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ESE 2020 : Prelims Exam
CLASSROOM TEST SERIES

E & T ENGINEERING

Test 12

Section A : Analog Circuits + Electronic Measurements and Instrumentation

Section B : Signals & Systems-1 + Basic Electrical Engineering-1

Section C : Analog and Digital Communication Systems-2

1.	**(d)**	**16.**	**(c)**	**31.**	**(d)**	**46.**	**(c)**	**61.**	**(d)**
2.	**(c)**	**17.**	**(b)**	**32.**	**(a)**	**47.**	**(c)**	**62.**	**(d)**
3.	**(d)**	**18.**	**(c)**	**33.**	**(c)**	**48.**	**(a)**	**63.**	**(d)**
4.	**(d)**	**19.**	**(c)**	**34.**	**(d)**	**49.**	**(c)**	**64.**	**(c)**
5.	**(c)**	**20.**	**(c)**	**35.**	**(d)**	**50.**	**(b)**	**65.**	**(c)**
6.	**(a)**	**21.**	**(b)**	**36.**	**(c)**	**51.**	**(a)**	**66.**	**(c)**
7.	**(c)**	**22.**	**(c)**	**37.**	**(d)**	**52.**	**(b)**	**67.**	**(c)**
8.	**(c)**	**23.**	**(a)**	**38.**	**(b)**	**53.**	**(b)**	**68.**	**(c)**
9.	**(c)**	**24.**	**(d)**	**39.**	**(c)**	**54.**	**(c)**	**69.**	**(a)**
10.	**(c)**	**25.**	**(c)**	**40.**	**(b)**	**55.**	**(b)**	**70.**	**(b)**
11.	**(c)**	**26.**	**(b)**	**41.**	**(a)**	**56.**	**(c)**	**71.**	**(d)**
12.	**(d)**	**27.**	**(c)**	**42.**	**(b)**	**57.**	**(c)**	**72.**	**(b)**
13.	**(c)**	**28.**	**(b)**	**43.**	**(a)**	**58.**	**(c)**	**73.**	**(b)**
14.	**(c)**	**29.**	**(a)**	**44.**	**(a)**	**59.**	**(d)**	**74.**	**(c)**
15.	**(c)**	**30.**	**(b)**	**45.**	**(c)**	**60.**	**(a)**	**75.**	**(a)**

Note : Answer key and solution of Q.36 have been updated.

Detailed Explanation
Section A : Analog Circuits + Electronic Measurements and Instrumentation

1. (d)

The forward resistance of a *p-n* junction diode when diode is used in DC circuit and applied forward voltage is DC, is called as static forward resistance.

The resistance offered by the *p-n* junction diode under AC condition is called as dynamic forward resistance.

2. (c)

3. (d)

The rms value of voltage at secondary winding

$$E_{\text{rms(s)}} = \frac{230}{3} = 76.667 \text{ V}$$

[∵ it is connected to a step down transformer]

Now, maximum voltage at the secondary winding is equal to

$$E_{m(\text{s})} = 76.667 \times \sqrt{2} \text{ V}$$
$$= 108.423 \text{ V}$$

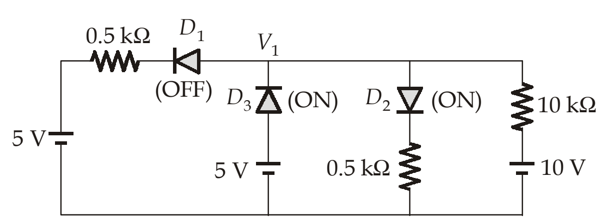
The peak output current, $$I_{m(\text{s})} = \frac{108.423}{10 \times 10^3 + 85} \approx 10.75 \text{ mA}$$

Now, $$I_{L(\text{avg})} = \frac{I_{\text{m(s)}}}{\pi} = \frac{10.75}{\pi} = 3.422 \text{ mA}$$

4. (d)

$$\% \text{ Regulation} = \frac{R_f}{R_L} \times 100 = \frac{10}{1000} \times 100 = 1\%$$

5. (c)



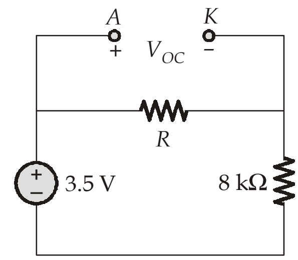
Diode D_3 will be in ON state, then we find that voltage V_1 will be equal to 5 – 0.6 = 4.4 V.

