

ELECTRONICS AND EXPERIMENTAL METHODS

NET/JRF (JUNE-2011)

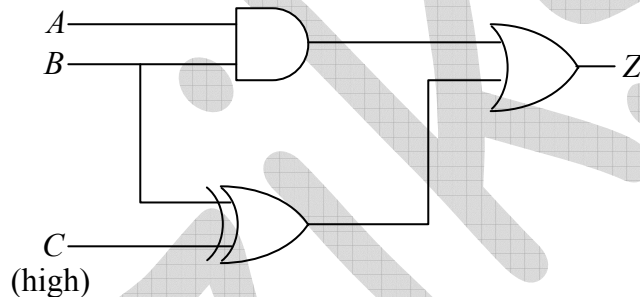
Q1. A signal of frequency 10 kHz is being digitalized by an A/D converter. A possible sampling time which can be used is

- (a) $100\ \mu\text{s}$ (b) $40\ \mu\text{s}$ (c) $60\ \mu\text{s}$ (d) $200\ \mu\text{s}$

Ans. : (b)

Solution: $f_s \geq 2f \Rightarrow T_s \leq \frac{1}{2f} = \frac{1}{20 \times 10^3} = 50\ \mu\text{s} \Rightarrow T_s \leq 50\ \mu\text{s}$

Q2. Consider the digital circuit shown below in which the input C is always high (1).



The truth table for the circuit can be written as

A	B	Z
0	0	1
0	1	0
1	0	1
1	1	1

The entries in the Z column (vertically) are

- (a) 1010 (b) 0100 (c) 1111 (d) 1011

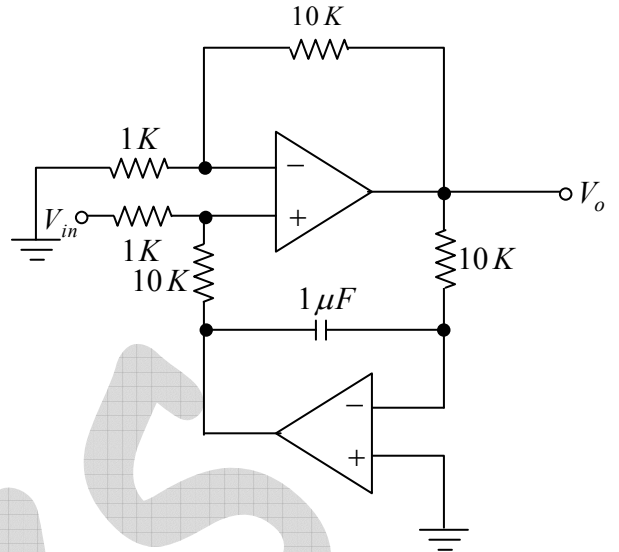
Ans. : (d)

Solution: $Z = A.B + (B \oplus 1)$

Q3. A time varying signal V_{in} is fed to an op-amp circuit with output signal V_o as shown in the figure below.

The circuit implements a

- (a) high pass filter with cutoff frequency 16 Hz
- (b) high pass filter with cutoff frequency 100 Hz
- (c) low pass filter with cutoff frequency 16 Hz
- (d) low pass filter with cutoff frequency 100 Hz



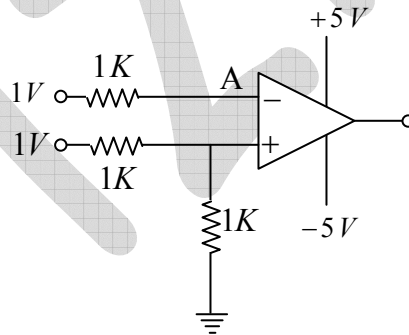
Ans. : (c)

Solution: Since circuit has R and C combination, its a Low Pass filter and cutoff frequency

$$= \frac{1}{2\pi RC} \approx 16\text{Hz}.$$

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Q4. In the operational amplifier circuit below, the voltage at point A is

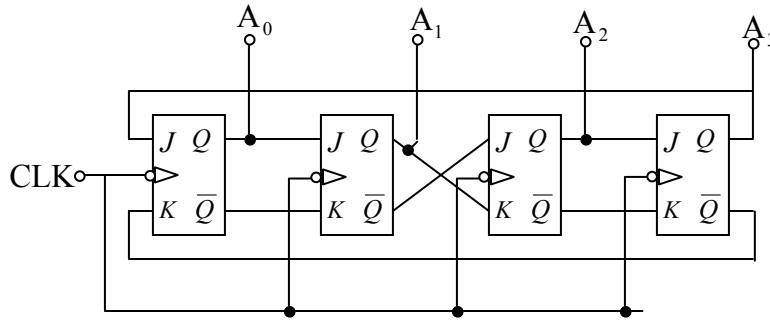


- (a) 1.0V
- (b) 0.5V
- (c) 0V
- (d) -5.0V

Ans. : (b)

Solution: $V_A = \frac{1}{1+1} \times 1 = 0.5V.$

Q5. A counter consists of four flip-flops connected as shown in the figure:

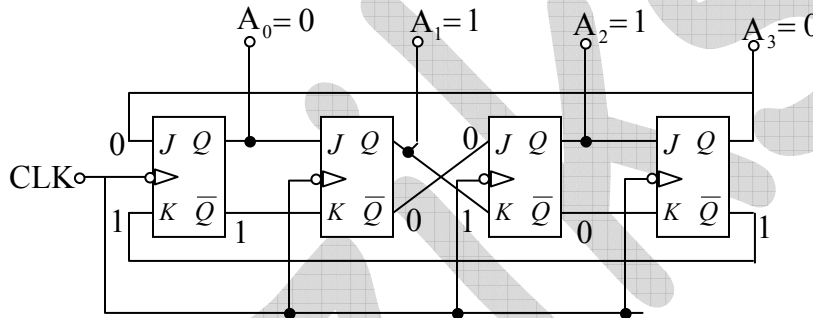


If the counter is initialized as $A_0A_1A_2A_3 = 0110$, the state after the next clock pulse is

- (a) 1000 (b) 0001 (c) 0011 (d) 1100

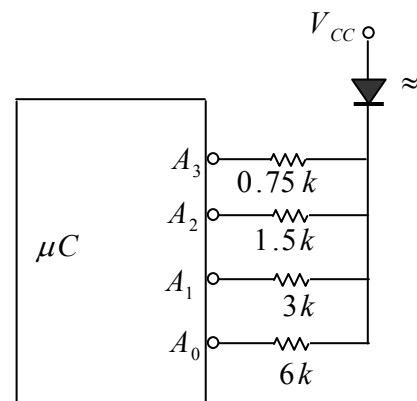
Ans: (b)

Solution:



Q6. The pins 0, 1, 2 and 3 of part A of a microcontroller are connected with resistors to drive an LED at various intensities as shown in the figure. For $V_{CC} = 4.2$ V and a voltage drop of 1.2 V across the LED, the range (maximum current) and resolution (step size) of the drive current are, respectively,

- (a) 4.0 mA and 1.0 mA
 (b) 15.0 mA and 1.0 mA
 (c) 7.5 mA and 0.5 mA
 (d) 4.0 mA and 0.5 mA



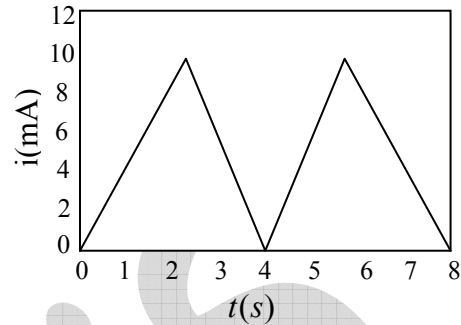
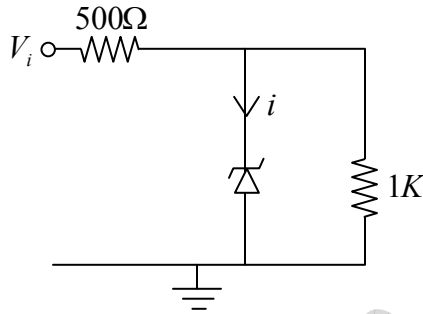
Ans: (c)

Solution: For Maximum current A_3, A_2, A_1, A_0
 0, 0, 0, 0

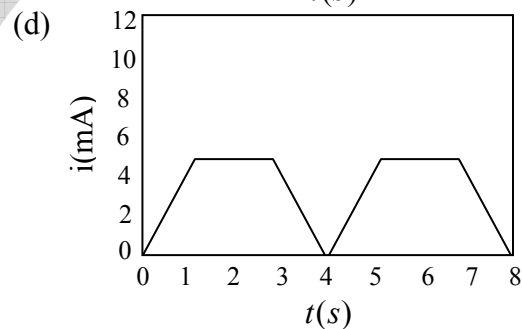
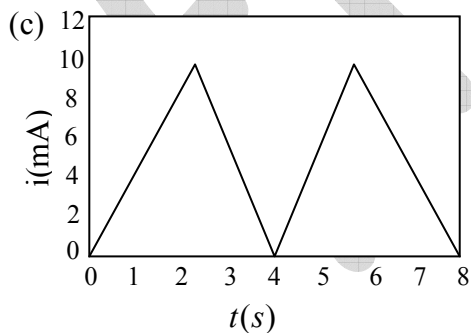
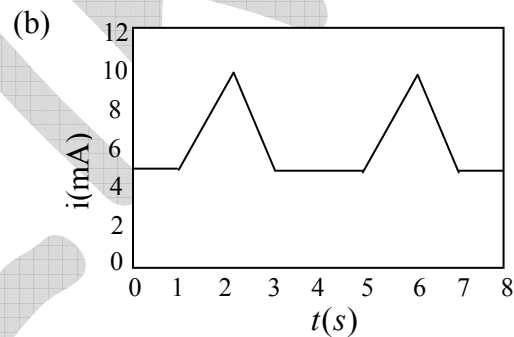
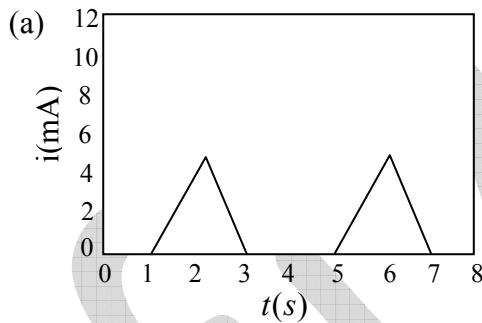
$$\text{Thus, } I_{\max} = \frac{4.2 - 1.2}{0.75k} + \frac{4.2 - 1.2}{1.5k} + \frac{4.2 - 1.2}{3k} + \frac{4.2 - 1.2}{6k} = 7.5mA$$

For Step size A_3, A_2, A_1, A_0 $0, 0, 0, 1$. Thus $I_0 = \frac{4.2 - 1.2}{6k} = 0.5mA$

Q7. The figure below shows a voltage regulator utilizing a Zener diode of breakdown voltage 5 V and a positive triangular wave input of amplitude 10 V.



