unit 1 tutorial sheet

28 October 2024 02:23 AM

unit 1 tutorial sh...

**Basics Electronics (22EC13)**

**Tutorial-1**

a) $\beta = \frac{\alpha}{1-\alpha} = \frac{0.98}{0.02} = 49$ ; $I_C = \cancel{\beta I_B}^{0} + (\beta+1) I_{CO} = 50(6n)$ ; $I_C = 0.3\mu A$

| | |
|---|---|
| 1 | a. A silicon transistor has its $I_{CO}$=6nA and α=0.98. If $I_B$=0 and $V_{CE}$=4V then $I_C$ = ____. <br> b. An NPN transistor has $I_{CO}$=30nA, $I_B$=0, $V_{CE}$=4V and $I_C$=30uA. The value of β = ____. |
| 2 | The measured terminal voltages (in Volts) of different NPN transistors are given in Table-1. For each of the transistors, find $V_{BE}$, $V_{CB}$ and identify the region of operation. |

| | $V_E$ | $V_B$ | $V_C$ |
|---|---|---|---|
| Q1 | 0 | 0.7 | 0.7 |
| Q2 | 0 | 0.8 | 0.1 |
| Q3 | -2.7 | -2.0 | 0 |
| Q4 | 0 | 0 | 0.3 |
| Q5 | 0.7 | 0.7 | 0 |

Table-1

$V_{BE}$: fb 0.7, fb 0.8, fb 0.7, 0, 0

$V_{CB}$: 0 rb, −0.7 fb, 2 rb, 0.3, −0.7

$\beta = \frac{\alpha}{1-\alpha}$ ; $\alpha = \frac{\beta}{1+\beta}$

β → 1, 4, 24, 49, 249

| | |
|---|---|
| 3 | a. Find the values of β that correspond to α value of 0.5, 0.8, 0.96, 0.98 and 0.996. <br> b. Find the values of α that correspond to β value of 40, 60, 80, 99, 149 and 249. |

0.975, 0.983, 0.987, 0.993, 0.996

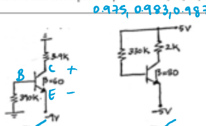



Fig 1 Fig 2

| | |
|---|---|
| 4 | In the fixed base current biasing circuits of fig 1 and 2. Determine the operating point of the silicon transistor. |
| 5 | In the circuit of fig 3, determine $V_C$, $V_E$, $V_B$ and $I_C$ |

Q $(V_{CE}, I_C)$

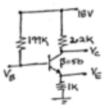



Fig 3

| | |
|---|---|
| 6 | In the circuit of fig 4, find $V_E$, $I_E$, $I_B$, $I_C$ and $V_C$. |

(a) $\beta = \frac{\alpha}{1-\alpha} = \frac{0.98}{0.02} = 49$

$I_C = \cancel{\beta I_B}^{0} + (\beta+1) I_{CO}$

$= 50(6n)$

$I_C = 0.3\mu A$

(b) $30\mu = (\beta+1)\, 30n$

$1000 = \beta + 1$

$\beta = 999$

② (a) fb, 0.7, 0.7, 0 — active

(b) fb, 0.1, 0.8, fb, 0 — saturation rg.

(c) rb, 0, −2, fb, −2.7, 0.3 — active

(d) rb, 0, rb, 0 — cutoff

(e) fb, 0, 0.7, rb, 0.7 — reverse

④ (a) $0 - (390k) I_B - V_{BE} = -9$

$9 = (390k) I_B + 0.7$

$I_B = \frac{9 - 0.7}{390K}$

$I_B = 0.0213 mA$

$I_B = 21.3 \mu A$

$I_C = \beta I_B = 60 \times 21.3\mu$

$I_C = 1.27 mA$

$0 - (3.9K)(I_C) - V_{CE} = -9$

$V_{CE} = 9 - (1.27m)(3.9K)$

$= 9 - 4.953$

$V_{CE} = 4.047 V$

(b) $5 - (330K) I_B - V_{BE} = -5$

$10 - 0.7 = (330K) I_B$

$I_B = \frac{9.3}{0K}$

$I_B = 28.2 \mu A$

$I_C = \beta I_B$

$= 80 \times 28.2\mu$

$I_C = 2.25 mA$

$5 - (2K) I_C - V_{CE} = -5$

$V_{CE} = 10 - (2K)(2.25m)$

$= 10 - 4.5$

$V_{CE} = 5.5 V$

⑤ $V_{CC} = 18V$ ; $R_C = 2.2$ ; $\beta = 50$ ; $R_E = 1k\Omega$ ; $R_B = 199k\Omega$

