# COMMUNICATIONS-3: (GATE - 2021) - REPORTS

OVERALL ANALYSIS | COMPARISON REPORT | SOLUTION REPORT

ALL(17) | CORRECT(13) | INCORRECT(1) | SKIPPED(3)

**Q. 1** Solution Video | Have any Doubt ?

The number of check bits for a particular (7, 4) linear block code is equal to ______.

A 1

B 2

C 3 — Your answer is **Correct**

**Solution :**
(c)
q = n − k = 7 − 4 = 3

D 4

QUESTION ANALYTICS +

**Q. 2** ? FAQ | Solution Video | Have any Doubt ?

The upper bound of the Shannon's channel capacity theorem for a signal with power equal to 'S' is equal to

A $\ln 2\left(\frac{S}{N_o}\right)$

B $\frac{1}{\ln 2}\left(\frac{S}{N_o}\right)$ — Your answer is **Correct**

C $\frac{1}{\log_2 5}\left(\frac{S}{N_o}\right)$

D $\log_2 5\left(\frac{S}{N_o}\right)$

QUESTION ANALYTICS +

**Q. 3** Solution Video | Have any Doubt ?

A communication channel of bandwidth 75 kHz is required to transmit binary data at a rate of 0.1 Mbps using raised cosine pulse. Then the roll-off factor α is equal to

A 0.1

B 0.3

C 0.5 — Your answer is **Correct**

**Solution :**
(c)

$$T_b = \frac{1}{0.1(10^6)} = 10^{-5}\text{ s}$$

$$f_b = 75\text{ kHz} = 75 \times 10^3\text{ Hz}$$

Now, $$\alpha = 2f_b T_b - 1 = 1.5 - 1 = 0.5$$

D 0.85

QUESTION ANALYTICS +

**Q. 4** Solution Video | Have any Doubt ?

If the number of bits in a PCM system is increased from n to n + 1, the signal to quantization noise ratio will increase by a factor of

A $\frac{(n+1)}{n}$

B $\frac{(n+1)^2}{n}$

C 2

D 4 — Your answer is **Correct**

**Solution :**
(d)

$$(\text{SNR}) \propto (2^n)^2$$

∴ $$\frac{(\text{SNR})_2}{(\text{SNR})_1} = \frac{(2^{n+1})^2}{(2^n)^2} = 4$$

QUESTION ANALYTICS +

**Q. 5** ? FAQ | Solution Video | Have any Doubt ?

A delta modulator is tested with a 10 kHz sinusoidal signal, 1 V peak to peak at input. The signal applied is sampled 10 times the nyquist rate, then the minimum step size required to prevent slope overload is equal

A 0.157 Volts — Your answer is **Correct**

**Solution :**
(a)

$$f_s = 10 f_N = 10 \times 20 = 200\text{ kHz}$$

$$\delta f_s \geq \text{Max}\left|\frac{dm(t)}{dt}\right|$$

$$\delta \times 200\text{ kHz} \geq 2\pi f_m A_m$$

$$\delta \geq \frac{2\pi \times (10 \times 10^3) \times \left(\frac{1}{2}\right)}{200\text{ kHz}}$$

$$\delta \geq 0.157\text{ Volts}$$

B 0.358 Volts

C 0.587 Volts

D 0.778 Volts

QUESTION ANALYTICS +

**Q. 6** ? FAQ | Solution Video | Have any Doubt ?

The message which was initially transmitted by a binary waveform at 9.6 kbps is now converted into octal waveform that is passed through a channel with a raised cosine roll of Nyquist filter characteristic. Then the baud rate of the system is _____ k symbols/sec.

3.2 — Your answer is **Correct**3.2

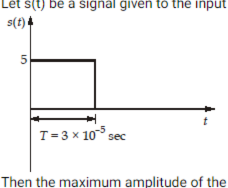
**Solution :**
3.2

$$\text{Baud rate} = \frac{R_b}{\log_2 M} = \frac{9.6}{3}\text{ k symbol/sec} = 3.2\text{ k symbol/sec}$$

QUESTION ANALYTICS +

**Q. 7** Solution Video | Have any Doubt ?

Let s(t) be a signal given to the input of a match filter receiver, where s(t) is shown below:




Then the maximum amplitude of the output signal of the match filter is equal to ______ μV.

