Experiment No.

COMMON EMITTER AMPLIFIER

AIM

1. To design a small signal voltage amplifier.

THEORY

Amplifiers are classified as small signal amplifiers and large signal amplifiers depending on the shift in operating point, from the quiescent condition caused by the input signal. If the shift is small, amplifiers are referred to as small signal amplifiers and if the shift is large, they are known as large signal amplifiers. In small signal amplifiers, voltage swing and current swing are small. Large signal amplifiers have large voltage swing and current swing and the signal power handled by such amplifiers remain large.

Voltage amplifiers come under small signal amplifiers. Power amplifiers are one in which the output power of the signal is increased. They are called large signal amplifiers. Figure shows the circuit diagram of a common emitter amplifier.

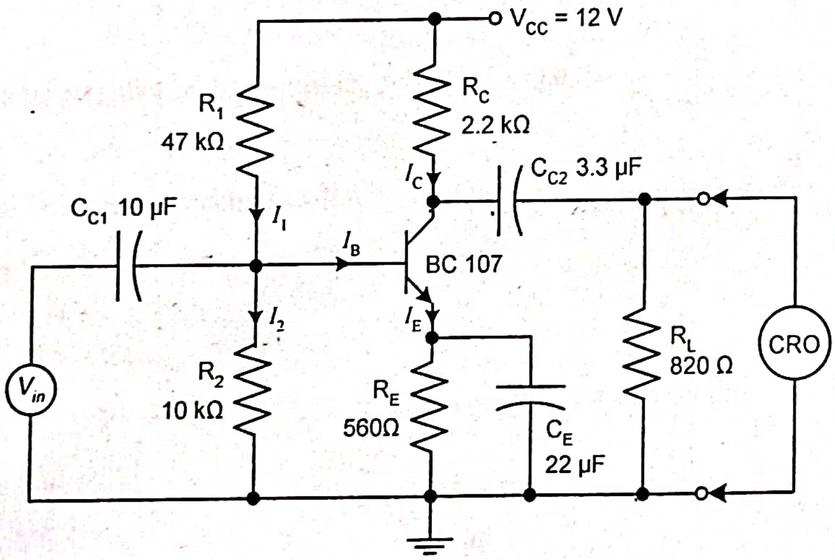

Fig 1. Circuit diagram

DESIGN

From the transistor data sheet, for BC107,

$h_{fe} = \beta = 110$, $I_{c\,max} = 100$ mA, $V_{CE\,max} = 45$V

Let $V_{CC} = 12$V, $I_c = 2$mA. Since the quiescent point is in the middle of the load line for the amplifier, $V_{CE} = 50\%$ of $V_{CC} = 6$V.

$V_{RE} = 10\%$ of $V_{CC} = 1.2$V.

Assuming $I_C = I_E$, $\qquad V_{RE} = I_C R_E = I_E R_E$

$$1.2 = 2\times10^{-3}\times R_E$$

$$R_E = \frac{1.2}{2\times10^{-3}} = 600\,\Omega$$ Select standard value of resistance 560 Ω.

Voltage across collector resistance, $V_{RC} = V_{CC} - V_{CE} - V_{RE}$

$$= 12-6-1.2 = 4.8\text{ V}$$

$$R_C = \frac{V_{RC}}{I_C} = \frac{4.8}{2\times10^{-3}} = 2.4\text{ k}\Omega$$ Select standard value of 2.2 kΩ .

Base current, $I_B = \dfrac{I_C}{\beta} = \dfrac{2\times10^{-3}}{110} = 18.2\,\mu\text{A}$

Take $I_2 = 10I_B$ then $I_1 = 10I_B + I_B = 11I_B$

Base voltage, $V_B = V_{RE} + V_{BE} = 1.2+0.6 = 1.8\text{ V}$

$$R_2 = \frac{V_B}{I_2} = \frac{1.8}{10\times18.2\times10^{-6}} = 9.9\text{ k}\Omega$$ Select standard value of 10 kΩ

$$R_1 = \frac{V_{CC}-V_B}{I_1} = \frac{12-1.8}{11\times18.2\times10^{-6}} = 51\text{ k}\Omega$$ Select standard value of 47 kΩ

Design of R_L:

Gain of the common emitter amplifier is given by the expression $A_V = -\left(\dfrac{r_c}{r_e}\right)$

where $r_c = R_C \,||\, R_L$ and $r_e = \dfrac{25\text{ mV}}{2\text{ mA}} = 12.5\,\Omega$

For a gain of 50, substituting it in the expression we get, R_L=873 Ω.

Select standard value of 820 Ω for R_L

Design of coupling capacitors C_{C1} and C_{C2}

X_{C1} should be less than the input impedance of the transistor. Here, R_{in} is the series impedance.

Then $X_{C1} \le \dfrac{R_{in}}{10}$

Here $R_{in} = R_1 \,||\, R_2 \,||\, h_{fe}\, r_e = 47\text{k}\Omega \,||\, 10\text{ k}\Omega \,||\, 110\times12.5\,\Omega = 1.17\text{ k}\Omega$

We get R_{in}=1.17 kΩ. Then $X_{C1} \le 117\,\Omega$.

For a lower cut off frequency of 200 Hz, $C_{C1} = \dfrac{1}{2\pi f X_{C1}} = \dfrac{1}{2\pi\times200\times117} = 6.8\,\mu\text{F}$

Select standard value of 10 μF for C_{C1}

Similarly, $X_{C2} \leq \frac{R_{out}}{10}$ where R_{out}=R_C. Then $X_{CE} \leq 220\Omega$.

$$\text{So, } C_{C2} = \frac{1}{2\pi f X_{C2}} = \frac{1}{2\pi \times 200 \times 220} = 3.6\ \mu F$$

Select standard value of 3.3 μF for C_{C2}

Design of bypass capacitors C_E

To bypass the lowest frequency (say 200 Hz), X_{CE} should be much less than or equal to the resistance R_E.

$$X_{CE} \leq \frac{R_E}{10}$$

$$X_{CE} \leq \frac{560}{10} \qquad \text{ie. } X_{CE} \leq 56$$

Apply value of f such that the amplifier has good gain at a lower cutoff frequency of 200 Hz

$$C_E \geq \frac{1}{2\pi f X_{CE}} = \frac{1}{2\pi \times 200 \times 56} = 14.2\ \mu F$$

Select standard value of 22 μF for C_E

: V_i= 100 mV

Sl No	Frequency	V_o (Volts)	Gain = V_o / V_i

Parameter	Measured Values	Expected Value
V_B		
V_C		
V_E		
V_{CE}		
I_C		

Table ,1:DCValues