

XMUT310 Communication Engineering

Tutorial 5: Digital Modulations Solutions

Answers are provided for your convenience.

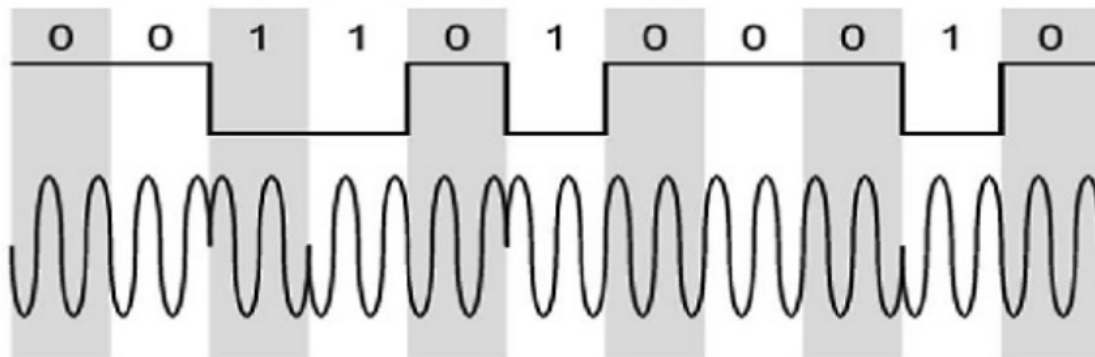
Q1.

Soln. Differential phase shift (DPSK) is non coherent version of the PSK. It is differentially coherent modulation method. DPSK does not need synchronous (Coherent) carrier at the demodulator. The input sequence of binary bits is modified such that the next bit depends upon the previous bit

Option (a)

In **Differential Phase Shift Keying** *DPSK* the phase of the modulated signal is shifted relative to the previous signal element. No reference signal is considered here. The signal phase follows the high or low state of the previous element. This DPSK technique doesn't need a reference oscillator.

The following figure represents the model waveform of DPSK.



It is seen from the above figure that, if the data bit is Low i.e., 0, then the phase of the signal is not reversed, but continued as it was. If the data is a High i.e., 1, then the phase of the signal is reversed, as with NRZI, invert on 1

Q2.

Soln. The given constellation has four signals which are 90° apart with the adjacent signal

These waveforms correspond to phase shifts of 0° , 90° , 180° and 270° as shown in the phase diagram.

The type of modulation is QPSK

Q3.

Soln. Quadrature carrier multiplexing (QCM) enables two DSBSC modulated waves, resulting from two different message signals to occupy the same transmission bandwidth and two message signals can be separated at the receiver.

It is also called Quadrature Amplitude Modulation (QAM) so it is quite different from FDM and TDM

Option (d)

Q4.

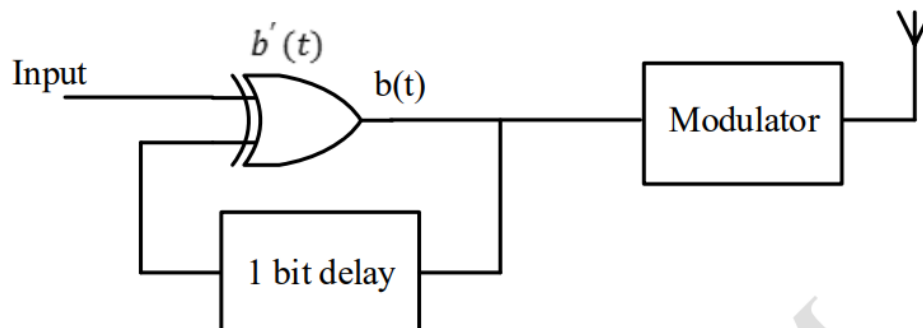
Soln.

