

Digital Com. S1-E2- a

Q1) a 3- bit PCM is used to convert a sinusoidal signal given by:

$$x(t) = \sin(2\pi 2000t). \quad \text{In to a binary form}$$

The sampling is done at twice (2) Nyquist rate and the first sample is taken at $t = 0.01$ msec

Draw the signal and its samples and for each sample, Find the value of:

- 1. Samples value 2. Quantized value 3. Quantization error 4. Sample code**

Q2) an analog signal of bandwidth 4 KHZ is converted to digital form by a PCM system and then transmitted over a transmission channel of supporting a transmission rate of 60 K bits/Sec.

If the input analog signal has peak value of 2 Volts and rms of 0.2 V

Calculate The signal to Noise ratio in dB

Q/1/

$$V = 3 \text{ bit}$$

$$X(t) = 2 \sin(2\pi 2000t)$$

$$\left\{ \begin{array}{l} F_s = 2 \text{ Nyquist rate} \end{array} \right.$$

$$\left\{ \begin{array}{l} \text{First Sample at } 0.01 \text{ mSec} \end{array} \right.$$

Answer (1)

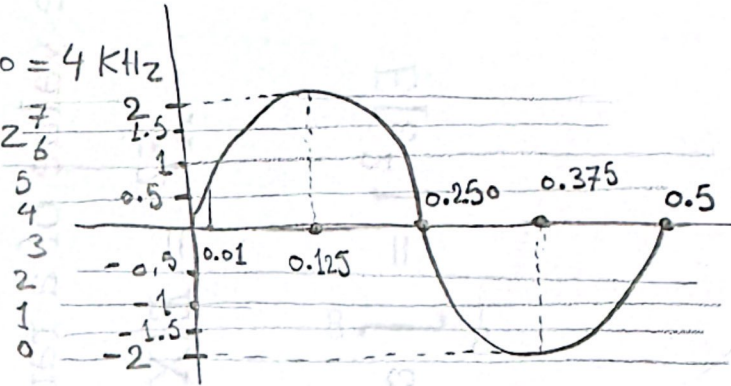
$$\text{Nyquist rate} = 2 F_m \Rightarrow 2(2000) = 4000 = 4 \text{ KHz}$$

$$F_s = 2 \text{ Nyquist rate} \Rightarrow 2(4) = 8 \text{ KHz}$$

$$T_s = \frac{1}{F_s} = \frac{1}{8 \times 10^3} = 0.125 \text{ mSec}$$

$$F_o = 2000$$

$$T_o = \frac{1}{2000} = 0.5 \text{ mSec}$$



$$\text{Sample 1} \Rightarrow X(t) = 2 \sin(2\pi * 2 * 10^3 * 0.01 * 10^{-3}) = 0.25$$

$$\text{Sample 2} \Rightarrow 0.01 + 0.125 = 0.135$$

$$X(t) = 2 \sin(2\pi * 2 * 10^3 * 0.135 * 10^{-3}) = 1.984$$

$$\text{Sample 3} \Rightarrow 0.135 + 0.125 = 0.260$$

$$X(t) = 2 \sin(2\pi * 2 * 10^3 * 0.260 * 10^{-3}) = -0.25$$

$$\text{Sample 4} \Rightarrow 0.260 + 0.125 = 0.385$$

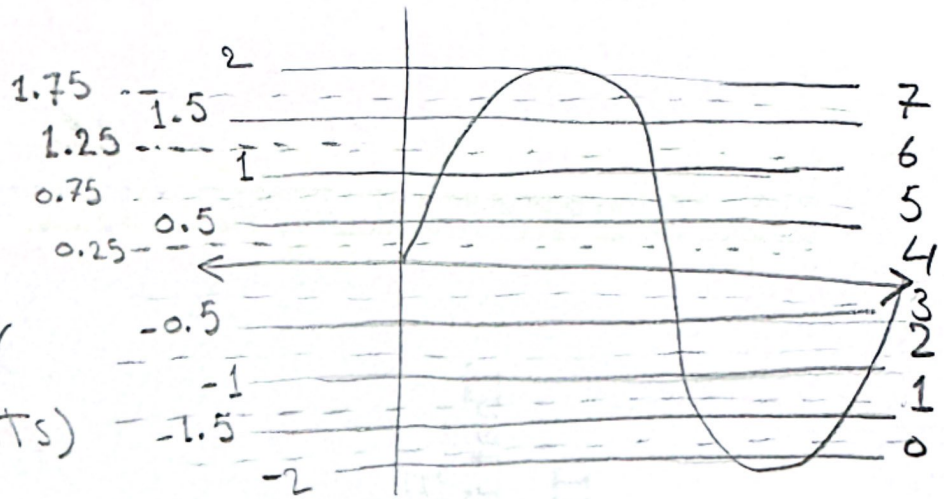
$$X(t) = 2 \sin(2\pi * 2 * 10^3 * 0.385 * 10^{-3}) = 1.984$$

