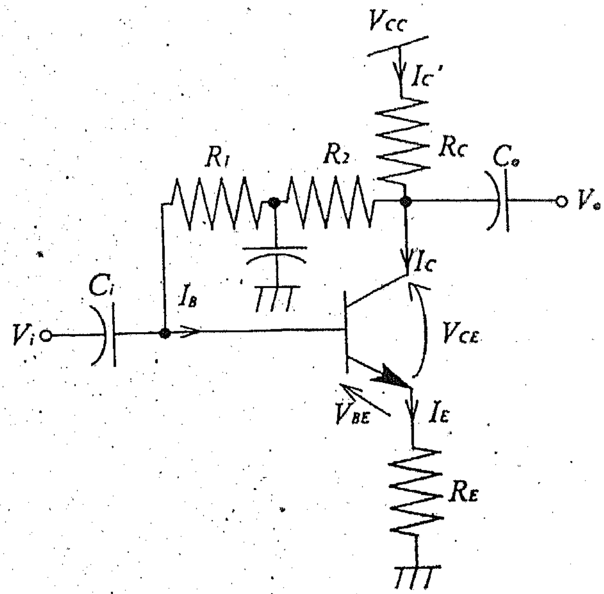
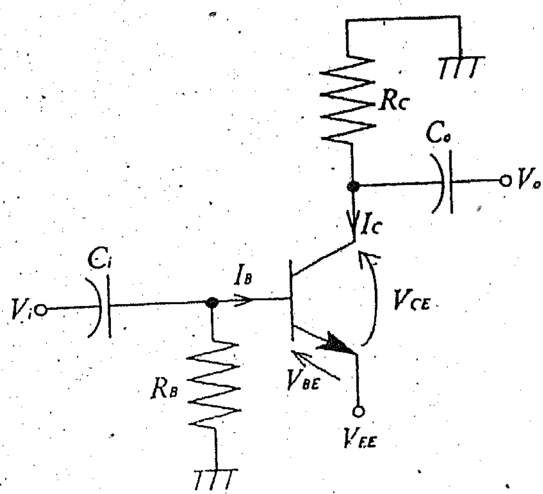
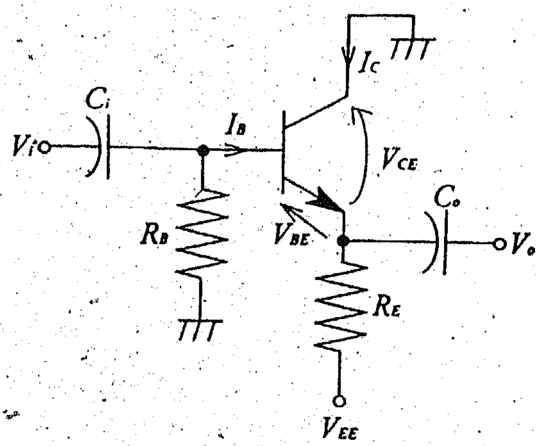
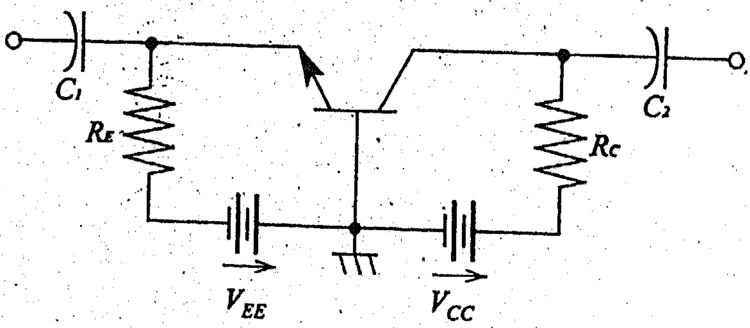


