GATE Online Coaching Classes

Digital Communications

Online Class-5

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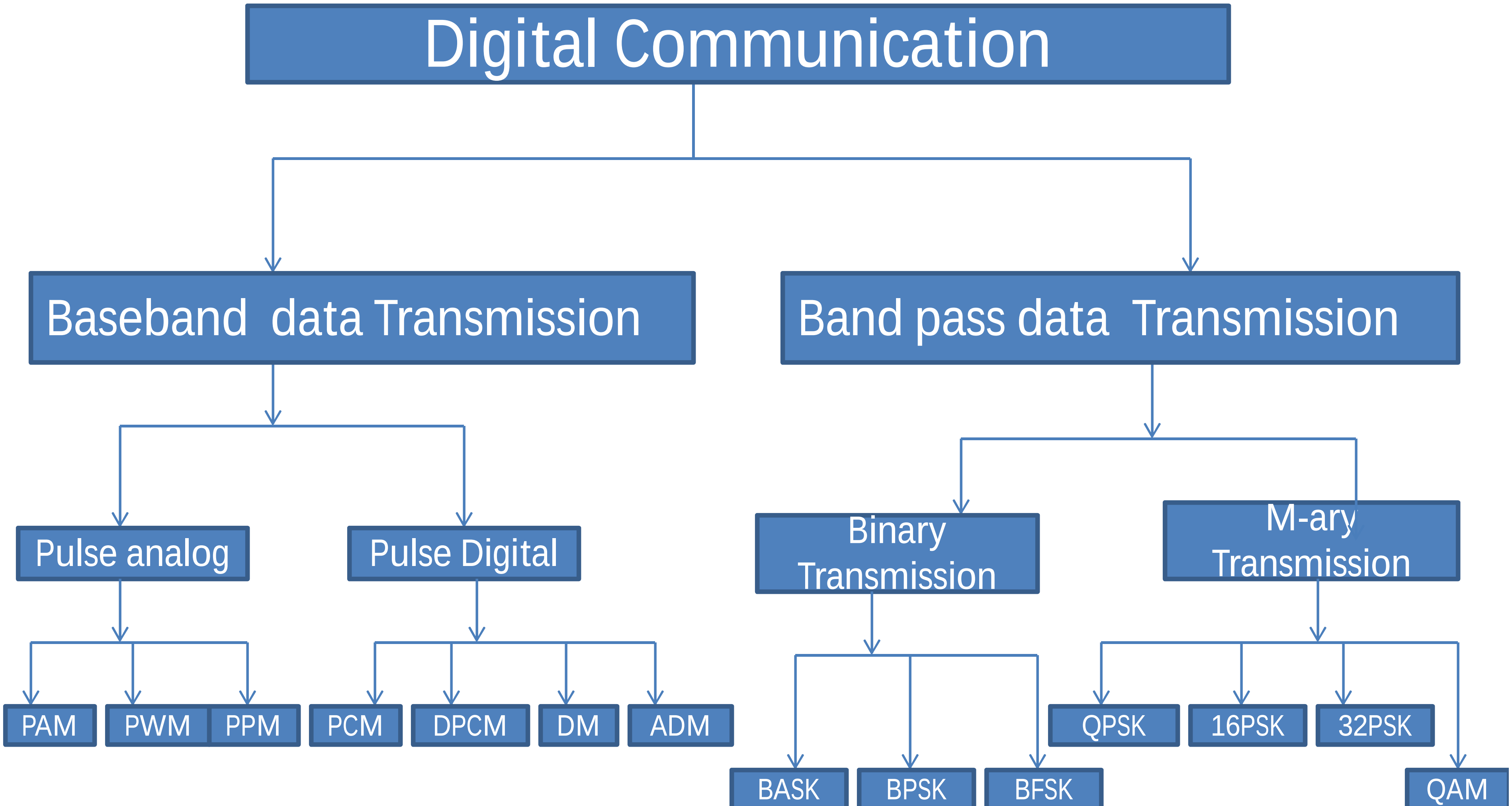
Session-5
Band Pass Transmission

- ❖Introduction
- ❖Binary Amplitude Shift keying (BASK)
- ❖Binary Frequency Shift keying(BFSK)
- ❖Binary Phase Shift keying (BPSK).
- ❖Objective Type Questions and Problems

Classification of Digital Communications



- Baseband digital signals have significant power content in the lower part of the frequency spectrum. Because of this, these signals can be conveniently transmitted over a pair of wires or co-axial cables.

- At the same time, because of the same reason, it is not possible to have efficient wireless transmission of baseband signals as it would require prohibitively large antennas, which would not be a practical or feasible proposition.

- Therefore, if baseband digital signals are to be transmitted over a wireless communication link, they should first modulate a continuous wave high-frequency carrier.

- Digital Modulation provides more information capacity, high data security, quicker system availability with great quality communication. Hence, digital modulation techniques have a greater demand, for their capacity to convey larger amounts of data than analog ones.

Digital Modulation Techniques

- Three well-known techniques available for the purpose include
  - Binary Amplitude Shift keying (BASK)
  - Binary Frequency Shift keying(BFSK) and
  - Binary Phase Shift keying (BPSK).

Types of Modulation

- Coherent Modulation
- Non Coherent modulation

- Coherent demodulation: requires a replica carrier wave of the same frequency and phase at the receiver.
    - Also known as synchronous demodulation
    - Carrier recovery methods
    - Applicable to: PSK, FSK, ASK, etc.
- The coherent detection makes the use of linear operation
- In this ,it is assumed that the local carrier at the receiver is perfectly Synchronized with the carrier used in the transmitter in terms of frequency and phase.

Types of Synchronization:

Two forms of Synchronization are required for the operation of coherent detection.

- ❖ **Timing Synchronization** : enables proper timing of decision making operation in the receiver

- ❖ **Phase Synchronization**: Which ensures that carrier wave generated locally in the receiver is locked in phase with respect to one that is employed in the transmitter.

- Advantage
  - It is efficient performance with high SNR
- Disadvantages
  - Requires complex circuit
  - Costly

Non-coherent demodulation: does not require a reference carrier wave

- ❖Non-coherent demodulation: does not require a reference carrier wave
- ❖It is less complex than coherent demodulation (easier to implement), but has worse performance
- ❖ Example: FSK non-coherent demodulator
- ❖Applicable to: DPSK, FSK, etc.
- ❖ Example: FSK non-coherent demodulator the received signal and replica carrier are cross-correlated

- ❖Advantage
  - ❖It is Simple
- ❖Disadvantages
  - ❖Probability of error increases

BASK

- ASK converts Digital signal into Analog signal

- The Amplitude of carrier signal(Analog carrier) is varied in accordance with the instantaneous values of modulating signal (Binary data)

- In the simplest form of amplitude shift keying (ASK), the carrier signal is switched ON and OFF depending upon whether a `1’ or `0’ is to be transmitted ASK is also known as ON-OFF keying (OOK).
- The signal in this case is represented by the following expression:

$$s(t) = A\cos \omega_c t \quad \text{for bit } 1$$
$$= 0 \quad \text{for bit } 0$$

