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ESE 2023 : Prelims Exam
CLASSROOM TEST SERIES

E & T ENGINEERING

Test 10

Section A : Signals & Systems + Basic Electrical Engineering

Section B : Analog & Digital Communication Systems-1

Section C : Electronic Devices & Circuits-2 + Analog Circuits Topics-2

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Detailed Explanation
Section A : Signals & Systems + Basic Electrical Engineering

1. (b)

We have,
$$x(t) = 2\cos\left(\frac{2\pi}{3}t\right) + \sin(\pi t)$$
$$\downarrow T_1 = 3 \qquad \downarrow T_2 = 2$$

$\therefore$ Fundamental time period "T" $= \text{LCM}[T_1, T_2]$
$= \text{LCM}[3, 2] = 6$

Now, fundamental frequency of the signal is $\omega_0 = \frac{2\pi}{6} = \frac{\pi}{3}\text{rad/s}$

2. (d)

Now,
$$y(t) = x(t) * h(t)$$
$$= \delta(t) * [te^{-t} \cdot u(t)]$$
$$= t \cdot e^{-t} \cdot u(t) \qquad \ldots[f(t) * \delta(t - t_0) = f(t - t_0)]$$

3. (d)

We know,

When two systems with impulse response $h_1(t)$ and $h_2(t)$ are connected in cascade, then overall impluse response is convolution of $h_1(t)$ and $h_2(t)$.

$\therefore$
$$h(t) = [h_1(t) * h_2(t)] + h_3(t)$$

4. (c)

N point DFT is defined as,
$$X[k] = \sum_{n=0}^{N-1} x[n] \cdot e^{-j\frac{2\pi k}{N}n}$$

Inverse DFT is defined as;
$$x[n] = \frac{1}{N}\sum_{k=0}^{N-1} X[k] \cdot e^{j\frac{2\pi k}{N}n}$$

5. (a)

FFT algorithm to solve N-point DFT will require;

Number of additions $= N \log_2 N$

Number of multiplications $= \frac{N}{2}\log_2 N$

$\therefore$ 16-point DFT $\Rightarrow$ $N = 16$

Number of multiplications $= \frac{N}{2}\log_2 N$
$= 8 \log_2 16 = 32$

6. (c)

FIR filter:

Length of impulse response is finite.

It is always stable.

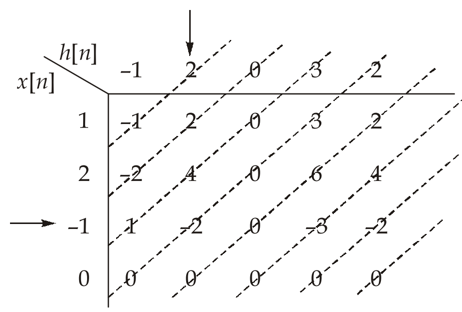
It may or may NOT be linear in phase. If $h[n] = h[N - 1 - n]$ where N is length of filter, then only linear phase is produced.

7. (d)

Rectangular window method is used to design FIR filter.

8. (b)

We know; $$y[n] = x[n] * h[n]$$



$$y[n] = \{-1, 0, 5, \underset{\uparrow}{1}, 8, 1, -2, 0\}$$

∴ $$y[0] = 1$$

9. (d)

The digital frequency (Ω) is related to the analog frequency(f) through the sampling frequency (f_s) as

$$\Omega = \frac{2\pi f}{f_s} = \omega T_s$$

10. (c)

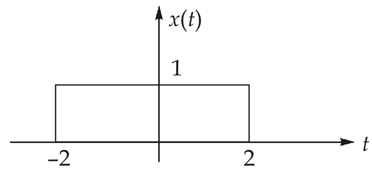
An anti-aliasing filter is used before a signal sampler to restrict the bandwidth of a signal to satisfy the Nyquist sampling theorem over the band of interest. Hence, the signal bandwidth is limited to $\omega_s/2$.

11. (a)

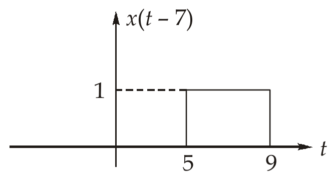
Let $$y(t) = \int_0^{10} [2x(t-3) * \delta(t-4)] \cdot dt$$

$$= \int_0^{10} [2x(t-7)] \cdot dt \qquad \ldots f(t) * \delta(t - t_0) = f(t - t_0)$$

$$= 2\int_0^{10} x(t-7) \cdot dt$$

Since; $x(t)$ is defined as 

For $x(t - 7)$, delay $x(t)$ with 7 unit.

