AMERICAN INTERNATIONAL UNIVERSITY – BANGLADESH
Faculty of Engineering

Course/Lab Name:	Data Communication		
Semester: Summer 2024-25	Term: Final	Assignment for Final Term	

Question Mapping with Course Outcomes:

Item	COs	POIs	K	P	A	Marks	Obtained Marks
All Problems	CO4	P.f.2.C6	K7	.	.	15	

Student Information:

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Section: D	Department: CSE

Instructions for submission:

1. Use this page as a cover page.
2. Use A4-size paper, and only **handwritten** answers are acceptable.
3. Submit a **hard copy** of your assignment to my office by **September 15, 2025 (4:00 PM)**.
3. **The submission will not be considered if the instructions are not followed. Also, if you miss the deadline, 3 marks will be deducted for each additional day.**

CO4 Description:	**Design** a solution for time and frequency division multiplexing problems in accordance with professional practices

Answer the following Questions:

Problem 01: Assume four baseband signals, each with a bandwidth of 4 kHz, are to be transmitted over a shared communication link using Amplitude Modulation (AM) and Frequency Division Multiplexing (FDM). The total transmission link bandwidth is 38 kHz, spanning from 100 kHz to 138 kHz. To avoid inter-channel interference, a 2000 Hz guard band is maintained between any two adjacent channels.

(i) **Compute** the carrier frequencies to be assigned for AM modulation of each baseband signal, ensuring proper spacing for the guard bands.

(ii) **Illustrate** the entire configuration using the time domain equations and frequency domain representation for both the FDM multiplexer with AM modulation and demultiplexer with AM demodulation.

Note: For FDM demultiplexing, you should use both bandpass and low pass filter with full AM demodulation to recover each Baseband signals.

Problem 02: Assume five ground stations each transmit data at a rate of 276 Mbps to the nearest LEO satellite utilizing the Ku-band uplink spectrum spanning between 14.25–14.50 GHz. The uplink uses frequency-division multiplexing (FDM) with 5000 kHz guard bands between adjacent channels. *(i)* **Compute** the effective bandwidth per ground station if bandwidth is allocated evenly, *(ii)* **Choose** an appropriate modulation scheme and **compute** its modulation order '*M*' to support minimal bit error rate in transmission, *(iii)* **Design** a suitable configuration to multiplex the five ground stations using the chosen modulation scheme and FDM with proper illustration. *(iv)* **Sketch** the constellation diagram for 16−QAM, ensuring the following:

- Properly label the axes for in-phase and quadrature components

Ans No 01

(i) Total baseband signal = 4

Bandwidth $B = 4 \text{ KHZ}$

Guard band $gb = 2000 \text{ Hz}$
$= 2 \text{ KHZ}$

AM Bandwidth $B_{AM} = 2B$
$= 2 \times 4$
$= 8 \text{ kHZ}$

Total bandwidth require $= 4 \times 8 \text{ kHZ}$
$= 32 \text{ KHZ}$

Total guardband require $= 3 \times 2 \text{ KHZ}$
$= 6 \text{ KHZ}$

In total = Total bandwidth + total guardband
$= 32 + 6 \text{ kHZ}$
$= 38 \text{ kHZ}$

which is equals to transmission link bandwidth spanning frequency from 100 KHZ to 138 KHZ

So, Carrier frequency for 1st sideband signal $f_{c_1} = 104 \text{ KHz}$
Carrier frequency for 2nd sideband signal $f_{c_2} = 114 \text{ KHZ}$
Carrier frequency for 3rd sideband signal $f_{c_3} = 124 \text{ KHZ}$
Carrier frequency for 4th sideband signal $f_{c_4} = 134 \text{ KHZ}$

(ii)