$$(2) \text{ } q \text{ levels} = 2^3 = 8$$

$$\text{Step Size } \delta = \frac{X_{\max} - X_{\min}}{q} = \frac{2 - (-2)}{8} = \frac{4}{8} = \frac{1}{2} = 0.5 \text{ V}$$

3) Quantization error

$$\epsilon = X_q(nTs) - X(nTs)$$



Sample 1: $\epsilon = 0.25 - 0.135 = 0.115$

Sample 2: $\epsilon = 1.984 - 1.75 = 0.234$

Sample 3: $\epsilon = -0.25 - (-0.135) = -0.115$

Sample 4: $\epsilon = -1.984 - (-1.75) = -0.234$

4) Sample code

0.135 (100)

1.984 (111)

-0.135 (011)

-1.984 (000)

$$Q2) f_m = 4 \text{ KHz}$$

$$r = 60 \text{ k bit/sec}$$

$$\text{Peak value} = 2 \text{ Volts}$$

$$r.m.s = 0.2 \text{ V}$$

$$\frac{S}{N} = \frac{3P}{X_{\max}^2} 2^{2V}$$

$$f_s = 2f_m = 2 * 4 = 8 \text{ KHz}$$

$$r = V \cdot f_s \Rightarrow V = \frac{r}{f_s} = \frac{60 * 10^3}{8 * 10^3} = 7.5 \approx 8 \text{ bits}$$

$$P = \frac{V^2}{R} \quad (\text{Normalized power } \therefore R=1)$$

$$P = \frac{(0.2)^2}{1} = 0.04 \text{ watt}$$

$$X_{\max} = 2 \text{ V}$$

$$\frac{S}{N} = \frac{3(0.04)}{(2)^2} * 2^{2(8)} = 1966.08$$

$$\begin{aligned} \frac{S}{N}(\text{dB}) &= 10 \log(1966.08) \\ &= 32.9 \approx 33 \text{ dB} \end{aligned}$$

DC – Mid - b

Q1) DM system is tested by a sinusoidal signal given by,

$$x(t) = 4 \sin(2\pi 12 \times 10^3 t)$$

The sampling is done at Ten times the Nyquist rate

1. What is the step size required to prevent slope overload distortion
2. What is the corresponding SNR?

Q2) Select the right answer

PCM	DM	ADM
1. Which error is introduced during the quantization process? a) Sampling error b) Quantization noise c) Aliasing	1. In Delta Modulation, what happens if the step size is too small? - A) The output will be inaccurate - B) The system will go into overload - C) The output will be too noisy - D) The output will be highly accurate	1. Which of the following is a disadvantage of Adaptive Delta Modulation? - A) Complexity of implementation - B) High bandwidth consumption - C) Inefficiency with low-frequency signals - D) Limited dynamic range
2. Aliasing in PCM occurs when: a) Sampling rate is too high b) Sampling rate is too low c) Quantization levels are high	2. Which of the following is a limitation of Delta Modulation? - A) High bandwidth requirement - B) Susceptibility to slope overload - C) Complexity of implementation - D) Low noise immunity	2. Which of the following signals is Adaptive Delta Modulation best suited for? - A) Constant signals - B) High-frequency signals - C) Signals with varying slopes - D) Purely digital signals
3. Bandwidth required for PCM increases with: a) Decreasing quantization levels b) Increasing sampling rate c) Decreasing noise immunity	3. What is the primary purpose of Delta Modulation? - A) To increase data bandwidth - B) To simplify analog-to-digital conversion - C) To enhance audio quality - D) To reduce the power consumption	10. What type of information is typically used to adjust the step size in Adaptive Delta Modulation? - A) The amplitude of the previous output - B) The average power of the signal - C) The rate of change of the input signal - D) The frequency spectrum of the input signal

Q3) a signal has peak to peak value of 4 V, rms value of 0.3 V and maximum frequency of 4 KHZ , is modulated by a PCM system and then transmitted over a transmission channel supporting a transmission rate of 60 K bits/sec.