For $V_i > 5V$, the Zener regulates the output voltage by channeling the excess current through itself. Which of the following waveforms shows the current i passing through the Zener diode?

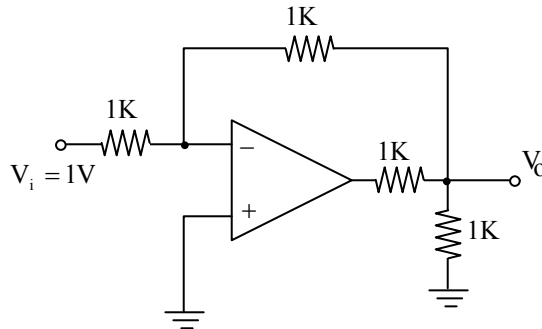


Ans: (a)

Solution: When zener is OFF zener current is zero when zener is ON zener current will flow.

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Q8. In the op-amp circuit shown in the figure below, the input voltage is 1V. The value of the output V_0 is



- (a) -0.33 V (b) -0.50 V (c) -1.00 V (d) -0.25 V

Ans. : (b)

Solution: $V_0 = -\frac{R_F V_{in}}{R_1} = -\frac{1}{2} V = -0.50$ where $R_F = \frac{1 \times 1}{1+1} = \frac{1}{2} K$ and $R_1 = 1K$.

Q9. An LED operates at 1.5 V and 5 mA in forward bias. Assuming an 80% external efficiency of the LED, how many photons are emitted per second?

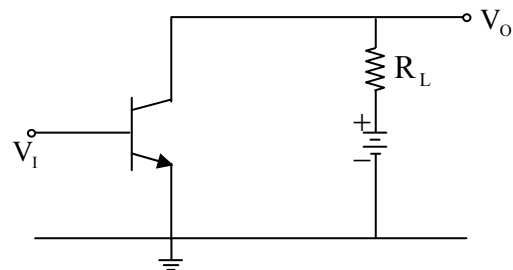
- (a) 5.0×10^{16} (b) 1.5×10^{16} (c) 0.8×10^{16} (d) 2.5×10^{16}

Ans. : (d)

Solution: $P_{in} = \eta_{ext} \frac{i}{e} hf$, number of photon = $\frac{P_{in}}{hf} = \eta_{ext} \frac{i}{e} = .8 \times \frac{5 \times 10^{-3}}{1.6 \times 10^{-19}} = 2.5 \times 10^{16}$

Q10. The transistor in the given circuit has $h_{fe} = 35\Omega$ and $h_{ie} = 1000\Omega$. If the load resistance $R_L = 1000\Omega$, the voltage and current gain are, respectively.

- (a) -35 and + 35
 (b) 35 and - 35
 (c) 35 and - 0.97
 (d) 0.98 and - 35



Ans. : (a)

Q11. The output, O, of the given circuit in cases I and II, where

Case I: A, B = 1; C, D = 0; E, F = 1 and G = 0

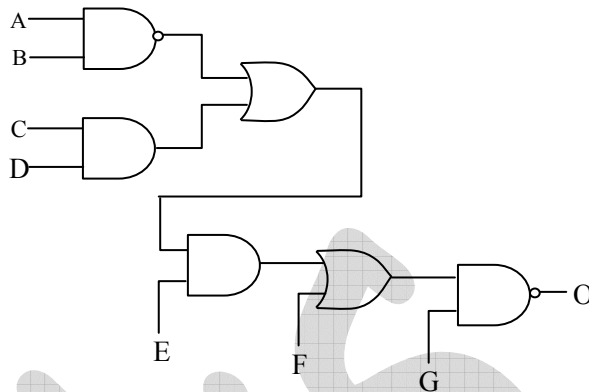
Case II: A, B = 0; C, D = 0; E, F = 0 and G = 1

are respectively

- (a) 1, 0
- (b) 0, 1
- (c) 0, 0
- (d) 1, 1

Ans. : (d)

Solution: $O = \overline{((\overline{AB} + CD)E + F)G}$



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Q12. A live music broadcast consists of a radio-wave of frequency 7 MHz, amplitude-modulated by a microphone output consisting of signals with a maximum frequency of 10 kHz. The spectrum of modulated output will be zero outside the frequency band

- (a) 7.00 MHz to 7.01 MHz
- (b) 6.99 MHz to 7.01 MHz
- (c) 6.99 MHz to 7.00 MHz
- (d) 6.995 MHz to 7.005 MHz

Ans: (b)

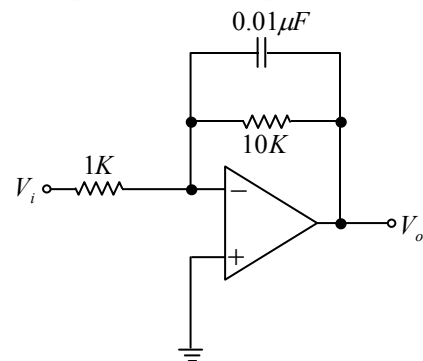
Solution: Spectrum consists of $f_c - f_m$ and $f_c + f_m$.

Q13. In the op-amp circuit shown in the figure, V_i is a sinusoidal input signal of frequency 10 Hz and V_o is the output signal. The magnitude of the gain and the phase shift, respectively, close to the values

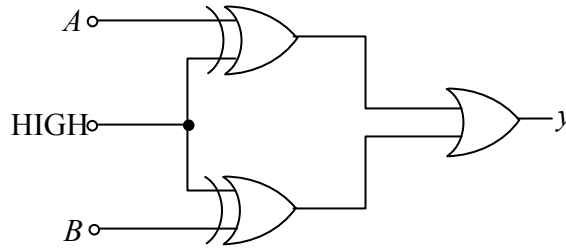
- (a) $5\sqrt{2}$ and $\pi/2$
- (b) $5\sqrt{2}$ and $-\pi/2$
- (c) 10 and zero
- (d) 10 and π

Ans: (d)

Solution: $\frac{v_0}{v_{in}} = -\frac{X_C R_F}{R_1(R_1 + R_F)} \Rightarrow \left| \frac{v_0}{v_{in}} \right| \approx 10$



Q14. The logic circuit shown in the figure below Implements the Boolean expression



- (a) $y = \overline{A \cdot B}$ (b) $y = \overline{A} \cdot \overline{B}$ (c) $y = A \cdot B$ (d) $y = A + B$

Ans: (a)

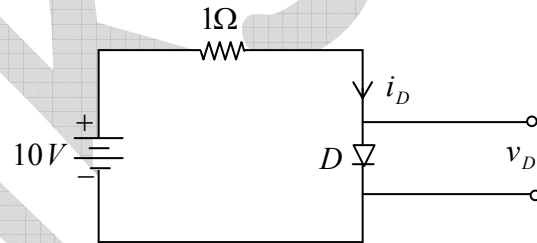
Solution: Output of each Ex-OR gate is \overline{A} and \overline{B} . Thus $y = \overline{A} + \overline{B} = \overline{A \cdot B}$

Q15. A diode D as shown in the circuit has an i - v relation that can be approximated by

$$i_D = \begin{cases} v_D^2 + 2v_D, & \text{for } v_D > 0 \\ 0, & \text{for } v_D \leq 0 \end{cases}$$

The value of v_D in the circuit is

- (a) $(-1 + \sqrt{11})V$ (b) 8 V
(c) 5 V (d) 2 V



Ans: (d)

Solution: $-10 + (v_D^2 + 2v_D) \times 1 + v_D = 0 \Rightarrow v_D = 2V$

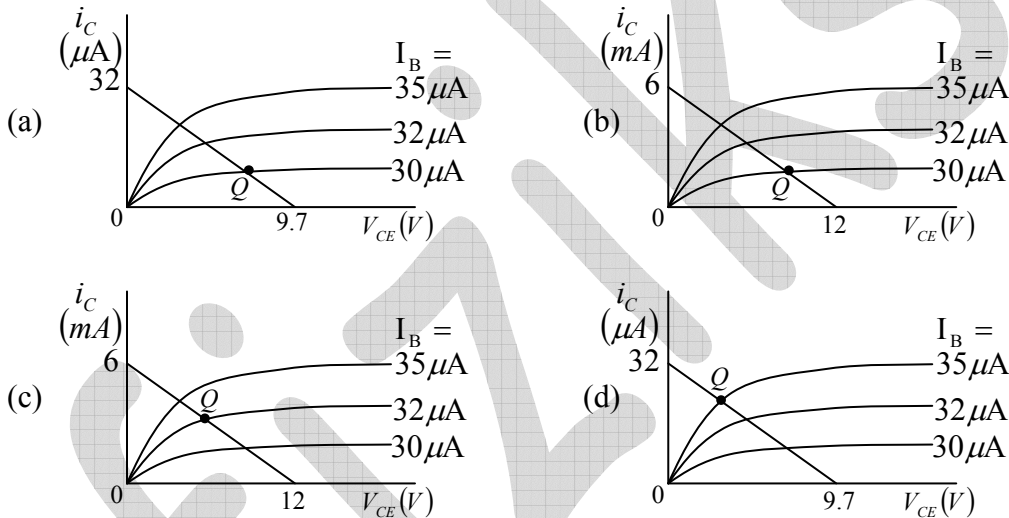
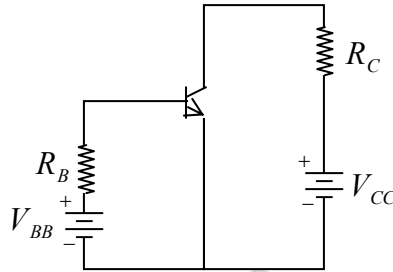
Q16. Band-pass and band-reject filters can be implemented by combining a low pass and a high pass filter in series and in parallel, respectively. If the cut-off frequencies of the low pass and high pass filters are ω_0^{LP} and ω_0^{HP} , respectively, the condition required to implement the band-pass and band-reject filters are, respectively,

- (a) $\omega_0^{HP} < \omega_0^{LP}$ and $\omega_0^{HP} < \omega_0^{LP}$ (b) $\omega_0^{HP} < \omega_0^{LP}$ and $\omega_0^{HP} > \omega_0^{LP}$
(c) $\omega_0^{HP} > \omega_0^{LP}$ and $\omega_0^{HP} < \omega_0^{LP}$ (d) $\omega_0^{HP} > \omega_0^{LP}$ and $\omega_0^{HP} > \omega_0^{LP}$

Ans: (b)

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Q17. A silicon transistor with built-in voltage 0.7 V is used in the circuit shown, with $V_{BB} = 9.7V$, $R_B = 300k\Omega$, $V_{CC} = 12V$ and $R_C = 2k\Omega$. Which of the following figures correctly represents the load line and quiescent Q point?



