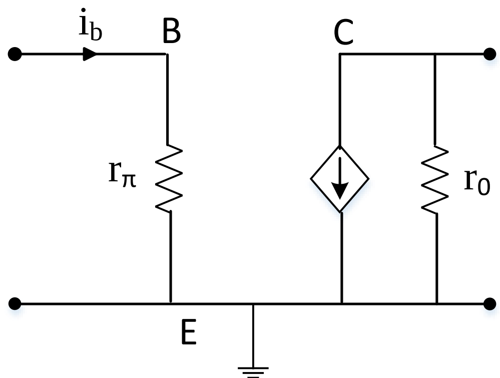
BJT Circuits (MCQs of Moderate Complexity)

1. The current i_b through base of a silicon npn transistor is 1+0.1 cos (1000πt) ma. At 300K, the r_π in the small signal model of the transistor is



(a) 250Ω
(b) 27.5Ω
(c) 25Ω
(d) 22.5Ω

[GATE 2012: 1 Mark]

Answer (c)

The current i_b through the base of a silicon npn transistor is 1+0.1 cos (10000 πt) ma. At 300 K, the r_π in the small signal model of the transistor is given by

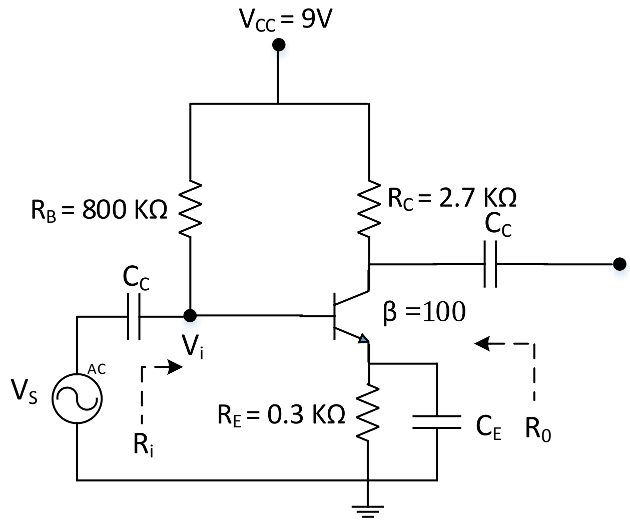
$$r_\pi = \beta . re = \beta \frac{V_T}{I_E}$$

$$\cong \beta \frac{V_T}{\beta i_b} = \frac{V_T}{i_b}$$

$$V_T = 25mv, i_b = 1ma$$

$$r_\pi = 25\ \Omega$$

2. The amplifier circuit shown below uses a silicon transistor. The capacitors C_C and C_E can be assumed to be short at signal frequency and the effect of output resistance $r_0$can be ignored. If C_E is disconnected from the circuit, which one of the following statements is TRUE?

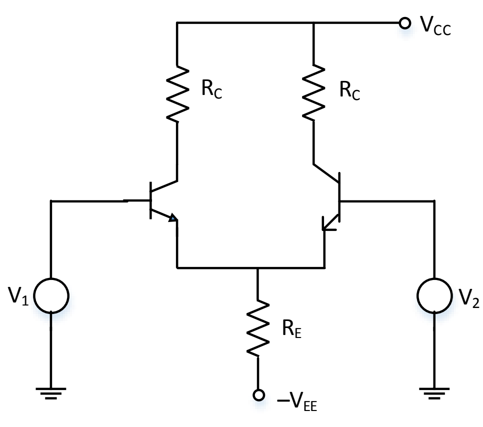


(a) The input resistance R_i increases and the magnitude of voltage gain A_V decreases.
(b) The input resistance R_i decreases and the magnitude of voltage gain A_V increases.
(c) Both input resistance R_i and the magnitude of voltage gain A_V decrease.
(d) Both input resistance R_i and the magnitude of voltage gain A_V increase.

