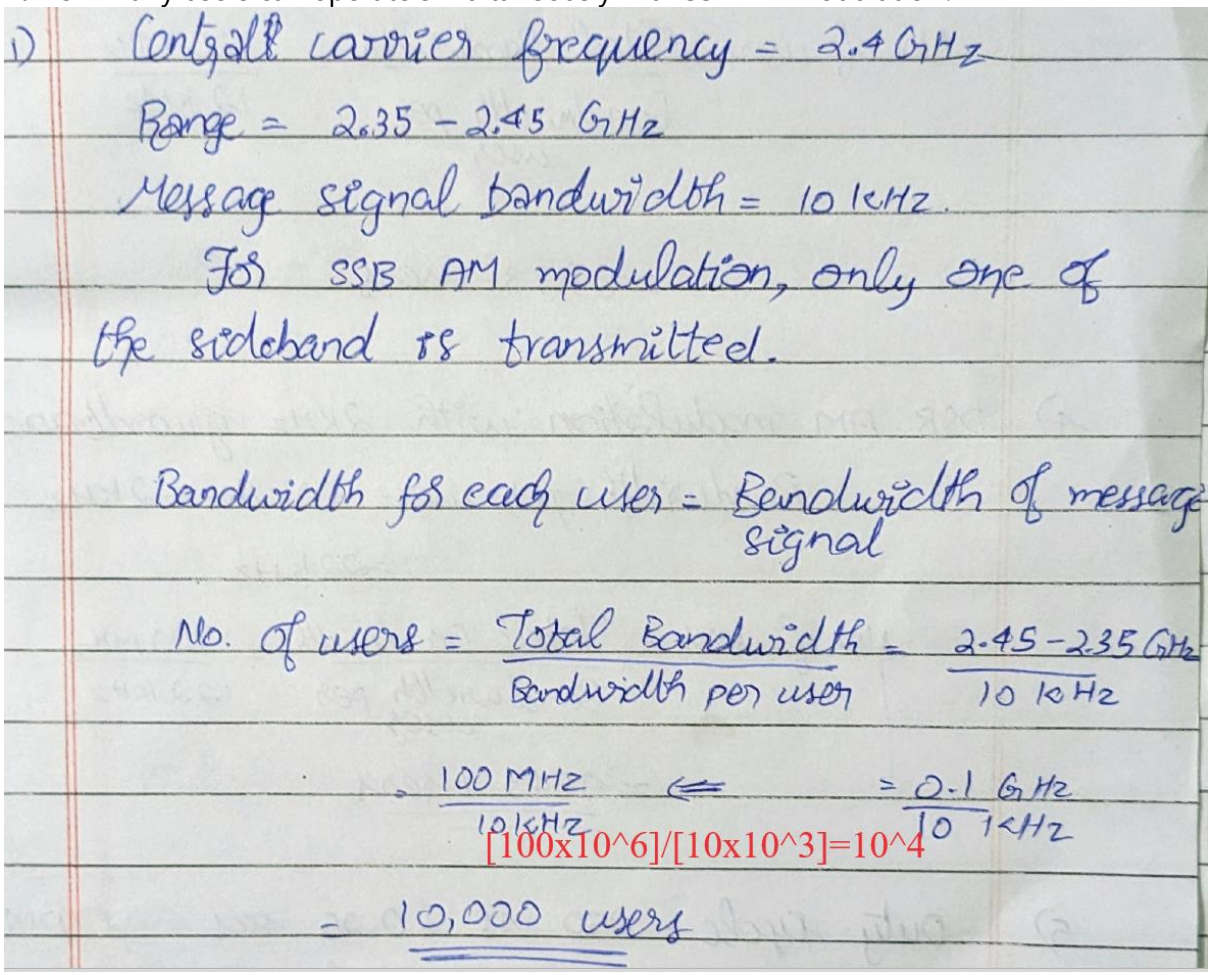
October 31, 2023, Deadline: Nov 03, 2023

L01-03, SLIDE 17

The central carrier frequency is 2.4 GHz; 2.35 to 2.45 GHz.
Message signal has bandwidth of 10 KHz.