$\therefore$ 

$\therefore$ $$y(t) = 2\int_5^9 1 \cdot dt = 2 \times 4 = 8$$

12. (d)

$x(t)$	*TFS* Coefficients
Even signal	$b_k = 0; a_k \neq 0$
Odd signal	$b_k \neq 0, a_k = 0$
Even + HWS	$a_k \neq 0$ ....for odd value of k; $b_k = 0$
Odd + HWS	$b_k \neq 0$ ....for odd value of k; $a_k = 0$
HWS	$a_k \neq 0$ and $b_k \neq 0$ for odd value of k

13. (a)

We know, $$e^{-a|t|} \xleftrightarrow{FT} \frac{2a}{\omega^2 + a^2}$$

$\because$ $$G(\omega) = \frac{2}{\omega^2 + 2^2} = \frac{1}{2}\left[\frac{2 \cdot (2)}{\omega^2 + 2^2}\right]$$

Taking inverse Fourier transform

$$g(t) = \frac{1}{2} \cdot e^{-2|t|}$$

at $t = 0$ $$g(0) = \frac{1}{2} = 0.5$$

14. (b)

The reason for using multistage decimators and interpolators:

- Multistage systems require reduced computation.
- Storage space required is less.
- Filter design problem is simple.
- Finite word length effects are less.

15. (b)

For backward difference method of derivative.

$$s = \frac{1-z^{-1}}{T} = 1 - z^{-1} \quad \text{... for } T = 1 \text{ sec}$$

$$H(s) \xrightarrow{s = 1 - z^{-1}} H(z) = \frac{1}{1-z^{-1}+2} = \frac{1}{3-z^{-1}} = \frac{z}{3z-1}$$

16. (b)

We have; $$H(s) = \frac{s+0.1}{(s+0.1)^2+16}$$

∴ Analog frequency (Ω) = 4

∵ relation between analog frequency (Ω) and digital filter (ω) is given as;

$$\Omega = \frac{2}{T}\tan\frac{\omega_r}{2} \quad \Rightarrow \quad 4 = \frac{2}{T}\tan\left(\frac{\pi}{4}\right)$$

∴ $T = 0.5$ sec

17. (d)

The butterworth low-pass filter has a magnitude response given as;

$$|H(j\Omega)| = \frac{A}{\left[1+\left(\frac{\Omega}{\Omega_c}\right)^{2N}\right]^{0.5}}$$

where; A = gain of filter

Ω_c = 3-dB cut-off frequency

N = order of filter

18. (d)

We know, $$x(t) = 0.5\cos\left(2\pi t + \frac{\pi}{2}\right)$$

∵ It is sampled with f_s = 4 Hz replace $t = nT_s = \frac{n}{f_s}$

$$x[n] = 0.5\cos\left[\frac{2\pi n}{f_s} + \frac{\pi}{2}\right] = 0.5\cos\left[\frac{2\pi n}{4} + \frac{\pi}{2}\right]$$

$$x[n] = 0.5\cos\left[\frac{\pi}{2}n + \frac{\pi}{2}\right]$$

at $n = 1$, $x[1] = 0.5\cos\pi = -0.5$

19. (b)

From pole zero plot; $$H(z) = \frac{(z-1)(z+1)}{z} = \frac{z^2-1}{z} = z - z^{-1}$$

$$H(z) = \frac{Y(z)}{X(z)} = z - z^{-1}$$

$$Y(z) = (z - z^{-1})\, X(z)$$
$$Y(z) = z \cdot X(z) - z^{-1} \cdot X(z)$$

Taking inverse z-transform

$$y[n] = x[n+1] - x[n-1]$$

Since, output sequence do NOT depends on its previous value, hence it is FIR filter.