$I_B = \frac{V_{CC} - V_{BE}}{R_B + (\beta+1) R_E}$

$= \frac{18 - 0.7}{(199K) + (51)(1K)}$

$= \frac{17.3}{250K}$

$I_B = 69.2 \mu A$

$I_C = \beta I_B = 50(69.2\mu)$

$I_C = 3.46 mA$ ✓

$I_E = (\beta+1) I_B = 51(69.2) = 3.529 mA$

$18 - I_C R_C = V_C$

$18 - (3.46m)(2.2K) = V_C$

$V_C = 10.38 V$ ✓

$V_E - I_E R_E = 0$

$V_E = (3.529m)(1K)$

$V_E = 3.529 V$ ✓

$18 - I_B R_B = V_B$

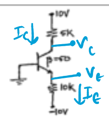
$V_B = 18 - (69.2\mu)(199K)$

$= 18 - 13.77$

$V_B = 4.2 V$ ✓

**Basics Electronics (22EC13)**

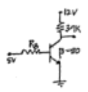
**Tutorial-1**




$V_{CC} = 10$ ; $R_C = 5K$ ; $\beta = 50$ ; $R_E = 10k$

Fig 4

| | |
|---|---|
| 7 | In the inverter circuit of fig 5, determine the maximum value of $R_B$, so that the circuit could be used an inverter. |




$V_{CC} = 12V$ ; $R_C = 3.9k\Omega$ ; $\beta = 80$

Fig 5

| | |
|---|---|
| 8 | In the inverter circuit of fig 6, determine the minimum value of β, so that the circuit could be used an inverter. |

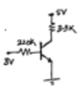
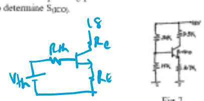



Fig 6

| | |
|---|---|
| 9 | Determine the operating point of silicon transistor in the voltage divider biasing circuit fig 7. Also determine $S_{(ICO)}$. |




$V_{CC} = 18V$ ; $R_C = 3.3k$ ; $\beta = 100$ ; $R_E = 2.7k$ ; $R_1 = 30k$ ; $R_2 = 15k$

Fig 7

| | |
|---|---|
| 10 | In an RC coupled CE amplifier, $R_1$ =50KΩ, $R_2$ =25KΩ, $R_C$ = $R_L$ =2KΩ, β=99 and $I_E$ =2mA. Determine the voltage gain, input impedance and output impedance of the amplifier. |

⑥ $0 - V_{BE} - I_E R_E = -10$

$-0.7 - I_E(10k) = -10$

$I_E = \frac{9.3}{10K}$

$I_E = 0.93 mA$

$I_E = (\beta+1) I_B$

$I_B = \frac{0.93m}{51}$

$I_B = 18.2 \mu A$

$I_C = \beta I_B$

$I_C = 0.91 mA$

$V_E - I_E R_E = -10$

$V_E = -10 + (0.93m)(10k)$

$V_E = -0.7V$

$10 - I_C R_C = V_C$

$V_C = 10 - (0.91m)(5k)$

$V_C = 5.45V$

⑩ $R_1 = 50k\Omega$ ; $R_2 = 25k\Omega$ ; $R_C = R_L = 2k\Omega$ ; $\beta = 99$ ; $I_E = 2mA$