Determine the maximum signal to noise ratio of this system.

$$Q1) X(t) = 4 \sin(2\pi 12 * 10^3 t)$$

$F_s = 10$ Nyquist rate

1) Step Size $\delta = ?$ (to prevent slope overload distortion)

$$f_m = 12 * 10^3 \text{ Hz}$$

$$\text{Nyquist rate} = 2 f_m \Rightarrow 2(12 * 10^3) = 24 * 10^3 = 24 \text{ KHz}$$

$$F_s = 10 (\text{Nyquist rate}) \Rightarrow 10(24 * 10^3) = 240 * 10^3 = 240 \text{ KHz}$$

$$T_s = \frac{1}{F_s} = \frac{1}{240 * 10^3} \text{ sec}$$

$$\therefore A_m \leq \frac{\delta}{2\pi f_m T_s} \Rightarrow 4 \leq \frac{\delta}{2\pi * (12 * 10^3) * (\frac{1}{240 * 10^3})}$$

$$\delta \geq 4 * 2\pi * (12 * 10^3) * (\frac{1}{240 * 10^3})$$

$$\delta \geq 1.256 \text{ Volt}$$

$$2) \frac{S}{N} = ?$$

$$\frac{S}{N} = \frac{3}{8\pi^2 f_m^2 T_s^2} \Rightarrow \frac{3}{8\pi^2 * (12 * 10^3)^2 * (\frac{1}{240 * 10^3})^2}$$

$$\frac{S}{N} = \frac{3}{0.197} = 15.228$$

$$\begin{aligned} \frac{S}{N} (\text{dB}) &= 10 \log\left(\frac{S}{N}\right) \\ &= 10 \log(15.228) \\ &= 11.82 \text{ dB} \end{aligned}$$

Q2)

	PCM	DM	ADM
1		b) the System will go into overload	
2	b) Sampling rate is too low	b) Susceptibility to slope overload	c) Signals with Varying Slopes
3	b) Increasing Sampling rate	b) to Simplify analog to digital conversion	c) the rate of change of the input signal

Q3) Peak to peak = 4V
 r.m.s = 0.3V
 $F_m = 4 \text{ KHz}$
 $V = 60 \text{ Kbit/Sec}$

} $\frac{S}{N} = ?$

$$\frac{S}{N} = \frac{3P}{X_{\max}^2} \cdot 2^{2V}$$

$$P = \frac{V^2}{R=1} \Rightarrow \frac{(r.m.s)^2}{1} \Rightarrow \frac{(0.3)^2}{1} = 0.09 \text{ W}$$

$$X_{\max} = \frac{\text{Peak to Peak}}{2} = \frac{4}{2} = 2 \text{ V}$$

$$F_s = 2F_m \Rightarrow 2(4 \times 10^3) = 8 \times 10^3 = 8 \text{ KHz}$$

$$V = V \cdot F_s \Rightarrow V = \frac{V}{F_s} = \frac{60 \times 10^3}{8 \times 10^3} = 7.5 \approx 8 \text{ bits}$$

$$\frac{S}{N} = \frac{3(0.09)}{(2)^2} \cdot 2^{2(8)}$$

$$= \frac{0.27}{4} \cdot 2^{16}$$

$$\frac{S}{N} = 4423.68 \xrightarrow{\text{dB}} 36.45 \text{ dB}$$

D. Communication – S2-E2- 8-3-25 -b

Q1) Select the correct answer or full the blank (Select 10)

30 MARKS

1. In QSK, If the Bit rate = 10Mbps, the Symbol rate, $F_s =$
2. In QPSK, if the second symbol is at 135° , the Fourth one will be at _____
3. PSK is particularly robust against which type of interference?
a. Frequency Interference, b. Amplitude Interference, c. Phase Interference
4. The symbol duration (T_s) in M-ary PSK is related to the bit duration (T_b) by:
a) $T_s = T_b$ b) $T_s = (\log M / \log 2) \cdot T_b$, c) $T_s = M \cdot T_b$
5. The bandwidth of QPSK compared to binary M-ary is:
a) Higher b) Lower c) The same
6. Why average transmitted power as M increases in M-ary PSK, Remain constant?