$$s(t) = A \cos \omega_c t \text{ for Symbol 1}$$

$$= 0 \qquad \text{for Symbol 0}$$

The Power of the symbol $P_s = (A/\sqrt{2})^2$

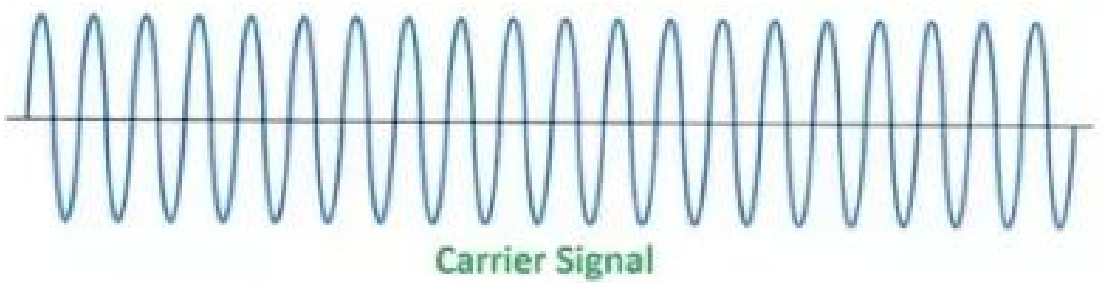
$$P_s = (A^2/2)$$

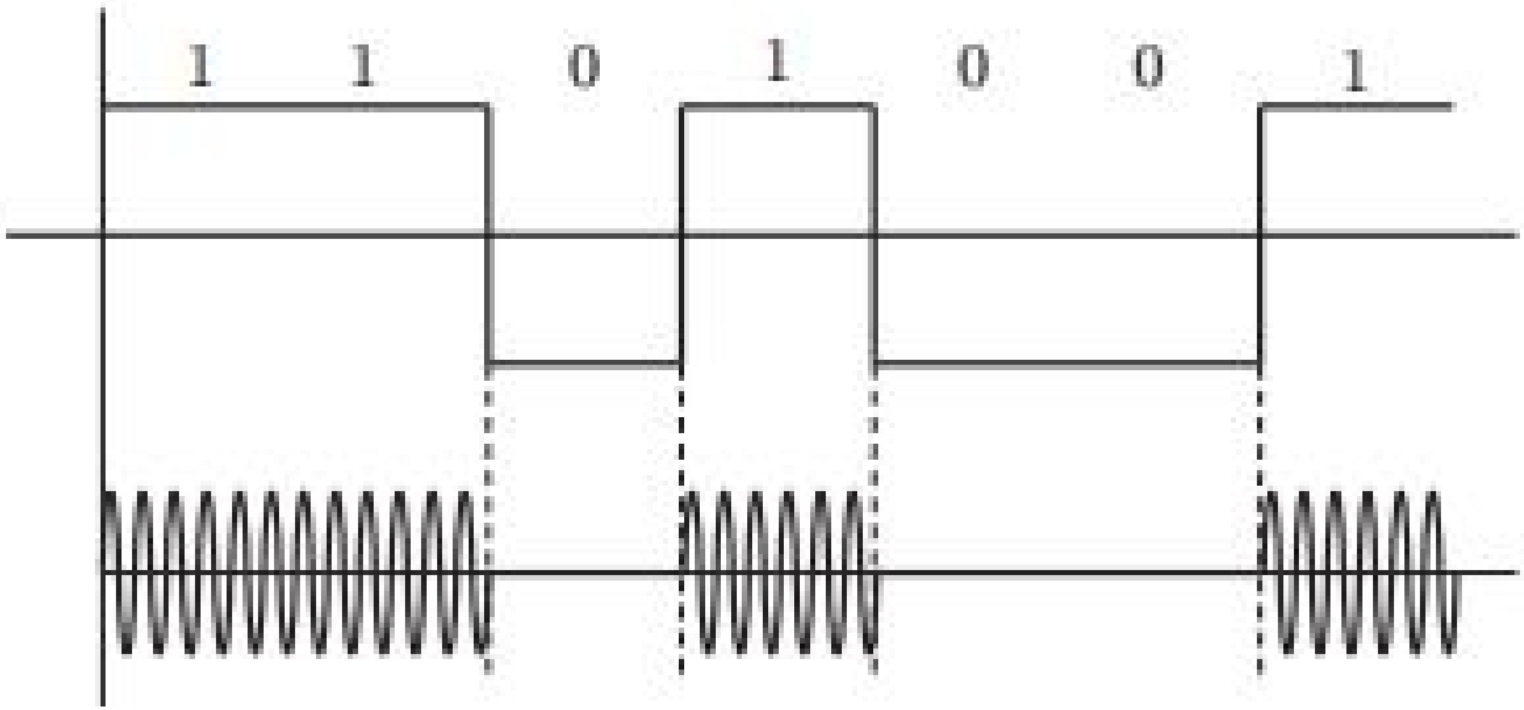
$$A = \sqrt{2P_s}$$

$$s(t) = A \sin \omega_c t = \sqrt{2P_s} \cos \omega_c t \text{ for Symbol 1}$$

$$\sqrt{2E_s/T_s} \cos \omega_c t$$

BASK



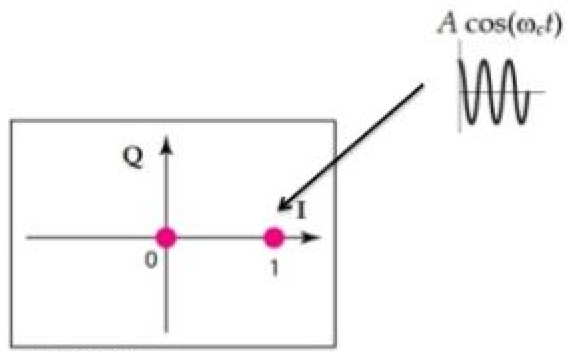


Constellation diagram

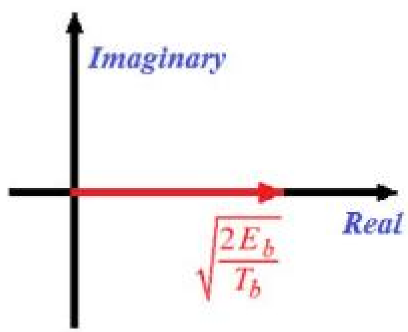
- Constellation diagram is a graphical representation of the complex envelope of each possible symbol state
- The x-axis represents the in-phase component and the y-axis the quadrature component of the complex envelope
- The distance between signals on a constellation diagram relates to how different the modulation waveforms are and how easily a receiver can differentiate between them.

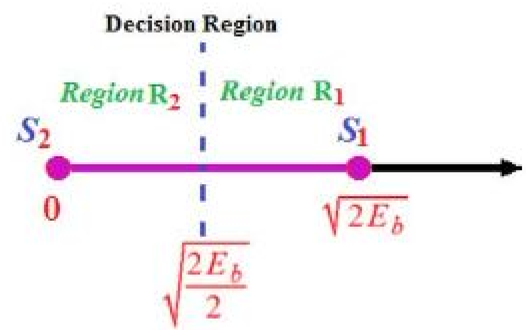
Constellation Diagram for ASK

$$s(t) = \begin{cases} A\cos(2\pi f_c t), & binary\ 1 \\ 0, & binary\ 0 \end{cases}$$



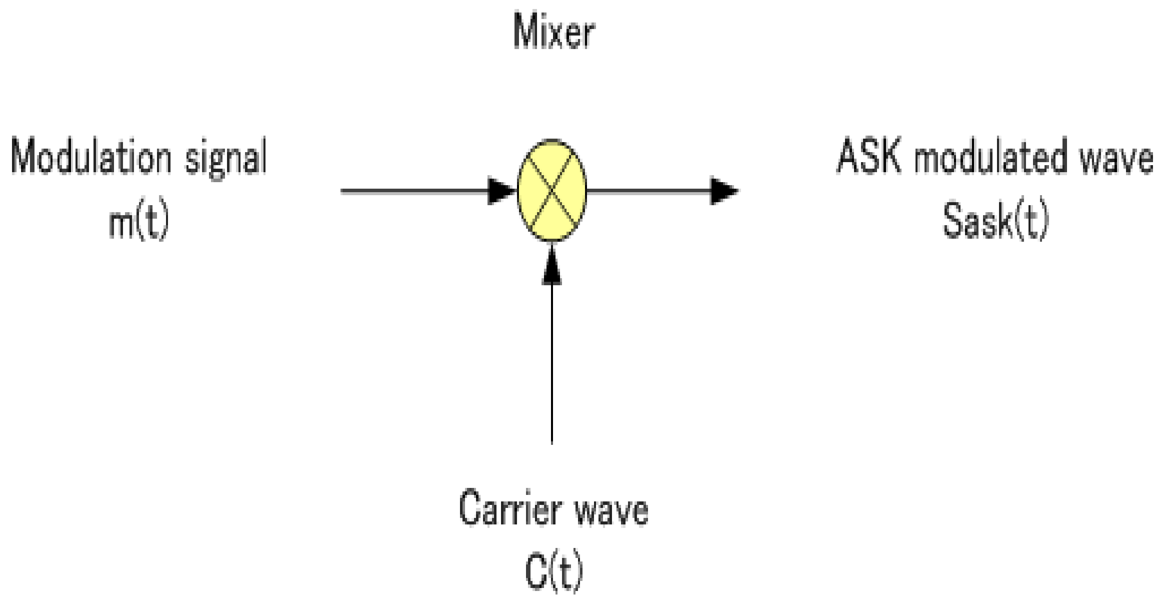
ASK (OOK)

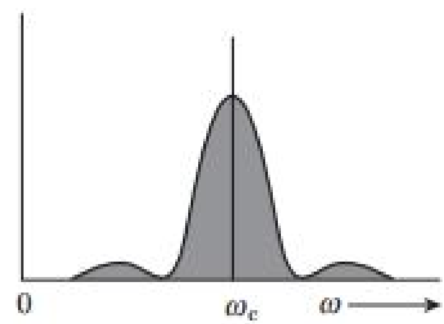




$$s(t) = \sqrt{\frac{2E_b}{T_b}}\cos 2\pi f_c t + j\,0 \quad 0 \le t \le T_b$$

Modulation of ASK

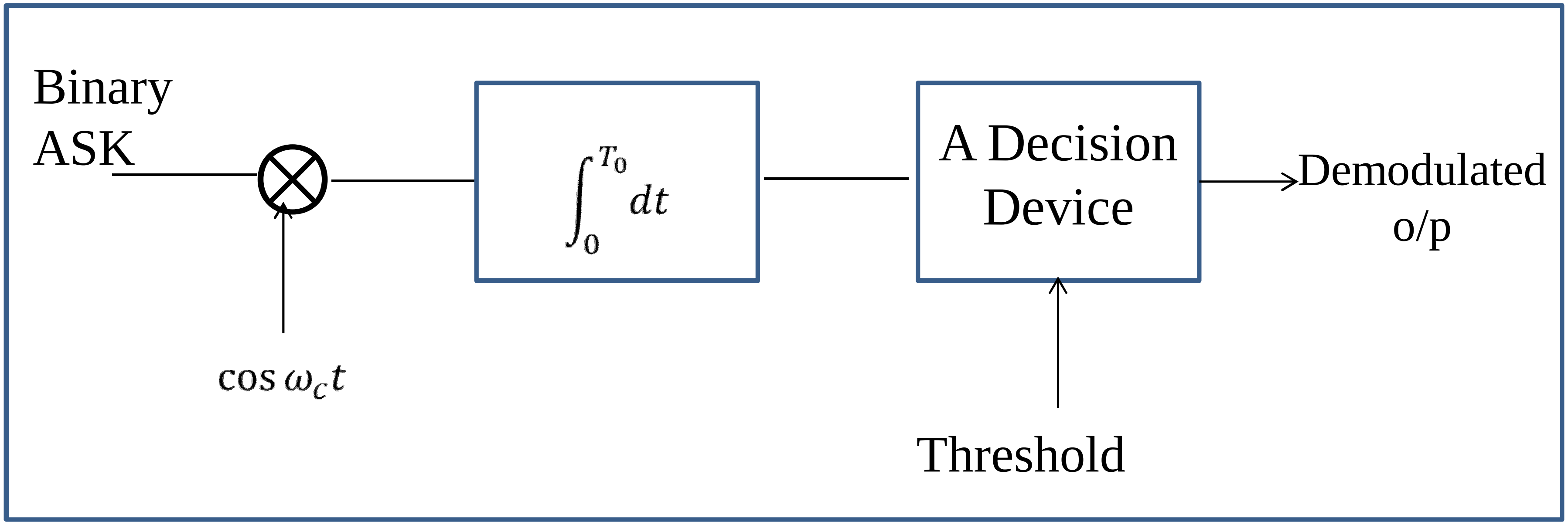




PSD of ASK signal.