Ans: (b)

Solution: $I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{9.7 - 0.7}{300 \times 10^3} = 30 \mu A$ and $I_{C,sat} = \frac{V_{CC}}{R_C} = \frac{12}{2 \times 10^3} = 6 mA$

Q18. If the analog input to an 8-bit successive approximation ADC is increased from 1.0 V to 2.0 V, then the conversion time will

- (a) remain unchanged
- (b) double
- (c) decrease to half its original value
- (d) increase four times

Ans: (a)

Q19. The input to a lock-in amplifier has the form $V_i(t) = V_i \sin(\omega t + \theta_i)$ where V_i, ω, θ_i are the amplitude, frequency and phase of the input signal respectively. This signal is multiplied by a reference signal of the same frequency ω , amplitude V_r and phase θ_r . If the multiplied signal is fed to a low pass filter of cut-off frequency ω , then the final output signal is

- (a) $\frac{1}{2} V_i V_r \cos(\theta_i - \theta_r)$ (b) $V_i V_r \left[\cos(\theta_i - \theta_r) - \cos\left(\frac{1}{2} \omega t + \theta_i + \theta_r\right) \right]$
 (c) $V_i V_r \sin(\theta_i - \theta_r)$ (d) $V_i V_r \left[\cos(\theta_i - \theta_r) + \cos\left(\frac{1}{2} \omega t + \theta_i + \theta_r\right) \right]$

Ans: (a)

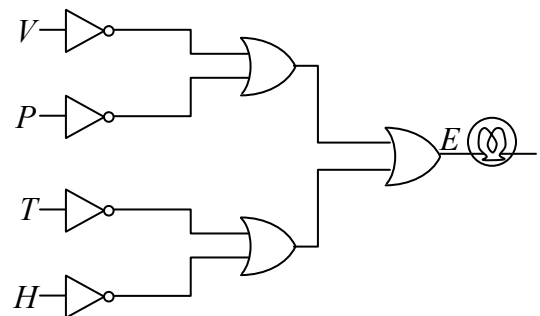
Solution: $V = V_r \sin(\omega t + \theta_r) \times V_i \sin(\omega t + \theta_i) = \frac{V_i V_r}{2} [\cos(\theta_i - \theta_r) - \cos(2\omega t + \theta_i + \theta_r)]$

Output of low pass filter = $\frac{V_i V_r}{2} \cos(\theta_i - \theta_r)$

Q20. Four digital outputs V, P, T and H monitor the speed v , tyre pressure p , temperature t and relative humidity h of a car. These outputs switch from 0 to 1 when the values of the parameters exceed 85 km/hr, 2 bar, 40°C and 50%, respectively. A logic circuit that is used to switch ON a lamp at the output E is shown below.

Which of the following condition will not switch the lamp ON?

- (a) $v < 85 \text{ km/hr}, p < 2 \text{ bar}, t > 40^\circ \text{C}, h > 50\%$
 (b) $v < 85 \text{ km/hr}, p < 2 \text{ bar}, t > 40^\circ \text{C}, h < 50\%$
 (c) $v > 85 \text{ km/hr}, p < 2 \text{ bar}, t > 40^\circ \text{C}, h < 50\%$
 (d) $v > 85 \text{ km/hr}, p > 2 \text{ bar}, t > 40^\circ \text{C}, h > 50\%$



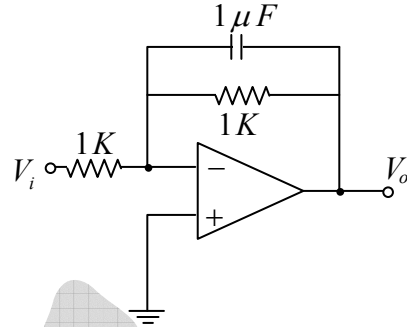
Ans: (d)

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Q21. Consider the op-amp circuit shown in the figure.

If the input is a sinusoidal wave $V_i = 5 \sin(1000t)$, then the amplitude of the output V_o is

- (a) $\frac{5}{2}$ (b) 5
 (c) $\frac{5\sqrt{2}}{2}$ (d) $5\sqrt{2}$



Ans: (c)

Solution: $\frac{v_o}{v_{in}} = -\frac{X_F}{R_1}$, $X_F = \frac{R_F X_C}{R_F + X_C} = \frac{10^3}{(1+j)}$ where $R_F = 1 \times 10^3 \Omega$, $X_C = \frac{1}{j \times 10^3 \times 10^{-6}}$

$$\left| \frac{v_o}{v_{in}} \right| = \frac{10^3}{\sqrt{2}} \times \frac{1}{10^3} = \frac{1}{\sqrt{2}} \Rightarrow v_o = \frac{5}{\sqrt{2}} \sin \omega t = \frac{5\sqrt{2}}{2} \sin \omega t$$

Q22. If one of the inputs of a J-K flip flop is high and the other is low, then the outputs Q and \bar{Q}

- (a) oscillate between low and high in race around condition
 (b) toggle and the circuit acts like a T flip flop
 (c) are opposite to the inputs
 (d) follow the inputs and the circuit acts like an $R-S$ flip flop

Ans: (d)

Q23. A sample of Si has electron and hole mobilities of 0.13 and 0.05 $m^2/V-s$ respectively at 300 K. It is doped with P and Al with doping densities of $1.5 \times 10^{21}/m^3$ and $2.5 \times 10^{21}/m^3$ respectively. The conductivity of the doped Si sample at 300 K is

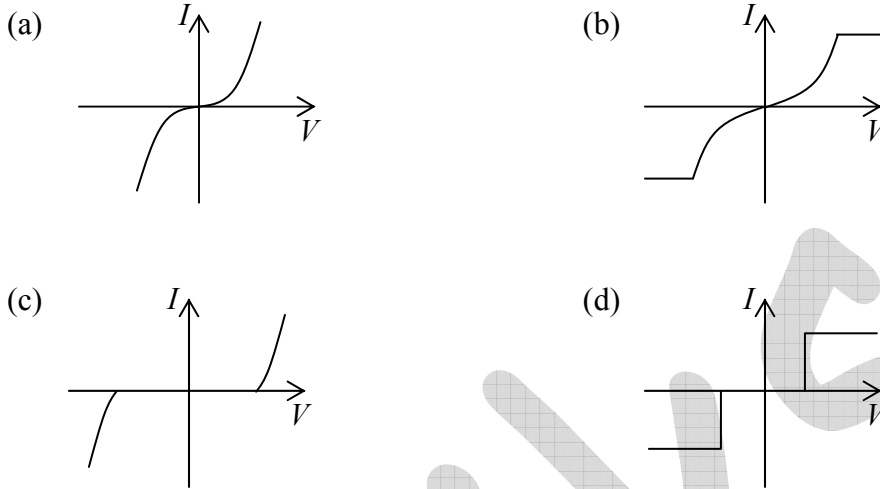
- (a) $8 \Omega^{-1}m^{-1}$ (b) $32 \Omega^{-1}m^{-1}$ (c) $20.8 \Omega^{-1}m^{-1}$ (d) $83.2 \Omega^{-1}m^{-1}$

Ans: (a)

Solution: Resulting doped crystal is p -type and $p_p = (2.5 - 1.5) \times 10^{21}/m^3 = 1 \times 10^{21}/m^3$

$$\sigma = e(n_p \mu_n + p_p \mu_p) \approx e p_p \mu_p = 1.6 \times 10^{-19} \times 1 \times 10^{21} \times 0.05 = 8 \Omega^{-1}m^{-1}$$

Q24. Two identical Zener diodes are placed back to back in series and are connected to a variable DC power supply. The best representation of the I - V characteristics of the circuit is



Ans: (d)

Q25. A 4-variable switching function is given by $f = \sum(5, 7, 8, 10, 13, 15) + d(0, 1, 2)$, where d is the do-not-care-condition. The minimized form of f in sum of products (SOP) form is

- (a) $\overline{A}\overline{C} + \overline{B}\overline{D}$ (b) $\overline{A}\overline{B} + \overline{C}\overline{D}$ (c) $AD + BC$ (d) $\overline{B}\overline{D} + BD$

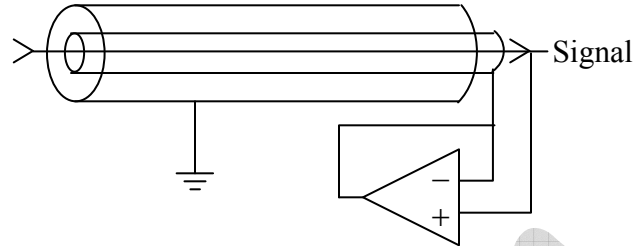
Ans: (d)

	$\overline{C}\overline{D}$	$\overline{C}D$	CD	$C\overline{D}$
$\overline{A}\overline{B}$	x	x		x
$\overline{A}B$		1	1	
AB		1	1	
$A\overline{B}$	1			1

Annotations: Dotted lines group the 'x' cells in the first row and the '1' cells in the first and last columns. Arrows point to the groups labeled $\overline{B}\overline{D}$ and BD .