Now, for V_1 = 4.4 V, diode D_1 will be OFF.

∴ Current through diode D_2 is equal to $I_2 = \frac{4.4 - 0.6}{0.5} \times 10^{-3} = 7.6 \text{ mA}$

6. (a)

Let us take the open circuit test,



For diode to be in ON state,

$$V_{OC} > 0.7 \text{ V}$$

$$\frac{R}{R+8\text{k}\Omega}(3.5) > 0.7$$

$$\frac{R+8\text{k}\Omega}{R} < 5$$

$$\frac{8\text{k}\Omega}{R} < 4$$

$$R > 2 \text{ k}\Omega$$

7. (c)

For the circuit given in the question,

$$S = \frac{\beta+1}{1+\beta\left[\frac{R_C}{R_B+R_C}\right]} = \frac{100+1}{1+100\times\frac{5}{15}} = 2.94$$

8. (c)

For I_{in} positive, we have D_1 = ON and D_2 = OFF

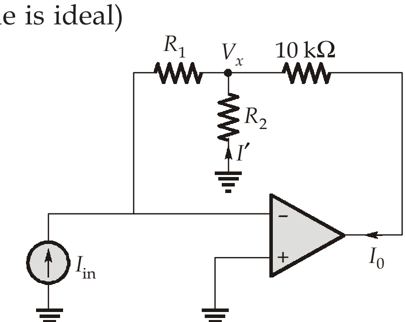
$\therefore$ $V_0 = R_1 I_{in}$

$\therefore$ $V_0 \propto I_{in}$

For I_{in} negative, we have D_1 = OFF and D_2 = ON

$\therefore$ $V_0 = V_{D2} = 0$ V (since the diode is ideal)

9. (c)



$$V_x = -R_1 I_{in}$$

$$I' = \frac{R_1}{R_2} I_{in} \quad (\because V_x = -I'R_2)$$

$\therefore$ $$I_0 = I_{in} + \frac{R_1}{R_2} I_{in} = \left(1+\frac{R_1}{R_2}\right) I_{in} = 20\, I_{in}$$

$\therefore$ $$\frac{R_1}{R_2} = 19$$

10. (c)

$$V_{id} = V_1 - V_2 = 500 - 440 = 60\ \mu V$$

$$V_{cm} = \frac{500+440}{2} = \frac{940}{2} = 470\ \mu V$$

$$\text{CMRR} = \frac{A_{id}}{A_{cm}}$$

$\therefore$
$$A_{cm} = \frac{A_{id}}{CMRR} = \frac{5000}{100} = 50$$

$$V_{out} = [5000 \times 60 + 50 \times 470] \times 10^{-6} = 0.3235\ V$$

11. (c)

$$\theta_{jA} = \frac{T_j - T_A}{P_D}$$

$$\theta_{jA} = \theta_{jC} + \theta_{CS} + \theta_{SA}$$

Now
$$\theta_{jA} = \theta_{jC} + \theta_{CA} = 8 + 20 = 28°C/W$$

where,
θ_{jA} = total thermal resistance (Junction to ambient)
θ_{jC} = total thermal resistance (Junction to case)
θ_{CS} = total thermal resistance (case to heat sink)
θ_{SA} = total thermal resistance (heat sink to ambient)
$\theta_{CA} = \theta_{CS} + \theta_{SA}$

$\therefore$
$$\theta_{jA} = \frac{T_j - T_A}{P_D}$$

$$T_j = (28 \times 2) + 25 = 56 + 25 = 81°C$$

12. (d)

Now,
$$g_m = \frac{I_C}{V_T} = \frac{1}{26}\ \text{A/V}$$

Now, because of degeneration the gain of the amplifier reduces by $(1 + g_m R_E)$

$\therefore$
$$1 + g_m R_E = \frac{20}{10}$$

$$g_m R_E = 1$$

$$R_E = 26\ \Omega$$

13. (c)

$$I = \frac{I_R}{1+\frac{2}{\beta}}$$

$\therefore$
$$I_R = I\left(1+\frac{2}{\beta}\right) = 4.3 \times \left(1+\frac{1}{50}\right) \approx 4.3\ \text{mA}$$

now,
$$I_R = \frac{5-(0.7)}{R} \Rightarrow R = \frac{4.3}{4.3} \times 10^3 = 1000\ \Omega$$