1. How many users can operate simultaneously with SSB AM modulation?



2. How many users can operate simultaneously with DSB AM modulation?

2) No. of users operating simult with DSB-AM modulation →

Both the sidebands are transmitted. Therefore, the bandwidth for each = 2 * 10

= 20 kHz

correct but too much of writing ...

No. of users = Total Band. / Bandw. per user.

DSB bandwidth is 2x of that of SSB. Thus, # of supported users is half, which is 10000/2 = 5,000 users

= 100 MHz / 20 kHz

= 5,000 users

3. How many users can operate simultaneously with SSB AM modulation if a 2 KHz guard band is needed?

4. How many users can operate simultaneously with DSB AM modulation if a 2 KHz guard band is needed?

4) DSB AM with guardband

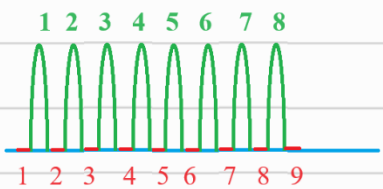
Bandwidth per user = (20 + 2) + 2

(for n+1 guardbands) = 24 kHz

n(users) = $\frac{0.1 \times 10^6 \text{ kHz}}{24 \text{ kHz}}$

≃ 4166.67

= 4166 users



5. If duty cycle is 250 ms, i.e., one is allowed to transmit only for 250 ms then how many users can be supported in each case?

Q5 sol) Duty Cycle = 250 ms = 0.25 seconds ⇒ Time Division Multiplexing (TDM).

⇒ The no. of users can be divided by the duty cycle.

⇒ SSB AM Modulation = $\frac{\text{No. of users}}{\text{Duty Cycle}} = \frac{10,000}{0.25}$