ASK Demodulator

ASK Coherent Demodulator



For a Symbol 1, the Acos $\omega_c t$ is one of the inputs to the product modulator of Receiver section

The out put of product modulator

$$= A\cos \omega_c t . \cos \omega_c t$$

$$= A \cos^2 \omega_c t$$

$$= A\,(1+\cos 2\omega_c t)\,/2$$

Demodulated out put = A /2 =logic 1

ASK Demodulator

ASK Non Coherent Demodulator

Bandwidth of ASK

- Bandwidth of ASK is proportional to baud rate of message signal
- BW α r
- B.W = (1+d) r

  = (1+d)R/n

  $0 \leq d \leq 1$,

d is Factor of modulating and filtering process

R-Bit rate or Data rate

N- number of bits per sample

For ideal modulation d=0, BW= r

For worst case modulation d=1, BW=2r

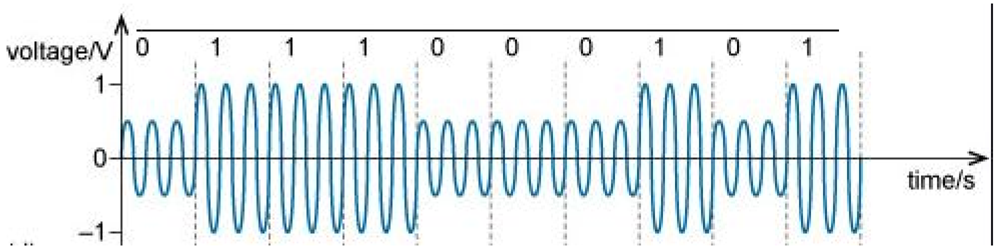
Applications

- ❖Broadcasting of Signals
- ❖Wireless Telegraph

BASK

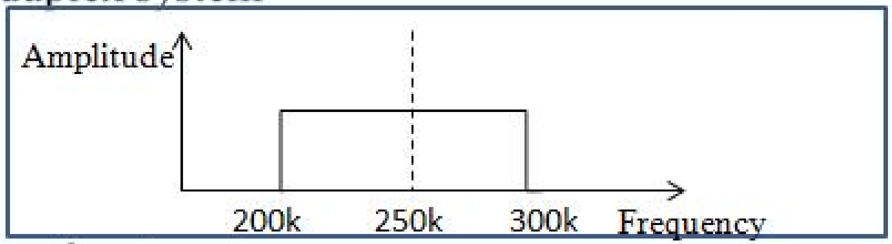
- The OOK has the disadvantage that appearance of any noise during transmission of bit `0’ can be misinterpreted as data.

- This problem can be overcome by switching the amplitude of the carrier between two amplitudes, one representing a `1’ and the other representing a `0’



EXAMPLE: We have an available Bandwidth of 100 kHz which spans over 200 to 300 kHz. What are the carrier frequency and bit rate, if we modulated our data by using BASK with modulation factor d=1.

Carrier Frequency for Half duplex system



Carrier frequency will be exactly at center

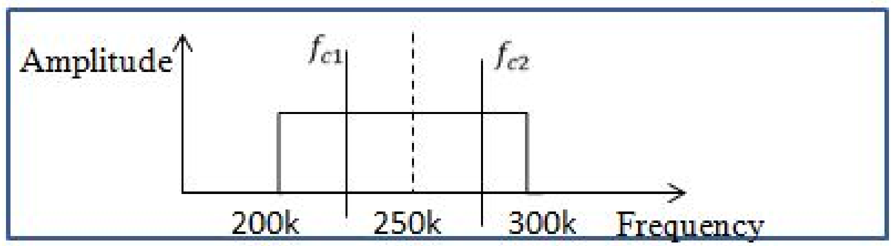
∴ The carrier for half duplex system =250 kHz

Carrier frequency for Full duplex System

Half of the band is used for transmitter

Half the band is used for receiver

Therefore we will have two carrier frequencies



$f_{c1} = 225kHz \; and \; f_{c2} = 275kHz$

∴ The carrier frequencies for Full duplex system are 225k & 275k

B.W=100kHz

B.W = 100k

n=1, d=1 R=?

B.W =(1+d)r

100k=2r

∴ r = 50k sample/sec

$$baud\ rate = \frac{Bit\,rate}{n} = \frac{R}{n}$$, n=1 for BASK

∴ Data Rate R= r*n=50*1= 50kbps

2. Find the minimum bandwidth (in kHz) required for transmitting an ASK signal at 2kbps in half duplex transmission mode.

Sol: In ASK, the baud rate and bit rate are the same (as d=1)

$\therefore$ Baud rate =2000 bauds

An ASK signal required a minimum bandwidth equal to its baud rate.

$\therefore$ Minimum Band Width = 2000 Hz = 2KHz.

3. A communication system employs ASK to transmit a 10kbps binary signal. Find the baud rate required in bauds and the minimum Band Width required in Hertz.

Sol : For an ASK system , the baud rate is as same as the bit rate of the signal.

$\therefore$ Baud rate =10000 bauds

$\therefore$ Minimum Band Width = Baud rate = 10KHz.

BFSK

- FSK converts Digital signal into Analog signal
- The Frequency of carrier signal(Analog carrier) is varied in accordance with the instantaneous values of the modulating signal (Binary data)

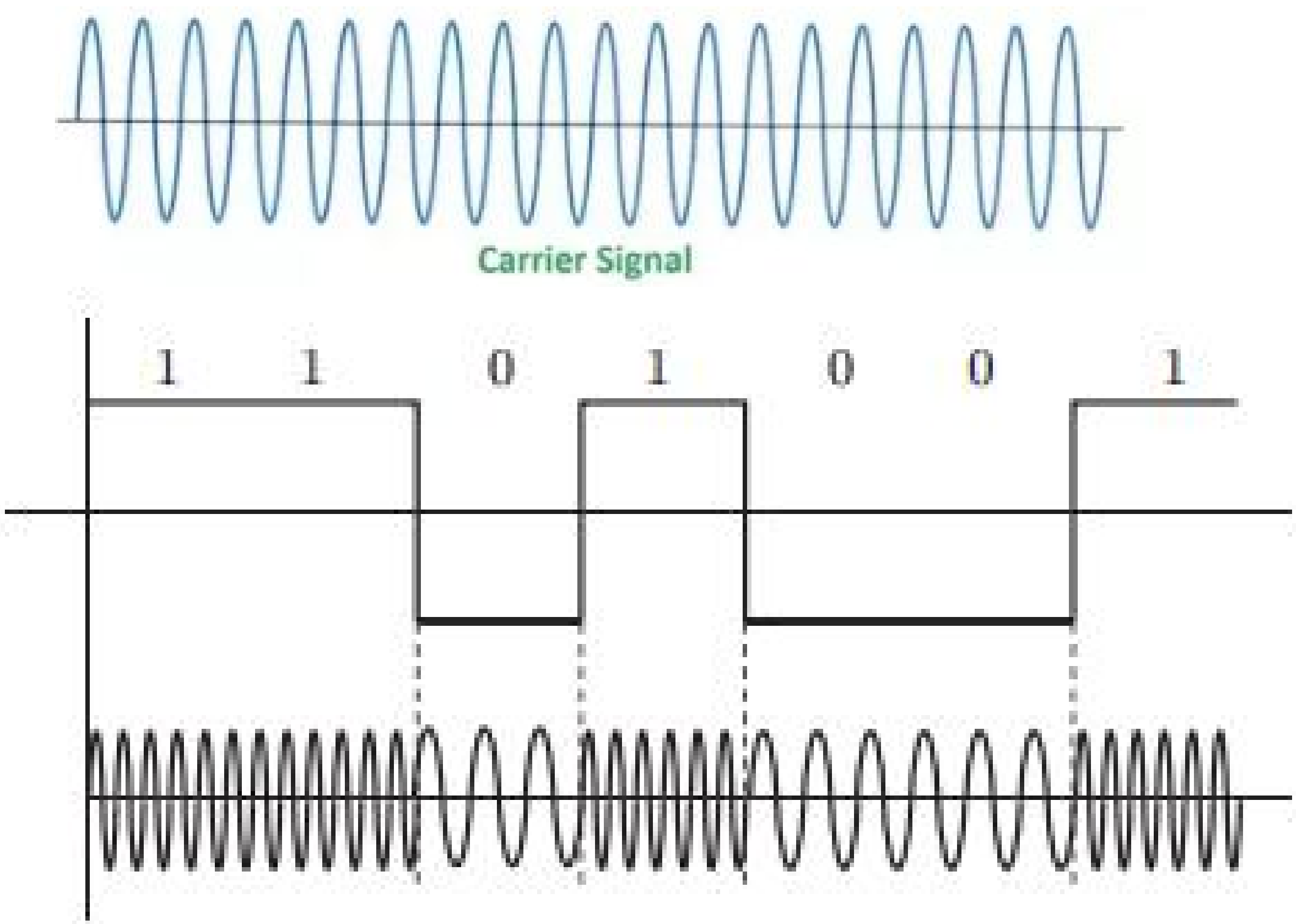
BFSK

In frequency shift keying (FSK), it is the frequency of the carrier signal that is switched between two values, one representing bit `1' and the other representing bit `0' as shown in Fig Modulated carrier signal in this case is represented by the following expression:

