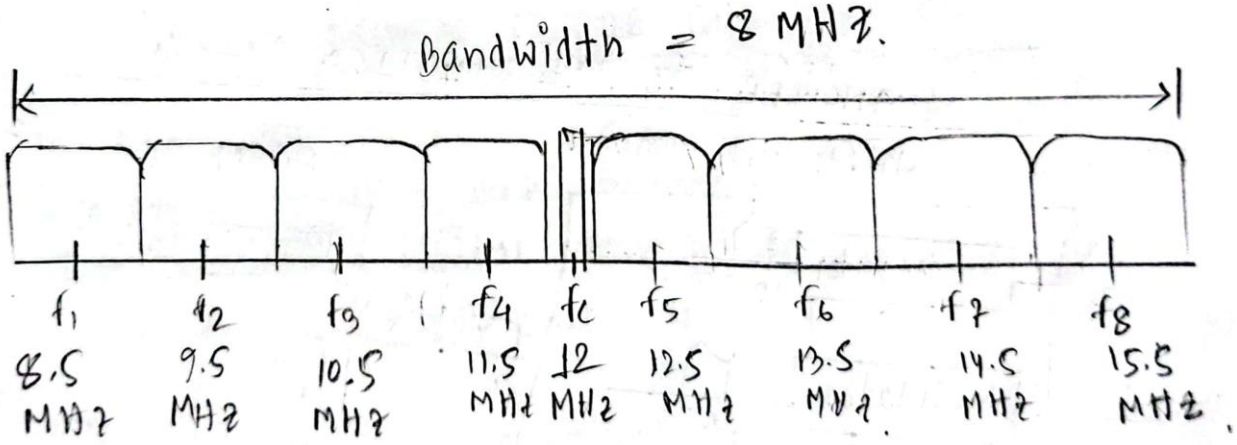
Bit rate, $N = 3$ Mbps.

Now, Number of levels, $L = 2^r = 2^3 = 8$,

The baud rate, $S = N \times \frac{1}{r} = 3 \times \frac{1}{3} =$ 1 Mbaud.

This means that the carrier frequencies must be 1MHz ($2\Delta f = 1$ MHz) apart.

So, The Bandwidth, $B = 8 \times 1 = 8$ MHz



Problem 03: **Compute** the bandwidth for a signal transmitting at 14 Mbps for QPSK considering the value of d = 1.

Answer:

ANSWER TO THE QUESTION No- 03

For QPSK, 2 bits are carried by one signal elemen. This means that, r=2.