14. (c)

Assuming that the MOS is in saturation region.

$$I_D = K_p (V_{SG} + V_T)^2$$
$$0.4 = 0.2(V_{SG} - 0.8)^2$$
$$V_{SG} = \sqrt{2} + 0.8 = 2.21 \text{ V}$$

Now,
$$V_S = 2.21 \text{ V} \qquad (\because V_G = 0)$$
$$V_D = I_D R_D - 5$$
$$= 0.4 \times 10^{-3} \times 5 \times 10^3 - 5 = -3 \text{ V}$$

∴
$$V_{SD} = 2.21 + 3 = 5.21 \text{ V}$$

15. (c)

∵ Both the transistor are matched thus

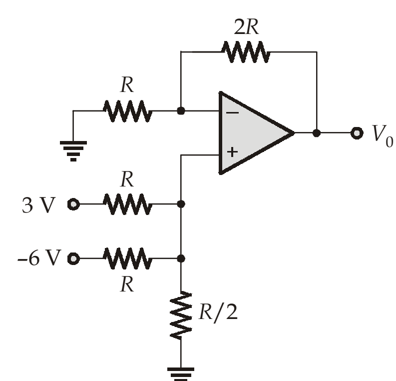
$$V_{DS1} = V_{DS2} = \frac{3}{2} = 1.5 \text{ V}$$

and
$$V_{DS} = V_{GS}$$

∴
$$I_D = \frac{\mu_n C_{ox} W}{2L}(V_{GS} - V_T)^2$$
$$= \frac{1}{2} \times 60 \times 10^{-6} (1.5 - 1)^2$$
$$= \frac{1}{8} \times 60 \times 10^{-6} = 7.5 \ \mu\text{A}$$

16. (c)

Applying KCL at node V_+ we get,



$$\frac{V_+ - 3}{R} + \frac{V_+ + 6}{R} + \frac{V_+}{R/2} = 0$$
$$4 V_+ = -3 \text{ V}$$
$$V_+ = -\frac{3}{4} \text{V}$$

Now,
$$V_0 = \left(1 + \frac{2R}{R}\right) V_+$$
$$= -3 \times \frac{3}{4} = \frac{-9}{4} = -2.25 \text{ V}$$

17. (b)

$$I_E = \frac{V_z}{100} = \frac{5}{100} = 50 \text{ mA}$$

∴
$$I_0 = I_B = \frac{I_E}{\beta + 1} = \frac{50}{49 + 1} \text{mA} = 1 \text{ mA}$$

18. **(c)**

$$V_0 = \frac{-V_i}{\left(1+\frac{2}{A_{OL}}\right)}$$

$$1+\frac{2}{A_{OL}} = -\frac{V_i}{V_0}$$

$$1+\frac{2}{A_{OL}} = \frac{2}{1.996}$$

$$\frac{2}{A_{OL}} = \frac{2}{1.996}-1$$

$$\frac{2}{A_{OL}} = \frac{0.004}{1.996}$$

$$\frac{2\times 1.996}{0.004} = A_{OL}$$

$$A_{OL} = 998\ \text{V/V}$$

19. **(c)**

20. **(c)**

21. **(b)**

22. **(c)**

In a voltage sensitive bridge, the bridge output is given by the following expression.

$$E_0 = \frac{E_i}{4}\times G.F\times\frac{\Delta L}{L}$$

where, E_i = 8 V, G.F = 3 and $\frac{\Delta L}{L} = 50\ \mu\text{m/m}$

$\therefore$ $$E_0 = \frac{8}{4}\times 3\times 50\times 10^{-6}$$

$\therefore$ $$E_0 = 300\ \mu\text{V}$$

23. **(a)**

The generalized expression for the gauge factor of a strain gauge is given by the expression

$$\text{G.F} = 1+2V+\frac{\Delta\rho/\rho}{\Delta L/L}$$

As it is specified as a metal, the term $\frac{\Delta\rho/\rho}{\Delta L/L} = 0$

$\therefore$ $$\text{G.F} = 1 + 2V$$ where, V is the Poisson's ratio

$$\text{G.F} = 1 + 2(0.75)$$

$$\text{G.F} = 2.5$$

24. (d)

25. (c)

26. (b)

27. (c)