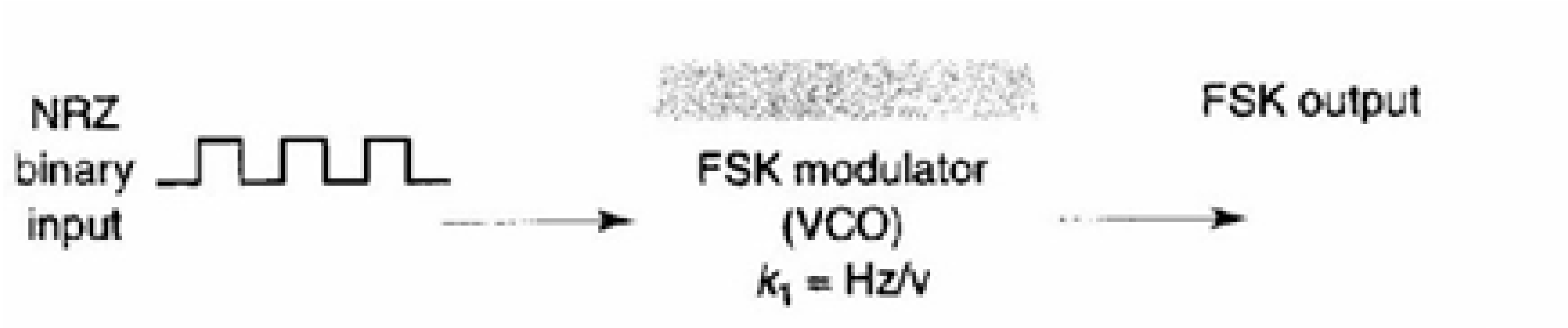
$$s(t) = A\cos \omega_{c1} t \qquad \text{for bit } 1$$
$$= A\cos \omega_{c2} t \qquad \text{for bit } 0$$

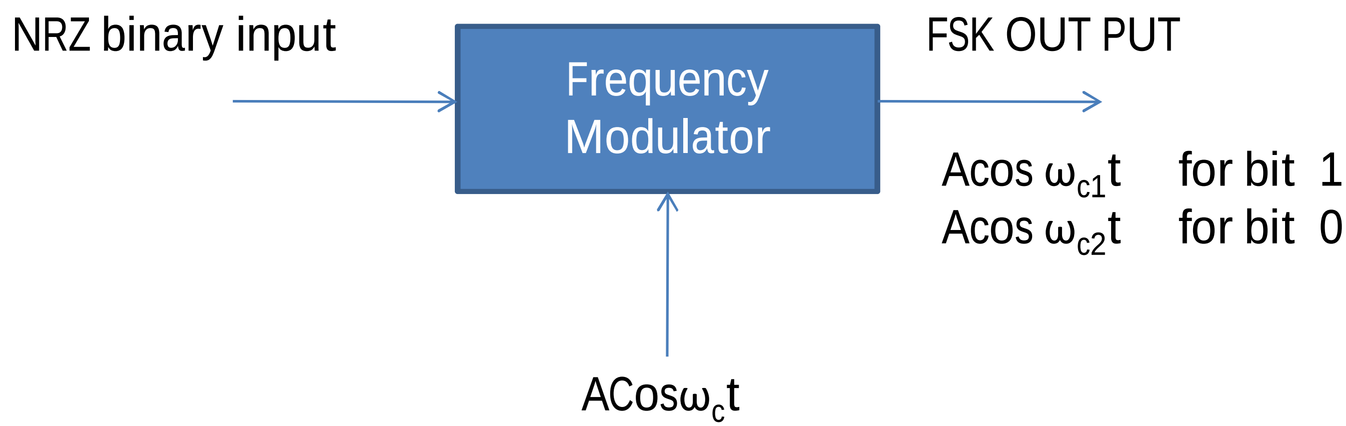
$$\omega_{c1} = (\omega_c t + \Omega) \quad \text{Mark Frequency}$$
$$\omega_{c2} = (\omega_c t + \Omega) \quad \text{Space Frequency}$$

BFSK

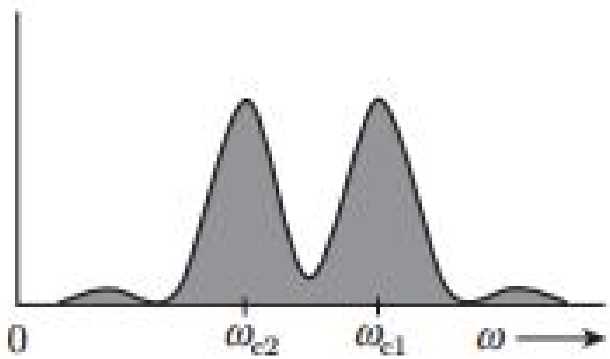


Modulation of FSK



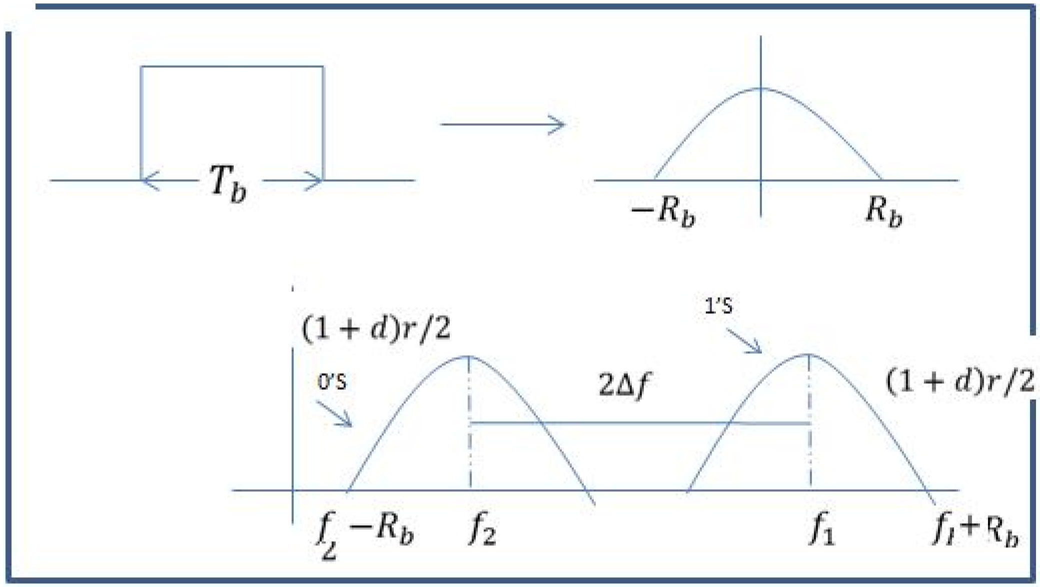


The spectrum of BFSK may be viewed as the sum of Two ASK spectra



PSD of an FSK signal.