750 — Your answer is **Correct**750

**Solution :**
750

The output of the matched filter receiver is the shifted version of the auto-correlation function of input

$$\text{Output} = R(t - T)$$

$$t = T$$

$$\text{Output} = R(0) = \text{Energy}$$

Maximum value of matched filter output = Energy of signal

$$\text{Energy of } s(t) = A^2T = (5)^2 \times 3 \times 10^{-5} = 75 \times 10^{-5} = 750 \times 10^{-6} = 750\ \mu\text{V}$$

QUESTION ANALYTICS +

**Q. 8** ? FAQ | Solution Video | Have any Doubt ?

A 30 channel PCM system samples voice at rate of 20 kHz. The minimum channel bandwidth required is 6 MHz. If the samples are encoded with n-bits/sample then

A the bandwidth of the signal depends upon the value of n. — Your option is **Correct**

B the bit rate is directly proportional to the number of channels. — Your option is **Correct**

C the bit rate is equal to the bandwidth of the signal.

D the number of bits n is equal to 10.

YOUR ANSWER - a,b | CORRECT ANSWER - a,b | STATUS - ✔

**Solution :**
(a, b,)

$$R_b = Nnf_s = 30 \times n \times 20\text{ K}$$

$$\text{Bandwidth} = \frac{R_b}{2}$$

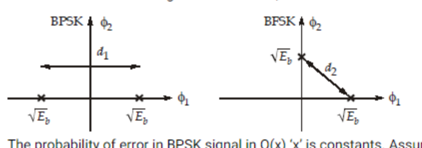
∴ $$6 \times 10^6 = \frac{n \times 600 \times 10^3}{2}$$

$$n = 20$$

QUESTION ANALYTICS +

**Q. 9** Solution Video | Have any Doubt ?

A data is transmitted using BPSK and BFSK, modulation scheme whose signal space diagram is shown below.




The probability of error in BPSK signal in Q(x) 'x' is constants. Assume the signals are received at the receivers which are perfectly synchronized, then the probability of BFSK signal is equal to

A the value of $d_1 > d_2$ — Your option is **Correct**

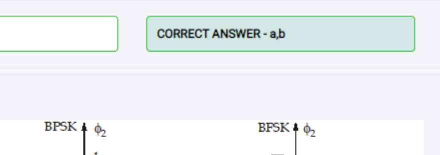
B the value of $P_{e(FSK)} > P_{e(PSK)}$ — Your option is **Correct**

C the value of $d_1 < d_2$

D the value of $P_{e(FSK)} < P_{e(PSK)}$

YOUR ANSWER - a,b | CORRECT ANSWER - a,b | STATUS - ✔

**Solution :**
(a, b)




$$P_e = Q\left(\frac{d}{\sqrt{2N_o}}\right)$$

∴ $$d_1 \text{ for BPSK} = 2\sqrt{E_b}$$

$$d_2 \text{ for BFSK} = \sqrt{2E_b}$$

∴ $$P_{e(QPSK)} = Q\left(\sqrt{\frac{2E_b}{N_o}}\right) = Q(x)$$

$$P_{e(FSK)} = Q\left(\sqrt{\frac{E_b}{N_o}}\right)$$

∴ $$P_{e(FSK)} = Q\left(\frac{x}{\sqrt{2}}\right)$$

QUESTION ANALYTICS +

**Q. 10** ? FAQ | Solution Video | Have any Doubt ?

A digital communication system, bit-1 and 0 are transmitted with probabilities $\frac{1}{3}$ and $\frac{2}{3}$ respectively. These bits are then transmitted using BPSK modulating scheme using an orthonormal function Φ(t). The wave +Φ(t) is send for bit 1 and −Φ(t) is send for bit 0. The modulated signal is transmitted through an AWGN channel with noise power spectral density $\frac{N_o}{2} = 1\text{ W/Hz}$. The channel output is received by a correlator receiver. If the optimum threshold $t_o$ is selected using MAP criteria to minimise the bit error rate, then the value of $t_o$ is equal to _____.