Output voltage of piezoelectric crystal,

$$e_0 = gPt$$

where,

$$g = 0.01 \text{ V-m/N}$$
$$P = 1.6 \times 10^6 \text{ N/m}^2$$
$$t = 3 \times 10^{-3} \text{ m}$$
$$e_0 = 0.01 \times 1.6 \times 10^6 \times 3 \times 10^{-3} = 48 \text{ V}$$

28. (b)

We know that,

$$\frac{f_Y}{f_X} = \frac{\text{Horizontal tangencies}}{\text{Vertical tangencies}}$$

$$\frac{f_Y}{6} = \frac{4}{2}$$

$\therefore$

$$f_Y = 12 \text{ kHz}$$

29. (a)

Given, emf of standard cell, $E_1 = 2$ V

$$l_1 = 800 \text{ mm}$$

Let, test cell emf is E_2, $l_2 = 850$ mm

The voltage of any point along the slide wire is proportional to length of slide wire.

i.e.,

$$E \propto l$$

$$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$

$\therefore$

$$E_2 = \frac{l_2}{l_1} \times E_1 = \frac{850}{800} \times 2 = 2.125 \text{ V}$$

30. (b)

Given,

$$I_{\text{MFSD}} = 10 \text{ A}, V_M = 0.1 \text{ V}$$

$\therefore$

$$R_M = \frac{0.1}{10} = 10 \times 10^{-3}\,\Omega$$

$$m = \frac{I_{FSD}}{I_{MFSD}} = \frac{100}{10} = 10$$

$\therefore$

$$R_{\text{sh}} = \frac{R_M}{m-1} = \frac{10 \times 10^{-3}}{10-1} = 1.11 \text{ m}\Omega$$

31. (d)

distributed capacitance, $C_d = \dfrac{C_1 - n^2 C_2}{n^2 - 1}$

where, $n = \dfrac{f_2}{f_1} = \dfrac{2f}{f} = 2$

$C_1 = 220$ pF; $C_2 = 10$ pF

$\therefore$ $C_d = \dfrac{220 - 40}{3} = \dfrac{180}{3} = 60$ pF

32. (a)

33. (c)

Deflection, $D = \dfrac{L l_d E_d}{2 d E_a}$

$\therefore$ Voltage applied to deflecting plates,

$$E_d = \frac{2 d E_a D}{L l_d}$$

$\therefore$ $E_d = \dfrac{2 \times 5 \times 10^{-3} \times 2500 \times 3 \times 10^{-2}}{0.3 \times 2 \times 10^{-2}}$ V $= 125$ V

34. (d)

Given full scale reading is 19.999 V, i.e., $4\frac{1}{2}$ digit DVM is used in 10 V range.

Resolution $= \dfrac{1}{10^N} \times 10$ V ($\because N = 4$ for $4\frac{1}{2}$ DVM)

$= \dfrac{1}{10^4} \times 10 \text{ V} = \dfrac{1}{10^3} = 1$ mV

35. (d)

For Resistor-1, $\Delta R_1 = 10\text{ k}\Omega \times \dfrac{2}{100} = 0.2\text{ k}\Omega$

For Resistor-2, $\Delta R_2 = 5\text{ k}\Omega \times \dfrac{5}{100} = 0.25\text{ k}\Omega$

Total resistance possible in series, R = 10 kΩ + 5 kΩ + 0.2 kΩ + 0.25 kΩ

R = 15.45 kΩ

Original resistance, R' = 10 kΩ + 5 kΩ = 15 kΩ

$\therefore$ % Error $= \dfrac{15.45 - 15}{15} \times 100\% = \dfrac{0.45}{15} \times 100\%$

% Error = 3%

36. (c)

$$\text{Error on reading 100 mV} = 100\text{ mV} \times \frac{0.5}{100} = 0.5\text{ mV}$$

also, $$\text{error due to } \pm 5 \text{ counts} = \frac{200}{2000} \times 5\text{ mV} = 0.5\text{ mV}$$

Hence, $$\text{Total error} = 0.5 + 0.5 = 1\text{ mV}$$

The DVM will read between (100 – 1) mV and (100 + 1) mV, i.e., between (99 mV and 101 mV).