So, $B = (1+d) \times S$ | $r = 1$, $d = 1$

$\Rightarrow B = 2 \times S$

$\Rightarrow B = 2 \times N \times \frac{1}{r}$

$\Rightarrow B = 2 \times N$

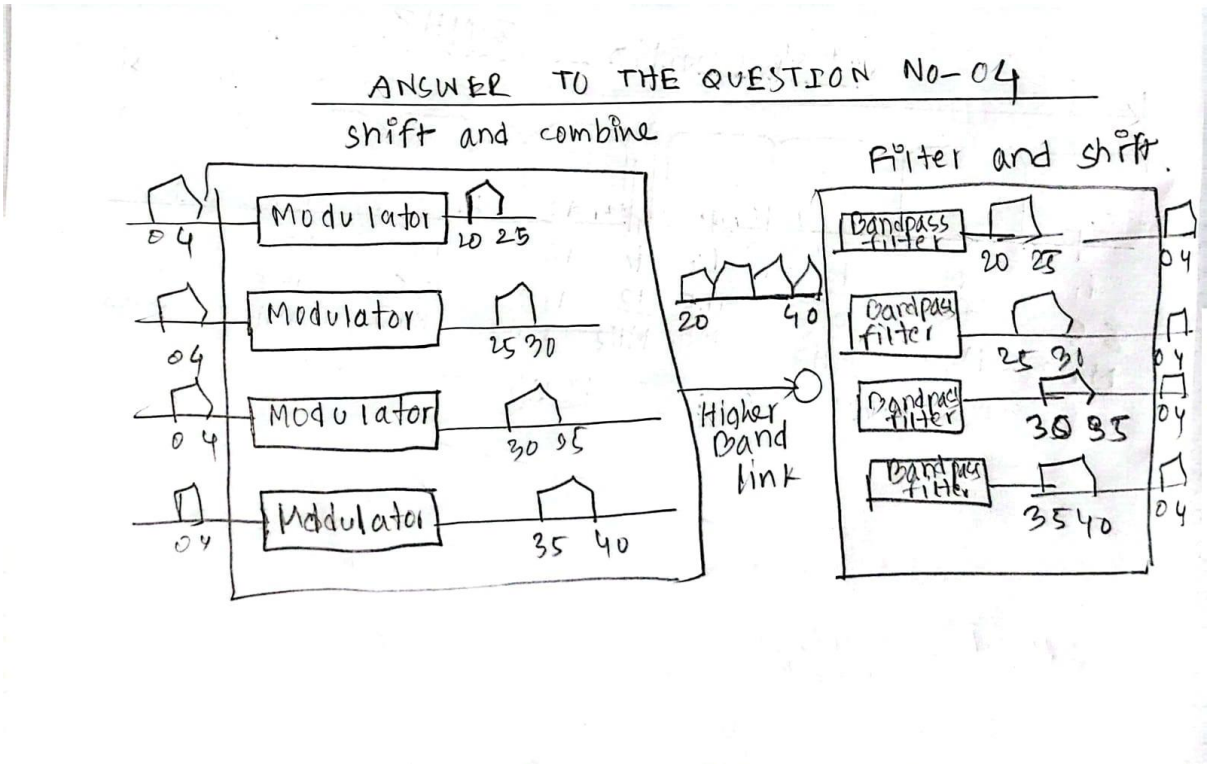
$\Rightarrow B = 2 \times 12\ Mbps$

$= 24\ MHz$

So, **Bandwidth, B = 24 MHz**.

Problem 04: Assume a voice channel occupies a bandwidth of 4 kHz. We need to combine four voice channels into a link with a bandwidth of 20 kHz, from 20 to 40 kHz. **Illustrate** the configuration, using the frequency domain. Assume there are no guard bands.

Answer:

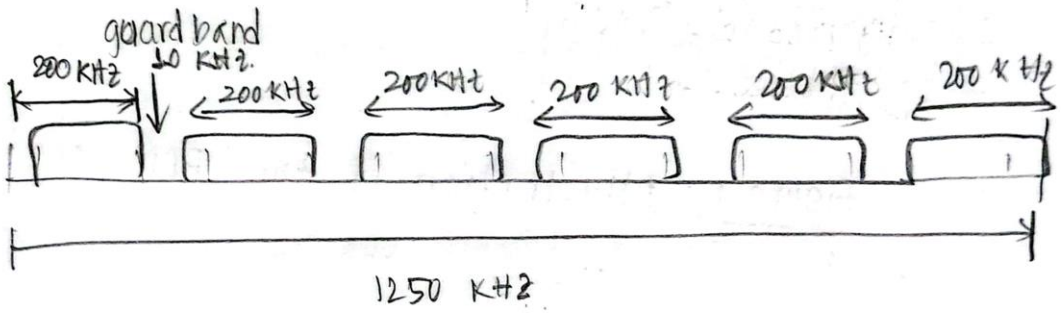


Problem 05: Six channels, each with a 200-kHz bandwidth, are to be multiplexed together using frequency division multiplexing (FDM). **Compute** the minimum bandwidth of the link if there is a need for a guard band of 10 kHz between the channels to prevent interference? **Sketch** the spectrum diagram for the whole bandwidth span of these six channels with five guard bands.
Answer:

ANSWER TO THE QUESTION NO-05

for six channels, we need at least 5 guard bands.
This means that, the required bandwidth is at least

$= 6 \times 200 + 5 \times 10 = 1250$ KHz



Problem 06: Four digital data channels, each transmitting at 1.5 Mbps, use an analog satellite channel with a bandwidth of 1 MHz. **Compute** the appropriate modulation scheme and its order to covert the digital channel data fit for analog satellite channel. **Design** an appropriate configuration to multiplex these four data channels data by using chosen modulation scheme and FDM.
Answer:

ANSWER TO THE QUESTION NO-06

The stateline channel is analog. So, we devide it into four channels, each channel having a 250 KHz bandwidth. Each digital channel of 1.5 Mbps, is modulated so that each 4 bits is modulated to 1.5 Hz.
One solution is 16-QAM modulation.

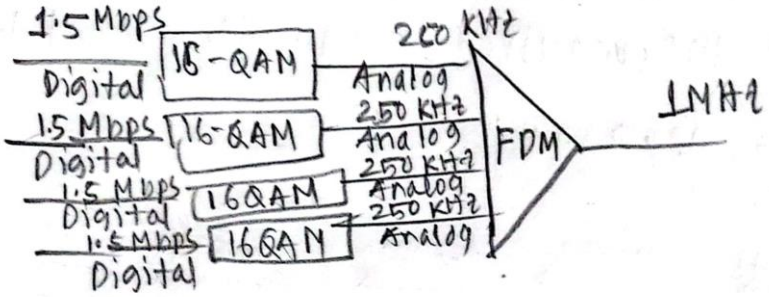


Figure 1: Illustration of the FDM configurat

Problem 07: Five 1 kbps connections are multiplex by using synchronous TDM. A unit is 1 bit for each timeslot within each frame. **Compute** followings: (***i***) duration of 1 bit before multiplexing, (***ii***) output transmission rate, (***iii***) duration of a timeslot within a frame, (***iv***) frame rate, and (***v***) frame duration.
Answer:

ANSWER TO THE QUESTION NO-07

(i)

Duration of 1 bit before Multiplexing $\frac{1}{1\text{Kbps}} = 1$ ms

(ii)

Output transmission Rate will be $5 \times 1\text{Kbps} = 5\text{K bps}$

(iii)

Duration of a time slot $= \frac{1}{5}$ ms $= 200$ μs.