Answer (a)

If C_E is disconnected from the circuit, this is negative feedback. The input impedance increases and voltage gain decreases.

3. In an ideal differential amplifier shown in the figure, a large value of (R_E).



(a) Increases both the differential and common-mode gains.
(b) Increases the common-mode gain only
(c) Decreases the differential-mode gain only
(d) Decreases the common-mode gain only

[GATE 2005: 2 Marks]

Answer (d)

Only common mode gain depends on R_E and differential mode gain is independent of R_E

4. The cascode amplifier is a multistage configuration of

(a) CC-CB (c) CB-CC

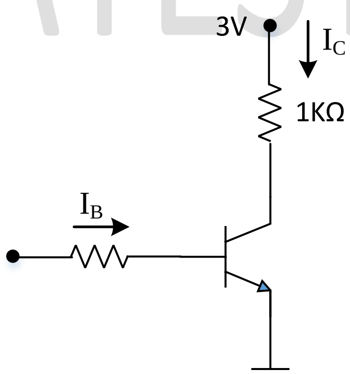
(b) CE-CB (d) CE-CC

[GATE 2005: 1 Mark]

Answer (b)

Cascode amplifier provides a high input impedance with low voltage gain to ensure minimum input miller capacitance, thus suitable for high frequency operation.

5. Assuming $V_{CEsat} = 0.2$ V and $\beta = 50$, the minimum base current (I_B) required to drive the transistor in the figure to saturation is



(a) 56 μA (c) 60 μA

(b) 140 μA (d) 3 μA

[GATE 2004: 1 Marks]

Answer (a)

$\boldsymbol{V_{CE}\,sat = 0.2V}$ & $\beta = 50$

$$\boldsymbol{V_{CE} = V_{CC} - I_C \times 1K}$$

$$\boldsymbol{0.2 = 3 - I_C \times 1K}$$

$$I_C = 2.8\ ma, \quad I_B = \frac{2.8\ ma}{50} = 56\ \mu a$$

6. Generally, the gain of a transistor amplifier falls at high frequency due to the
   (a) Internal capacitance of the device
   (b) Coupling capacitor at the input
   (c) Skin effect
   (d) Coupling capacitor at the output [GATE 2003: 1 Mark]

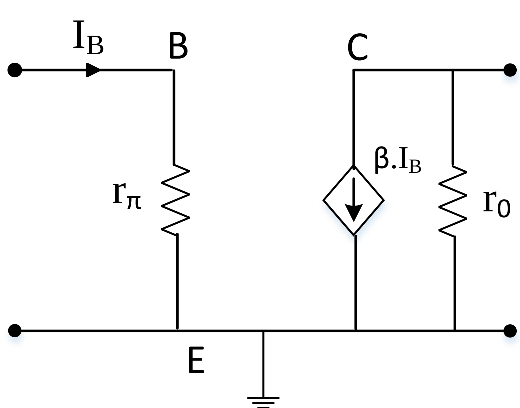
   Answer (a)

   The gain of the transistor amplifier falls at high frequency due to internal capacitance of the device.

7. The current gain of a BJT is
   (a) $g_m r_0$
   (b) g_m / r_o
   (c) $g_m r_\pi$
   (d) g_m / r_π
   [GATE 2002: 1 Mark]

   Answer (c)

   The current gain of a BJT is β or h_{fe}



$$g_m = \frac{I_C}{V_i} = \frac{\beta\, I_B}{I_B r_\pi}\ or\ g_m = \frac{\beta}{r_\pi}\ so\ \beta = g_m r_\pi$$