Time domain equation for entire configuration,

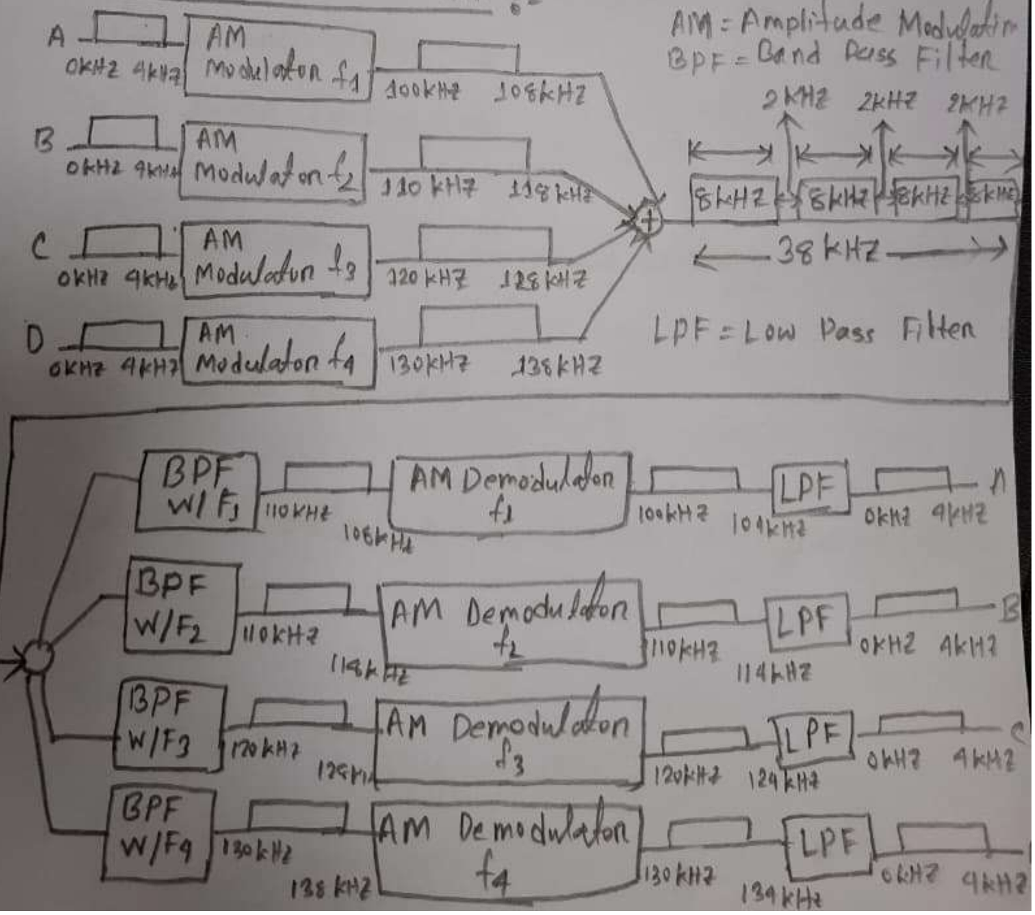
$$s_1(t) = [A_{c_1} + A_{m_1} \cos(2\pi(108 \times 10^3)t] \cos(2\pi(104 \times 10^3)t)$$

$$s_2(t) = [A_{c_2} + A_{m_2} \cos(2\pi(118 \times 10^3)t] \cos(2\pi(114 \times 10^3)t)$$

$$s_3(t) = [A_{c_3} + A_{m_3} \cos(2\pi(128 \times 10^3)t] \cos(2\pi(124 \times 10^3)t)$$

$$s_4(t) = [A_{c_4} + A_{m_4} \cos(2\pi(138 \times 10^3)t] \cos(2\pi(134 \times 10^3)t)$$