20. (b)

Given: E_2 = 600 V; f = 50 Hz; N_2 = 100

We know,
$$E_2 = 4.44\, N_2 f \phi_m$$
$$\phi_m = \frac{600}{4.44 \times 100 \times 50} = 0.027 \text{ Wb} = 27 \text{ mWb}$$

21. (d)

Given: $\%R$ = 3%; V.R. = 1.2%; p.f. = 0.8 leading

$$\text{V.R.} = \%R\cos\phi - \%X\sin\phi$$
$$1.2 = 3 \times 0.8 - \%X \times 0.6$$
$$\%X = \frac{1.2}{0.6} = 2\%$$

22. (b)

Type of Motor	Starting torque	Power factor
Shaded pole	Low	Low
Capacitor start	High	Low
Capacitor run	Low	High
Split phase	Low	Low

23. (c)

Properties of Ideal transformer:

(i) The core of the transformer requires negligible magnetomotive force (mmf) to set up the flux in the core.

(ii) Its leakage flux is zero.

(iii) The resistance of primary and secondary winding is negligible.

(iv) There is no losses due to hysteresis and eddy currents.

24. (d)

Given: P = 4; f = 50 Hz; N_r = 1410 rpm

$$N_s = \frac{120 f}{P} = \frac{120 \times 50}{4} = 1500 \text{ rpm}$$

Full load slip,
$$s_{FL} = \frac{N_s - N_r}{N_s} = \frac{1500 - 1410}{1500} = 0.06$$

$$\frac{T_{st}}{T_{FL}} = \left(\frac{I_{st}}{I_{FL}}\right)^2 \cdot \left(\frac{s_{FL}}{s_{st}}\right) \qquad (s_{st} = 1)$$

$$\frac{T_{st}}{T_{FL}} = (5)^2 \times 0.06 = 1.5$$

$$\frac{T_{FL}}{T_{st}} = 0.667$$

$$T_{FL} = 0.667\ T_{st}$$

$$\%\ \text{change} = \left(\frac{T_{FL} - T_{st}}{T_{st}}\right) \times 100\% = -33.33\%$$

So, full load torque is 33.33% lower than starting torque.

25. (a)

Given: 3-ϕ induction motor.

$$V = 250\ \text{Volt},\quad I_L = 75\ \text{A},\quad \cos\phi = 0.8\ \text{lagging}$$

$$P_{cu(\text{stator})} = 750\ \text{W},\quad P_{\text{core(stator)}} = 500\ \text{W}$$

Stator input,
$$P_{i(\text{stator})} = \sqrt{3}\, V \cdot I_L \cos\phi$$

$$P_{i\,(\text{stator})} = \sqrt{3} \times 250 \times 75 \times 0.8 = 25980.76\ \text{W} = 25.98\ \text{kW}$$

$$\text{Air gap power} = P_{i\,(\text{stator})} - P_{\text{loss(stator)}} = 25.98 - 0.75 - 0.5$$

$$P_g = 24.73\ \text{kW}$$

26. (b)

In order to increase the ampere-hour rating of a battery, cells are connected in parallel.

27. (b)

In lead-acid cell,

Number of negative plates = Number of positive plates + 1

28. (a)

Hydroelectric power stations are generally located in hilly areas where dams can be built conveniently and large water reservoirs can be obtained.

29. (d)

Given: V_t = 400 V; R_a = 0.2 Ω; N_1 = 1970 rpm; I_{a_1} = 30 A; R_{ext} = 1.8 Ω; I_{a_2} = 22 A

$$\phi_2 = 80\%\ \text{of}\ \phi_1 = 0.8\ \phi_1$$

We know for series motor,
$$E_b = k\phi N$$

$$E_{b_1} = 400 - I_{a_1} R_a = 400 - 30 \times 0.2 = 394\ \text{V}$$

$$E_{b_2} = 400 - I_{a_2}(R_a + R_{ext}) = 400 - 22(0.2 + 1.8) = 356\ \text{V}$$

$$\frac{E_{b_2}}{E_{b_1}} = \frac{N_2 \phi_2}{N_1 \phi_1}$$

$$N_2 = \frac{356}{394} \times \frac{1}{0.8} \times 1970 = 2225\ \text{rpm}$$

30. (c)

Given: $I_a = 25$ A; At starting, $\omega = 0$

So, back emf, $E_{b\,(\text{start})} = 0$ V

For series motor, $T \propto I_a^2$

To develop rated torque at starting,

$$I_{st} = I_a = 25 \text{ A}$$

$$V_t = E_b(\text{start}) + I_{st}(R_a + R_{se} + R_{ext})$$

$$R_{ext} = \frac{V_t - E_b(\text{start})}{I_{st}} - R_a - R_{se}$$

$$= \frac{240-0}{25} - 0.3 - 0.2 = 9.6 - 0.5 = 9.1\ \Omega$$

31. (b)