A 0.125

B 0.854

C 0.346 — Your answer is **Correct**

**Solution :**
(c)

According to MAP criterion

$$\frac{f_X(r|s_1)}{f_X(r|s_o)} \underset{H_1}{\overset{H_o}{\lessgtr}} \frac{P_o}{P_1}$$

Now, $$f_X(r \mid s_1) = \frac{1}{\sqrt{\pi N_o}} \exp -\frac{(x-\mu)^2}{N_o}$$

and $$f_X(r \mid s_1) = \frac{1}{\sqrt{\pi N_o}} \exp -\frac{(x-1)^2}{N_o}$$

$$f_X(r \mid s_0) = \frac{1}{\sqrt{\pi N_o}} \exp -\frac{(x+1)^2}{N_o}$$

∴ ACC to MAP criterion

$$\frac{\exp -\frac{(t_o-1)^2}{N_o}}{\exp -\frac{(t_o+1)}{2}} = \frac{P_0}{P_1} = 2$$

$$4t_o = 2\ln 2$$

$$t_o = \frac{1}{2}\ln 2 = 0.346$$

D 0.575

QUESTION ANALYTICS +

Item 1-10 of 17 « previous 1 2 next »

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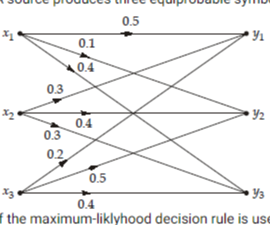
## Q. 11

? FAQ | Solution Video | Have any Doubt ?

A source produces three equiprobable symbols $x_1$, $x_2$ and $x_3$ which are transmitted on a channel shown in the figure below:




If the maximum-liklyhood decision rule is used, then the minimum error probability of the channel is equal to

A 0.4125

B 0.6911

C 0.533 — Correct Option

**Solution :**
(c)

$$P_e = 1 - P_c$$

Now, since we are using ML criterion, and the input symbols are equally likely, then we can directly choose the output based on the maximum value of the transmission probabilities.

$$P_c = P(x_1)\,P(y_1 \mid x_1) + P(x_2)\cdot P(y_2 \mid x_2) + P(x_3)\cdot P(y_2 \mid x_3)$$
$$= \frac{1}{3}[0.5+0.4+0.5] = \frac{7}{15}$$

$\therefore$
$$P_e = 1-\frac{7}{15} = \frac{8}{15} = 0.533$$

D 0.919

QUESTION ANALYTICS +

## Q. 12

? FAQ | Solution Video | Have any Doubt ?

A BPSK signal with equiprobable bits is transmitted through an AWGN channel and received by a correlator receiver. If there is a phase mismatch of 30° between the carrier used in transmitter and receiver, then the probability of error will be

A $Q\left[\sqrt{\frac{E_b}{2N_0}}\right]$ — Your answer is **Wrong**

B $Q\left[\sqrt{\frac{(1.5)E_b}{N_0}}\right]$ — Correct Option

**Solution :**
(b)

Probability of error in BPSK system with a phase mismatch of $\phi_e$ is,

$$P_e = Q\left[\sqrt{\frac{2E_b\cos^2\phi_e}{N_0}}\right] = Q\left[\sqrt{\frac{2E_b(\cos 30°)^2}{N_0}}\right]$$

$$P_e = Q\left[\sqrt{\frac{3E_b}{2N_0}}\right] = Q\left[\sqrt{\frac{(1.5)E_b}{N_0}}\right]$$

C $Q\left[\sqrt{\frac{2E_b}{N_0}}\right]$

D $Q\left[\sqrt{\frac{3E_b}{N_0}}\right]$

QUESTION ANALYTICS +

## Q. 13

? FAQ | Solution Video | Have any Doubt ?

Consider a source $m(t)$, whose amplitude statistics are as follows:

$$f_m(m) = \begin{cases} 1/4 & ; \; -1 \le m \le 1 \\ 1/12 & ; \; -4 \le m \le -1 \\ 1/12 & ; \; 1 \le m \le 4 \\ 0 & ; \; \text{Otherwise} \end{cases}$$

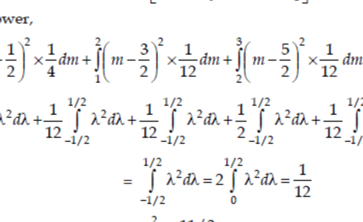
The message is passed through a three bit quantize having uniform step size of 1 V. Reconstruction levels of the quantizer are mid points of the decision boundaries. Then the value of signal to quantization noise is equal to

A 6.85 dB

B 16.43 dB — Correct Option

**Solution :**
(b)

To create an optimum quantize of 3-bits all the message symbols should be equiprobable thus, the area under each quantized value must be same




Thus, for a 3-bit quantizer we need 8 levels. From the graph we can observe that the quantization level can be chosen as $\pm\frac{1}{2}, \pm\frac{3}{2}, \pm\frac{5}{2}$ and $\pm\frac{7}{2}$.

