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.

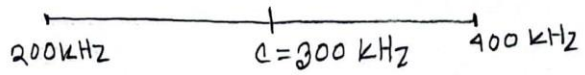
Answer:

Problem-01 :

Given that,

Bandwidth = 200 kHz

(a)



Carrier frequency $= \frac{400 + 200}{2} = 300\,kHz$

(b) Given that,

$d = 1$

$P = 1.$

We know,

$$B = (1+d)S$$

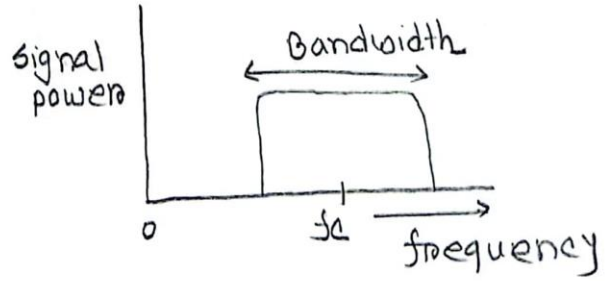
$$B = (1+1)S$$

$$= 2 \times \frac{N}{P}$$

$$N = \frac{B}{2}$$

$$= \frac{200}{2}$$

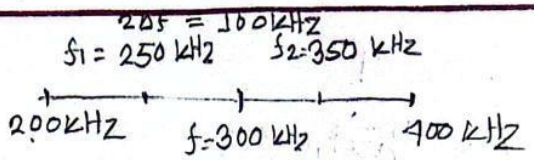
∴ Bit rate $N = 100$ kbps



Frequency spectrum for ASK in half-duplex

(c) Given that,

$d = 1$



We know,

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

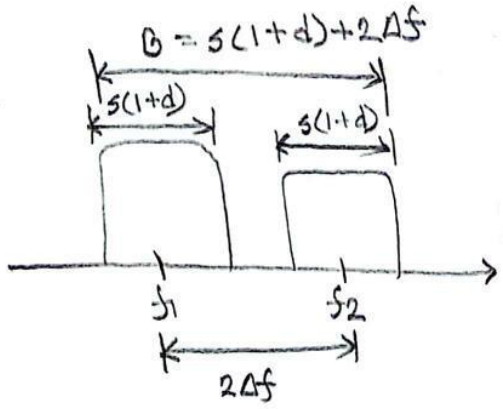
$= (1+1) \times S + 100$

$B = 2N + 100$

$N = \frac{B-100}{2}$

$= \frac{200-100}{2}$

$\therefore$ bit rate $N = 50$ kbps



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

$B = N$

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

Figure : The frequency spectrum 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:

Problem-02:

Given that,

Data element $n = 3$

Bit rate $N = 3$ Mbps

Carrier frequency $c = 12$ MHz

$$\text{Level} = 2^n = 2^3 = 8$$

$$\text{Baud rate} = \frac{N}{n} = \frac{3}{3} = 1 \text{ Mbaud}$$

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

$$\therefore \text{Bandwidth } B = L \times 2\Delta f = 8 \times 1 = 8 \text{ MHz}$$

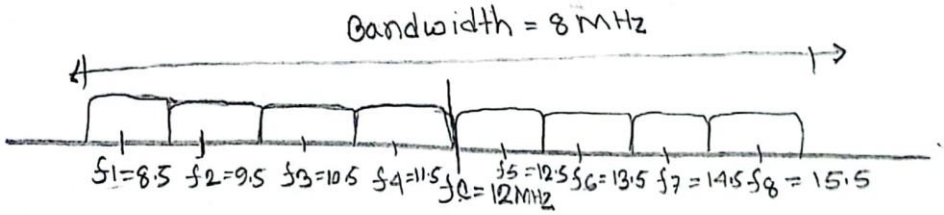


Figure: Frequency spectrum

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

Answer:

Problem-03:

We know,

For QPSK, $r = 2$

Given that,

Bit rate $N = 14$ Mbps

$d = 1$

Again we know,

$$S = N \times \frac{1}{r}$$

$$= \frac{14}{2}$$

$$S = 7 \text{ Mbaud}$$

And again we know,

$$B = (1+d) \times S$$

$$= (1+1) \times 7$$

$$\therefore B = 14 \text{ MHz}$$

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-04:

We shift each of the four voice channels to a different bandwidth, as shown in the figure.