Copper loss = 2% = 0.02

Maximum efficiency occurs at a load 288.68 KVA

$$x = \frac{288.68}{500} = 0.577$$

i.e. $$x = \frac{1}{\sqrt{3}} \text{ pu}$$

At maximum efficiency, $P_{cu} = P_i$

$$x^2 P_{cu_{FL}} = P_i$$

$$P_i = \left(\frac{1}{\sqrt{3}}\right)^2 \times 0.02 = \frac{1}{150}$$

Efficiency, $$\eta = \frac{x(\text{KVA})\cos\phi}{x(\text{KVA})\cos\phi + P_i + P_{cu}}$$

In p.u. $$\eta = \frac{1\times1\times0.8}{1\times1\times0.8 + \frac{1}{150} + 0.02} = 96.77\%$$

32. (d)

The speed of a DC shunt motor can be varied using 3 methods:

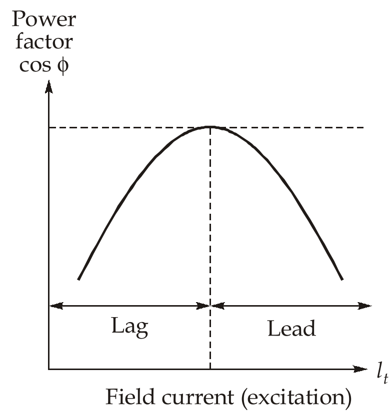
1. Field flux control.

2. Armature voltage control

3. Armature resistance control.

33. (a)

The power factor of a synchronous motor can be varied by varying the excitation of it's field winding.



34. (c)

In series DC motor,

The back emf, $E_b \propto \phi N$

To change the direction, ϕ should be reversed.

35. (a)

Given: $R_a = 0.1\ \Omega$; $V_{OC} = 450$ V; $I_{SC} = 150$ A

$$Z_s = \frac{V_{OC}}{I_{SC}} = \frac{450}{150} = 3\ \Omega$$

$$X_s = \sqrt{Z_s^2 - R_a^2} = \sqrt{(3)^2 - (0.1)^2} \simeq 3\ \Omega$$

36. (d)

Given: $P = 500$ MW ; $V_t = 13.5$ KV; $\cos\phi = 0.8$

We know, $P = \sqrt{3}\, V_t I \cos\phi$

$$I = \frac{500 \times 10^6}{\sqrt{3} \times 13.5 \times 0.8 \times 10^3} = 26.73 \text{ kA}$$

37. (b)

- In Fleming's right hand rule, if thumb is pointing towards the conductor's motion and the forefinger pointing towards the magnetic field direction, the middle finger gives the direction of the induced current or induced emf.
- The Permeance in magnetic circuit resembles the conductance in electric circuit.

38. (a)

Bilinear transformation only preserves the magnitude response of the analog filter.

39. (d)

The magnetizing current and magnetic leakage for an induction motor are more as compared to transformer of the same KVA rating, because of the presence of air gap and therefore, high reluctance.

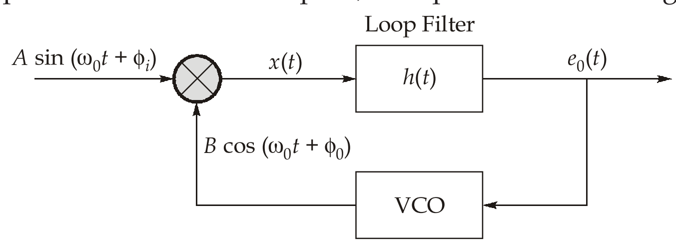
Section B : Analog and Digital Communication Systems-1

40. (b)

For small values of the modulation index β compared to one radian, the FM wave assumes a narrow-band form consisting essentially a carrier, an upper side frequency component, and a lower side-frequency component.

41. (c)

Major components required for PLL are multiplier, a loop filter and a voltage controlled oscillator.