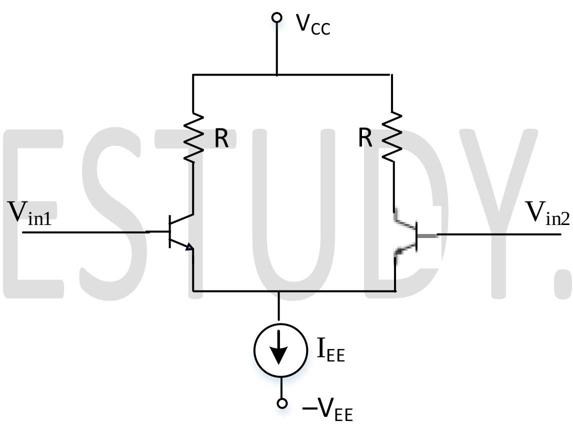
8. The current gain of a bipolar transistor drops at high frequencies because of
   (a) Transistor capacitances
   (b) High current effects in the base
   (c) Parasitic inductive elements
   (d) The Early effect

[GATE 2000: 1 Mark]

Answer (a)

The current gain of a bipolar transistor drops at high frequencies because of transistor internal capacitances.

9. In the differential amplifier of the figure, if the source resistance of the current source I_{EE} is infinite, then common-mode gain is



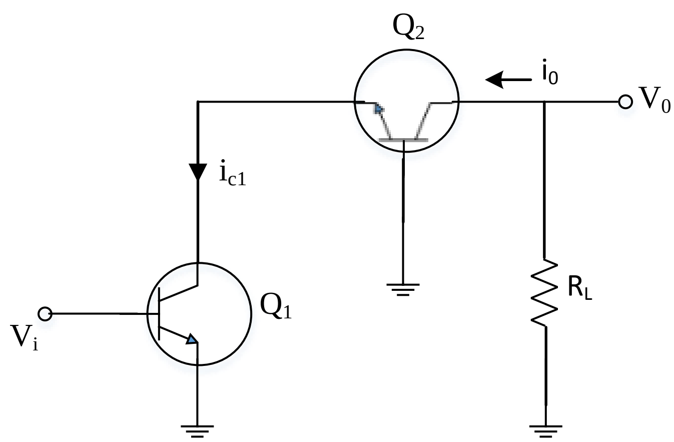
   (a) Zero
   (b) Infinite
   (c) Indeterminate
   (d) $(V_{in1} + V_{in2}) + 2V_T$

[GATE 2000: 1 Mark]

Answer (a)

The Common mode gain, $V_C = A_C V_i \quad (V_{i_1} = V_{i_2} = V_i)$. If the source resistance of current source (Rs) is infinite then due to symmetry common mode gain V_C is zero.

10. In the cascode amplifier shown in the figure, if the common-emitter stage (Q_1) has a trans conductance g_{m1} and the common base stage (Q_2) has a trans conductance g_{m2} then the overall trans conductance $g(=i_0 / V_i)$ of the cascode amplifier is



(a) g_{m1}

(b) g_{m2}

(c) $g_{m1} / 2$

(d) $g_{m2} / 2$

[GATE 1999: 1 Mark]

Answer (a)

Q_1 has transconductance g_{m_1}

Q_2 has transconductance g_{m_2}

Overall transconductance $g = \frac{i_0}{V_i}$

$$i_0 = i_{E_2} = i_{C_1} \; so \; g = g_{m_1}$$

11. the unit of q / KT are

(a) V

(b) V^{-1}

(c) J

(d) J / K

[GATE 1998: 1 Mark]

Answer (b)

Thermal voltage $= V_T = \frac{KT}{q}$

12. A multistage Amplifier has a low-pass Response with three real poles at s = $-\omega_1, -\omega_2$ and ω_3 The approximate overall bandwidth B of the Amplifier will be given by

(a) $B = \omega_1 + \omega_2 + \omega_3$

(b) $\frac{1}{B} = \frac{1}{\omega_1} + \frac{1}{\omega_2} + \frac{1}{\omega_3}$

(c) $B = (\omega_1 + \omega_2 + \omega_3)^{1/3}$

(d) $B = \sqrt{\omega_1^2 + \omega_2^2 + \omega_3^3}$

[GATE 1998: 1 Mark]