EX-OR

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

$$Y = A \oplus B$$

Output is 1 when both input are different



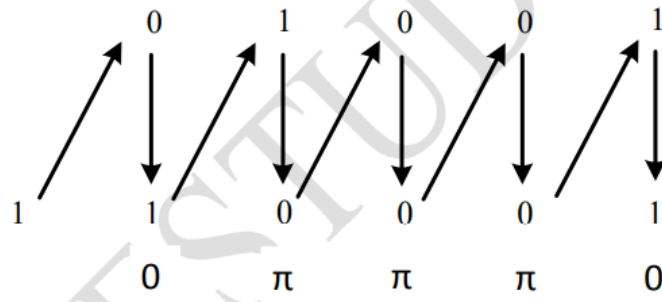
Bit stream

0 1 0 0 1

Ref. bit 1

Logic 0 $\rightarrow \pi$

Logic 1 $\rightarrow 0$



Option (c)

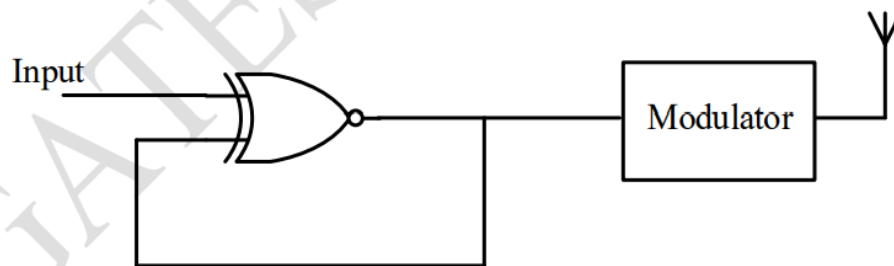
Q5.

Soln. Message bits sequence 1 1 0 0 1 1

Let, Logic 1 $\rightarrow 0^0$

Logic 0 $\rightarrow \pi$

Ref. bit = 0



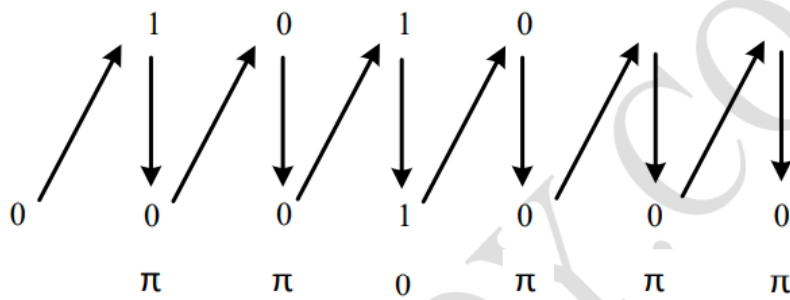
Ex NOR

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

$$Y = A \odot B$$

$$= AB + \bar{A}\bar{B}$$

(output is 1 when both input are same)



Remaining message bits are

0 π π π

Option (c)

Q6.

Soln. Frames per sec = 625

Pixels per frame = 400×400

64 intensity levels per pixels

Can be represented by bits per pixel

Data rate = $625 \times 400 \times 400 \times 6 = 600 \text{ Mbps}$

Option (c)

Q7.

Soln. In an ideal Nyquist channel, bandwidth required for ISI (Inter Symbol Interference) free transmission is

$$W = \frac{R_b}{2}$$

Here modulations is 32 QAM

i.e. $2^n = 32$ or $n = 5$ bits

Signaling rate is

$$R_b = \frac{R}{5} \text{ kbps}$$

Where R is bit rate

Min. bandwidth

$$W = \frac{R_b}{2} = \frac{R}{5 \times 2} = \frac{R}{10} \text{ KHz}$$

Option (b)

Q8.

Soln. Given

Bit rate = 8 kbps

The transmitted frequencies in coherent BFSK should be integral multiple of 8 i.e. the option

32 KHz & 40 KHz is the choice.

Since both frequencies are multiple of 8

Option (d)

Q9.

Soln. Bandwidth (B) = $\frac{R_b}{\log_2 M} (1 + \alpha)$

$$\text{Or, } 100 \text{ KHz} = \frac{200 \times 10^3}{\log_2 M}$$

$$\text{Or, } \log_2 M = 4$$

$$\text{Or, } M = 16$$

Q10.