42. (d)

Let internal loss in modulator is L

$$\therefore \quad P_t = 60 + L \; ; \quad P_c = 48 \text{ W} \; ; \quad \mu = 0.75$$

$$P_t = P_c\left(1+\frac{\mu^2}{2}\right)$$

$$(60 + L) = 48\left[1+\frac{(0.75)^2}{2}\right] = 48\left[1+\frac{3}{4}\times\frac{3}{4}\times\frac{1}{2}\right] = \frac{48\times 41}{32} = 61.5$$

$$L = 1.5 \text{ W}$$

43. (b)

$$Q = \frac{f_o}{\text{BW}}$$

Given bandwidth = 10 kHz

We have, f_o = 455 kHz (for standard AM receiver IF frequency = 455 kHz)

$$\therefore \quad Q = \frac{455}{10}$$

$$Q = 45.5$$

44. (c)

For proper envelope detection

$$\frac{1}{f_c} < R_L C < \frac{1}{f_m}$$

$$\frac{1}{f_c} = \frac{1\times 10^{-6}}{1.6} = 0.625\,\mu\text{sec}$$

$$\frac{1}{f_m} = \frac{1}{5\times 10^{3}} = 200\,\mu\text{sec}$$

Hence, $0.625\ \mu\text{sec} < R_L C < 200\ \mu\text{sec}$

∴ Correct option is 100 μsec.

45. (d)

Threshold effect: It is defined as the value of input signal to noise ratio below which the output signal to noise ratio decreases much rapidly than the input signal to noise ratio.

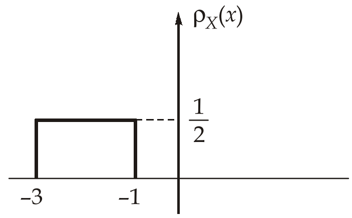
Threshold effect arise in every non-linear detector. Envelope detector is non-linear detector. On the other hand, such an effect does not arise in coherent detector.

46. (b)

$F_X(x)$ is a non-decreasing function i.e.

$$F_X(x_1) \le F_X(x_2) \quad \text{for } x_1 \le x_2$$

47. (d)



For uniform pdf, $E[X] = \frac{a+b}{2} = \frac{-3-1}{2} = -2 \qquad \left(\because \begin{matrix} a=-3 \\ b=-1 \end{matrix}\right)$

Now, expectation of $Y(t) = E[Y(t)] = E[Xt + X + 5]$

$$= E[Xt] + E[X] + E[5]$$

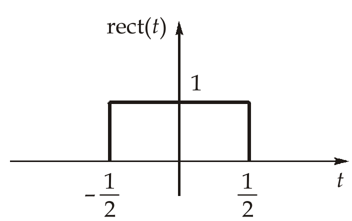
$$= tE[X] + E[X] + E[5]$$

$$= -2t - 2 + 5 \qquad (\because E[\text{Constant}] = \text{constant})$$

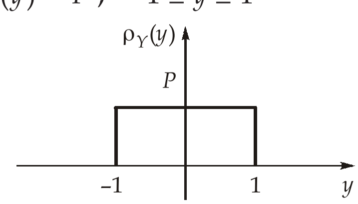
$$E[Y(t)] = -2t + 3$$

48. (a)

rect(t) =



$\therefore \quad \rho_Y(y) = P\,; \quad -1 \le y \le 1$



We know, $\displaystyle\int_{-\infty}^{\infty} \rho_Y(y)\,dy = 1$

$$P \times 2 = 1$$

$$P = \frac{1}{2}$$

Also given, $X = 2Y \Rightarrow \frac{dX}{dY} = 2$

$$\therefore \quad \rho_X(x) = \left|\frac{dY}{dX}\right|\rho_Y(x)$$

$$\rho_X(x) = \frac{1}{2}\rho_Y(x) \quad \text{...(i)}$$

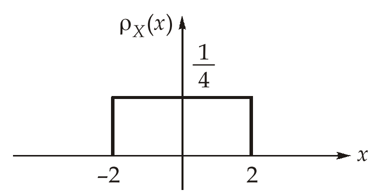
We have, $\rho_Y(x) = \frac{1}{2};\ -1 \le \frac{x}{2} \le 1 \qquad \left(\because Y = \frac{X}{2}\right)$

$$\therefore \quad \rho_Y(x) = \frac{1}{2};\ -2 \le x \le 2$$

Now from equation (i),

$$\rho_X(x) = \frac{1}{2}\times\frac{1}{2};\ -2 \le x \le 2$$

$$\rho_X(x) = \frac{1}{4};\ -2 \le x \le 2$$

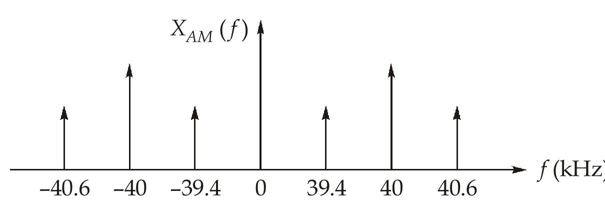


$$\therefore \quad \rho_X(x) = \frac{1}{4}\text{rect}\left(\frac{x}{4}\right)$$

$$\therefore \quad Q = \frac{1}{4} = 0.25 \quad \text{(upon comparing)}$$

49. (c)