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Q26. The inner shield of a triaxial conductor is driven by an (ideal) op-amp follower circuit as shown. The effective capacitance between the signal-carrying conductor and ground is



- (a) unaffected (b) doubled (c) halved (d) made zero

Ans: (a)

Q27. An op-amp based voltage follower

- (a) is useful for converting a low impedance source into a high impedance source.
 (b) is useful for converting a high impedance source into a low impedance source.
 (c) has infinitely high closed loop output impedance
 (d) has infinitely high closed loop gain

Ans: (b)

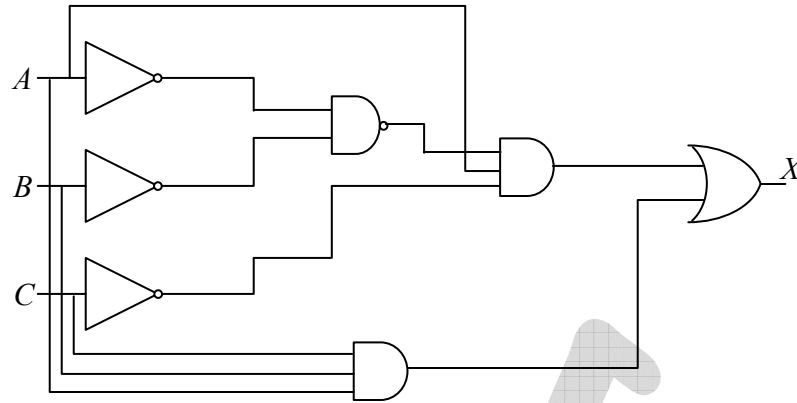
Q28. An RC network produces a phase-shift of 30° . How many such RC networks should be cascaded together and connected to a Common Emitter amplifier so that the final circuit behaves as an oscillator?

- (a) 6 (b) 12 (c) 9 (d) 3

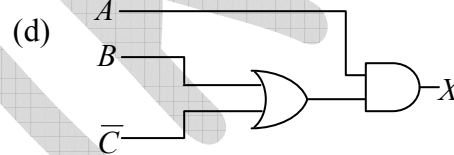
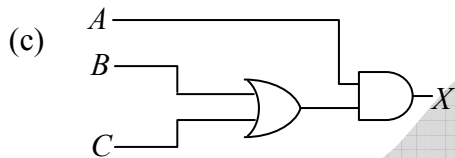
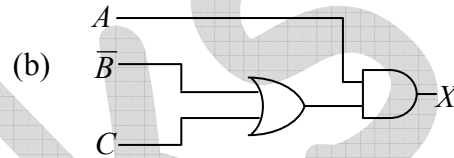
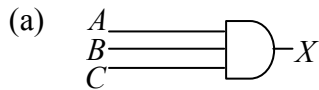
Ans: (a)

Solution: Total phase shift must be 0 or 360° . Common Emitter amplifier has phase change of 180° so we need 6 RC network for next 180° phase shift.

Q29. For the logic circuit shown in the below

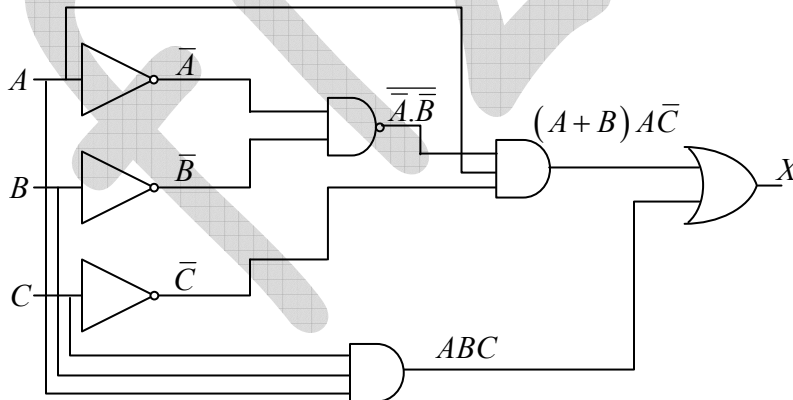


A simplified equivalent circuit is



Ans: (d)

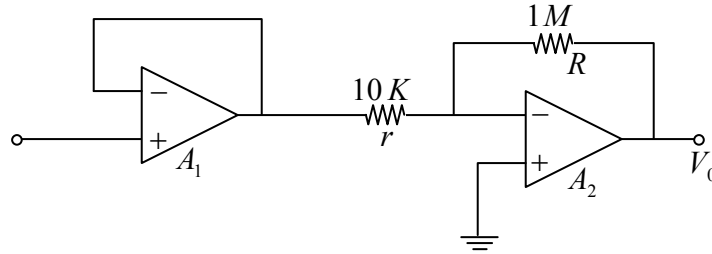
Solution:



$$X = (A+B)A\bar{C} + ABC = A\bar{C} + AB\bar{C} + ABC = A\bar{C} + AB = A(B + \bar{C})$$

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Q30. Consider the amplifier circuit comprising of the two op-amps A_1 and A_2 as shown in the figure.



If the input ac signal source has an impedance of $50k\Omega$, which of the following statements is true?

- (a) A_1 is required in the circuit because the source impedance is much greater than r
- (b) A_1 is required in the circuit because the source impedance is much less than R
- (c) A_1 can be eliminated from the circuit without affecting the overall gain
- (d) A_1 is required in the circuit if the output has to follow the phase of the input signal

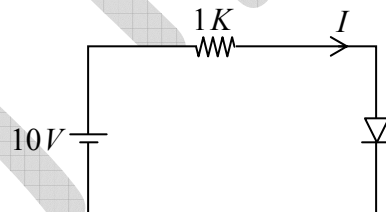
Ans: (a)

Solution: A_1 is required in the circuit because the source impedance is much greater than r

Q31. The $I - V$ characteristics of the diode in the circuit below is given by

$$I = \begin{cases} (V - 0.7)/500 & \text{for } V \geq 0.7 \\ 0 & \text{for } V < 0.7 \end{cases}$$

where V is measured in volts and I is measured in amperes.



The current I in the circuit is

- (a) 10.0 mA
- (b) 9.3 mA
- (c) 6.2 mA
- (d) 6.7 mA

Ans: (c)

Solution: Applying K.V.L. $-10 + 1000 \times I + V = 0 \Rightarrow -10 + 1000 \times (V - 0.7)/500 + V = 0$

$$\Rightarrow -10 + 2(V - 0.7) + V = 0 \Rightarrow 3V = 11.4 \Rightarrow V = 3.8 \text{ Volts}$$

$$\text{Thus } I = (V - 0.7)/500 = (3.8 - 0.7)/500 = 3.1/500 = 6.2 \text{ mA}$$

Q32. In a measurement of the viscous drag force experienced by spherical particles in a liquid, the force is found to be proportional to $V^{1/3}$ where V is the measured volume of each particle. If V is measured to be 30 mm^3 , with an uncertainty of 2.7 mm^3 , the resulting relative percentage uncertainty in the measured force is

- (a) 2.08 (b) 0.09 (c) 6 (d) 3

Ans: (b)

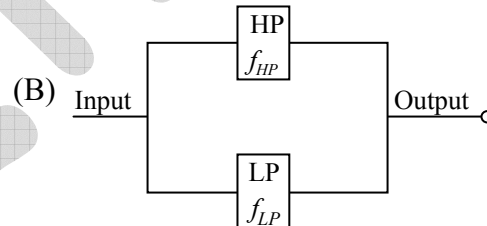
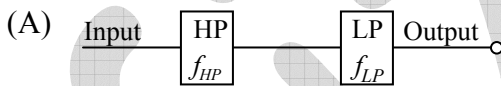
Solution: The relative percentage uncertainty in the measure force is $\sigma_F^2 = \left(\frac{\partial F}{\partial V}\right)^2 \sigma_V^2$

$$\Rightarrow \sigma_F = \left(\frac{\partial F}{\partial V}\right) \sigma_V \text{ where } \sigma_V \text{ is the uncertainty in the measurement of volume.}$$

$$\because F = V^{1/3} \Rightarrow \frac{\partial F}{\partial V} = \frac{1}{3} V^{-2/3}$$

$$\therefore \sigma_F = \frac{1}{3V^{2/3}} \times \sigma_V = \frac{1}{3(30)^{2/3}} \times 2.7 = \frac{1}{3 \times (900)^{1/3}} \times 2.7 = \frac{1}{3 \times 9.7} \times 2.7 \Rightarrow \sigma_F = 0.09$$

Q33. Consider a Low Pass (LP) and a High Pass (HP) filter with cut-off frequencies f_{LP} and f_{HP} , respectively, connected in series or in parallel configurations as shown in the Figures A and B below.



Which of the following statements is correct?

- (a) For $f_{HP} < f_{LP}$, A acts as a Band Pass filter and B acts as a band Reject filter
 (b) For $f_{HP} > f_{LP}$, A stops the signal from passing through and B passes the signal without filtering
 (c) For $f_{HP} < f_{LP}$, A acts as a Band Pass filter and B passes the signal without filtering
 (d) For $f_{HP} > f_{LP}$, A passes the signal without filtering and B acts as a Band Reject filter

Ans: (c)

Q34. The power density of sunlight incident on a solar cell is 100 mW/cm^2 . Its short circuit current density is 30 mA/cm^2 and the open circuit voltage is 0.7 V . If the fill factor of the solar cell decreases from 0.8 to 0.5 then the percentage efficiency will decrease from

- (a) 42.0 to 26.2 (b) 24.0 to 16.8 (c) 21.0 to 10.5 (d) 16.8 to 10.5

Ans: (d)

Solution: The efficiency of a solar cell is determined as the fraction of incident power which is converted to electricity and is defined as

$$\eta = \frac{V_{oc} I_{sc} FF}{P_{in}} \text{ and } P_{\max} = V_{oc} I_{sc} FF$$

where V_{oc} is the open circuit voltage, I_{sc} is the short circuit current density, FF is the Fill factor, P_{in} is the input power and η is the efficiency of the solar cell.