$Z_i = R_{th} \,||\, (\beta+1) r_e$

$Z_o = R_L \,||\, R_C$

$A_V = -\frac{R_C || R_L}{r_e}$

$R_{th} = R_1 || R_2 = \frac{50K \cdot 25K}{50K + 25K}$

$R_{th} = 16.67k\Omega$

$r_e = \frac{26mV}{I_E} = \frac{26mV}{2mA}$

$r_e = 13\Omega$

$Z_i = \frac{R_{th} \cdot (\beta+1) r_e}{R_{th} + (\beta+1) r_e}$

$= \frac{(16.67K)(100)(13)}{16.67K + 100 \times 13}$

$= \frac{21671K}{17.97K}$

$= 1205.95$

$Z_i = 1.206k\Omega$

$Z_o = R_C || R_L = \frac{(2K)(2K)}{2K + 2K}$

$Z_o = 1k\Omega$

$A_V = -\frac{R_C || R_L}{r_e} = \frac{-1K}{13}$

$A_V = -76.9231$

⑨ Q-pt $(V_{CE}, I_C) = ?$, $S_{ICO} = ?$

→ $V_{th} = \frac{V_{CC} R_2}{R_1 + R_2}$

$= \frac{18 \times 15K}{30K + 15K}$

$V_{th} = 6V$

$R_{th} = R_1 || R_2$

$= \frac{30K \cdot 15K}{30K + 15K}$

$R_{th} = 10k\Omega$

→ $V_{th} - I_B R_{th} - V_{BE} - I_E R_E = 0$ , $I_E = (\beta+1) I_B$

$I_B = \frac{V_{th} - V_{BE}}{R_{th} + (\beta+1) R_E}$

$= \frac{6 - 0.7}{10K + 101(2.7K)}$

$= \frac{5.3}{282.7K}$

$I_B = 18.7 \mu A$

$I_C = \beta I_B = 100 I_B = 1.87 mA$

$I_E = (\beta+1) I_B = 101 I_B = 1.88 mA$

→ $V_{CC} - I_C R_C - V_{CE} - I_E R_E = 0$

$18 - (1.87m)(3.3k) - V_{CE} - (1.88m)(2.7k) = 0$

⑦ → $12 - I_C R_C - V_{CE} = 0$

$12 - (\beta+1) I_B R_C - 0.3 = 0$ (saturation)

$12 - (80) I_B (3.9k) - 0.3 = 0$

$I_B = \frac{11.7}{312k}$ ⇒ $I_B = 37.5 \mu A$

→ $5 - I_B R_B - V_{BE} = 0$

$5 - (37.5\mu) R_B - 0.7 = 0$

$R_B = \frac{4.3}{37.5\mu}$

⑧ $5 - I_C R_C - V_{CE} = 0$

$5 - \beta I_B R_C - V_{CE} = 0$

$5 - \beta(10.5\mu)(3.3k) - 0.3 = 0$

$\beta = \frac{4.7}{10.5 \times 10^{-6} \times 3.3 \times 10^{3}}$

$\beta = 135.6 \approx 136$

$3 - I_B R_B - V_{BE} = 0$

$3 - I_B(220k) - 0.7 = 0$

$R_{th} = 10K\Omega$

$I_E = (\beta+1)I_B = 101 I_B = 1.88mA$

$\rightarrow V_{CC} - I_C R_C - V_{CE} - I_E R_E = 0$

$18 - (1.87m)(3.3k) - V_{CE} - (1.88m)(2.7k) = 0$

$V_{CE} = 18 - 6.171 - 5.076$

$V_{CE} = 6.753\ V$

Q-pt $(V_{CE}, I_C)$

$Q_{pt} = (6.753V, 1.87mA)$

$\rightarrow S_{ICO} = \dfrac{1+\beta}{1 + \dfrac{\beta R_E}{R_{th}+R_E}}$

$= \dfrac{101}{1 + \dfrac{100 \times 2.7K}{10K + 2.7K}}$

$= \dfrac{101}{1 + \dfrac{270}{12.7}} = \dfrac{101}{21.25}$

$S_{ICO} = 4.7529$

$\rightarrow 5 - I_B R_B - V_{BE} = 0$

$5 - (37.5\mu) R_B - 0.7 = 0$

$R_B = \dfrac{4.3}{37.5\mu}$

$R_B = 114.7k\Omega$

$P = 159\ldots$

$3 - I_B R_B - V_{BE} = 0$

$3 - I_B(220k) - 0.7 = 0$

$I_B = \dfrac{2.3}{220k}$

$I_B = 10.5\mu A$

$38 = 20\log\left[\dfrac{200}{V_i}\right]$ $\quad P = \dfrac{V^2}{R}$ $\quad 40 = \dfrac{V^2}{1000}$

**Basics Electronics (22EC13)**

**Tutorial-1**

| | |
|---|---|
| 11 | a) Three amplifiers of voltage gains 20dB, 26dB and 32dB are cascaded to obtain an output voltage of 2V. Calculate the input voltage needed.<br>b) An amplifier having a power gain of 17dB delivers a power output of 40W to a load of 1KΩ. Calculate i) the input power needed and (ii) the input voltage needed, if the voltage gain of the amplifier is 38dB. |
| 12 | Calculate the voltage gain vo/vi , input impedance Zi and output impedance Zo for the circuits of fig 8 and 9 |

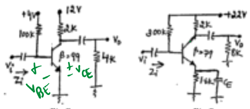



Fig 8 Fig 9

$V_{CC} = 12V$, $R_C = 2k\Omega$, $\beta = 99$, $R_B = 100k\Omega$, $R_L = 4k\Omega$

$Z_i = R_B \parallel (\beta+1) r_e$

$\times\ 12 - I_C(2K) - V_{CE} = 0$

$4 - (100K)(I_B) - 0.7 = 0$

$I_B = 33\mu A$ ✓

$I_C = \beta I_B$

$I_E = (\beta+1) I_B$

$= 100 I_B$

$= 3.3mA$

$Z_i = \dfrac{R_B(\beta+1)r_e}{R_B + (\beta+1)r_e}$ $\quad A_v = \dfrac{-R_L \parallel R_C}{r_e}$