37. (d)

38. (b)

39. (c)

Given, resistance of ammeter, $R_a = 2\ \Omega$

Test resistance, $R_T = 100\ \Omega$

$$\therefore \quad \%\text{ error} = \frac{R_a}{R_T} \times 100 = \frac{2}{100} \times 100 = 2\%$$

40. (b)

For closed Lissajous pattern,

$$\frac{f_y}{f_x} = \frac{\text{Number of Tangencies in Horizontal plane}}{\text{Number of Tangencies in Vertical plane}}$$

$$\frac{f_y}{f_x} = \frac{3f}{f} = \frac{3}{1}$$

Hence, option (b) is correct.

41. (a)

42. (b)

43. (a)

44. (a)

45. (c)

Analog data acquisition systems are used when low accuracies can be tolerated.

Section B : Signals and Systems-1 + Basic Electrical Engineering-1

46. (c)

For system 1, $$y(n) = \sum_{k=-\infty}^{n} x(k) \Rightarrow \text{Invertible}$$

Inverse system, $y(n) = x(n) - x(n-1)$

For system 2, $y(n) = 0 \Rightarrow$ Non invertible

For system 3, $y(n) = \cos[x(n)] \Rightarrow$ Non invertible

For system 4, $y(n) = \sum_{k=-\infty}^{n} \left(\frac{1}{2}\right)^{n-k} x(k) \Rightarrow$ Invertible

Inverse system, $y(n) = x(n) - \frac{1}{2}x(n-1)$

47. **(c)**

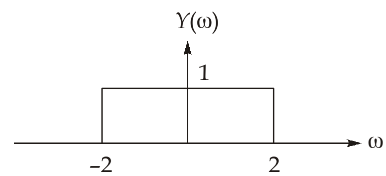
48. **(a)**

Since, $y(t) = x(t)\cos t$

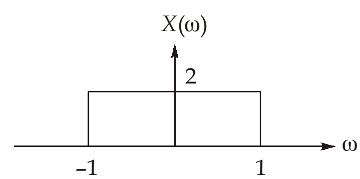
Taking Fourier transform, $Y(\omega) = \frac{1}{2}[X(\omega - 1) + X(\omega + 1)]$

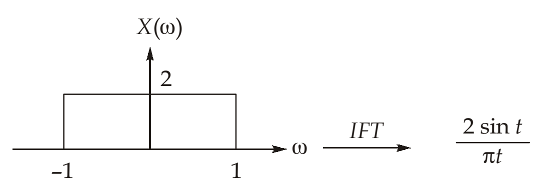
[using modulation property of Fourier transform]

and also given that,



so, $X(\omega)$ will be





49. **(c)**

$$t^{100}e^{-t}u(t) \xleftrightarrow{L.T.} \frac{100!}{(s+1)^{101}}$$

$$\frac{d^{100}}{dt^{100}} t^{100}e^{-t}u(t) \xleftrightarrow{L.T.} \frac{s^{100}\,100!}{(s+1)^{101}}$$

$$e^{t}\left(\frac{d^{100}}{dt^{100}} t^{100}e^{-t}u(t)\right) \xleftrightarrow{L.T.} \frac{(s-1)^{100}}{s^{101}} \times 100!$$

50. **(b)**

Only complex exponentials are periodic.

$x_2(t) = e^{t(j+1)} = e^{jt}e^{t}$

(because of this term x_2(t) is non-periodic)

51. (a)

52. (b)

Load, $P = 500\text{ kW}$

Load kVA, $S = \dfrac{P}{\cos\phi} = \dfrac{500}{0.707} = 500\sqrt{2}\text{ kVA}$

Power factor angle, $\phi = \cos^{-1} 0.707 = 45°$

$$\text{Load kVAR} = S \times \sin\phi = 500\sqrt{2} \times \sin 45° = 500\text{ kVAR}$$

Thus a synchronous motor when connected to improve power factor in over-excited condition will operate as a synchronous condenser. The power required to be supplied by synchronous condenser, therefore is 500 kVAR and p.f is zero (leading).

53. (b)

The flux in the circuit, $\Psi = \dfrac{\text{MMF}}{\text{Reluctance}} = \dfrac{N_1 i_1}{l/\mu A} = \dfrac{N_1 i_1 \mu A}{2\pi r}$

According to Faraday's law, the emf induced in the second coil is

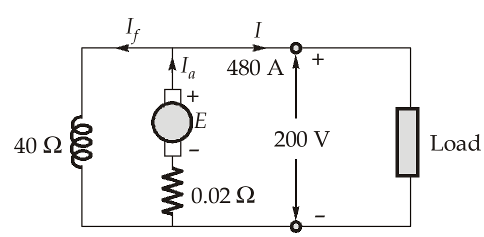
$$e_2 = -N_2 \frac{d\Psi}{dt} = \frac{-100 \times 200 \times 500 \times 4\pi \times 10^{-7} \times 10^{-3}}{2\pi \times 10 \times 10^{-2}} \frac{di_1(t)}{dt}$$

$$= -\frac{1}{50}\frac{d}{dt}(3\sin 100\pi t) = -6\pi \cos 100\pi t \text{ V}$$

54. (c)

Copper loss is not included in no-load losses of dc machine.