f_c = 40 kHz; f_m = 0.6 kHz



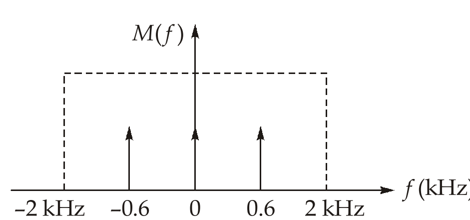
Local oscillator frequency = 40 kHz

Output of multiplier $(MUL)_O$ = (39.4 – 40), (39.4 + 40), (40 – 40), (40 + 40), (40.6 – 40), (40.6 + 40)

[Taking positive frequencies only]

$(MUL)_O$ = –0.6 kHz, 79.4 kHz, 0 kHz, 80 kHz, 0.6 kHz, 80.6 kHz

Now output of LPF



∴ Frequency present at the output of HPF = 0.6 kHz = 600 Hz.

50. (a)

$$I_t = I_c \sqrt{1+\frac{\mu^2}{2}}$$

$$I_t = 14.14\sqrt{\frac{9}{8}} = \frac{14.14\times 3}{2\times\sqrt{2}} = 15\text{ A}$$

51. (a)

We know that, the angle modulated signal is,

$$S(t) = A_c \cos[2\pi f_c t + \phi(t)]$$

Peak frequency deviation, $\Delta f = \frac{1}{2\pi}\left|\frac{d}{dt}\phi(t)\right|_{\text{max}}$

$$\Delta f = \frac{1}{2\pi}\left|\frac{d}{dt}(45\sin(4\times 10^3 \pi t))\right|_{\text{max}}$$

$$= \frac{1}{2\pi}\times 45\times 4\times 10^3\pi = 90\text{ kHz}$$

52. (b)

Correlation coefficient ρ_{XY} = 0.3,

$$m_x = 0, \quad m_y = 0$$

$$\sigma_X^2 = 1, \quad \sigma_Y^2 = 9$$

Now, covariance, $\sigma_{XY} = \rho_{XY}\cdot\sigma_X\cdot\sigma_Y = 0.3\times 1\times\sqrt{9} = 0.3\times 3 = 0.9$

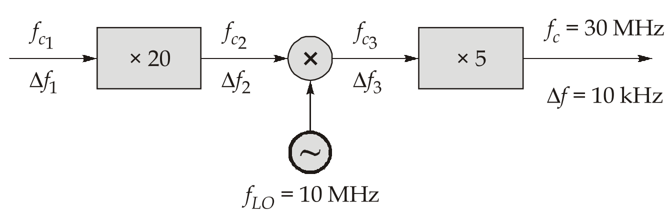
53. (d)

Variance, $\sigma^2 = m_2 - m_1^2$

$$\sigma^2 = E[X^2] - [E[X]]^2$$

54. (b)

From the figure



$$\Delta f = 10\text{ kHz}; \quad f_c = 30\text{ MHz}$$

$$f_{c_3}\times 5 = 30$$

$$f_{c_3} = 6\text{ MHz}$$

$\because$ Down conversion $(f_{LO} > f_{c_2})$

$\therefore$ $f_{c_2} = f_{LO} - f_{c_3}$

$$f_{c_2} = 10 - 6 = 4\text{ MHz}$$

55. (d)

$$f_L = 1100 \text{ kHz}, \quad f_s = 645 \text{ kHz}$$
$$f_{IF} = f_L - f_s = 455 \text{ khz}$$
$$\therefore \quad f_{si} = f_s + 2f_{IF}$$
$$f_{si} = 645 + 2\,(455) = 1555 \text{ kHz}$$

Section C : Electronic Devices & Circuits-2 + Analog Circuits Topics-2

58. (d)

- BJT is a current-controlled device. The current through the two terminals is controlled by a current at the third terminal (base).
- BJT has low input impedance because it's input is forward-biased.