Given $P_{in} = 100 \text{ mW/cm}^2$, $I_{sc} = 30 \text{ mA/cm}^2$, $V_{oc} = 0.7 \text{ V}$

Let η_1 is the efficiency of solar cell when $FF = 0.8$

$$\therefore \eta_1 = \frac{(0.7 \text{ V}) \times (30 \times 10^{-3} \text{ A/cm}^2) \times 0.8}{100 \times 10^{-3} \text{ W/cm}^2} = \frac{16.8}{100} \Rightarrow \eta_1 = 0.168$$

Let η_2 is the efficiency of solar cell when $FF = 0.5$

$$\therefore \eta_2 = \frac{(0.7 \text{ V}) \times (30 \times 10^{-3} \text{ A/cm}^2) \times 0.5}{100 \times 10^{-3} \text{ W/cm}^2} = \frac{10.5}{100} \Rightarrow \eta_2 = 0.105$$

Thus efficiency decreases from $\eta_1 = 16.8\%$ to $\eta_2 = 10.5\%$

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Q35. The concentration of electrons, n and holes p , for an intrinsic semiconductor at a temperature T can be expressed as $n = p = AT^{\frac{3}{2}} \exp\left(-\frac{E_g}{2k_B T}\right)$, where E_g is the band

gap and A is a constant. If the mobility of both types of carrier is proportional to $T^{-\frac{3}{2}}$, then the log of the conductivity is a linear function of T^{-1} , with slope

- (a) $\frac{E_g}{(2k_B)}$ (b) $\frac{E_g}{k_B}$ (c) $\frac{-E_g}{(2k_B)}$ (d) $\frac{-E_g}{k_B}$

Ans. (c)

Solution: $\sigma_i = n_i e (\mu_e + \mu_p) \propto T^{\frac{3}{2}} \exp\left(\frac{-E_g}{2k_B T}\right) \times T^{-\frac{3}{2}} \Rightarrow \sigma_i = C \exp\left(\frac{-E_g}{2k_B T}\right)$

$$\ln(\sigma_i) = \frac{E_g}{2k_B T} + \ln C \Rightarrow \text{slope is } \frac{-E_g}{2k_B}$$

- Q36. The viscosity η of a liquid is given by Poiseuille's formula $\eta = \frac{\pi P a^4}{8lV}$. Assume that l and V can be measured very accurately, but the pressure P has an rms error of 1% and the radius a has an independent rms error of 3%. The rms error of the viscosity is closest to
- (a) 2% (b) 4% (c) 12% (d) 13%

Ans. (c)

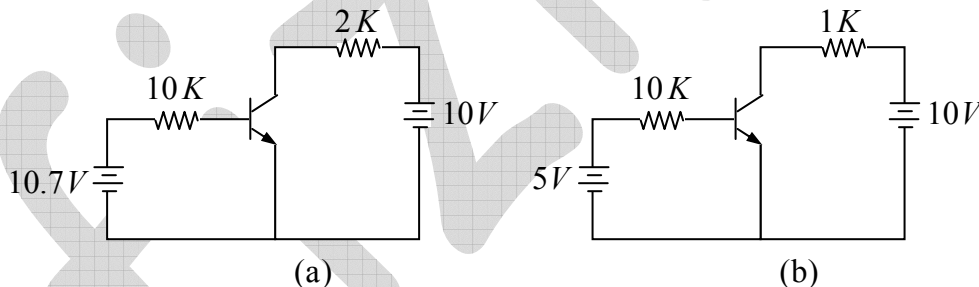
Solution: $\eta = k p a^4$

$$\sigma_n^2 = \left(\frac{\partial \eta}{\partial P}\right)^2 \sigma_p^2 + \left(\frac{\partial \eta}{\partial a}\right)^2 \sigma_a^2 = (a^4)^2 \sigma_p^2 + (4Pa^3)^2 \sigma_a^2$$

$$\left(\frac{\sigma_n}{n} \times 100\right)^2 = \left(\frac{\sigma_p}{p} \times 100\right)^2 + 16 \left(\frac{\sigma_a}{a} \times 100\right)^2 = (1)^2 + 16(3)^2 = 1 + 144 = 145$$

$$\left(\frac{\sigma_n}{n} \times 100\right) = 12\%$$

- Q37. Consider the circuits shown in figures (a) and (b) below



If the transistors in Figures (a) and (b) have current gain (β_{dc}) of 100 and 10 respectively, then they operate in the

- (a) active region and saturation region respectively
 (b) saturation region and active region respectively
 (c) saturation region in both cases
 (d) active region in both cases

Ans. (b)

Solution: In both case input section is F.B.

For figure (a) $I_B = \frac{10.7 - 0.7}{10} = 1 \text{ mA} \Rightarrow I_C = \beta I_B = 100 \text{ mA}$

Thus $V_{CB} = V_C - V_B = (10 - 2 \times 100) - 0.7 = -ve$

\Rightarrow output section is F.B.

since both section are F.B. so it is in saturation region.

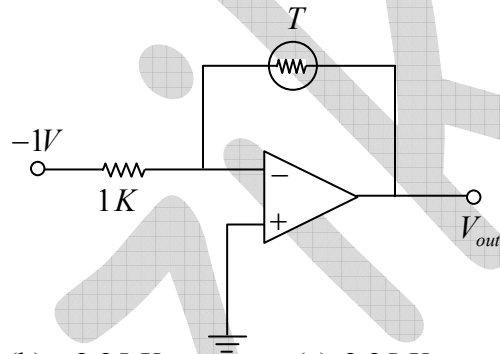
For Figure (b) $I_B = \frac{5 - 0.7}{10} = 0.43 \text{ mA} \Rightarrow I_C = \beta I_B = 4.3 \text{ mA}$

Thus $V_{CB} = V_C - V_B = (10 - 4.3) - 0.7 = +ve$

\Rightarrow out put section is R.B.

Thus it is in active region

Q38. In the circuit given below, the thermistor has a resistance $3 \text{ k}\Omega$ at 25°C . Its resistance decreases by 150Ω per $^\circ\text{C}$ upon heating. The output voltage of the circuit at 30°C is



- (a) -3.75 V (b) -2.25 V (c) 2.25 V (d) 3.75 V

Ans. (c)

Solution: At 30°C Resistance

$$= 3000 - 150 \times 5 = 2250 \Omega$$

$$\Rightarrow V_0 = -\frac{R_F}{R_1} v_i = \frac{-2250}{1000} \times -1 \Rightarrow V_0 = 2.25 \text{ volts}$$

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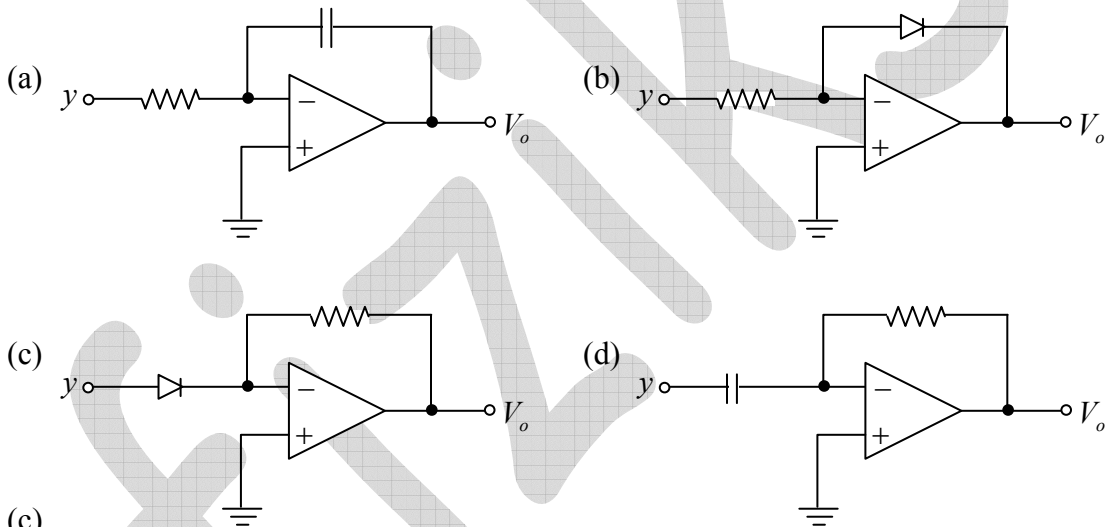
Q39. If the reverse bias voltage of a silicon varactor is increased by a factor of 2, the corresponding transition capacitance

- (a) increases by a factor of $\sqrt{2}$ (b) increases by a factor of 2
 (c) decreases by a factor of $\sqrt{2}$ (d) decreases by a factor of 2

Ans.: (c)

Solution: $C_T \propto \frac{1}{\sqrt{V}} \Rightarrow \frac{C'_T}{C_T} = \sqrt{\frac{V}{V'}} \Rightarrow \frac{C'_T}{C_T} = \sqrt{\frac{V}{2V}} \Rightarrow C'_T = \frac{1}{\sqrt{2}} C_T$

Q40. If the parameters y and x are related by $y = \log(x)$, then the circuit that can be used to produce an output voltage V_o varying linearly with x is



Ans.: (c)

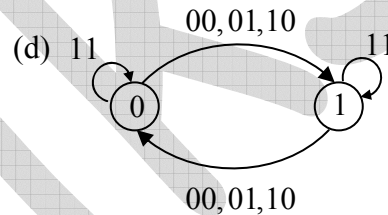
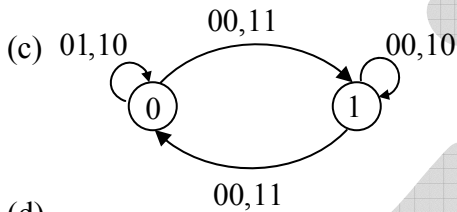
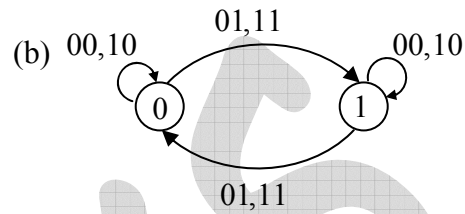
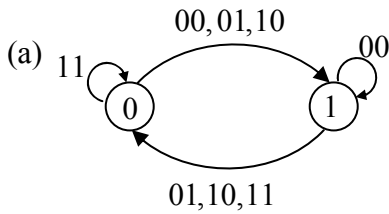
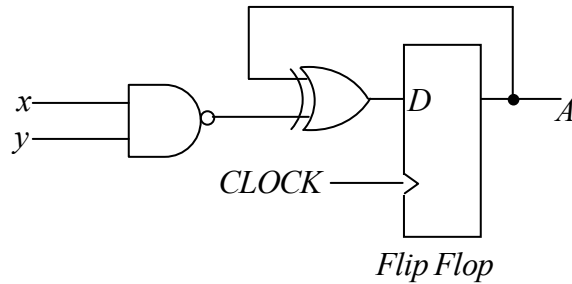
Solution: (1) Integrator