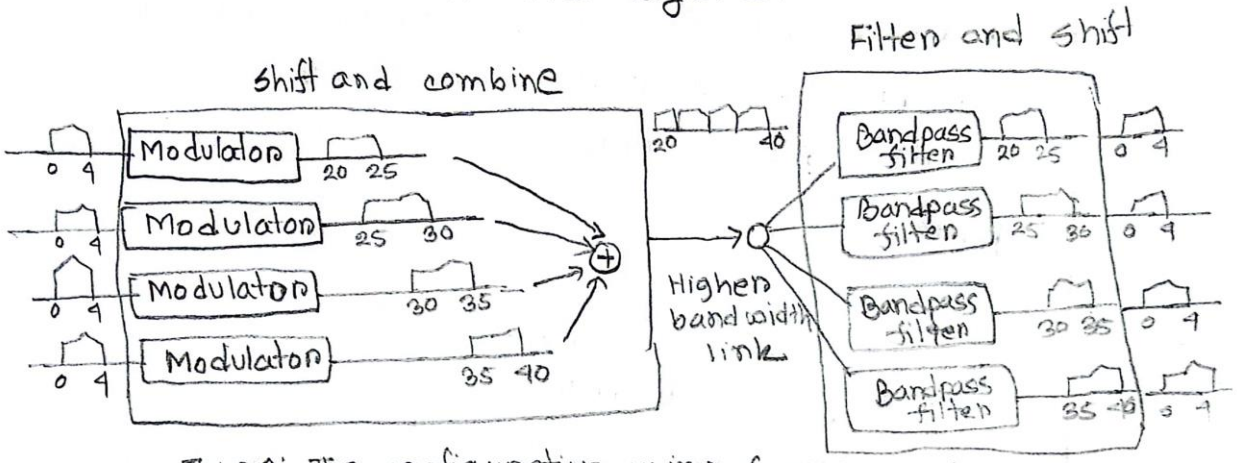


Figure: The configuration using frequency domain

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:

Problem-05:

Given that,

Channel = 6

Bandwidth = 200 kHz

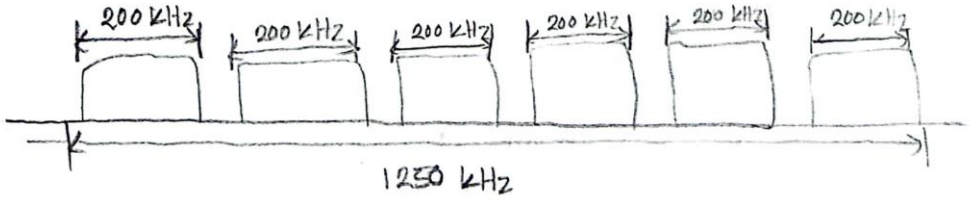
Guard band = 10 kHz

For 6 channels we need at least 5 guard bands.

Minimum bandwidth = (6×200) + (10×5)

= 1200 + 50

= 1250 kHz

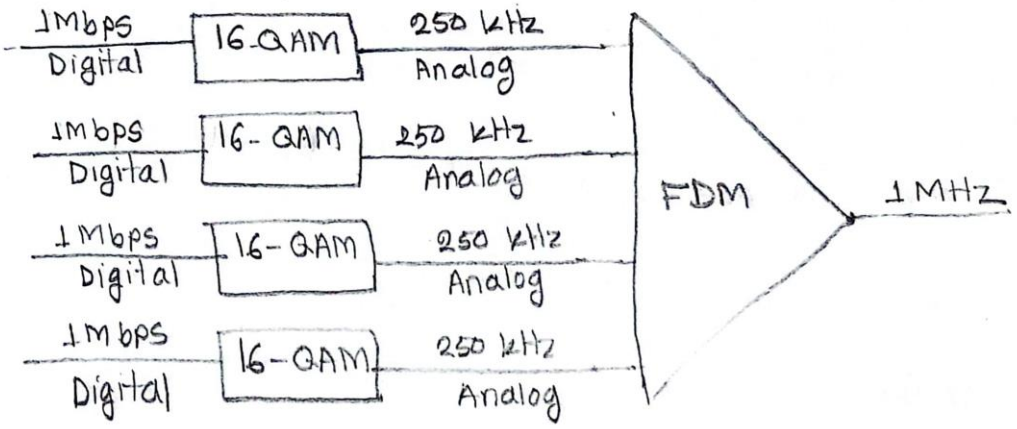


Problem 06: Four digital data channels, each transmitting at 1.5 Mbps, use an analog satellite channel with a bandwidth of 1 MHz. **Compute** the appropriate modulation scheme and its order to covert the digital channel data fit for analog satellite channel. **Design** an appropriate configuration to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

Problem-06:

The satellite channel is analog. We divide 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 Hz. One solution is 16-QAM modulation.

Figure:



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:

Problem-07 :

(i) The duration of 1 bit before multiplexing is 1/1 kbps
= 0.001 s
= 1 ms

(ii) Output transmission rate = 5 kbps

(iii) Duration of time slot within a frame = $\frac{1}{5 \times 10^3}$ = 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:

Problem-08 :

(i) Data rate for each source = 100 × 8 = 800 bps = 8 kbps.

(ii) Frame size = 3 × 8 + 1.
= 25 bits

(iii) Frame rate = 100 frame/second.

(iv) Frame duration = $\frac{1}{\text{Frame rate}}$ = $\frac{1}{100}$ = 0.01 s = 1 ms

(v) Data rate = frame rate * 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:

Problem-09:

(I) Frame rate $= \frac{5 \times 100\,kb}{10} = \frac{500 \times 10^3}{10} = 50 \times 10^3 = 50000$ Frame/s

(II) Frame duration $= \frac{1}{\text{Frame rate}} = \frac{1}{50000} = 20\,\mu s$

(III) Frame size $= 2 \times 5 = 10$ bits

(IV) Bit rate $= 5 * 100$
$= 500$ kbps

(V) Bit duration $= \frac{1}{500\,kbps} = 2\,\mu s.$

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:

Problem-10:

We can solve this problem by using Multilevel multiplexing and pulse stuffing technique

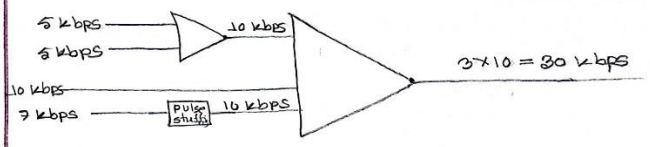


Figure: Illustration of the solution to the Data rate mismatch problem