

Q1: baud rate? for given bit rate and modulation.

(a) 2000 bps, FSK.

Sol:

(Phase, AMP) FSK ≠
• دَفعَر بَعمَ فreq تَبَع لَدَا

BFsk لَدَا بَعمَ Fsk ≠

• two levels تَبَع

$$\therefore r = \log_2 2 = 1$$

$$S = \frac{1}{r} \times 2000 = 2000 \text{ band}$$

use

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

$$r = \log_2 L$$

of
different
Signal
element.

(b) 4000 bps, Ask. → (BASK) ⇒ using only two levels.

Sol: $r = \log_2 2 = 1$

$$S = 4000 \text{ band}$$

(c) 6000 bps, QPSK. ⇒ Psk تَبَع خَرَايَا

Sol:

two sperate تَبَع
BPsk

$$r = \log_2 4 = 2$$

$$S = \frac{1}{2} \times 6000 = 3000 \text{ band}$$

(d) 36000 bps, 64-QAM. ⇒ Psk, Ask تَبَع بَعمَ : QAM ≠

Sol: $r = \log_2 64 = 6$ • 2 carrier تَبَع

$$S = \frac{1}{6} \times 36000 = 6000 \text{ band}$$

⇒ Q2: bit rate ? for given band rate & type of modulation.

(a) 1000 band, FSK.

Sol: $r = \log_2 2 = 1$

$$r = \frac{N}{r} \Rightarrow S = N = \boxed{1000 \text{ bps}}$$

(b) 1000 band, ASK.

Sol: $r = \log_2 2 = 1$

$$r = \frac{N}{r} \Rightarrow S = N = \boxed{1000 \text{ bps}}$$

(c) 1000 band, BPSK.

Sol: $r = \log_2 2 = 1$

$$S = \frac{N}{r} \Rightarrow S = N = \boxed{1000 \text{ bps}}$$

(d) 1000 band, 16-QAM.

Sol:

$$\Rightarrow r = \log_2 16 = 4$$

$$\Rightarrow S = \frac{N}{r} \Rightarrow N = S \times r = 4 \times 1000 = \boxed{4000 \text{ bps}}$$

⇒ Q3: #bits per band ? → $r = ??$

(a) ASK with four different amplitudes.

Sol: $r = \log_2 4 = \boxed{2 \text{ bits/band}}$

b) FSK with 8 different freq.

Sol: $r = \log_2 8 = \boxed{3 \text{ bits/ baud}}$

c) PSK with 4 different phases.

Sol: $r = \log_2 4 = \boxed{2 \text{ bits/ baud}}$

d) QAM with constellation of 128 points.

Sol: $r = \log_2 128 = \boxed{7 \text{ bits/ baud}}$

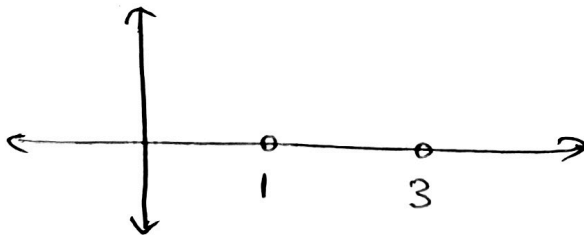
⇒ P5.4: Draw the constellation diagram for:

a) ASK, with peak amp. values 1 & 3.

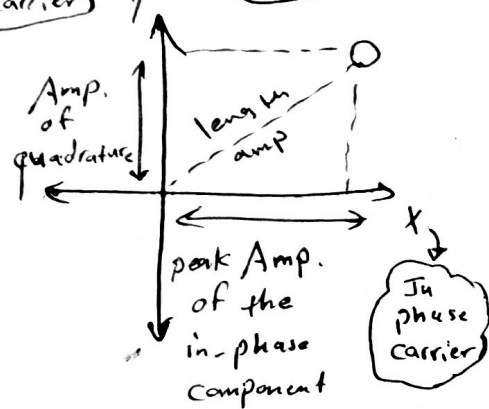
Sol: ASK peak , two signals lie at 1 & 3

phase لا يتغير (نقطة phase ب 0)

Sol:



⇒ Constellation
نقطة phase , amp.
Signal element



in-phase carrier ASK : 1 bit

وصلة النقطتين يكونوا على

نقطة (X-axis)

⑥ BPSK, with peak amp value of 2.