Bandwidth of FSK



$$\boxed{Band\ Width\ of\ BFSK = f_1 - f_2 + 2R_b}$$

Band Width = $2\Delta f$ $+2R_b$ Δf Frequency deviation

$$Band\ Width\ of\ BFSK = (1+d)r + 2\Delta f$$

For minimum Band Width $2\Delta f = (1+d)r$

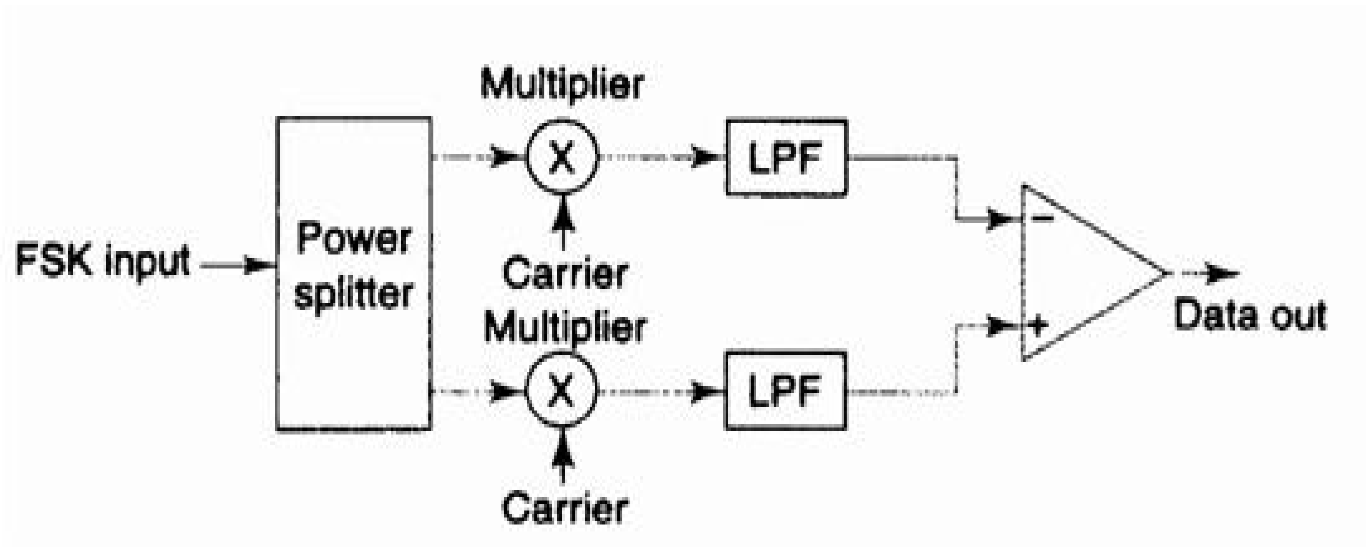
When d=0, $2\Delta f = r$

Band Width = 2*r

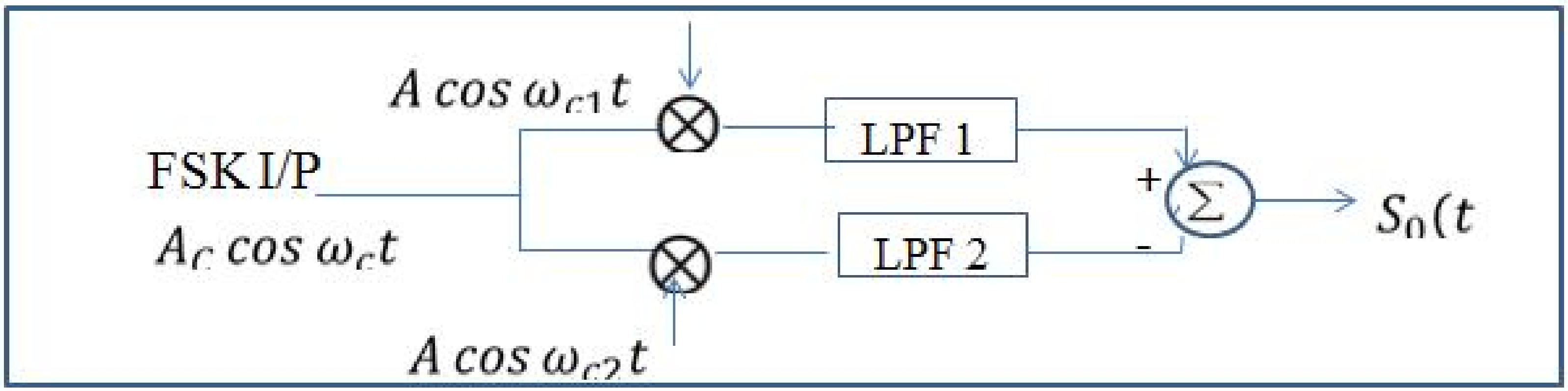
Minimum Band Width = 2 R_b

Demodulation of FSK

Coherent Demodulator



Coherent FSK demodulator


$A \cos \omega_{c1} t$
LPF 1
FSK I/P
$A_C \cos \omega_c t$
+
Σ
-
$S_0(t$
LPF 2
$A \cos \omega_{c2} t$

When $V_{FSK}(t) = A\cos\omega_{c1}t = A\cos 2\pi f_{c1}t$

The I/P to the LPF1 = $A^2\, cos^2\, 2\pi f_{c1}t = \frac{A^2}{2} + \frac{\cos 4\pi f_{c1}t}{2}$

The O/P of the LPF1 $= \frac{A^2}{2}$

The I/P to the LPF2 $= A^2 \cos 2\pi f_{c1}t . \cos 2\pi f_{c2}t$

$$= \frac{A^2}{2}\{\cos 2\pi(f_{c1} + f_{c2})t + \cos 2\pi(f_{c1} - f_{c2})t\}$$

The LPF eliminates the high frequency components.

∴ The O/P of LPF 2 = 0

∴ The output of the adder $= \frac{A^2}{2} + 0 = +\frac{A^2}{2}$

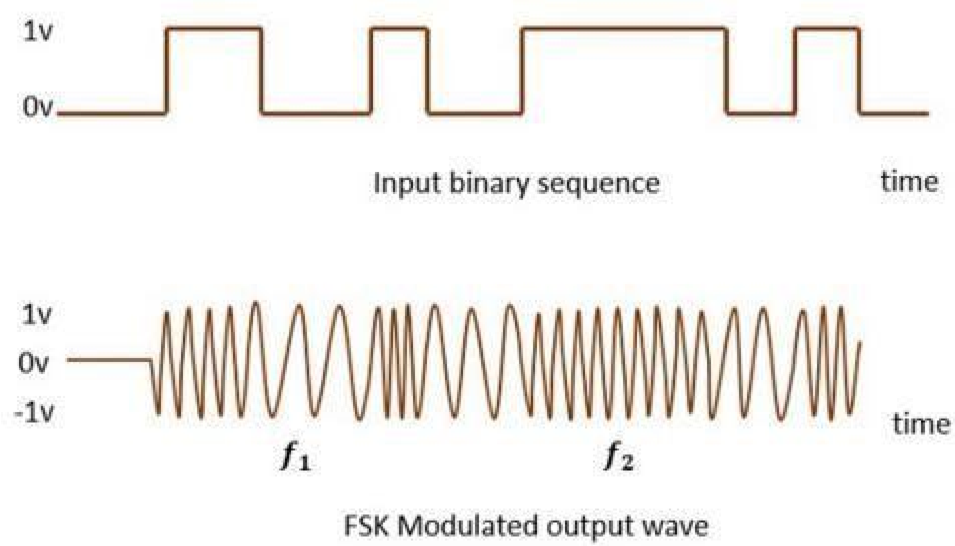
Similarly when $V_{FSK}(t) = A\cos\omega_{c2}t = A\cos 2\pi f_{c2}t$

The output of the adder $= -\frac{A^2}{2} + 0 = -\frac{A^2}{2}$

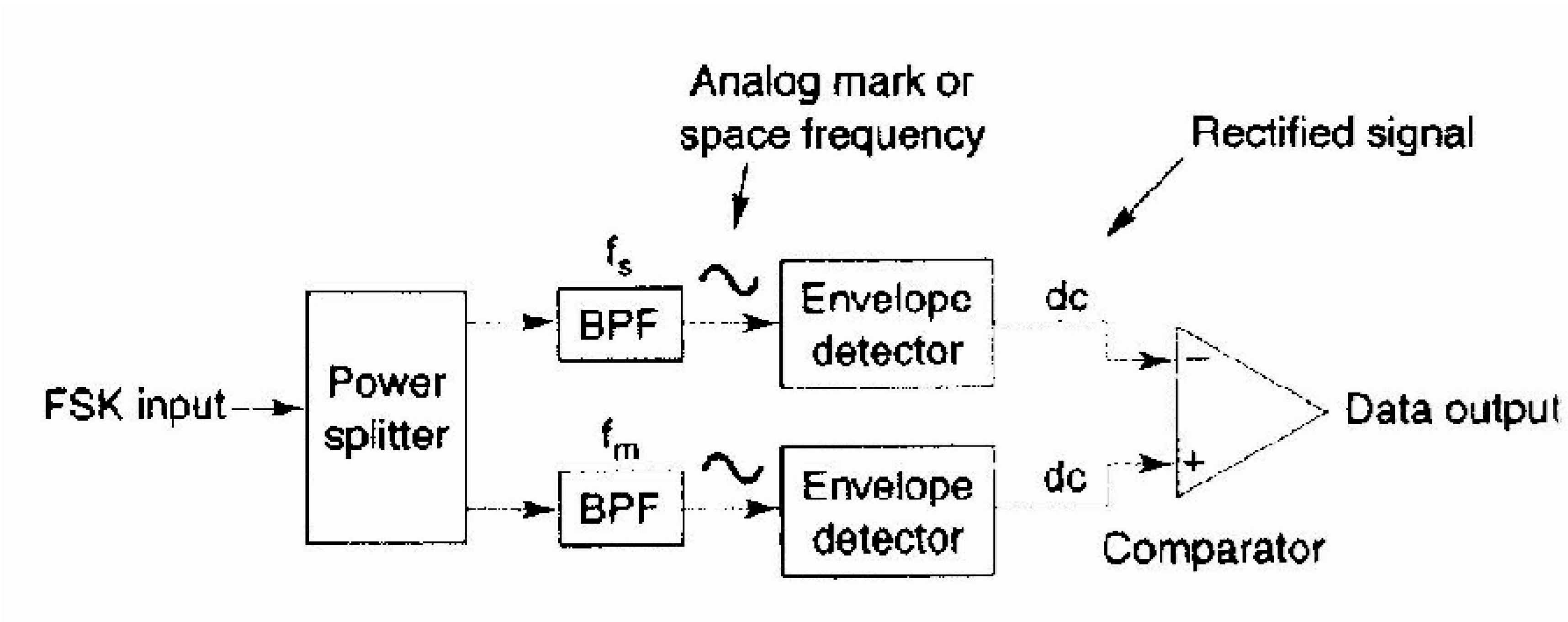
∴ Thus if $S_0(\mathrm{t}) = +\frac{A^2}{2}$ '1' has been received

$= -\frac{A^2}{2}$ '0' has been received

Practically PLL is used as demodulator for FSK


1v
0v
Input binary sequence
time
1v
0v
-1v
time
f_1
f_2
FSK Modulated output wave

Noncoherent Demodulator



Non coherent FSK demodulator

Applications

- In telephone line modem used FSK to transmit 300 bits/sec at two frequencies 1070Hz & 1270 Hz

- In case of FSK, when modulation rate increases, the difference between the two chosen frequencies to represent a `1’ and a `0’ also needs to be higher.