(2) Logarithmic Ampere ($V_o \propto \log y$)

(3) Anti-log ($V_o \propto e^y \propto x$)

(4) Differentiator

Q41. The state diagram corresponding to the following circuit is

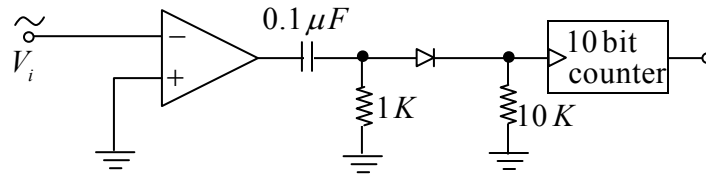


Ans.: (d)

Solution: $D_A = \overline{xy} \oplus A$

Input x y	Present State A	Flip-Flop Input D_A	Next State A
0 0	0	1	1
0 0	1	0	0
0 1	0	1	1
0 1	1	0	0
1 0	0	1	1
1 0	1	0	0
1 1	0	0	0
1 1	1	1	1

- Q42. A sinusoidal signal of peak to peak amplitude $1V$ and unknown time period is input to the following circuit for 5 second's duration. If the counter measures a value $(3E8)_H$ in hexadecimal, then the time period of the input signal is



- (a) 2.5 ms (b) 4 ms (c) 10 ms (d) 5 ms

Ans.: (d)

Solution: $(3E8)_H \rightarrow 3 \times 16^2 + 14 \times 16 + 8 \times 1 = (1000)_{10}$

In 5 sec, number of counts is 1000

Then count per sec is = 200 count/sec

So, $T = \frac{1}{200}\text{ sec} = 5\text{ ms}$

NET/JRF (JUNE-2016)

- Q43. The dependence of current I on the voltage V of a certain device is given by

$$I = I_0 \left(1 - \frac{V}{V_0} \right)^2$$

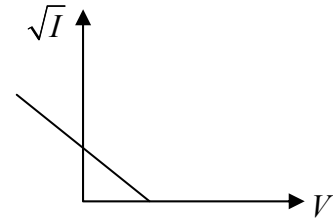
where I_0 and V_0 are constants. In an experiment the current I is measured as the voltage V applied across the device is increased. The parameters V_0 and $\sqrt{I_0}$ can be graphically determined as

- (a) the slope and the y -intercept of the $I - V^2$ graph
 (b) the negative of the ratio of the y -intercept and the slope, and the y -intercept of the $I - V^2$ graph
 (c) the slope and the y -intercept of the $\sqrt{I} - V$ graph
 (d) the negative of the ratio of the y -intercept and the slope, and the y -intercept of the $\sqrt{I} - V$ graph

Ans: (d)

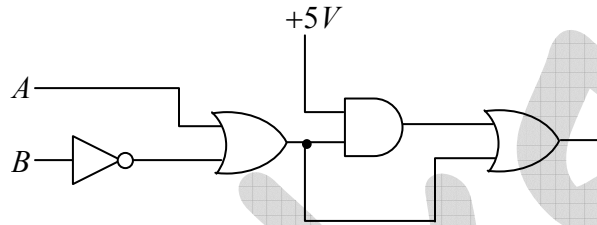
Solution: $I = I_0 \left(1 - \frac{V}{V_0}\right)^2 \Rightarrow \sqrt{I} = \sqrt{I_0} \left(1 - \frac{V}{V_0}\right) \Rightarrow \sqrt{I} = -\frac{\sqrt{I_0}}{V_0} V + \sqrt{I_0}$

Slope = $\frac{-\sqrt{I_0}}{V_0} \Rightarrow \frac{-\sqrt{I_0}}{\frac{-\sqrt{I_0}}{V_0}} = V_0$



Intercept on y-axis = $\sqrt{I_0}$

Q44. In the schematic figure given below, assume that the propagation delay of each logic gate is t_{gate} .



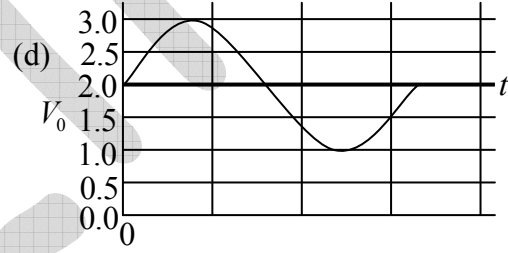
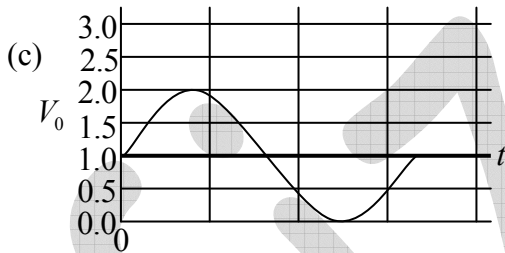
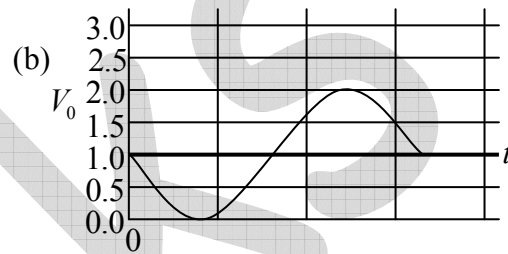
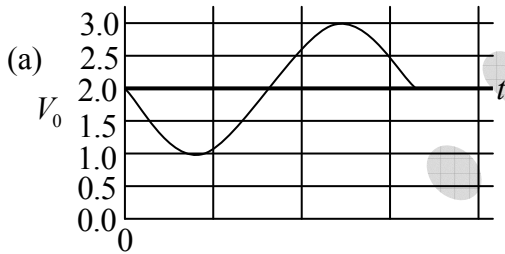
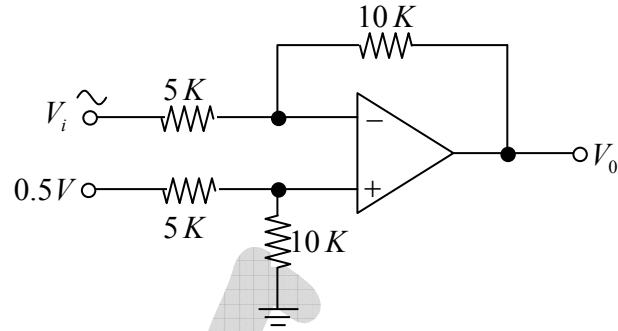
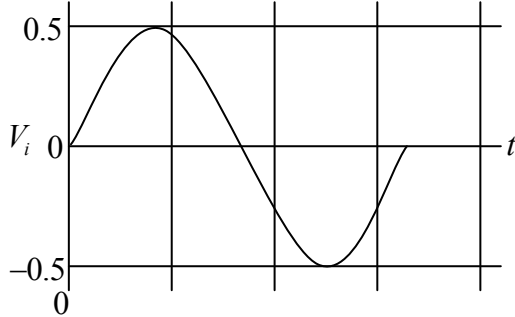
The propagation delay of the circuit will be maximum when the logic inputs A and B make the transition

- (a) $(0,1) \rightarrow (1,1)$
- (b) $(1,1) \rightarrow (0,1)$
- (c) $(0,0) \rightarrow (1,1)$
- (d) $(0,0) \rightarrow (0,1)$

Ans: (d)
Solution:

Input		Output				
A	B	NOT	OR	AND	OR	
0	1	0	0	0	0	3t
1	1	0	1	1	1	
1	1	0	1	1	1	3t
0	1	0	0	0	0	
0	0	1	1	1	1	t
1	1	0	1	1	1	
0	0	1	1	1	1	4t
0	1	0	0	0	0	

Q45. Given the input voltage V_i , which of the following waveforms correctly represents the output voltage V_0 in the circuit shown below?



Ans: (b)

Solution: $V_0 = \left(1 + \frac{10}{5}\right) \times \frac{10}{15} \times 0.5 - \frac{10}{5} \times V_i \Rightarrow V_0 = 1 - 2V_i$

When $V_i = 0 \Rightarrow V_0 = 1V$, when $V_i = 0.1V \Rightarrow V_0 = 0.8V$, when $V_i = 0.5V \Rightarrow V_0 = 0V$

Q46. The decay constants f_p of the heavy pseudo-scalar mesons, in the heavy quark limit, are

related to their masses m_p by the relation $f_p = \frac{a}{\sqrt{m_p}}$, where a is an empirical parameter

to be determined. The values $m_p = (6400 \pm 160) \text{ MeV}$ and $f_p = (180 \pm 15) \text{ MeV}$ correspond to uncorrelated measurements of a meson. The error on the estimate of a is

- (a) $175 (\text{MeV})^{\frac{3}{2}}$ (b) $900 (\text{MeV})^{\frac{3}{2}}$ (c) $1200 (\text{MeV})^{\frac{3}{2}}$ (d) $2400 (\text{MeV})^{\frac{3}{2}}$

Ans.: (c)