سؤال:

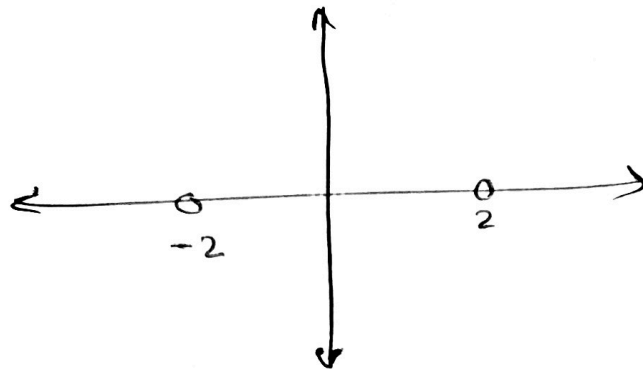
• in-phase carrier بتردد BPSK

• BPSK بتردد two signals موجدة في الجانب

الموجدة موجدة في الجانب

• two signals بتردد 180 درجة

• phase
• 180



⑦ QPSK, with peak amp. value of 3.

سؤال:

(quadrature, in-phase) two carriers بتردد QPSK

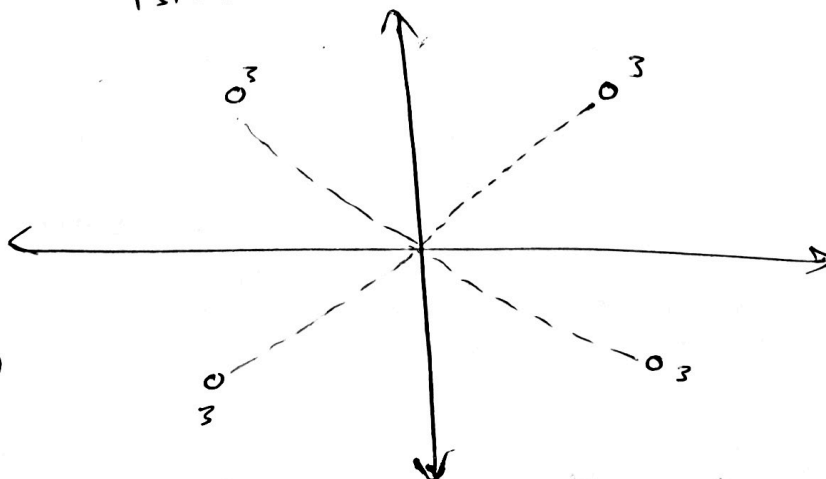
• 4 signals في QPSK

• amp. في 4 signals

(-45° , -135° , 135° , 45°) 4 signals في phases

315° 225°

1st one



• phase
• في
• phase
• في
• 90

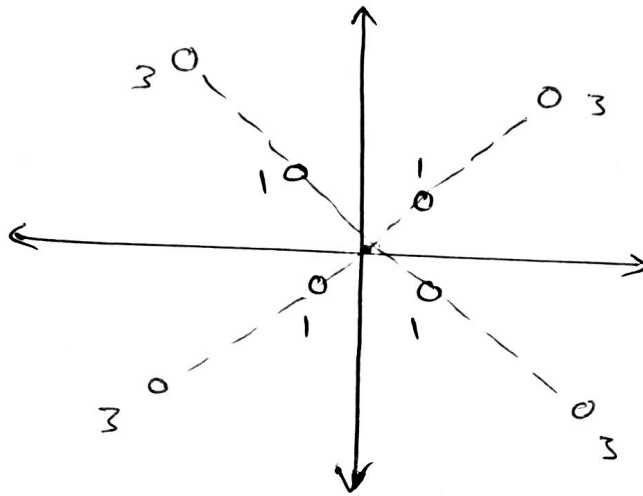
① 8-QAM with different two peak values 1, 3 and four different phases.

Sol:

6 bits (4 phases) 4 ←

• (C) 8 ←

• two amp. 1, 3 ←



⇒ P5-5: Draw constellation diagram? Find peak amp? for (ASK, FSK, PSK, QAM).