Thus, signal power,
$$\sigma_m^2 = \int_{-4}^{4} m^2 f_m(m)\,dm$$
$$= 2\left[\left[\frac{1}{4}\frac{m^3}{3}\right]_0^1 + \left[\frac{1}{12}\cdot\frac{m^3}{3}\right]_1^4\right] = \frac{11}{3}\text{ Watts}$$

Quantized noise power,
$$\sigma_q^2 = 2\left[\int_0^1\left(m-\frac{1}{2}\right)^2\times\frac{1}{4}dm + \int_1^2\left(m-\frac{3}{2}\right)^2\times\frac{1}{12}dm + \int_2^3\left(m-\frac{5}{2}\right)^2\times\frac{1}{12}dm + \int_3^4\left(m-\frac{7}{2}\right)^2\times\frac{1}{12}dm\right]$$
$$= 2\left[\frac{1}{4}\int_{-1/2}^{1/2}\lambda^2 d\lambda + \frac{1}{12}\int_{-1/2}^{1/2}\lambda^2 d\lambda + \frac{1}{12}\int_{-1/2}^{1/2}\lambda^2 d\lambda + \frac{1}{2}\int_{-1/2}^{1/2}\lambda^2 d\lambda + \frac{1}{12}\int_{-1/2}^{1/2}\lambda^2 d\lambda\right]$$
$$= \int_{-1/2}^{1/2}\lambda^2 d\lambda = 2\int_0^{1/2}\lambda^2 d\lambda = \frac{1}{12}$$
$$(\text{SNR})_9 = \frac{\sigma_m^2}{\sigma_n^2} = \frac{11/3}{1/12} = 44$$

$\therefore$
$$(\text{SNR})_{9\,(\text{dB})} = 10\log_{10}(44) = 16.43\text{ dB}$$

C 25.28 dB

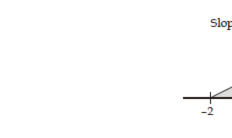
D 9.77 dB

QUESTION ANALYTICS +

## Q. 14

? FAQ | Solution Video | Have any Doubt ?

The amplitude of a random signal has the probability density function as shown in the figure below.

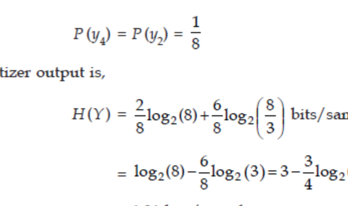



Samples of this random signal are applied to a 4-level quantizer. If the decision boundaries of the quantization regions are set at −1, 0 and 1, then the entropy at the quantizer output for the given message signal will be ______ bits/sample.

1.81 (1.77 - 1.85) — Correct Option

**Solution :**
1.81 (1.77 - 1.85)

Considering the given PDF with quantization regions, as follows:




The quantized samples exist at the output of the quantizer with the probabilities as follows:

$$P(y_1) = \text{Area of region} - 1 = \frac{1}{2}\times 1\times\frac{1}{4} = \frac{1}{8}$$
$$P(y_2) = \text{Area of region} - 2 = \frac{1}{2}-\frac{1}{8} = \frac{3}{8}$$
$$P(y_3) = P(y_2) = \frac{3}{8}$$
$$P(y_4) = P(y_2) = \frac{1}{8}$$

Entropy at the quantizer output is,

$$H(Y) = \frac{2}{8}\log_2(8) + \frac{6}{8}\log_2\left(\frac{8}{3}\right)\text{ bits/sample}$$
$$= \log_2(8) - \frac{6}{8}\log_2(3) = 3 - \frac{3}{4}\log_2(3)\text{ bits/sample}$$
$$= 1.81\text{ bits/sample}$$

QUESTION ANALYTICS +

## Q. 15

? FAQ | Solution Video | Have any Doubt ?

Consider a non uniform quantizer as shown below:


The input to the quantizer is a message signal whose PDF is uniformly distributed in the range [−3, 2] Volts is applied to this quantizer, then the quantization noise power will be ____ W.