Solution: $a = f_p m_p^{1/2}$

$$\sigma_a^2 = \left(\frac{\partial a}{\partial f_p} \right)^2 \sigma_{f_p}^2 + \left(\frac{\partial a}{\partial m_p} \right)^2 \sigma_{m_p}^2 \Rightarrow \frac{\partial a}{\partial f_p} = m_p^{1/2} \text{ and } \frac{\partial a}{\partial m_p} = \frac{f_p}{2m_p^{1/2}}$$

$$\Rightarrow \sigma_a^2 = m_p \sigma_{f_p}^2 + \frac{f_p^2}{4m_p} \sigma_{m_p}^2 \Rightarrow \frac{\sigma_a^2}{a^2} = \left(\frac{\sigma_{f_p}}{f_p} \right)^2 + \left(\frac{\sigma_{m_p}}{2m_p} \right)^2 \Rightarrow \sigma_a = a \left[\left(\frac{\sigma_{f_p}}{f_p} \right)^2 + \left(\frac{\sigma_{m_p}}{2m_p} \right)^2 \right]^{1/2}$$

$$\because a = f_p m_p^{1/2} = (180 \text{ MeV})(6400 \text{ MeV})^{1/2} = 180 \times 80 (\text{MeV})^{3/2}$$

$$\left(\frac{\sigma_{f_p}}{f_p} \right)^2 = \left(\frac{15}{180} \right)^2 = 6.9 \times 10^{-3} \text{ and } \left(\frac{\sigma_{m_p}}{2m_p} \right)^2 = \left(\frac{160}{2 \times 6400} \right)^2 = 1.56 \times 10^{-4}$$

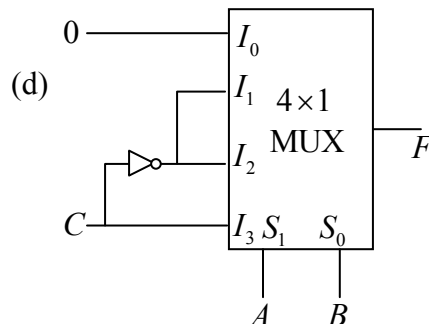
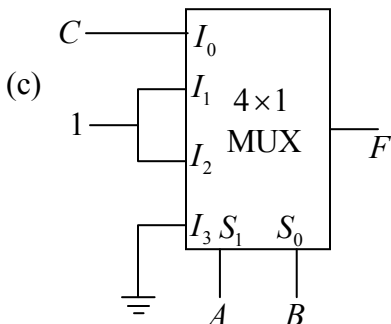
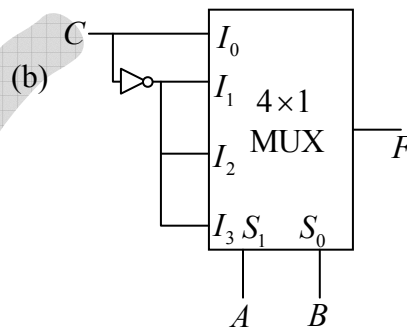
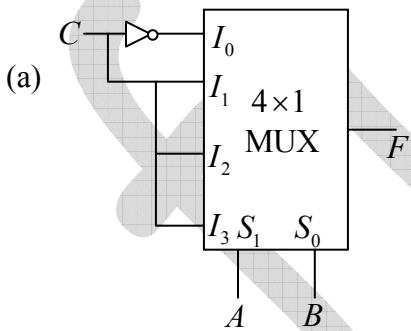
$$\sigma_a = 180 \times 80 (\text{MeV})^{3/2} [6.9 \times 10^{-3} + 1.56 \times 10^{-4}]^{1/2} = 180 \times 80 \times (7 \times 10^{-3})^{1/2} (\text{MeV})^{3/2}$$

$$\Rightarrow \sigma_a = 1204 (\text{MeV})^{3/2}$$

NET/JRF (DEC-2016)

Q47. Which of the following circuits implements the Boolean function

$$F(A, B, C) = \sum(1, 2, 4, 6)?$$

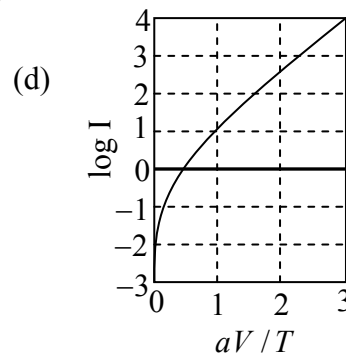
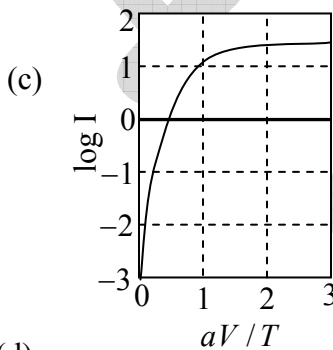
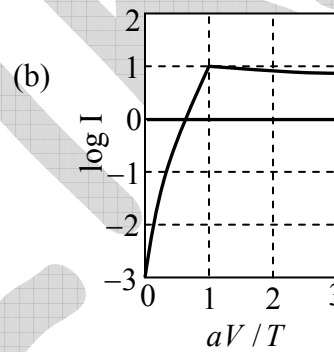
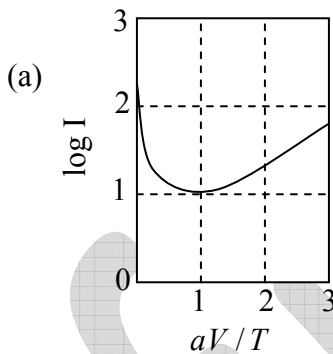


Ans. : (b)

Solution:

A	B	C	F
0	0	0	0
0	0	1	1 $F = C$
0	1	0	1
0	1	1	0 $F = \bar{C}$
1	0	0	1
1	0	1	0 $F = \bar{C}$
1	1	0	1
1	1	1	0 $F = \bar{C}$

Q48. The $I-V$ characteristics of a device can be expressed as $I = I_s \left[\exp\left(\frac{aV}{T}\right) - 1 \right]$, where T is the temperature and a and I_s are constants independent of T and V . Which one of the following plots is correct for a fixed applied voltage V ?



Ans. : (d)

Solution: Let $\frac{aV}{T} = x$ For large x ; $I = I_s e^x \Rightarrow \log_e I = \log_e I_s + x \Rightarrow \log_e I \propto x$

- Q49. The active medium in a blue LED (light emitting diode) is a $Ga_xIn_{1-x}N$ alloy. The band gaps of GaN and InN are $3.5 eV$ and $1.5 eV$ respectively. If the band gap of $Ga_xIn_{1-x}N$ varies approximately linearly with x , the value of x required for the emission of blue light of wavelength $400 nm$ is (take $hc \approx 1200 eV \cdot nm$)
- (a) 0.95 (b) 0.75 (c) 0.50 (d) 0.33

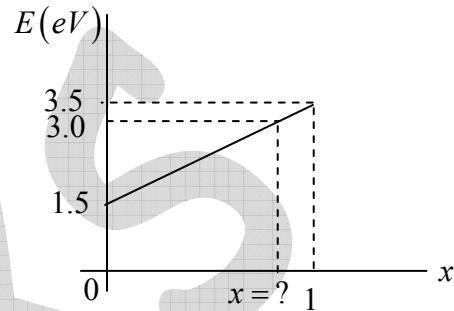
Ans. : (b)

Solution: $E_{g_{GaN}} = 3.5 eV$ and $E_{g_{InN}} = 1.5 eV$

Band Gap energy of $Ga_xIn_{1-x}N$ is $E \propto x$.

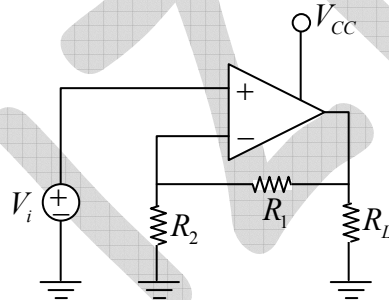
For blue light of wavelength $400 nm$, the band gap

$$\text{energy is } = \frac{hc}{\lambda} = \frac{1200 eV \cdot nm}{400 nm} = 3.0 eV.$$



$$\text{Thus equating slopes we get; } \left(\frac{3.5 - 1.5}{1 - 0} \right) = \left(\frac{3.0 - 1.5}{x - 0} \right) \Rightarrow 2x = 1.5 \Rightarrow x = 0.75$$

- Q50. In the circuit below, the input voltage V_i is $2V$, $V_{cc} = 16V$, $R_2 = 2k\Omega$ and $R_L = 10k\Omega$



The value of R_1 required to deliver $10 mW$ of power across R_L is

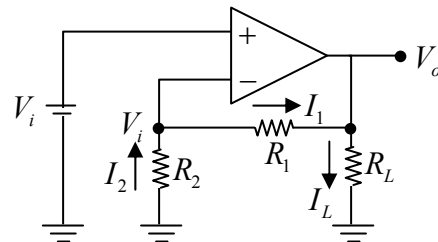
- (a) $12k\Omega$ (b) $4k\Omega$ (c) $8k\Omega$ (d) $14k\Omega$

Ans. : (c)

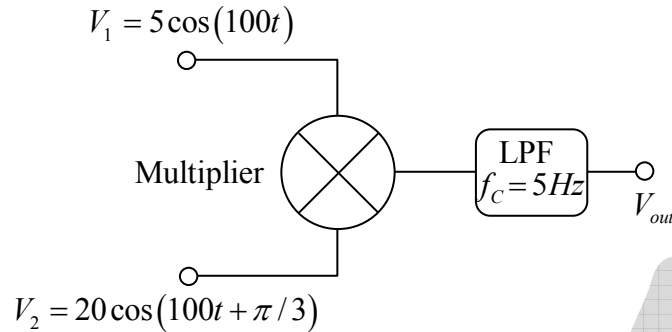
Solution: Apply kCL ; $I_2 = I_1 = I_L \Rightarrow \frac{0 - v_i}{R_2} = \frac{v_i - v_0}{R_1} = \frac{v_0 - 0}{R_L}$

$$p_L = \frac{v_0^2}{R_L} = 10 mW \Rightarrow v_0 = 10V$$

$$\Rightarrow \frac{0 - 2}{2} = \frac{2 - 10}{R_1} = \frac{10V}{10k} \Rightarrow -1 = \frac{-8}{R_1} \Rightarrow R_1 = 8k\Omega$$



Q51. Two sinusoidal signals are sent to an analog multiplier of scale factor $1V^{-1}$ followed by a low pass filter (LPF).