• (I, Q) ←

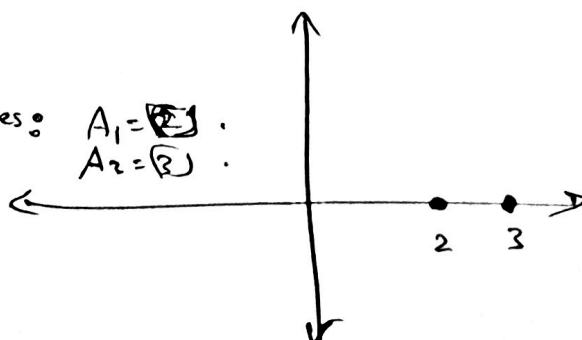
② Two points at $(2, 0)$ and $(3, 0)$. ⇒ ASK

Sol:

• In-phase ←

∴

⇒ peak amp values: $A_1 = 2$, $A_2 = 3$.

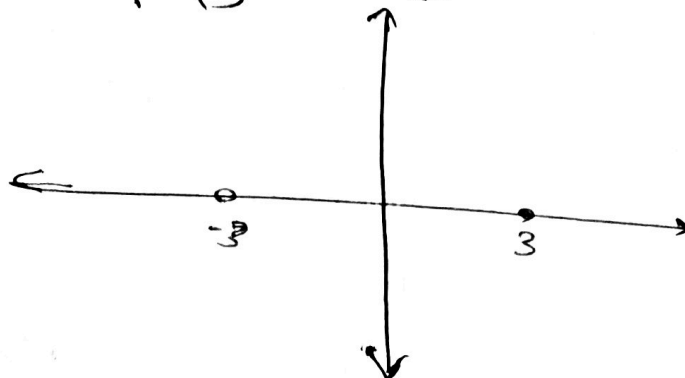


• ASK ←
two amp. 2, 3
• phase 0 ←

⑥ Two points at $(3,0)$ & $(-3,0) \Rightarrow$ BPSK.

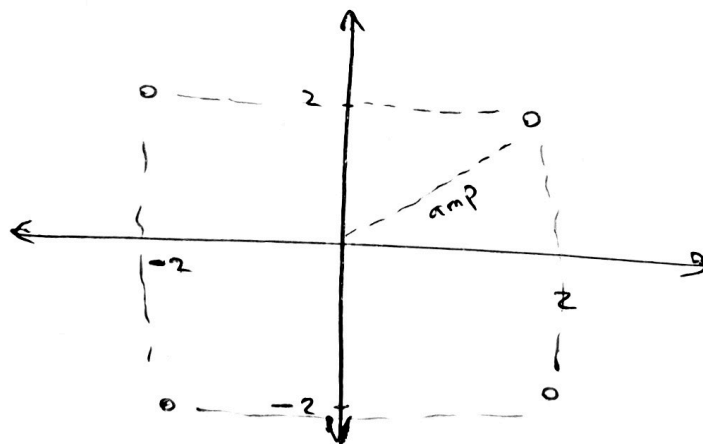
- Summary:
- $(0^\circ, 180^\circ)$: ω & ϕ , ϕ & ω ←
 - In-phase & π ←
 - Peak amp = $[3]$ ←

amp. is 3
• 3 ←



⑦ Four points at $(2,2)$, $(-2,2)$, $(-2,-2)$ and $(2,-2)$.

- Summary:
- (one amp & four phases) QPSK notation ←
 - or
 - (one amp & 4 phases) 4-QAM