Answer (b)

$$\frac{1}{B} = \frac{1}{\omega_1} + \frac{1}{\omega_2} + \frac{1}{\omega_3}$$

Cascading of amplifier results in decrease of higher cutoff frequency (f_H) and increase in lower cutoff frequency (f_L)

$$B.W = f_H - f_L \qquad so\ B.W.Decreases$$

13. A distorted sinusoid has the amplitude, A_1, A_2, A_3.... of the fundamental, second harmonic, third harmonic,……… respectively. The total harmonic distortion is

(a) $\frac{A_2 + A_3 + \cdots}{A_1}$

(b) $\frac{\sqrt{A_2^2 + A_3^2 + \cdots}}{A_1}$

(c) $\frac{\sqrt{A_2^2 + A_3^2 + \cdots}}{\sqrt{A_1^2 + A_2^2 + A_3^2}}$

(d) $\frac{(A_2^2 + A_3^2 + \cdots)}{A_1}$

[GATE 1998: 1 Mark]

Answer (b)

The total harmonic distortion is

$$T.H.D = \frac{\sqrt{A_2^2 + A_3^2 + ---}}{A_1}$$

14. From measurement of the rise time of the o/p pulse of an amplifier whose input is a small amplitude square wave, one can estimate the following parameter of the amplifier.

(a) Gain-bandwidth product

(b) Slew-Rate

(c) Upper-3-dB frequency

(d) Lower-3-dB frequency

[GATE 1998: 1 Mark]

Answer (c)

Upper 3dB frequency

$$B.W = f_H = \frac{0.35}{t_r}$$

t_r is the rise time

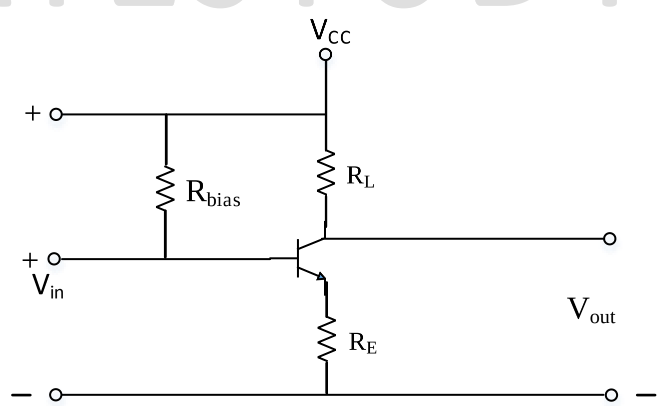
15. A cascode amplifier stage is equivalent to
    (a) A common emitter stage following by a common base stage
    (b) A common base stage followed by an emitter follower
    (c) An emitter follower stage followed by a common base stage
    (d) A common base stage followed by a common emitter stage

[GATE 1997: 1 Mark]

Answer (a)

A common emitter stage followed by a common base stage

16. In the BJT amplifier shown in the figure is the transistor is biased in the forward active region putting a capacitor across R_E will



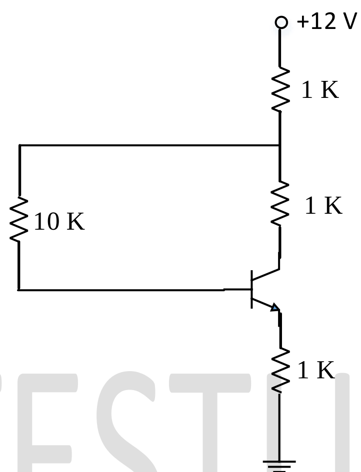
(a) Decrease the voltage gain and decrease the i/p impedance
(b) Increase the voltage gain and decrease the i/p impedance
(c) Decrease the voltage gain and increase the i/p impedance
(d) Increase the voltage gain and increase the i/p impedance

[GATE 1997: 1 Mark]

Answer (b)