(iv)

Frame rate = 1000 frames/second

(v)

Frame duration = bit duration = 1 ms

Problem 08: Three sources each creating 100 characters/second and each character size is 1 byte. If the interleaved unit is a character and one synchronizing bit is added to each frame, **compute** followings: (**i**) data rate for each source, (**ii**) frame size, (**iii**) frame rate, (**iv**) frame duration, (**v**) data rate of the link.
Answer:

ANSWER TO THE QUESTION NO-08

(i)

Data rate of each source is $100 \times 8 = 800$ bps.

(ii)

frame siz $= 3 \times 8 + 1 = 25$ bits.

(iii)

frame rate $= 100$ frames per second.

(iv)

Duration of each frame $= \frac{1}{100} = 1$ ms.

(v)

Data rate = frame rates * no of bits/frame.

$= 100 * 25 = 2500$ bps

$= 2.5$ kbps.

Problem 09: A synchronous time division multiplexer combines five 100 kbps using a time slot of 2 bits. **Compute** followings: (***i***) frame rate, (***ii***) frame duration, (***iii***) frame size, (***iv***) bit rate, and (***v***) bit duration.
Answer:

ANSWER TO THE QUESTION NO-09

(i)

$$\text{Frame rate} = \frac{\text{Data rate}}{\text{No of bits/frame}} = \frac{500 \text{ Kbps}}{2 \times 5}$$

$$= 50000 \text{ frames}$$

(ii)

$$\text{Frame duration} = \frac{1}{50000} = 20 \text{ µs}.$$

(iii)

$$\text{Frame size} = 2 * 5 = 10 \text{ bits}$$

(iv)

$$\text{Bit rate} = 5 * 100 = 500 \text{ kbps}$$

(v)

$$\text{Bit duration} = \frac{1}{500 \text{ kbps}} = 2 \text{ µs}.$$

Problem 10: Four input channels, two with a data rate of 5 kbps, one with 10 kbps each, and the last one with data rate 7 Kbps, need to be multiplexed using synchronous TDM. A maximum of 3 Kbps data can be added using the pulse stuffing method. **Illustrate** the data rate mismatch problem solution by showing suitable data rate management techniques.

Answer:

ANSWER TO THE QUESTION NO-10

We can solve this problem by using Multilevel Multiplexing and Pulse stuffing technique.

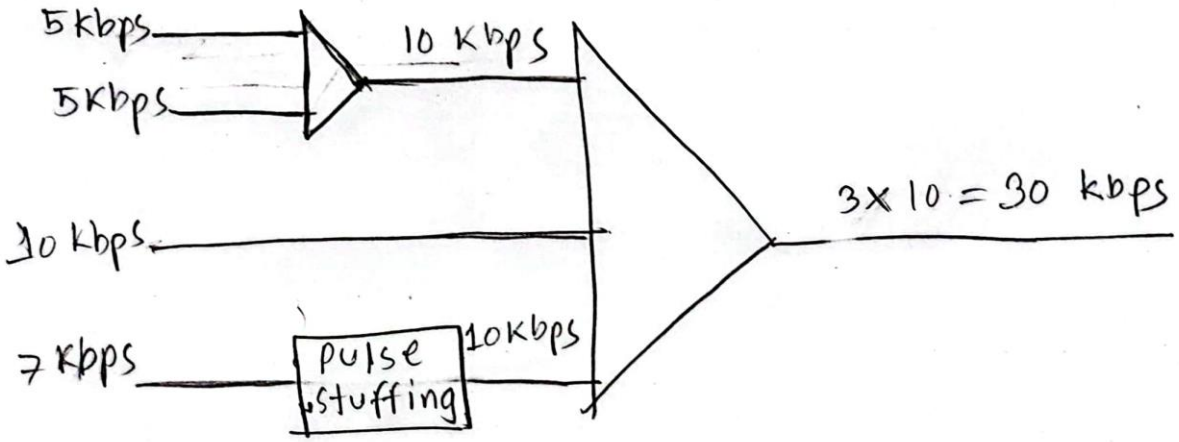


Figure 1: Illustration of the solution to the Data rate mismatch problem.

The End