تعريف -

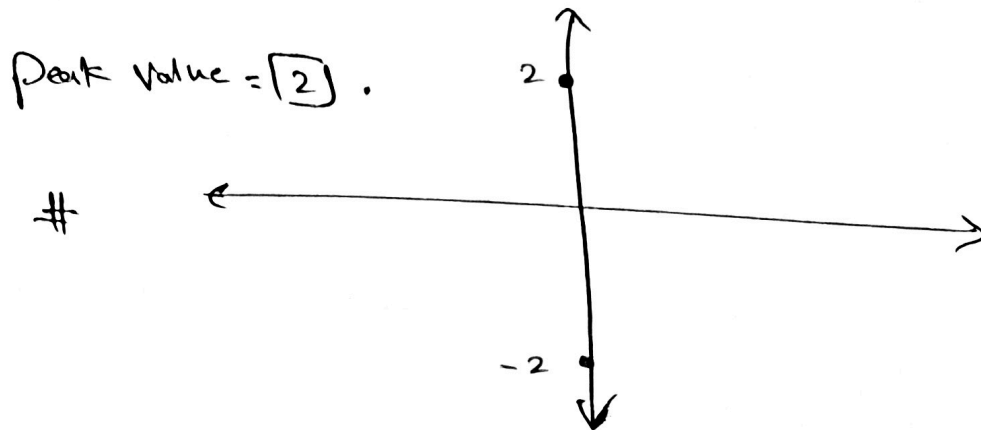
• amp. $\Rightarrow$ amp. is the distance between a point and the origin

$$\text{amp} = \sqrt{2^2 + 2^2} = \boxed{2.83} \text{ V.}$$

قانون
افكاره
#

d) two points at $(0, 2)$ and $(0, -2)$.

Sol: (circular amp. $\rightarrow$ BPSK) $\rightarrow$ phase only



P5-6: # bits per baud, for the following points?

a) 2

b) 4

c) 16

d) 1024

Sol:

$$r = \log_2 L$$

$$a) r = \log_2 2 = \boxed{1}$$

$$b) r = \log_2 4 = \boxed{2}$$

$$c) r = \log_2 16 = \boxed{4}$$

$$d) r = \log_2 1024 = \boxed{10}$$

#

✓

P5.7: required Bandwidth? $N = 4000 \text{ bps}$, $d = 1$.

Sol:

(a) ASK

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

$$= (1+1) \frac{N}{r}$$

$$= (1+1) 4000$$

$$= \boxed{8000 \text{ Hz}}$$

$$r = \log_2 2 = \boxed{1}$$

(b) FSK with $2\Delta f = 4 \text{ kHz}$.

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

$$= (1+d) \frac{N}{r} + 2\Delta f$$

$$= 2 \times 4000 + 4000$$

$$= \boxed{12000 \text{ Hz}}$$

Since:

$$r = \log_2 2 = \boxed{1}$$

(c) QPSK:

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

$$= (1+d) \frac{N}{r}$$

$$= (1+1) \frac{4000}{2}$$

$$= \boxed{4000 \text{ Hz}}$$

$$r = \log_2 4 = \boxed{2}$$

(d) 16-QAM:

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

$$= (1+1) \frac{N}{r}$$

$$= 2 \times \frac{4000}{4} = \boxed{2000 \text{ Hz}}$$

$$r = \log_2 16 = \boxed{4}$$

(8)

P5.8 : $BW = 4k$, maximum number of bits Ξ , $d=0$.
we can sending?

a) Ask.

b) QPSK.

c) 16-QAM.

d) 64-QAM.

$N = ??$

using

~~AB~~

Sol:

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

$$B = (1+0)S$$

$$B = S \Rightarrow S = 4k$$

$$\Rightarrow S = \frac{1}{T} N = \frac{N}{T}$$

$$N = Sr = \underline{4000 r}$$

$$\text{a) Ask} \Rightarrow N = Sr, \quad r = \log_2 2 = [1] \\ = 4000 r = 4000 \times 1 = \underline{4kps}$$

$$\text{b) QPSK} \Rightarrow N = 4000 r, \quad r = \log_2 4 = [2] \\ = 4000 \times 2 \\ = \underline{8000 \text{ bps}}$$

$$\text{c) 16-QAM} \Rightarrow N = 4000 r, \quad r = \log_2 16 = [4] \\ = 4000 \times 4 = \underline{16k \text{ bps}}$$

$$\text{d) 64-QAM} \Rightarrow N = 4000 r, \quad r = \log_2 64 = [6] \\ = 4000 \times 6 = \underline{24k \text{ bps}}$$

Q5-7:

$BW = 1 \text{ MHz}$ (low pass), $d = 0$.

N

التردد
العرضي
التردد

10 channels, each capable of sending at least 10 Mbps.