- Keeping in view the restriction in available bandwidth, it would not be possible to achieve bit transmission rate beyond a certain value.

We need to send data 3 bits at a time at 9 bit rate of 3 mbps. The carrier frequency is 10 MHz. Calculate the number of levels, the baud rate and Band Width.

Sol : n = 3 bits

R = 3 Mbps

f_c = 10 MHz

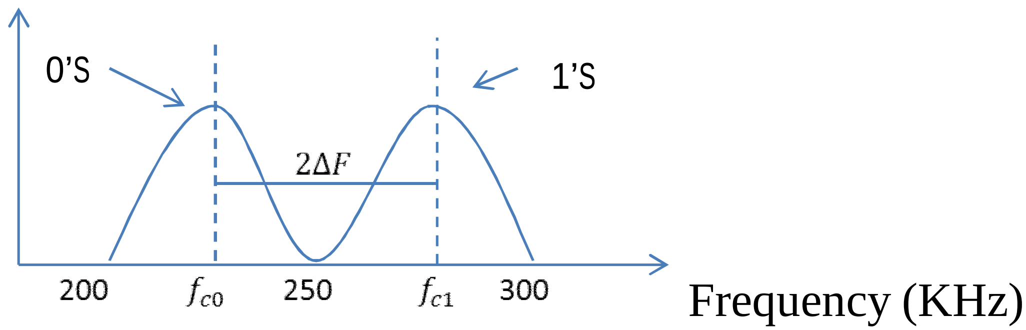
L = $2^n = 2^3 = 8$

∴ The number of levels =8

Baud Rate $r = \frac{Bit\,rate}{n} = \frac{3\,Mbps}{3} = 1Mbaud$

Band Width = L $*$ r $= 8 * 1\,Mbaud = 8\,MHz$

We have an available Band Width of 100 KHz which spans from 200 to 300KHz. What should be carrier frequency and the bit rate if we modulated our data by using FSK.



$$f_{c0} = 225\ KHz$$
$$f_{c1} = 275\ KHz$$

$$B.W = f_{c1} - f_{c0} + 2R_b$$
$$100K = (275 - 225) + 2R_b$$
$$100K = (50) + 2R_b$$
$$R_b = 25\ K\ baud$$

BPSK

- PSK converts Digital signal into Analog signal
- The Phase of the carrier signal(Analog carrier) is varied in accordance with the instantaneous values of modulating signal (Binary data)

- In phase shift keying (PSK), the phase of the carrier is discretely varied with respect to either a reference phase or to the phase of the immediately preceding signal element in accordance with the data being transmitted.

- For example, when encoding bits, the phase shift could be 0° for encoding a bit `0’ and 180° for encoding a bit `1’ as shown in Fig The phase shift could have been -90° for encoding a bit `0’ and +90° for encoding a bit `1’. The essence is that representations for `0’ and `1’ are a total of 180° apart.

- Such PSK systems in which the carrier can assume only two different phase angles are known as binary phase shift keying (BPSK) systems.

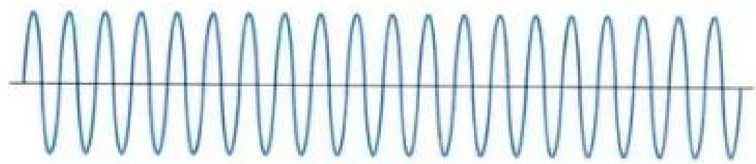
- We can appreciate that in BPSK system, each phase change carries one bit of information that is the bit rate equals the modulation rate

The carrier signals used to represent `0' and `1' bits could be expressed as follows:

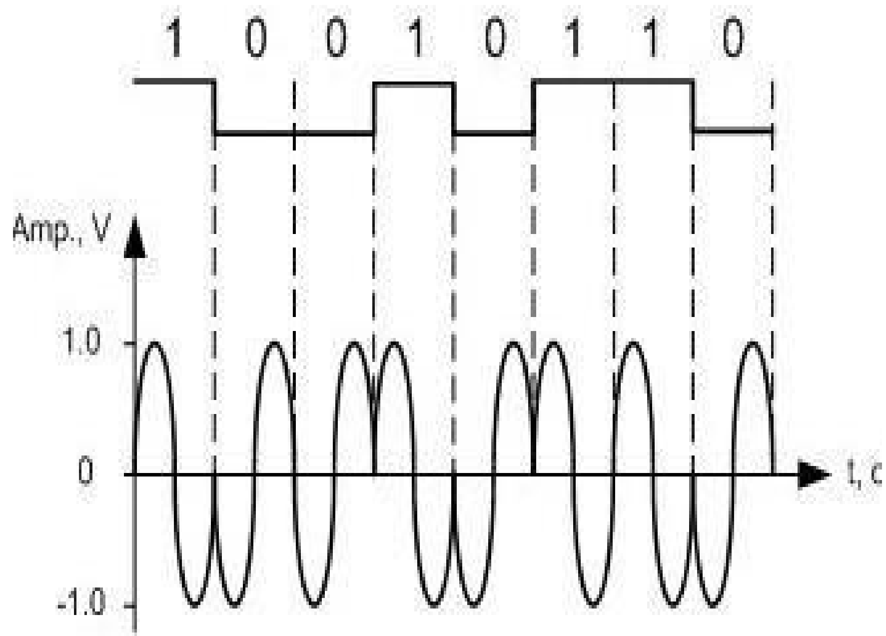
$$s(t) = A\cos \omega_c t \qquad \text{for bit } 1$$
$$= A\cos (\omega_c t+\pi) \qquad \text{for bit } 0$$

(OR)

$$s(t) = A\cos \omega_c t \qquad \text{for bit } 1$$
$$= -A\cos (\omega_c t) \qquad \text{for bit } 0$$



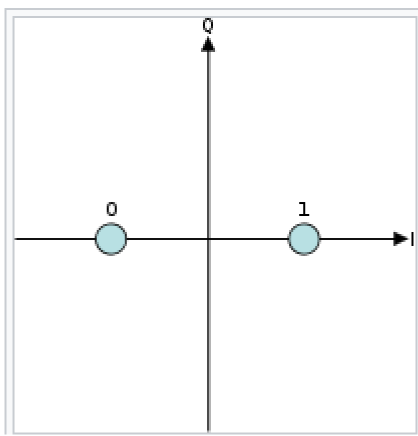
Carrier Signal



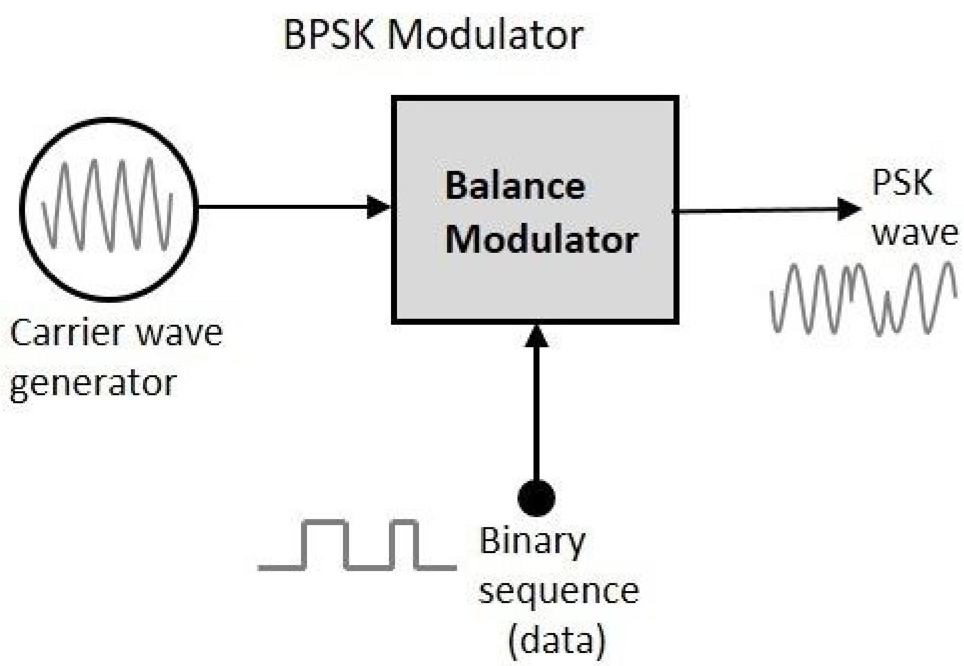
Phase shift keying (PSK)

Constellation Diagram for PSK

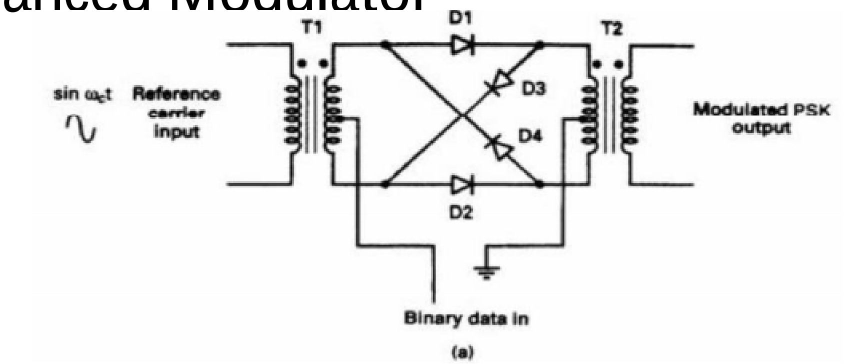
- The constellation diagram for BPSK displays the characteristic of **antipodal signalling**.
- This means that the symbols used are equal and opposite to each other in the constellation space.
- antipodal signalling is a prerequisite for achieving optimum data detection performance in noise.