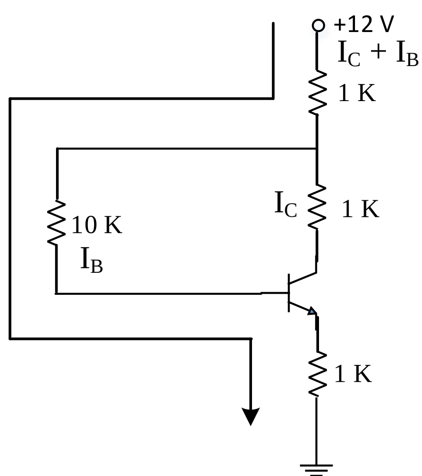
The bypass capacitor C across R_E will act as short circuit for ac signal. Thus there is no negative feedback hence increases the voltage gain and decreases the input impedance.

17. A transistor having α =0.99 and V_{BE} = 0.7V, is used in the circuit of the figure is the value of the collector current will be



[GATE 1995: 1 Mark]

Answer I_C = 5.33 mA



$\alpha = 0.99, V_{BE} = 0.7V,$ **collector current is I_C?**

KVL for the base circuit

$$(I_C + I_B)1K + 10K\, I_B + V_{BE} + (I_C + I_B)1K = 12$$

$$I_B = \frac{I_C}{\beta} \;\; and\; \beta = \frac{\alpha}{1-\alpha} = \frac{0.99}{1-0.99} = 99$$

Upon solving I_C=5.33 ma

18. A BJT is said to be operating in the saturation Region if
    (a) Both the junction are reverse biased.
    (b) Base-emitter junction is reverse biased and base-collector junction is forward biased.
    (c) Base-emitter junction is forward biased and base-collector junction is reverse-biased.
    (d) Both the junction are forward biased.

[GATE 1995: 1 Mark]

Answer (d)

Both the junction are forward biased in saturation

19. A common emitter transistor amplifier has a collector current of 1.0 mA when it's a base current is 25 μ A at the room temperature. Its input resistance is approximately equal to…

[GATE 1994: 1 Mark]

Answer: Z_{in} = 1 KΩ

Input resistance is approximately equal to β . r_e

$$where\; r_e = \frac{25mV}{I_E} = \frac{V_T}{I_E}$$

$$Z_{in} = \beta\,.\,r_e = \frac{V_T}{I_B} = \frac{25mV}{25\mu a} = 1K\Omega$$

20. The bandwidth of an n-stage tuned amplifier, with each stage having a bandwidth of B, is given by.
    (a) B/n
    (b) $B/\sqrt{n}$
    (c) $B\sqrt{2^{1/n}-1}$
    (d) $B/\sqrt{2^{1/n}-1}$

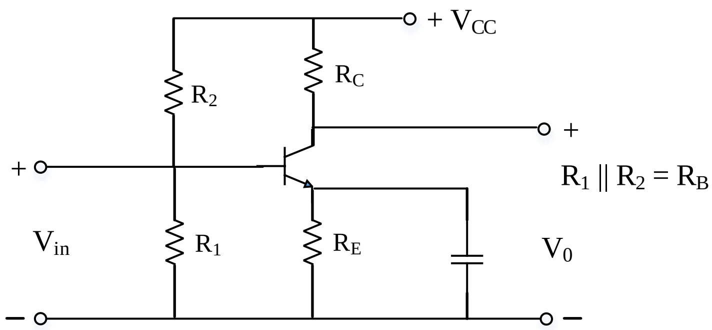
[GATE 1993: 1 Mark]

Answer (c)

The overall bandwidth of an n-stage tuned amplifier is

$$BW^n = B\sqrt{2^{1/n}-1}$$

21. For good stabilized biasing of the transistor of the CE amplifier of figure we should have



(a) $\frac{R_E}{R_B} \ll 1$
(b) $\frac{R_E}{R_B} \gg 1$
(c) $\frac{R_E}{R_B} \ll h_{FE}$
(d) $\frac{R_E}{R_B} \gg h_{FE}$