59. (a)

In a MOSFET, the gate and channel are separated by a thin layer of SiO_2, and they form a capacitance that varies along with gate voltage. Hence, MOSFET can be used as a voltage-controlled capacitor. Also, MOSFET behaves as a voltage controlled resistor in ohmic or linear region. By increasing substrate doping concentration, minority carriers decreases, hence more voltage needs to be applied to get the required charge. Hence, threshold voltage increases in an N-channel EMOSFET.

60. (c)

$$I_C = \beta I_B + (1+\beta) I_{CO}$$

but
$$\beta = \frac{\alpha}{1-\alpha}$$

$$\therefore \quad I_C = \beta I_B + \left(1 + \frac{\alpha}{1-\alpha}\right) I_{CO} = \beta I_B + \frac{1-\alpha+\alpha}{1-\alpha} I_{CO}$$

$$I_C = \beta I_B + \frac{1}{1-\alpha} I_{CO}$$

61. (b)

If an MOS device with short channel length is applied with strong electric field, the carrier velocity reaches a maximum value, saturation velocity, which results in saturation of the current.

62. (d)

Reverse leakage current gets double at every 10°C rise in temperature.

63. (d)

$$I_D \propto (1 + \lambda V_{DS}) \qquad \text{(in saturation region)}$$

$$\therefore \quad \frac{I_{D2}}{I_{D1}} = \frac{(1+\lambda V_{DS2})}{(1+\lambda V_{DS1})}$$

$$I_{D2} = \frac{(1+0.1\times 1)}{(1+0.1\times 0.5)} \times 1\times 10^{-3} = \frac{1.1}{1.05} \times 1 \times 10^{-3}$$

$$I_{D2} = 1.048 \text{ mA}$$

$$\therefore \quad \Delta I_D = 48 \ \mu\text{A}$$

64. (c)

Turn off time depends on minority storage charge. Since in MOSFETs, minority carriers are absent, their turn off time is less.

65. (d)

We know that,
the drain current for JFET is,

$$I_{D(\text{sat})} = I_{DSS}\left(1-\frac{V_{GS}}{V_P}\right)^2$$

transconductance of JFET

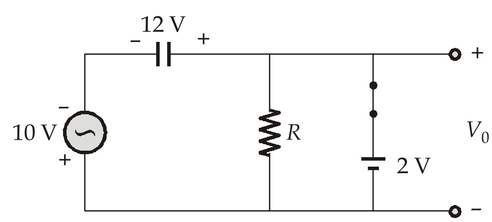
$$g_m = \frac{\partial I_D}{\partial V_{GS}} = \frac{\partial}{\partial V_{GS}}\left[I_{DSS}\left(1-\frac{V_{GS}}{V_P}\right)^2\right] = \frac{2I_{DSS}}{|V_P\}}\left(1-\frac{V_{GS}}{V_P}\right)$$

Maximum transconductance, $g_{m(\text{max})} = \dfrac{2I_{DSS}}{|V_P|}$ $(\because V_{GS} = 0)$

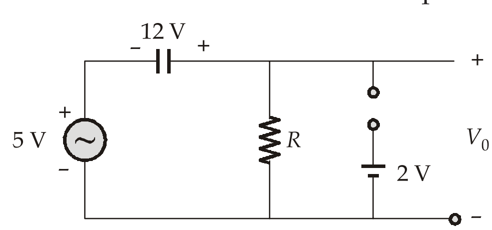
$$g_{m(\text{max})} = \frac{2\times 1}{5} = 0.4 \text{ m sec}$$

66. (b)

For (–ve) half cycle the diode will be forward-biased and acts as short-circuit.



The capacitor is charged to V_c = –12V.
and for (+ve) half-cycle, the diode will be OFF. Hence the output voltage will be



Since, RC is very large the capacitor doesn't discharge much, hence the diode remains reverse biased with

$$V_0 = V_i + 12$$

67. (a)

The current of both the transistors are equal since they are perfectly matched.