If the roll-off frequency of the LPF is $f_c = 5 \text{ Hz}$, the output voltage V_{out} is

- (a) $5V$ (b) $25V$ (c) $100V$ (d) $50V$

Ans. : (b)

Solution: After multiplying

$$5 \cos(100t) \times 20 \cos\left(100t + \frac{\pi}{3}\right) \times 1V^{-1} = 100 \times \frac{1}{2} \left[\cos\left(200t + \frac{\pi}{3}\right) + \cos\left(\frac{-\pi}{3}\right) \right]$$

$$= 50 \left[\cos\left(200t + \frac{\pi}{3}\right) + \frac{1}{2} \right]$$

After pass L.P.F. $v_0 = 50 \times \frac{1}{2} = 25V$

Q52. The resistance of a sample is measured as a function of temperature, and the data are shown below.

$T(^{\circ}C)$	2	4	6	8
$R(\Omega)$	90	105	110	115

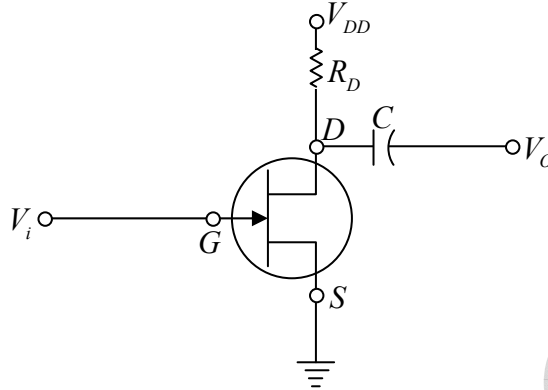
The slope of R vs T graph, using a linear least-squares fit to the data, will be

- (a) $\frac{6\Omega}{^{\circ}C}$ (b) $\frac{4\Omega}{^{\circ}C}$ (c) $\frac{2\Omega}{^{\circ}C}$ (d) $\frac{8\Omega}{^{\circ}C}$

Ans. : (b)

NET/JRF (JUNE-2017)

Q53. In the n -channel JFET shown in figure below, $V_i = -2V$, $C = 10pF$, $V_{DD} = +16V$ and $R_D = 2k\Omega$.



If the drain D - source S saturation current I_{DSS} is $10mA$ and the pinch-off voltage V_p is $-8V$, then the voltage across points D and S is

- (a) 11.125 V (b) 10.375 V (c) 5.75 V (d) 4.75 V

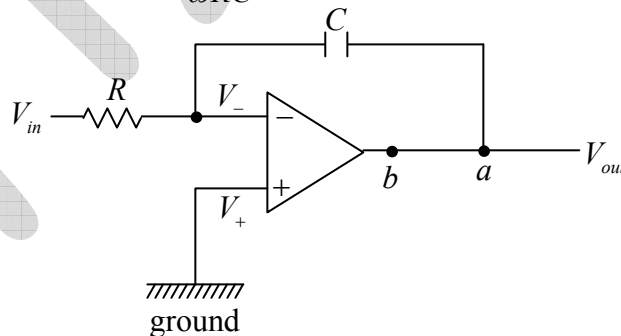
Ans. : (d)

Solution: $V_{GSQ} = -V_{GG} = -2V$

$$I_{DQ} = I_{DSS} \left(1 - \frac{V_{GS}}{V_p} \right)^2 = 10mA \left(1 - \frac{-2}{-8} \right)^2 = 5.63mA$$

$$V_{DS} = V_{DD} - I_D R_D = 16 - 5.63 \times 2 \approx 4.8V$$

Q54. The gain of the circuit given below is $-\frac{1}{\omega RC}$.



The modification in the circuit required to introduce a dc feedback is to add a resistor

- (a) between a and b
 (b) between positive terminal of the op-amp and ground
 (c) in series with C
 (d) parallel to C

Ans. : (d)

Q55. A 2×4 decoder with an enable input can function as a

- (a) 4×1 multiplexer (b) 1×4 demultiplexer
(c) 4×2 encoder (d) 4×2 priority encoder

Ans. : (b)

Q56. The experimentally measured values of the variables x and y are 2.00 ± 0.05 and 3.00 ± 0.02 respectively. What is the error in the calculated value of $z = 3y - 2x$ from the measurements?

- (a) 0.12 (b) 0.05 (c) 0.03 (d) 0.07

Ans. : (a)

Solution: $z = 3y - 2x$

$$\sigma_z^2 = \left(\frac{\partial z}{\partial y}\right)^2 \sigma_y^2 + \left(\frac{\partial z}{\partial x}\right)^2 \sigma_x^2 = 9\sigma_y^2 + 4\sigma_x^2 \approx 0.12$$

Q57. Let I_0 be the saturation current, η the ideality factor and v_F and v_R the forward and reverse potentials respectively, for a diode. The ratio R_R / R_F of its reverse and forward resistances R_R and R_F , respectively, varies as (In the following k_B is the Boltzmann constant, T is the absolute temperature and q is the charge.)

- (a) $\frac{v_R}{v_F} \exp\left(\frac{qv_F}{\eta k_B T}\right)$ (b) $\frac{v_F}{v_R} \exp\left(\frac{qv_F}{\eta k_B T}\right)$
(c) $\frac{v_R}{v_F} \exp\left(-\frac{qv_F}{\eta k_B T}\right)$ (d) $\frac{v_F}{v_R} \exp\left(-\frac{qv_F}{\eta k_B T}\right)$

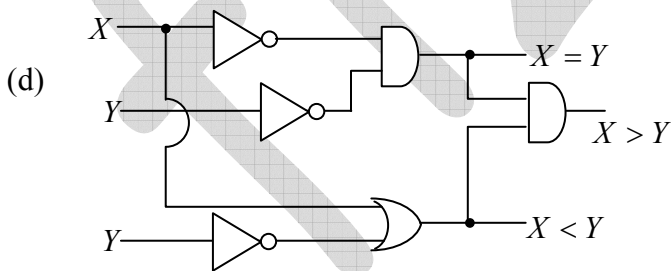
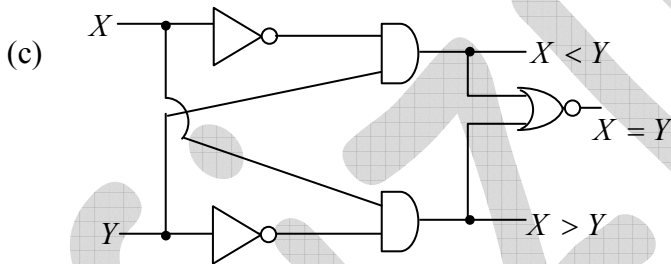
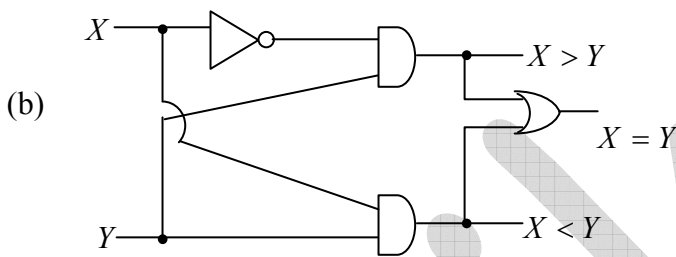
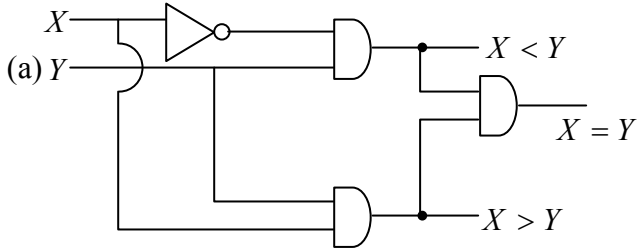
Ans. : (a)

Solution: $I = I_0 (e^{V/\eta V_T} - 1)$, $V_T = \frac{KT}{q}$

$$\frac{R_R}{R_F} = \frac{V_R / I_R}{V_F / I_F} = \frac{V_R}{V_F} \times \frac{I_F}{I_R}$$

$$\Rightarrow \frac{R_R}{R_F} = \frac{V_R}{V_F} \frac{I_0 e^{V_F/\eta V_T}}{I_0} = \frac{V_R}{V_F} \exp\left[\frac{qV_F}{\eta K T}\right]$$

Q58. In the figures below, X and Y are one bit inputs. The circuit which corresponds to a one bit comparator is



Ans. : (c)

Solution: (a) $0_1 = \bar{X}Y, 0_2 = XY, 0_3 = 0$

(b). $0_1 = \bar{X}Y, 0_2 = XY, 0_3 = Y$

(c) $0_1 = \bar{X}Y, 0_2 = X\bar{Y}, 0_3 = \bar{X}Y + X\bar{Y} = \overline{X \oplus Y}$ (equality comparator)

(d) $0_1 = \bar{X}\bar{Y}, 0_2 = X + \bar{Y}, 0_3 = \bar{X}\bar{Y}$

Ans. : (d)

$$\text{Solution: } \frac{V_o}{V_{in}} = -\frac{z_F}{z_i} = -\frac{R_F \parallel X_{C_F}}{R_i + X_{C_i}} = -\frac{R_F \times \frac{1}{j\omega C_F} / R_F + \frac{1}{j\omega C_F}}{\left(R_i + \frac{1}{j\omega C_i}\right)}$$

$$\frac{V_o}{V_{in}} = \frac{-R_F / (j\omega C_F R_F + 1)}{(j\omega C_i R_i + 1) / j\omega C_i} = \frac{-R_F}{(j\omega C_F R_F + 1)} \times \frac{j\omega C_i}{(1 + j\omega R_i C_i)}$$

$$\Rightarrow \left| \frac{V_o}{V_{in}} \right| = \frac{\omega C_i R_F}{\sqrt{1 + (\omega C_F R_F)^2} \sqrt{1 + (\omega R_i C_i)^2}}, \omega = 2\pi f$$

$$\Rightarrow \left| \frac{V_o}{V_{in}} \right| = \frac{(2\pi \times 16 \times 10^3)(10 \times 10^{-9})(200 \times 10^3)}{\sqrt{1 + 4\pi^2 (16 \times 10^3)^2 (200 \times 10^3)^2 (100 \times 10^{-12})^2} \sqrt{1 + 4\pi^2 (16 \times 10^3)^2 (20 \times 10^3)^2 (10 \times 10^{-9})^2}}$$

$$= \frac{64\pi}{20.12 \times 20.12} \approx 4.96$$