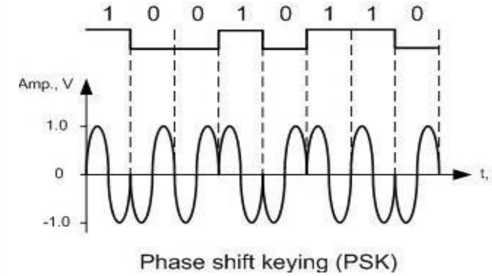


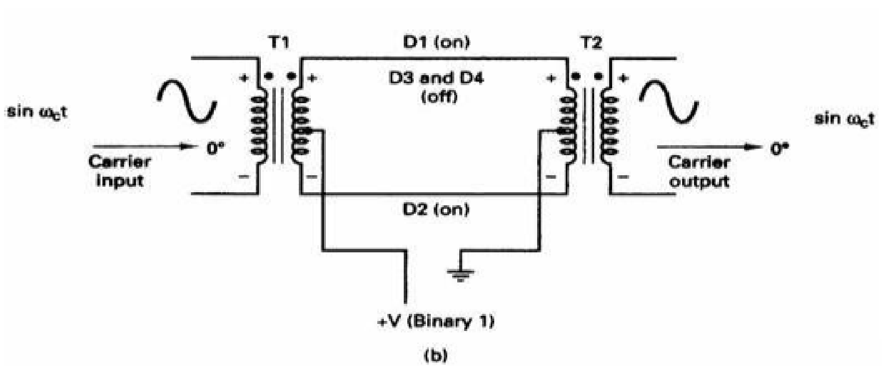
Modulation of BPSK

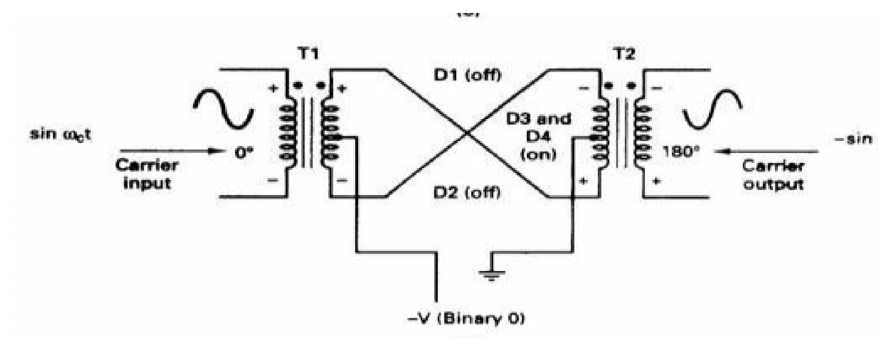


Operation of Balanced Modulator



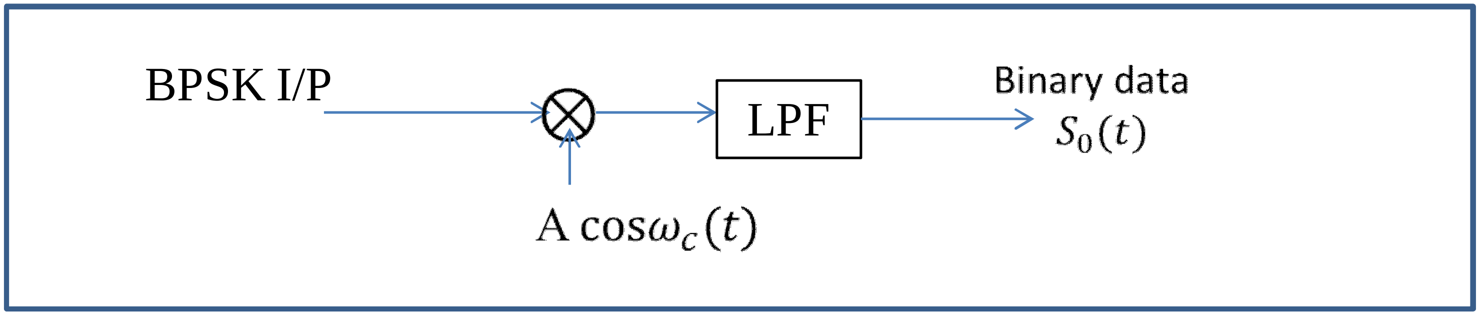






❖For binary bit 1,D_1 and D_2 are in off state and D2 and D4 are in on state with the polarities shown.
For binary bit 0,D_2 and D_4 are in off state and D_1 and D_2 are in on state with the polarities shown.

Demodulation of BPSK



- If the BPSK i/p is +A $\cos\omega_c(t)$ (logic '1') , the O/P of the product modulator is

$$(\text{A } \cos\omega_c(t))\text{A}\cos\omega_c(t) = A^2 cos^2\omega_c t = \frac{A^2}{2} + \frac{A^2}{2}\, cos2\omega_c t$$

The LPF elements the high frequency components.

$$S_0(t) = \frac{A^2}{2} = logic'1'$$

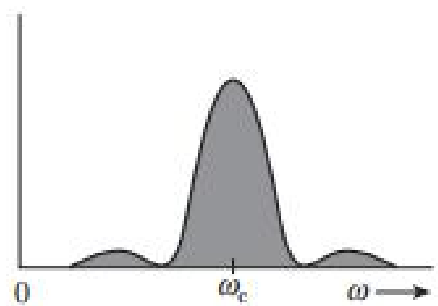
- If the BPSK i/p is $-\text{A}\cos\omega_c(t)$ $(logic'0')$, the O/P of the product modulated is $-\text{A } \cos\omega_c(t))\text{A}\cos\omega_c(t) = -\frac{A^2}{2} - \frac{A^2}{2}\, cos2\omega_c t$

$$S_0(t) = -\frac{A^2}{2} = logic'0'$$

Bandwidth of BPSK

❖The Spectrum of BPSK is same as BASK.

❖Bandwidth of BPSK is same as BASK



PSD of a PSK signal.

If R_b is the bit rate, the Bandwidth of BPSK is $2R_b$

The Minimum Bandwidth of BPSK is R_b

Advantages of PSK:

- ❖ Better than FSK and ASK
- ❖Bandwidth is better than FSK
- ❖Noise Immunity
- ❖Better data rate than FSK

Drawbacks:

- ❖No Non coherent detection
- ❖Costly

Applications:

- ❖In Digital Communications
- ❖ it was also used in telephone modems with data rate 2400 and 4800bps.

Prob: A voice signal is sampled at the rate of 8000 samples/sec and each sample is encoded in to 8 bits using PCM . The binary data is transmitted into free space after modulation. Determine the Bandwidth of modulated signal, if the modulation technique is ASK, PSK & FSK for $f_1 = 10\ MHz$, $f_2 = 8\ MHz$.

Sol : Bit rate $R_b = r * n$

Baud rate = 8000 samples/sec

No.of bits per sample =8

$\therefore R_b$= 8000*8 = 64000

Band Width of ASK $= 2 * R_b$

= 2* 64000 = 128 kHz

Band Width of PSK $= 2 * R_b$

= 2* 64000 = 128 kHz

Band Width of FSK = $(f_1 - f_2) + 2R_b$

= (10 - 8)+ (2*64000)

= 2M + 128000

= 2M+O.128M

=2.128 M

Comparisons

Scheme	$S_1(t)$ and $S_2(t)$	BW	P_e	Complexity
Coherent ASK	$S_1(t) = A_c \cos 2\pi f_c t$ $S_2(t) = 0$	$2R_b$	high	high
Non-coherent ASK	$S_1(t) = A_c \cos \omega_c t$ $S_2(t) = 0$	$2R_b$	high	low
Coherent FSK	$S_1(t) = A_c \cos 2\pi f_1 t$ $S_2(t) = A_c \cos 2\pi f_2 t$ $(f_1 > f_2)$	$2R_b + (f_1 - f_2)$	moderate	high
Non-Coherent FSK	$S_1(t) = A_c \cos 2\pi f_1 t$ $S_2(t) = A_c \cos 2\pi f_2 t$	$> 2R_b$	moderate	low
Coherent PSK	$S_1(t) = A_c \cos \omega_c t$ $S_2(t) = -A_c \cos \omega_c t$	$2 R_b$	low	high

Objective Type questions and Problems

1. The detection method where carrier's phase is given importance is called as
   a) Coherent detection
   b) Non coherent detection
   c) Coherent detection & Non coherent detection
   d) None

2. The coherent modulation techniques are
   a) PSK
   b) FSK
   c) ASK
   d) All of the mentioned

3. The real part of a sinusoid carrier wave is called as

   a) Inphase
   b) Quadrature
   c) Inphase & Quadrature
   d) None of the mentioned

4. Which modulation scheme is also called as on-off keying method?

   a) ASK
   b) FSK
   c) PSK
   d) GMSK

5. Determine the peak frequency deviation, for a binary FSK signal with a mark frequency of 51 kHz, a space frequency of 49 kHz, and an input bit rate of 2 .