PAM Technology.

minimum number of bits per band for each channel?

of points in the constellation for each channel?

تردد عرضي
10 channels
بتردد 10 MHz
بتردد 10 MHz

الحل:

channel BW

BW

$$= \frac{1 \text{ MHz}}{10} =$$

$$100 \text{ kHz}$$

channels

channel

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

$$= (1+0) \frac{N}{r}$$

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

$$\therefore r = \frac{N}{B} = \frac{10 \text{ M}}{100 \text{ k}} = 100$$

$$\# \text{ of points in constellation } (L) = 2^r = 2^{100} =$$

of levels

#

#

$$\Rightarrow \underline{Q5-10}: \Rightarrow BW = \boxed{6 \text{ MHz}}.$$

data rate for each resident, 64 QAM.
! $\hat{m}$ $\hat{d}$ N $\hat{r}$

Sol:

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

$$B = (1+d) \frac{N}{6}$$

$$\text{Let } \boxed{d=1}$$

$$\left. \begin{array}{l} B = (1+d) f \\ B = (1+d) \frac{N}{6} \end{array} \right\} \boxed{r = \log_2 64 = 6}$$

$$N = \frac{6 * B}{(1+d)}$$

$$= \frac{6 * 6 \text{ M}}{2} = \boxed{18 \text{ Mbps}}.$$

$\Rightarrow \underline{Q5-11}: BW = ??$ we need to modulate a 5-KHz voice.

(a) AM.

$$\underline{\text{Sol:}} \quad \boxed{B_{AM} = 2B} = 2 * 5k = \boxed{10 \text{ KHz}}.$$

(b) FM ($\beta=5$)

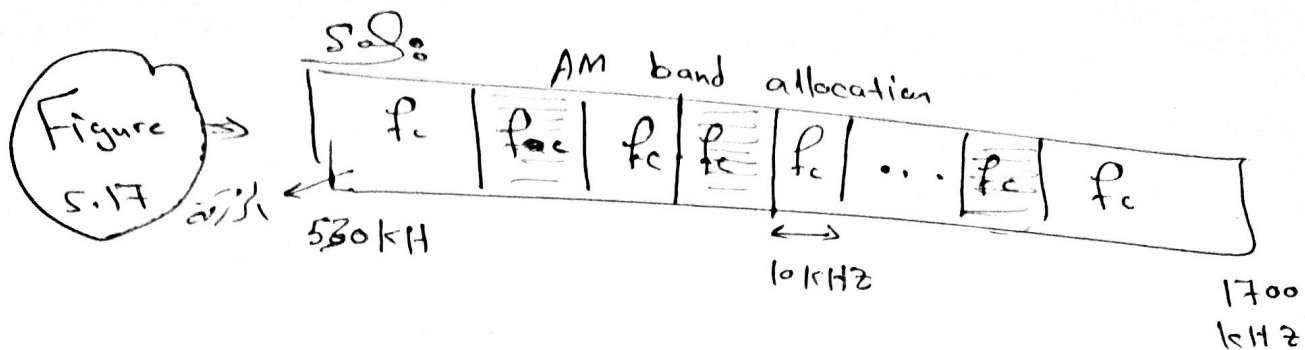
$$\boxed{B_{FM} = 2(1+\beta)B} = 2 * (1+5) * 5k = \boxed{60 \text{ KHz}}.$$

(c) PM ($\beta=1$)

$$\boxed{B_{PM} = 2(1+\beta)B} = 2 * (1+1) * 5k = \boxed{20 \text{ KHz}}. \quad \text{②}$$

Q 5.12: total number of channel ?

① AM



⇒ AM stations carrier freq. between 530 kHz & 1700 kHz, anywhere

⇒ each station's carrier freq. must be separated from those on either side of it at least 10 kHz.

$$n = \frac{(1700 - 530) \text{ kHz}}{10 \text{ kHz}} = \boxed{117}.$$

② FM.

⇒ FM station allowed carrier freq's anywhere between 88 & 108 MHz.

⇒ Stations must be separated by at least 200 kHz.

So:

$$n = \frac{(108 - 88) \text{ MHz}}{200 \text{ kHz}} = \boxed{100}.$$

End of ch 5 #