Thus, $$\frac{I}{2} = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)(V_{GS1} - V_t)^2$$

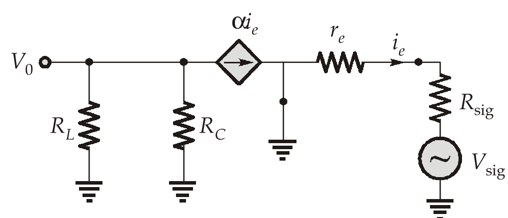
$$10 \times 10^{-3} = \frac{1}{2} \times 500 \times 10^{-6} \times 100(V_{GS1} - 0.5)^2$$

∴ $$V_{GS1} = V_{GS2} = 1.132 \text{ V}$$

Thus, $$V_S = V_{cm} - V_{GS1} = 3 - 1.132 = 1.868 \text{ V}$$

68. (b)

The small signal r_e equivalent circuit can be drawn as



$$V_0 = -\alpha(R_C \parallel R_L)i_e \qquad ...(i)$$

and $$i_e = \frac{-V_{sig}}{R_{sig} + r_e} \qquad ...(ii)$$

Combining equation (i) and (ii), we get,

$$V_0 = \frac{\alpha(R_C \parallel R_L)}{R_{sig} + r_e} \cdot V_{sig}$$

thus, $$\frac{V_0}{V_{sig}} = \frac{\alpha(R_C \parallel R_L)}{R_{sig} + r_e}$$

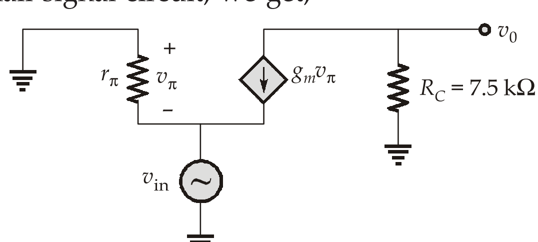
69. (b)

From the figure it can be seen that,

$$I_C = I_E = 0.5 \text{ mA} \qquad (\because I_B \approx 0 \text{ as } \beta \text{ is very large})$$

now, $$g_m = \frac{I_C}{V_T} \approx \frac{I_E}{V_T} = \frac{0.5 \times 10^{-3}}{25 \times 10^{-3}} \text{ A/V} = 20 \text{ mA/V}$$

Drawing the equivalent small signal circuit, we get,



Now, applying KVL, we get

$$v_{in} + v_\pi = 0$$
$$v_{in} = -v_\pi$$

and $$v_0 = -g_m v_\pi \times R_C$$
$$v_0 = g_m R_c v_{in}$$
$$\frac{v_0}{v_{in}} = g_m R_c = 20 \times 10^{-3} \times 7.5 \times 10^3 = 150$$

70. (b)

$$V_0 = V_{in} \times A_v$$

$$\therefore \quad S.R = \left|\frac{\partial V_0}{\partial t}\right|_{max} = A_v\left|\frac{\partial V_{in}}{\partial t}\right|_{max} = A_v \cdot \omega \cdot A,$$

where $A = 0.5$ and $A = 1 + R_2/R_1$

$$\therefore \quad f_{max} = \frac{1\times10^9 \text{ V/s}}{0.5\times\left(1+\frac{3}{1}\right)\times 2\pi} = \frac{1000}{4\pi}\text{ MHz}$$

$$= 79.61 \text{ MHz}$$

71. (d)

Due to the diode, the charging current of capacitor will bypass the resistor R_b. Hence, the positive pulse width of an astable multivibrator is,

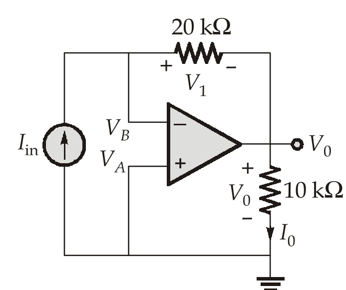
$$T_{ON} = 0.693R_aC$$

$$= 0.693 \times 22 \times 10^3 \times 0.01 \times 10^{-6}$$

$$= 0.152 \times 10^{-3}$$

$$\therefore \quad T_{ON} = 0.152 \text{ m sec}$$

72. (a)



Using the virtual short concept, $V_A = V_B = 0$ V

$\therefore \quad -V_1 = V_0$

now, $\quad -(20\text{ k}\Omega) \times I_{in} = (10\text{ k}\Omega)I_0$

$$\therefore \quad \frac{I_0}{I_{in}} = -2$$

73. (d)

$$\frac{dA_f}{A_f} = \frac{dA}{A}\left(\frac{1}{1+A\beta}\right)$$

$$\frac{0.5}{100} = \frac{10}{1000}\left[\frac{1}{1+1000\beta}\right]$$

$$0.5 + 500\beta = 1$$

$$500\beta = 0.5$$

$$\beta = 0.001$$

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