Spring-2023 (Decipher)

2.

a) Here, positive pulse : 0   Data rate = $2f$ bps

negative pulse : 1   Duration of each pulse = $1/2f$

$$\# \; S(t) = A \times (4/\pi) \times \sum_{k\,odd,\,k=1}^{\infty} \sin(2\pi k f t)/k$$

Case-1:

Let, $f = 10^6$ cycle/sec = 1 MHz

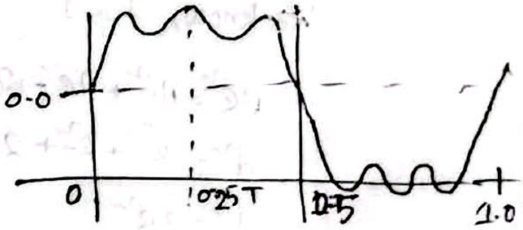
frequency components = $1f, 3f, 5f$

Bandwidth = $5f - f = 4f = 4 \times 1$ MHz = 4 MHz

Time period, $T = \frac{1}{10^6} = 10^{-6} = 1\ \mu s$

Duration of each pulse = $\frac{1}{2 \times (10^6)}$ [2 because 1 bit occurs at every 0.5 μs]

Data Rate = $2 \times 1 = 2$ mbps



Case-2: (Frequency increased)

Let, $f = 2 \times 10^6$ cycle/sec = 2 MHz

frequency component = $1f, 3f, 5f$

Bandwidth = $5f - f = 4f = 4 \times 2 = 8$ MHz

Time period, $T = \frac{1}{2 \times 10^6} = 0.5\ \mu$

Duration of each pulse = $\frac{1}{2 \times (2 \times 10^6)}$ [4 because 1 bit occurs at every 0.25 μs]

Data Rate = $2f = 2 \times 2 = 4$ mbps

Case-3: (Frequency component decreased)

Let, $f = 2 \times 10^6$ cycle/sec = 2 MHz

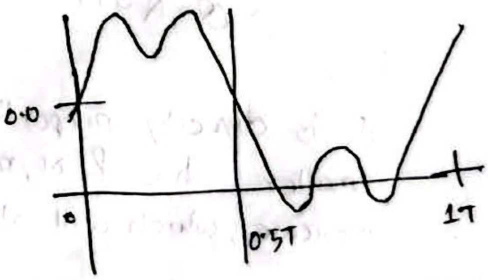
frequency component = $1f, 3f$

Bandwidth = $3f - f = 2f = 2 \times 2 = 4$ MHz

Time period, $T = \frac{1}{f} = \frac{1}{2 \times 10^6} = 0.5\ \mu s$

Duration of each pulse = $\frac{1}{2 \times (2 \times 10^6)}$

Data Rate = $2f = 2 \times 2 \times 10^6 = 4$ mbps



From Case 1 and 2:
- Bandwidth increases
  data rate increases
  same signal quality

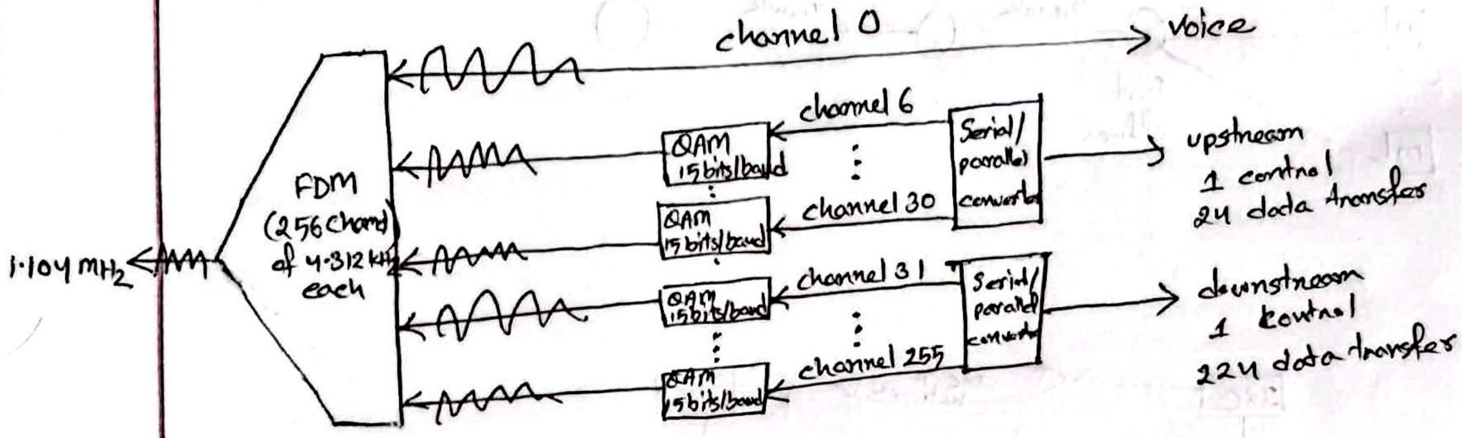
From 1 and 3:
- Same bandwidth
  data rate decreases
  signal quality increases