$= \dfrac{-Z_o}{r_e}$

$Z_o = R_L \parallel R_C$

$\dfrac{(2k)(4k)}{2k+4k}$

$= 1.33K\Omega$

$= \dfrac{-1.33K}{7.87}$

$=$

$r_e = \dfrac{26mV}{I_E} = \dfrac{26mV}{3.3mA}$

$r_e = 7.87\Omega$

(11a) $A_{v_1} = 20dB$ $\quad V_o = 2V$

$A_{v_2} = 26dB$ $\quad V_i = ?$

$A_{v_3} = 32dB$

$A_{v_{tot}} = 20\log\left(\dfrac{V_o}{V_i}\right)$

$20 + 26 + 32 = 20\log\left[\dfrac{2}{V_i}\right]$

$\dfrac{78}{20} = \log\left[\dfrac{2}{V_i}\right]$

$10^{3.9} = \dfrac{2}{V_i}$

$V_i = \dfrac{2}{10^{3.9}} = \dfrac{2}{7943.28} = 0.3mV$

$A_v, Z_i, Z_o\ ?$

(12a) $Z_i = R_B \parallel (\beta+1) r_e$

$= \dfrac{R_B(\beta+1)r_e}{R_B + (\beta+1)r_e}$

$= \dfrac{(100k)(100)(7.87)}{100k + (100)(7.87)}$

$= \dfrac{7.87 \times 10^{7}\ 10^4}{100k + 0.787k}$

$Z_i = 781\Omega$

$r_e = \dfrac{26mV}{I_E}$

$4 - I_B R_B - V_{BE} = 0$

$4 - I_B(100k) - 0.7 = 0$

$I_B = \dfrac{3.3}{100k}$

$I_B = 33\mu A$

$I_E = (\beta+1) I_B = 3.3mA$

$r_e = \dfrac{26mV}{3.3mA}$

$r_e = 7.87\Omega$

$\rightarrow Z_o = R_L \parallel R_C$

$= \dfrac{(4K)(2K)}{4K + 2K}$

$Z_o = 1.33k\Omega$

$\rightarrow A_v = \dfrac{-R_C \parallel R_L}{r_e}$

$= \dfrac{-1.33k}{7.87m}$

$(A_v) = -169$

(11b) $A_p = 17dB$ $\quad$ i) $P_i = ?$

$P_o = 40W$ $\quad$ ii) $V_i = ?$ if $A_v = 38dB$

$R = 1k\Omega$

$\rightarrow A_p = 10\log\left(\dfrac{P_o}{P_i}\right)$

$17 = 10\log\left(\dfrac{40}{P_i}\right)$

$P_i = \dfrac{40}{10^{1.7}}$

$P_i = 0.798W$ (i)

$\rightarrow A_v = 20\log\left(\dfrac{V_o}{V_i}\right)$

$P = \dfrac{V^2}{R}$

$V_o = \sqrt{P_o R}$

$= \sqrt{40 \times 1k}$

$V_o = 200$

$38 = 20\log\left(\dfrac{200}{V_i}\right)$

$\log\left(\dfrac{200}{V_i}\right) = 1.9$

$V_i = \dfrac{200}{10^{1.9}}$

$V_i = 2.5179V$ (ii)

(12b) $Z_i = R_B \parallel (\beta+1) r_e$ ; $\quad r_e = \dfrac{26mV}{I_E}$

$= \dfrac{R_B(\beta+1)r_e}{R_B + (\beta+1)r_e}$

$= \dfrac{(300k)(80)(6.5261)}{(300k) + (80)(6.5261)}$

$Z_i = 521.18$

$22 - I_B R_B - V_{BE} - I_E R_E = 0$

$I_B = \dfrac{22 - V_{BE}}{R_B + (\beta+1)R_E}$

$= \dfrac{22 - 0.7}{300k + (80)(1.6k)}$

$= \dfrac{21.3}{428k}$

$I_B = 49.8\mu A$

$I_E = (\beta+1) I_B = 80 I_B$

$I_E = 3.984mA$

$Z_o = R_C \parallel R_L$

$= \dfrac{(2K)(8K)}{2K + 8K}$

$Z_o = 1.6K$

$A_v = \dfrac{-Z_o}{r_e} = \dfrac{-1.6k}{6.5261}$

$= 245.16$

$r_e = \dfrac{26mV}{3.984mA}$

$r_e = 6.5261\Omega$