frequency domain representin :-



Ans to the Ans 02

(i)
Given,
datarate, b = 276 Mbps

Spanning between 14.25 – 14.50 GHz. 6o transmission link

bandwidth is = 14.50 – 14.25
= 0.25 GHZ
= 250 MHZ

guard band gb = 5000 kHZ
= 5 MHZ

Total ground station = 5

total guard band = 4×5
= 20 MHZ

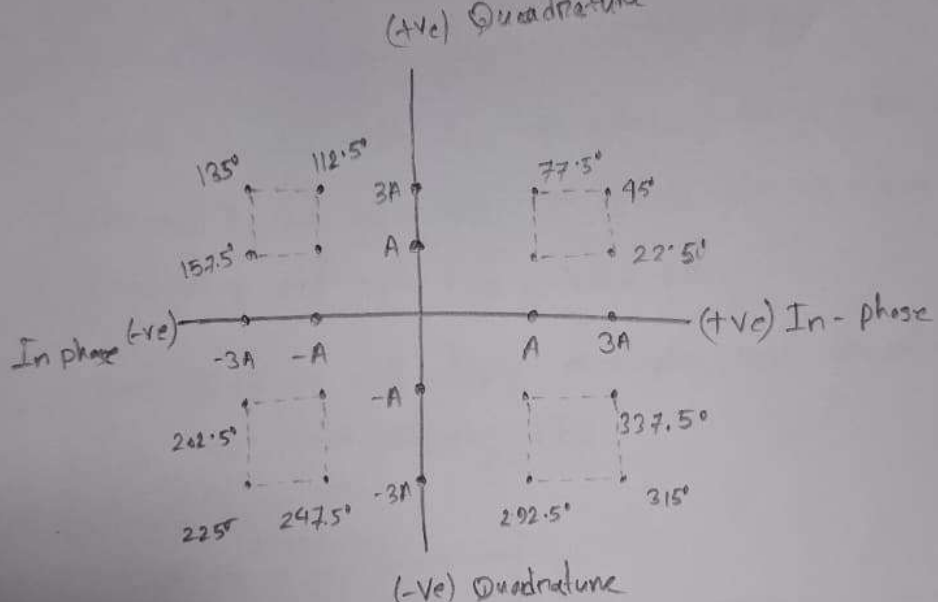
Total bandwidth withouth guard band = 250 - 20 MHZ
= 230 MHZ

Each station bandwidth = 230/5
= 46 MHZ

that mean affective bandwidth per ground station is 46 MHZ

(iv)

Constellation diagram for 16-QAM



Ans No 03

(i)

Here,

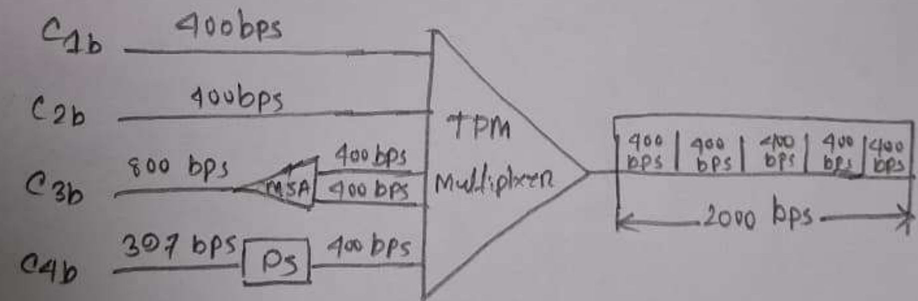
Channel 1 bit rate C_{1b} = 50 bytes/s = 50×8 = 400 bps

Channel 2 bit rate C_{2b} = 50 bytes/s = 50×8 = 400 bps

Channel 3 bit rate C_{3b} = 100 bytes/s = 100×8 = 800 bps

Channel 4 bit rate C_{4b} = 397 bps

For C_{3b} we will apply multiple slot allocation and for C_{4b} pulse stuffing (PS)



(ii) frame rate = 400 frame/s

(iii) frame duration = $\frac{1}{400}$ = 2.5 ms

(iv) bit rate of the output link = 5×400 = 2000 bps

(v) output bit duration = $\frac{1}{2000}$ = 0.5 ms

(Ans)