55. (b)



$$I_f = \frac{200}{40} = 5\text{ A}$$

$$I_a = I + I_f = 480 + 5 = 485\text{ A}$$

The armature voltage drop, $I_a R_a = 485 \times 0.02 = 9.70\text{ V}$

For generator, $E = V + I_a R_a = 200 + 9.70 = 209.7\text{ V}$

56. (c)

The generated emf in dc generator is given by,

$$E = \frac{P\phi NZ}{60\text{ A}}$$

P = Number of pole = 6
ϕ = Flux per pole in Weber
N = Speed in rpm = 1500 rpm
Z = Number of conductors
A = Number of parallel paths = 2
E = Generated emf = 200 V

Total number of conductors = Number of slots × Number of conductors in each slot
= 24 × 40 = 960 conductors

Flux per pole,
$$\phi = \frac{60 \times E \times A}{P \times N \times Z} = \frac{60 \times 200 \times 2}{6 \times 1500 \times 960} = 2.78 \text{ mWb}$$

57. (c)

Due to idleness of field coil, only residual magnetism will be absent. So, for the period of developing residual voltage only, it needs separately excited source. After that, the machine will pick up automatically.

58. (c)

Air gap flux in alternator is due to current in armature as well as dc excitation on field winding also. Hence statement 2 is not correct.

59. (d)

60. (a)

As nuclear plants require long period of time to heat upto operating temperature, these power plants may take many hours, if not days to change their power output. Hence these are best suited for base load operation.

Section C : Analog and Digital Communication Systems-2

61. (d)

- Digital communication systems give better noise performance than any analog communication system.
- So, among the given choices, PCM provides better noise performance.

62. (d)

Bandwidth, B = 4 kHz = 4000 Hz

$$\text{SNR} = \frac{S}{N_0 B} = \frac{100 \times 10^{-6}}{2 \times 10^{-12} \times 4000} = 1.25 \times 10^4$$

Capacity, $C = B \log_2(1 + \text{SNR})$
$= 4 \log_2(1 + 1.25 \times 10^4) \simeq 54.4$ kbps

63. (d)

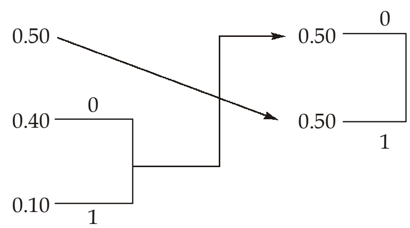
$$H(X) = -0.2\log_2(0.2) - 0.8\log_2(0.8) \text{ bits/symbol}$$
$$\simeq 0.722 \text{ bits/symbol}$$

64. (c)

The mutual information between two random variables X and Y can be expressed in the following ways:

$$I(X;Y) = H(X) - H(X|Y) = H(Y) - H(Y|X)$$
$$= H(X) + H(Y) - H(X;Y)$$
$$= H(X;Y) - H(X|Y) - H(Y|X)$$

65. (c)



x_i	$P(x_i)$	Code word	l_i
x_0	0.50	1	1
x_1	0.40	00	2
x_2	0.10	01	2

Average length of code words,

$$\bar{L} = \sum_{i=0}^{2} P(x_i) l_i$$
$$= (0.50 \times 1) + (0.40 \times 2) + (0.10 \times 2) \text{ bits/symbol}$$
$$= 1.50 \text{ bits/symbol}$$

66. (c)

For a baseband binary transmission,

$$\frac{R_b}{2} \le (\text{Channel BW})$$
$$R_b \le 2\,(20 \text{ kHz}) = 40 \text{ kHz}$$
$$nf_s \le 40 \text{ kHz}$$