1.13 (1.0 - 1.2) — Your answer is **Correct** 1.133

**Solution :**
1.13 (1.0 - 1.2)

$$N_o = E[(X-x_q)^2] = \int_{-\infty}^{\infty}(x-x_q)^2 f_X(x)\,dx$$

Now, since the input is in the range of [–3 to 2] the PDF of the input signal can be drawn as



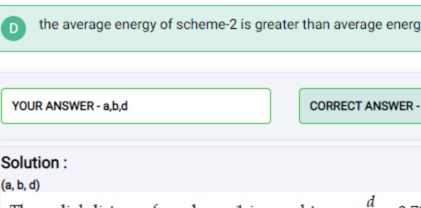

$\therefore$
$$N_o = \int_{-3}^{0}\frac{1}{5}(x+1)^2 dx + \int_0^2\frac{1}{5}(x-2)^2 dx$$
$$= \frac{1}{5}\frac{(x+1)^3}{3}\Bigg|_{-3}^{0} + \frac{1}{5}\frac{(x-2)^3}{3}\Bigg|_0^2$$
$$= \frac{1}{15}(1+8) + \frac{1}{15}(+8) = \frac{17}{15}\text{ W} = 1.13\text{ W}$$

QUESTION ANALYTICS +

## Q. 16

? FAQ | Solution Video | Have any Doubt ?

Two constellation diagram are shown in figure below:




Then,

A the value of $r_1 = 0.707d$ — Your option is **Correct**

B the value of $r_2 > r_1$ — Your option is **Correct**

C the average energy of scheme-1 is greater then the average energy of scheme-2.

D the average energy of scheme-2 is greater than average energy of scheme-1. — Your option is **Correct**

YOUR ANSWER - a,b,d | CORRECT ANSWER - a,b,d | STATUS - ✓

**Solution :**
(a, b, d)

The radial distance for scheme-1 is equal to $r_1 = \frac{d}{\sqrt{2}} = 0.707\,d$

and the radial distance $r_2$ for scheme-2 is equal to

$$r_2 = \frac{d}{2\sin\left(\frac{\pi}{m}\right)} = \frac{d}{2\sin\left(\frac{\pi}{8}\right)} = 1.306\,d$$
$$E_{avg1} = \frac{(0.707\,d)^2\times 4}{4} = 0.5\,d^2$$
$$E_{avg2} = \frac{(1.306\,d)^2\times 8}{8} = 1.7056\,d^2$$
$$E_{avg2} > E_{avg1}$$

QUESTION ANALYTICS +

## Q. 17

? FAQ | Solution Video | Have any Doubt ?

In a telemetry system, eight message signals having 2 kHz bandwidth, each are time division multiplexed using a binary PCM. The sampling rate is 25% above the Nyquist rate and the error in sampling amplitude cannot be greater than 1% of the peak to peak amplitude. If raised cosine pulses with roll-off factor $\alpha = 0.05$ are used then

A the minimum bit rate that can be achieved is equal to 0.24 Mbps. — Your option is **Correct**

B the bandwidth of the signal is equal to 240 kHz.

C the sampling rate is equal to 4 kHz.

D the value of minimum number of bits '$n$' is equal to 6. — Your option is **Correct**

YOUR ANSWER - a,d | CORRECT ANSWER - a,d | STATUS - ✓

**Solution :**
(a, d)

$$\text{Error} = \frac{\Delta}{2} = \frac{V_{PP}}{2L} = 0.01\text{ V}$$
$$\text{Since error} \le \frac{V_{pp}}{100}$$

So,
$$\frac{V_{pp}}{2.2^n} \le \frac{V_{pp}}{100}$$

$\Rightarrow$
$$n \ge 5.64$$
$$n_{min} = 6$$

and $f_s = 1.25\,f_n = 1.25\times 2\times 2\times 10^3 = 5\text{ kHz}$

Thus, the bit rate $R_b = nN\,f_s = 8\times 6\times 5\times 10^3 = 240\text{ kbps}$

Therefore, the bandwidth is given by

$$\text{BW} = (1+\alpha)\cdot\frac{R_b}{2} = (1+0.05)\times\frac{240}{2}\text{ kbps} = 126\text{ kHz}$$

QUESTION ANALYTICS +