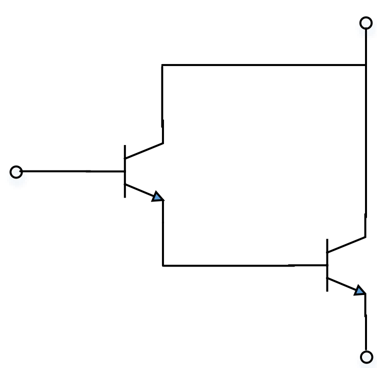
[GATE 1990: 1 Mark]

Answer (b)

Stability factor of potential divider biasing is given by $s = 1 + \frac{R_B}{R_E}$

For an ideal case S=1 so for a good stability $\frac{R_B}{R_E} \ll 1$ or $\frac{R_E}{R_B} \gg 1$

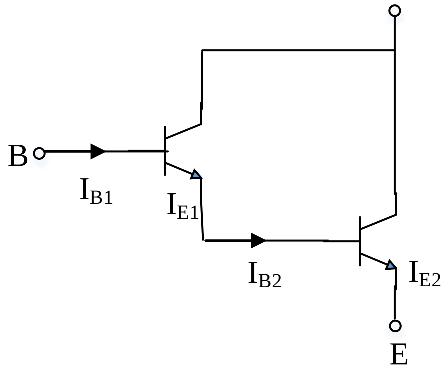
22. Each transistor in the Darlington pair (see Figure below) has h_{fe} =100. The overall h_{FE} of the composite transistor neglecting the leakage currents is



(a) 10000
(b) 10001
(c) 10100
(d) 10200

[GATE 1988: 2 Marks]

Answer (c)



h_{fe} = 100

$$I_{E_1} = I_{B_1} + I_{C_1} = I_{B_1}(1+\beta)$$

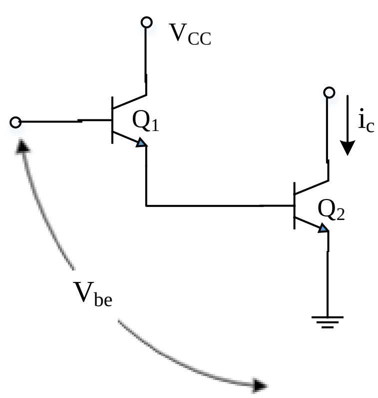
$$I_{B_2} = I_{E_1} = I_{B_1}(1+\beta)$$

$$I_{C_2} = \beta\, I_{B_2} = I_{B_1}(\beta+1)\beta$$

Overall h_{fe} of composite transistor

$$\frac{I_{C_2}}{I_{B_1}} = (\beta+1)\beta = 100(100+1) = 10100$$

23. A Darlington stage is shown in the is if the trans conductance is given by g_m is given by



(a) g_{m1}
(b) $0.5\, g_{m1}$
(c) g_{m2}
(d) $0.5\, g_{m2}$

[GATE 1996: 2 Marks]

Answer (d)

Transconductance of $Q_1 = g_{m_1}$, **transconductance of** $Q_2 = g_{m_2}$

$$g_{m_2} = \frac{I_C}{V_{b_e}}$$

Overall transconductance $\frac{I_C}{2\,V_{b_e}} = \frac{g\,m_2}{2} = 0.5\;g_{m_2}$

24. The quiescent collector current I_C of a transistor is increased by changing resistances. As a result.
    (a) g_m will not be affected
    (b) g_m will decrease
    (c) g_m will increase
    (d) g_m will increase or decrease depending upon bias stability.