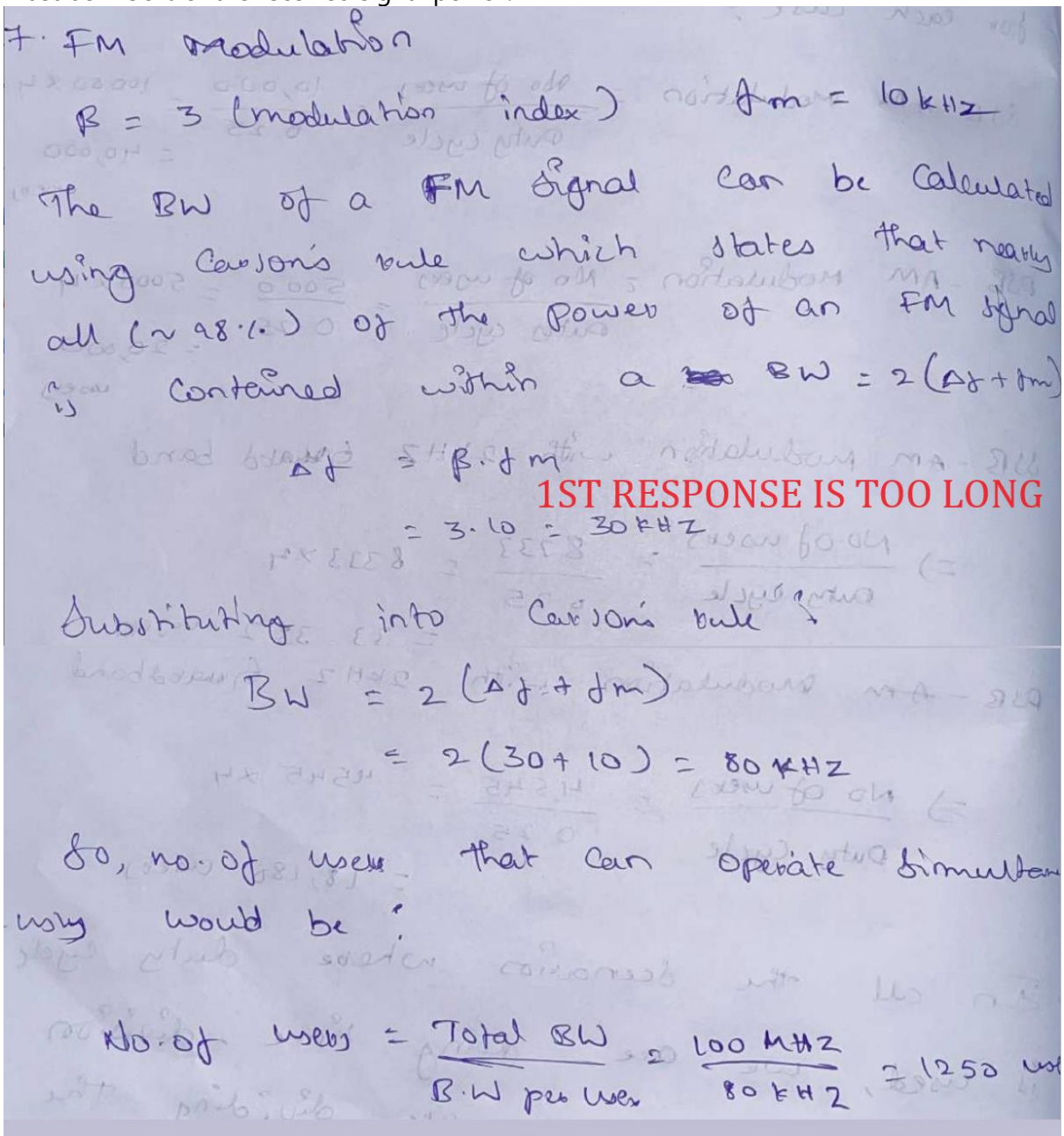
$= 10,000 \times 4 = 40,000$ users

6. In which of the 8 cases above are we doing time-division multiplexing?

6. In case 5, we are doing time division multiplexing because we are dividing the time into slots & allowing each user to transmit in their allocated slots.

All cases in case 5. NOTE: justification has NOT been asked!

7. If the signals were not AM-modulated by FM-modulated, assuming β is 3, how many users can operate simultaneously if receiver cannot operate correctly if the filtered signal power must be > 98% of the received signal power?



$\beta c = 2[1+\beta f]fm$. Thus, $\beta c = 2[1+3]10*10\text{^}3 = 80\ KHz$

# of users: [100 MHz/80 KHz] = 1,250.

8. Speed of light in vacuum is 3 lac km/s.
Speed of light in sea water is 2.25 lac km/s.
Speed of sound in sea water is 1.5 km/s.

For a submarine, assuming transmissions are at 800 MHz in the electromagnetic spectrum and 500 Hz for sound, what is the minimum length of each antenna given that for efficient coupling of generated to transmitted EM energy, antenna must be > 1/10 λ.

8. $\lambda = \frac{c}{f}$

λ(Seawater) = $\frac{2,25,000 \text{ km/s}}{800 \text{ mhz}}$

$= 0.28125 \text{ m}$

Minimum Antenna Length = $1/10 \times \lambda$

$= 1/10 \times 0.28125 \text{ m}$

28.13 mm $\Rightarrow$ 2.8125 cm

Similarly

Speed of sound in water is 1.5 km/s

$\frac{2,25,000 \text{ km/s}}{500 \text{ mhz}}$

Sound F is 500 Hz

$\Rightarrow 0.003 \text{ m}$

$\lambda = [1.5*10^3]/500 = 30$ meter

$\therefore 1/10 \times 0.003 \text{ m}$

Thus, antennae length must be 30/10 = 3 meter $= 0.0003 \text{ m}$

$= 0.3 \text{ mm}$