7. What is the primary factor limiting the practical implementation of very high M values in M-ary PSK?
a) Bandwidth availability b) Transmitter power c) Phase noise and synchronization
8. Which Digital modulation type is more spectrally efficient than Binary PSK?
a) M-ary PSK ($M > 2$) b) Frequency Modulation (FM) c) BPSK
9. Why In QPSK, M-aryPSK the carrier is extracted from the received signal.

10. Which of following is disadvantage of BPSK
a. Constant out- put average power b. High signal Bandwidth c. complex system implementation
11. In Digital Continuous Modulation, the Amplitude of modulated signal,
a. Varies with Bit rate b. Varies with Carrier frequency c. Remain constant
12. in Digital Continuous Modulation, the Modulating signal : is a. Digital b. Discrete c. analog

Q2) a Digital signal of bit rate (6) Mbps is to be transmitted by:

70 MARKS

BFSK, QPSK, 64-ary PSK

1. For each type of Modulation, FIND:

Bit Duration (T_b), Symbol Duration (T_s), Symbol Rate(F_s), Signal Bandwidth
2. If the channel bandwidth is 1.9 MHZ KHZ, Which type of above modulation will you select, WHY?

Q 1)

(b) فرع

1) $F_s = \frac{F_b}{2} = \frac{10}{2} = 5 \text{ Mbps}$

2) 315°

3) C. phase interference

4) b. $t_s = \left(\frac{\log M}{\log 2} \right) \cdot t_b$

5) b. Lower

6)

7) C. phase Noise and Synchronization

8) a. M-ary PSK

9)

10) b. High Signal Bandwidth

11)

12) a. Digital

Q 2) $F_b = 6 \text{ Mbps}$

11, $M = 2^V \Rightarrow V = \frac{\log(M)}{\log(2)} \Rightarrow \frac{\log(64)}{\log(2)} = 6 \text{ bit}$

①

BPSK

QPSK

64-ary PSK

 T_b

$$T_b = \frac{1}{F_b} = \frac{1}{6 \times 10^6} \text{ Sec}$$
$$= 6 \times 10^{-6} \text{ Sec}$$

$$T_b = \frac{1}{6 \times 10^6}$$
$$= 6 \times 10^{-6} \text{ Sec}$$

$$T_b = \frac{1}{6 \times 10^6}$$
$$= 6 \times 10^{-6} \text{ Sec}$$

 t_s

$$t_s = N \cdot t_b = 1 \times 6 \times 10^{-6}$$
$$= 6 \times 10^{-6} \text{ Sec}$$

$$t_s = N \cdot t_b = 2 \times 6 \times 10^{-6}$$
$$= 12 \times 10^{-6} \text{ Sec}$$

$$t_s = N \cdot t_b = 6 \times 6 \times 10^{-6}$$
$$= 36 \times 10^{-6}$$

 F_s

$$F_s = \frac{1}{t_s} = \frac{1}{6 \times 10^{-6}}$$
$$= 6 \times 10^6 = 6 \text{ Ms/sec}$$
$$M(\text{Symbol/sec})$$

$$F_s = \frac{1}{t_s} = \frac{1}{12 \times 10^{-6}}$$
$$= 12 \times 10^6 = 12 \text{ Ms/sec}$$
$$M(\text{Symbol/sec})$$

$$F_s = \frac{1}{t_s} = \frac{1}{36 \times 10^{-6}}$$
$$= 36 \times 10^6$$
$$= 36 \text{ M Symbol/sec}$$

Bw

$$Bw = 2 F_b$$
$$= 2(6 \times 10^6)$$
$$= 12 \text{ MHz}$$

$$Bw = F_b$$
$$= 6 \times 10^6$$
$$= 6 \text{ MHz}$$

$$B = \frac{2 F_b}{N}$$
$$= \frac{2(6 \times 10^6)}{6}$$
$$= 2 \text{ MHz}$$

② Channel Bandwidth = 1.9 MHz

* none of these modulation types fit the (1.9 MHz channel Bandwidth)