[GATE 1988: 2 Marks]

Answer (c)

$g_m = \frac{I_C}{V_T}$, **If** $I_C \uparrow$, $g_m \uparrow$

If the quiescent collector current I_C increases then the transconductance g_m also increases

25. which of the following statements are correct for basic transistor amplifier configurations
    (a) CB amplifier has low input impedance and low current gain.
    (b) CC amplifier has low output impedance and high current gain
    (c) CE amplifier has very poor voltage gain but very high input impedance
    (d) The current gain of CB amplifier is higher than the current gain of CC

[GATE 1990: 2 Marks]

Answer (a) & (b)

Common base (CB) amplifier has low input impedance and low current gain (α)

Common collector (CC) amplifier has low output impedance and high current gain(γ)

$$\gamma = \frac{I_e}{I_b}$$

26. Match the following

List-I

(A) The current gain of a BJT will be increased
(B) The current gain of a BJT will be reduced
(C) The break-down voltage of a BJT will be reduced

List-II

(1) The collector doping concentration is increased
(2) The base width is reduced
(3) The emitter doping concentration to base doping concentration ratio is reduced
(4) The base doping concentration is increased keeping the ratio of the emitter doping concentration to base doping concentration constant
(5) The collector doping concentration is reduced

[GATE 1994: 2 Marks]

Answer (A-2, B-3, C-1)

As the base width of BJT is reduced, then the recombination current (base current I_B) decrease as a result collector current increases so, the current gain increase.

If the emitter doping concentration to base doping concentration is reduced then the emitter infection efficiency decrease, the current gain of a BJT reduces.

If the collector doping concentration is increased the breakdown voltage is reduced as breakdown voltage $BV \propto \frac{1}{N_D}$ N_D doping concentration

27. Match the following

(a) Cascode amplifier
(b) Differential amplifier
(c) Darlington pair common-collector amplifier

Amplifier

(1) Does not provide current gain
(2) Is a wide band amplifier
(3) Has very high input impedance and very high current gain
(4) Provides high common mode voltage rejection

[GATE 1996: 2 Marks]

Answer (a-2, b-4, c-3)

Cascade amplifier is a wideband amplifier. Differential amplifier provides high common mode voltage rejection

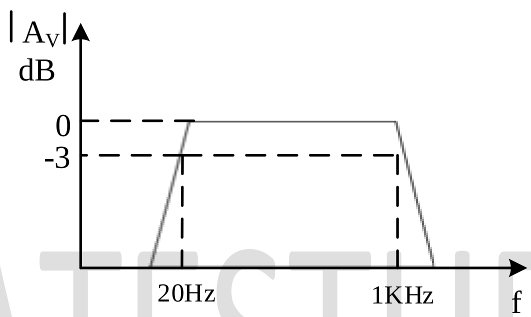
Darlington pair common collector has high input impedance and very high current gain

28. Three identical RC-coupled transistor amplifier has a frequency response as shown in the figure, the overall frequency response is as given in

(a) f_L = 20 Hz , f_H = 1 KHz
(b) f_L = 40 Hz , f_H = 0.5 KHz
(c) f_L = 40 Hz , f_H = 1 KHz
(d) f_L = 40 Hz , f_H = 2 KHz

[GATE 2002: 1 Mark]

Answer (b)



f_L = 20 Hz , f_H = 1 KHz

for a cascaded stage $f_l^* = \frac{f_L}{\sqrt{2^{1/n}-1}} = \frac{20}{\sqrt{2^{1/3}-1}} = 39.2Hz$

$$f_H^* = f_H\sqrt{2^{1/n}-1} = 1\sqrt{2^{1/3}-1} = 0.5K$$

29. Choose the correct match for input resistance of various amplifier configurations shown below

Configuration
CB: common base
CC: common collector
CE: common emitter
Input resistance
LO: Low
MO: Moderate
HI: High
(a) CB-LO, CC-MO, CE-HI
(b) CB-LO, CC-HI, CE-MO

(c) CB-MO, CC-HI, CE-LO
(d) CB-HI, CC-LO, CE-MO

[GATE 2003: 1 Mark]

Answer (b)

Common base has low input impedance

Common collector has high input impedance

Common emitter has moderate input impedance