For a delta modulator based system, $n = 1$

So, $$f_s \le 40 \text{ kHz}$$
$$f_{s(\max)} = 40 \text{ kHz}$$

For proper reconstruction of the sampled message signal,

$$f_s \ge 2 f_{m(\max)}$$
$$2 f_{m(\max)} = f_{s(\max)} = 40 \text{ kHz}$$
$$f_{m(\max)} = 20 \text{ kHz}$$

67. (c)

Number of message signals, $m = 5$

$f_{m(\max)} = 10$ kHz

Minimum sampling rate, $f_{s(\min)} = 2f_{m(\max)} = 20$ kHz

Bits/sample, $n = \log_2(L) = \log_2(64) = 6$ bits/sample

Minimum sampling rate of multiplexed signal,

$$f_a = mf_{s(\min)} = 5 \times 20 \text{ kHz} = 100 \text{ kHz}$$

Minimum bit rate, $R_{b(\min)} = nf_a = 600$ kbps

68. (c)

Both the signals can be used for modelling the binary data for ISI free transmission.

With $\text{sinc}\left(\frac{t}{T_b}\right)$ as basic pulse $\Rightarrow (\text{BW})_{\min} = \frac{R_b}{2}$

With $\text{sinc}^2\left(\frac{t}{T_b}\right)$ as basic pulse $\Rightarrow (\text{BW})_{\min} = R_b$

69. (a)

$$\text{sinc}(1000t) \xleftrightarrow{\text{CTFT}} \frac{1}{1000}\text{rect}\left(\frac{f}{1000}\right) \Rightarrow f_{\max} = 500 \text{ Hz}$$

$$x_1(t) = \text{sinc}^2(1000t) \xleftrightarrow{\text{CTFT}} \frac{1}{10^6}\left[\text{rect}\left(\frac{f}{1000}\right) * \text{rect}\left(\frac{f}{1000}\right)\right] \Rightarrow f_{\max} = 1000 \text{ Hz}$$

$$x_2(t) = \text{sinc}^3(2000t) \xleftrightarrow{\text{CTFT}} \frac{1}{(2000)^3}\left[\text{rect}\left(\frac{f}{2000}\right) * \text{rect}\left(\frac{f}{2000}\right) * \text{rect}\left(\frac{f}{2000}\right)\right] \Rightarrow f_{\max} = 3000 \text{ Hz}$$

$$x(t) = x_1(t) * x_2(t) \xleftrightarrow{\text{CTFT}} X_1(f)X_2(f) \Rightarrow f_{\max} = \min\{1000 \text{ Hz}, 3000 \text{ Hz}\} = 1000 \text{ Hz}$$

So, $f_{s\,(\min)} = 2f_{\max} = 2000 \text{ Hz} = 2$ kHz

70. (b)

Given that, $R_b = 6$ kbps

For baseband pulse shaping using raised cosine filter,

$$(\text{BW})_{\text{signal}} = \frac{R_b}{2}(1+\alpha) = 3(1+\alpha) \text{ kHz}$$

Given that, $(\text{BW})_{\text{channel}} = 4$ kHz

For proper transmission of signal,

$$(\text{BW})_{\text{signal}} \le (\text{BW})_{\text{channel}}$$

$$3(1+\alpha) \le 4$$

$$1 + \alpha \le \frac{4}{3}$$

$$\alpha \le \frac{1}{3}$$

$$\alpha_{\max} = \frac{1}{3} = 0.33$$

71. (d)

$$y_{max} = \text{Energy of } s(t) = \int_{-\infty}^{\infty} |s(t)|^2 \, dt = \int_{0}^{0.50} e^{-2t} \, dt$$

$$= \left[\frac{e^{-2t}}{-2}\right]_0^{0.50} = \frac{1}{2}(1 - e^{-1}) = \frac{e-1}{2e} \approx \frac{2.72-1}{2 \times 2.72} = \frac{1.72}{5.44} = 0.316$$

72. (b)

Probability of error for coherent BPSK is,

$$P_{e\,(\text{BPSK})} = Q\left[\sqrt{\frac{2E_P}{N_0}}\right]$$

Probability of error for coherent BFSK is,

$$P_{e\,(\text{BFSK})} = Q\left[\sqrt{\frac{E_F}{N_0}}\right]$$

When both have same error performance,

$$\frac{2E_P}{N_0} = \frac{E_F}{N_0}$$

$$\frac{E_P}{E_F} = \frac{1}{2} = 0.50$$

73. (b)

74. (c)

Prefix-free condition is not necessary for unique decodability.

75. (a)

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