Soln. For raised cosine spectrum transmission bandwidth is given as

$$B_T = \frac{R_b}{2}(1 + \alpha)$$

Where α – Roll off factor

R_b – bit rate

$$B_T = \frac{R_b}{2}(1 + \alpha)$$

Where R_b – maximum signaling rate

$$\text{Or, } 3500 \text{ Hz} = \frac{R_b}{2}(1 + 0.75)$$

Or,

$$R_b = \frac{3500 \times 2}{1.75} = 4000 \text{ bps}$$

Option (c)

Q11.

Soln. For coherent FSK modulation probability of error

$$(P_e) = \frac{1}{2} \operatorname{erfc} \left[\frac{E_b}{2N_0} \right]$$

Given

$$\text{Data rate } R_b = 500 \text{ kbps} = 500 \times 10^3 \text{ bps}$$

$$\frac{N_0}{2} = 0.5 \times 10^{-12} \text{ W/Hz}$$

$$\alpha = 4 \times 10^{-3} \text{ V}$$

$$T_b = \frac{1}{R_b} = \frac{1}{500 \times 10^3} = 2 \times 10^{-6} \text{ sec}$$

$$\text{Signal energy } E_b = T_b \times \text{signal Power}$$

$$\begin{aligned}
&= 2 \times 10^{-6} \times \frac{A^2}{2} \\
&= 2 \times 10^{-6} \times \frac{\alpha^2}{2} \\
&= 2 \times 10^{-6} \times \frac{(4 \times 10^{-3})^2}{2} \\
&= 10^{-6} \times 16 \times 10^{-6} \\
E_b &= 16 \times 10^{-12} \text{ Joules}
\end{aligned}$$

$$\begin{aligned}
\text{Here } P_e &= \frac{1}{2} \operatorname{erfc} \left[\sqrt{\frac{16 \times 10^{-12}}{2 \times 10^{-12}}} \right] \\
&= \frac{1}{2} \operatorname{erfc} [\sqrt{8}] = \frac{1}{2} \operatorname{erfc} \left[\frac{4}{\sqrt{2}} \right]
\end{aligned}$$

Note,

$$\frac{1}{2} \operatorname{erfc} \left[\frac{y}{\sqrt{2}} \right] = Q(y)$$

$$P_e = Q(4)$$

Option (c)

Q12.

Soln. Given,

Bit error rate (BER) of BPSK system with AWGN channel = $Q\sqrt{\gamma}$
 additive white Gaussian Noise (AWGN) with power spectral density $N_0/2$
 γ parameter is function of bit energy and Noise power spectral density.

Demodulator receives the output of both channels.

$$\begin{aligned}
\text{So, } BER &= Q(\sqrt{\gamma + \gamma}) \\
&= Q(\sqrt{2\gamma}) \\
&= Q(\sqrt{2} \sqrt{\gamma})
\end{aligned}$$

By comparing we find

$$Q(\sqrt{2} \sqrt{\gamma}) = Q(b\sqrt{\gamma})$$

$$\text{So, } b = \sqrt{2}$$

Q13.

Soln. We know that the probability of error in coherent BPSK is given by

$$P_e = Q \left[\sqrt{\frac{2E}{N_0}} \right]$$

Since the local oscillator in coherent receiver is ahead by 45° with respect to received signal. It will decrease the signal energy by factor of

$$\cos^2 45^\circ = \frac{1}{2}$$

$$\text{So, } P_e = Q \left[\sqrt{\frac{E}{N_0}} \right]$$

Option (b)

Q14.

Soln. Probability of error for coherent PSK and FSK is given as

For FSK

$$P_e = \frac{1}{2} \operatorname{erfc} \left(\sqrt{\frac{E_b}{2N_0}} \right)$$

PSK

$$P_e = \frac{1}{2} \operatorname{erfc} \left(\sqrt{\frac{E_b}{N_0}} \right)$$

From the table of error function table it is found that Binary FSK is 3 dB inferior to binary PSK

Option(b)

Q15.

Soln. For coherent detection one can use matched filter or correlation receiver, others are not coherent. Matched filter is used when you have only one signal. But FSK has two signals of different frequencies

So, use Correlation receiver

Option (a)

Q16.