From 2 and 3:
- Same data rate
  Bandwidth increase
  higher signal quality.

Fall-22

2(a)

Discrete Multitone Technique (DMT) is a modulation technique standard for ADSL which combines QAM and FDM.



Each channel bandwidth of $= 4.312\ kHz \approx 4\ kHz$

QAM speed = 15 bits/baud

upstream: (6 to 30) = 24 channel

speed: $24 \times 15 \times 4 = 1440\ kbps = 1.440\ mbps$

downstream: (31 to 255): 224

speed: $224 \times 15 \times 4 = 13440\ kbps = 13.440\ mbps$

b)

For same size of cells and same power transmitted from Base station

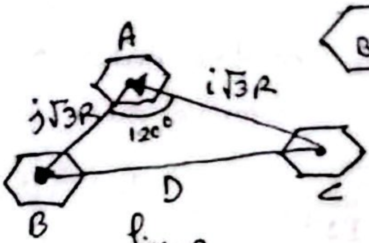


fig:-2

fig:1

We know, fig-1

$$BC^2 = AB^2 + AC^2 - 2.AB.AC.\cos(120^\circ)$$

$$d^2 = R^2 + R^2 - 2.R.R.\left(-\frac{1}{2}\right)$$

$$d^2 = 3R^2$$

$$d = \sqrt{3}R$$

D: minimum distance between the centre of co-channel cells.

R: Radius of the cell

d: distance between centers of adjacent cells.

N: number of cells, where $N = i^2 + ij + j^2$

$Q = \frac{D}{R}$; co-channel reuse ratio

Now, fig-2

$$D = \sqrt{(i\sqrt{3}R)^2 + (j\sqrt{3}R)^2 - 2.(i\sqrt{3}R).(j\sqrt{3}R).\cos(120^\circ)}$$

$$= \sqrt{i^2 3R^2 + j^2 3R^2 - 2.i\sqrt{3}R.j\sqrt{3}R.\left(-\frac{1}{2}\right)}$$

$$= \sqrt{3R^2(i^2 + j^2 + ij)}$$

$$= R\sqrt{3N}$$

$$\therefore D = R\sqrt{3N}$$

We know,

$$Q = \frac{D}{R} = \frac{R\sqrt{3N}}{R}$$

$$\therefore Q = \sqrt{3N}.$$

Q is directly proportional to $\sqrt{N}$. A smaller value of Q means a smaller value of N, means reuse will be more and, the capacity will increase, which will also generate higher co-channel interference.

$Q\downarrow$ $N\downarrow$ capacity$\uparrow$ CCI$\uparrow$

2(b)

SNR	SIR
① Signal to Noise Ratio	① Signal to interference ratio
② Ratio of Signal power and background noise.	② Ratio of signal power and power of interfering signal.
③ Caused by thermal noise, environment or device noise	③ Caused by interfence of nearby cells or overlapping frequencies.
④ Used in Communication channel radio broadcasting.	④ in cellular network and wireless system.

SIR at center:

$$SIR = \frac{\text{Signal Power}}{\text{Interference Power}}$$

$$= \frac{P_0 \left(\frac{R}{d_0}\right)^{-n}}{P_0 \left(\frac{D}{d_0}\right)^{-n}}$$

$$= \sum_{i=1}^{i_0} \left(R/D\right)^{-n}$$

$$= \frac{(R/D)^{-n}}{6} \quad ; 6 = i_0$$

$$= \frac{(D/R)^n}{i_0} = \frac{(\sqrt{3N})^n}{i_0}$$

SIR at boundary:

$$SIR = \frac{S}{I} = \frac{R^{-4}}{2(D-R)^{-4} + 2(D+R)^{-4} + 2(D)^{-4}}$$

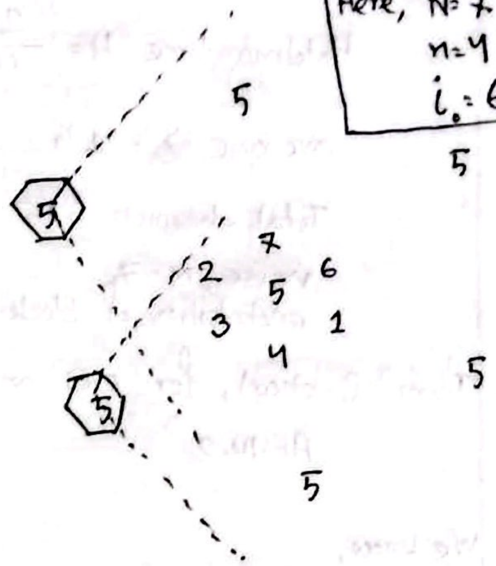
$$= \frac{1}{2(Q-1)^{-4} + 2(Q+1)^{-4} + 2(Q)^{-4}}$$

c) <u>Without Sectoring</u>

We know,

$$SIR = \frac{(\sqrt{3N})^n}{i_0} = \frac{(\sqrt{3\times 7})^4}{6}$$
$$= 73.5$$
$$= 10\log(73.5)$$
$$= 18.66\ dB$$

Here, $N=7$
$n=4$
$i_0 = 6$ (hexa)



<u>With sectoring</u>

$$SIR = \frac{(\sqrt{3N})^n}{i_0} = \frac{(\sqrt{3\times 7})^4}{2}$$
$$= 220.5$$
$$= 10\log(220.5)$$
$$= 23.45\ dB$$

For 120°;

- 3 sectors.
- number of affected cluster $= 2 = i_0$

∴ SIR increases with sectoring.

For 120° sectoring 3 antennas are used, as SIR is increased, other co-channel cannot affect their signal.

∴ CCI is low.

Our accepted SIR value is 18.66 dB, So, with sectoring we need to decrease the N to acheive the SIR value.

For $N=4$ $(i=2, j=0)$

$$SIR = \frac{(\sqrt{3\times 4})^4}{2} = 72 = 18.57\ dB$$

So, N↓

∴ capacity increases.

∴ Q or reuse ratio decreases

Assume, (without sectoring)

Holding time, $H = \frac{2\,min}{60} = \frac{1}{30}$ hour

average, $\lambda = 1$ h

Total channel = 395 $\therefore$ channel per cell = $\frac{395}{7} \approx 57$

reuse, $N = 7$

probability of blocking = 0.01

From B-chart, for 0.01 and 57;

$A = 44.2$

We know,

Here, $A_u = \lambda H$

$= 1 \times \frac{1}{30}$

$= 0.03333$

$A = UA_u$

$U = \frac{A}{A_u} = \frac{44.2}{0.03333}$

$= 1326$

A_u = Traffic intensity per user

U = Total no. of user supported per cell

A = Traffic intensity per cell

With sectoring

For 120° sector;

3 sectors.

$\therefore$ number of channel per sector = $\frac{57}{3} = 19$

For B-chart for 0.01 and 19;

$A = 11.2$

$\therefore U = \frac{11.2}{0.03333}$

$= 336$

$\therefore$ for 3 sectors = $(336 \times 3) = 1008$

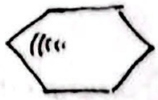
Efficiency = $\left(\frac{1326 - 1008}{1326}\right) \times 100 = 24\%$

$\therefore$ sectoring decreases trunking efficiency.

2 (c) Microcell zone concept:

(1) A cell is conceptually divided into microcells.

(2) Directional Antenna placed on cell edge, radiating power inward.



(3) Central Base station connects to all zones, assigns channels as needed.

(4) As Base station has all channel's information, seamless zone transition with no handoff, simply switches channel to the next zone.

Benefits: (1) Improve coverage, fewer call drops, higher capacity in dense areas.

Without microzone

$$SIR = \frac{(\sqrt{3N})^n}{i_0}$$

$= 18.66\,dB$

$n = 4$

$N = 7$

$i_0 = 6$

With (3 zone)

$$SIR = \frac{(\sqrt{3N})^n}{i_0} = \frac{(\sqrt{3 \times 3})^4}{1}$$

$= 20\,dB$

$n = 4$

$N = 3$

$i_0 = 1$; there will be atleast one interferer.

So, N↓ SIR↑ CCI↑ capacity↑