The peak frequency deviation is

Δf =(mark frequency-space frequency)/2

=|49kHz - 51 kHz| / 2 =1 kHz kbps.

6.For the above problem 5, determine minimum bandwidth

minimum bandwidth = 2(Δf + $2R_b$)

= 2(1+2) =6K

7 .For the above problem 5, determine baud Rate

For FSK, N = 1, and the baud rate = bit rate

baud = 2000 / 1 = 2000

8. The BPSK is also known as

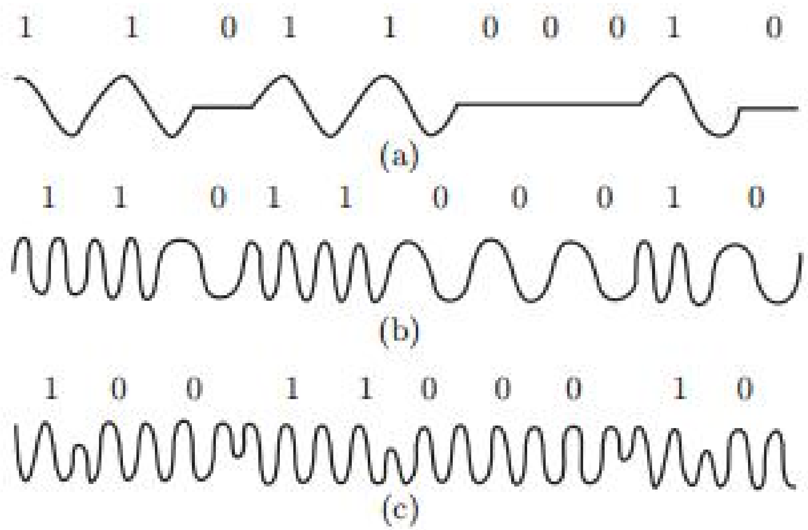
a. Phase Reversing Keying

b. Bi Phase modulation

c. Both a and b

d. None of the above

9. For the bit stream 1101100010, the waveforms in the following figures (a), (b) and (c) correspond to which of the keying techniques, respectively



(a) ASK, BFSK, BPSK
(b) BFSK, BPSK, ASK
(c) ASK, BPSK, BFSK
(d) BFSK, ASK, BPSK

10. The Minimum Band Width of ASK is equal to, if bit Rate is R_b

a. R_b

b. 2R_b

c. 3 R_b

d. 4 R_b

11. Which One of the following band pass digital modulation scheme cannot be detected noncoherently

a. ASK

b. BFSK

c. BPSK

d. None of the above

12. For a bit rate of 8 kbps, the best possible values of the transmitted frequencies in a coherent binary FSK system are

(a) 16 kHz and 20 kHz
(b) 20 kHz and 32 kHz
(c) 20 kHz and 40 kHz
(d) 32 kHz and 40 kHz

As bit rate is 8 kbps, transmitted frequencies in coherent BFSK should be integral multiple of 8 kbps, that is, 32 kHz and 40 kHz

13. In Binary FSK, mark and space respectively represent

a. 1 and 0

b. 0 and 1

c. 11 and 00

d. 00 and 11

14. The maximum bandwidth is occupied by

a. ASK

b. BPSK

c. FSK

d. Same for all

15. The frequency shifts in the BFSK usually lies in the range

a. 50 to 1000 Hz
b. 100 to 2000 Hz
c. 200 to 500 Hz
d. 500 to 10 Hz

16. The number of bits of data transmitted per second is called

a. Data signaling rate
b. Modulation rate
c. Coding
d. None of the above

17. ASK modulated signal has the bandwidth

a. Same as the bandwidth of baseband signal
b. Half the bandwidth of baseband signal
c. Double the bandwidth of baseband signal
d. None of the above

18. Coherent detection of binary ASK signal requires

a. Phase synchronization
b. Timing synchronization
c. Amplitude synchronization
d. Both a and b

19. In Binary Phase Shift Keying system, the binary symbols 1 and 0 are represented by carrier with phase shift of

a. Π/2
b. Π
c. 2Π
d. 0

20. BPSK system modulates at the rate of

a. 1 bit/ symbol
b. 2 bit/ symbol
c. 4 bit/ symbol
d. None of the above

21. The BPSK signal has +V volts and -V volts respectively to represent

a. 1 and 0 logic levels
b. 11 and 00 logic levels
c. 10 and 01 logic levels
d. 00 and 11 logic levels

22. The spectrum of BPSK signal is

a. Same as BASK
b. Same as BFSK
c. zero bandwidth
d. None of the above

23. The spectrum of BFSK may be viewed as the sum of

a. Two ASK spectra
b. Two PSK spectra
c. Two FSK spectra
d. None of the above

24. Find the maximum bit rates of an FSK signal in bps, if the bandwidth of the medium is 12 kHz and the difference between the two carriers is 2 kHz(given that transmission mode is full duplex)

Solution. Given that the transmission is full duplex, therefore only 6 kHz is allocated for each direction.

$$\text{Bandwidth} = 2\text{Bit Rate} + f_{c1} - f_{c0}$$

Therefore,

$$\begin{aligned} 2\,\text{Bit Rate} &= \text{Bandwidth} - (f_{c1} - f_{c0}) \\ &= 6000 - 2000 = 4000 \\ \text{Bit Rate} &= 2000 \text{ bps} \end{aligned}$$

25. A BPSK modulator has a carrier frequency of 70 MHz and an input bit rate of 10 Mbps. The maximum upper sideband frequency in MHz is

(a) 75

(b) 65

(c) 70

(d) 5

(o/p)BPSK= (Sin2π f_at)(Sin2πf_ct)

f_a is Maximum fundamental frequency of binary input =fb/2

fb is input bit rate

fc is reference carrier frequency

The output of a BPSK modulator with carrier frequency of 70 MHz and bit rate of 10 Mbps is

$$(O/P)_{BPSK} = [\sin(2\pi \times 5 \times 10^6)t] \times [\sin(2\pi \times 70 \times 10^6)t]$$

$$= 0.5\cos[2\pi \times (70 \times 10^6 - 5 \times 10^6)t] - 0.5\cos[2\pi \times (70 \times 10^6 + 5 \times 10^6)t]$$

Therefore, the maximum upper sideband frequency $= 70 \times 10^6 + 5 \times 10^6 = 75$ MHz

26. For the modulator given in the above Question 25, the minimum lower sideband frequency in MHz is

(a) 75 **(b) 65** (c) 70 (d) 5

Minimum lower sideband frequency $= 70 \times 10^6 - 5 \times 10^6 = 65$ MHz

27. For the modulator given in the above Question 25, the minimum required baud rate (in Mbauds) of the system is

(a) 75 (b) 65 (c) 20 **(d) 10**

minimum required baud rate =Bit Rate = 10Mbps

28. For the modulator given in the above Question 25, the minimum Nyquist band width and the minimum Nyquist Sampling rate of the system is

The minimum Nyquist band width = USB-LSB

=75-65 = 10MHz

$$\text{Minimum Nyquist sampling rate} = 2 \times (75 - 65)\ \text{MHz} = 20\ \text{MHz}$$

29. In a digital communication system employing FSK, the 0 and 1 bits are represented by sine waves of 10 kHz and 25 kHz, respectively. These waveforms will be orthogonal for a bit interval of

(a) 45 μs **(b) 200 μ s** (c) 50 μ s (d) 250 μ s

For orthogonality of two sine waves in T_b duration there should be integral multiple of cycles of both the sine waves.

Time period of first sine wave

$$T_{b1} = \frac{1}{10 \times 10^3} = 100\ \mu s$$

Time period of the second sine wave

$$T_{b2} = \frac{1}{25 \times 10^3} = 40\ \mu s$$

Therefore, 200 μs is the integral multiple of both T_{b1} and T_{b2}. Hence, the two given waveforms will be orthogonal for a bit interval of 200 μs.

30. Find the minimum bandwidth (in kHz) required for transmitting an ASK signal at 2 kbps in half duplex transmission mode.

    In ASK, the baud rate and bit rate are the same.
    Therefore, baud rate is 2000 bauds.
    An ASK signal requires a minimum bandwidth equal to its baud rate.
    Therefore, minimum bandwidth = 2000 Hz = 2 kHz

31. A communication system employs ASK to transmit a 10 kbps binary signal. Find the baud rate required in bauds.

    For an ASK system, the baud rate required is the same as the bit rate of the signal.
    The baud rate = 10000 bauds

32. For the data given in the above Question, find the minimum bandwidth required in hertz

    For an ASK system, the minimum bandwidth is the same as the bit rate of the signal.
    Therefore, minimum bandwidth = 10000 Hz

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