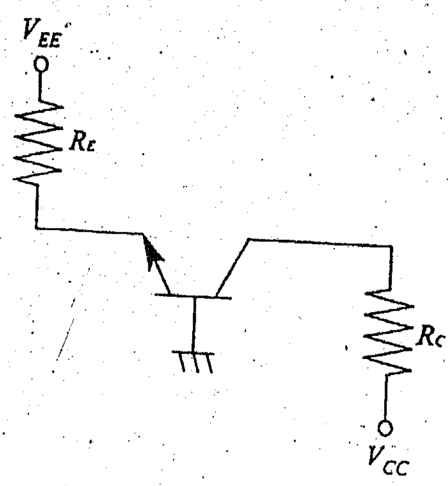
V_{CC}
I_C'
R_C
R_1
R_2
C_o
V_o
C_i
I_B
I_C
V_i
V_{CE}
V_{BE}
I_E
R_E



R_C
C_o
V_o
I_C
C_i
I_B
V_i
V_{CE}
V_{BE}
R_B
V_{EE}


I_C
C_i
I_B
V_i
V_{CE}
C_o
R_B
V_{BE}
V_o
R_E
V_{EE}


C_1
R_E
R_C
C_2
V_{EE}
V_{CC}


V_{EE}
R_E
R_C
V_{CC}

All the four biasing circuit studied in the previous section can be used for amplifier design. However they defer in terms of stability of Q-point due to the change in surrounding and junction temperature.

In ascending order of Q-point stability, it is fixed bias, then emitter-stabilized bias followed by dc bias voltage feedback and finally voltage divider bias. Which means that voltage divider bias circuit is the most stable biasing circuit compared to all other three biasing circuits discussed.

When designing an amplifier, the following approach can serve as a reference.

Approach of designing an amplifier :

1) Decide on the biasing circuits to be used for your applications.

   fixed biasing

   emitter-stabilized biasing

   voltage divider biasing

   dc bias voltage feedback

   Assuming that voltage divider biasing is your choice.

2) Find out what is the required supply voltage V_{CC} for the circuit and choose a suitable transistor for your application. After you have identified a particular transistor, find out the saturation collector current I_{Csat} from the transistor data. Assuming that $V_{CC} = 25V$ & $I_C = 8mA$.

3) Choose the Q-point to be at the middle of the active region so to allow maximum swing of the signal with minimum distortion. The Q-point is determined by the following approximation.

$$I_{CQ} = \frac{I_{C(sat)}}{2} = \frac{8mA}{2} = 4mA$$

and

$$V_{CEQ} = \frac{V_{CC}}{2} = \frac{25V}{2} = 12.5V$$

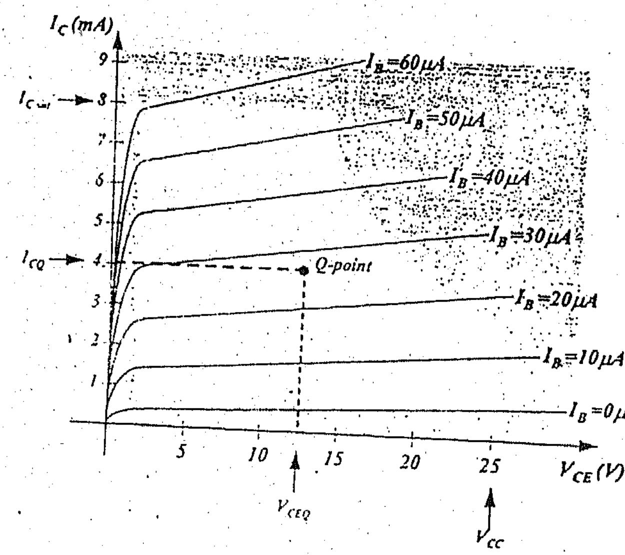


Fig 1. 29

4) Calculate the individual resistors values for the voltage divider circuit chosen base on the above conditions.

i) Calculate R_E , by rule of thumb, we assume V_E to be 10% of V_{CC}. If β of the transistor is large, we can have the approximation of $I_E \cong I_C$.

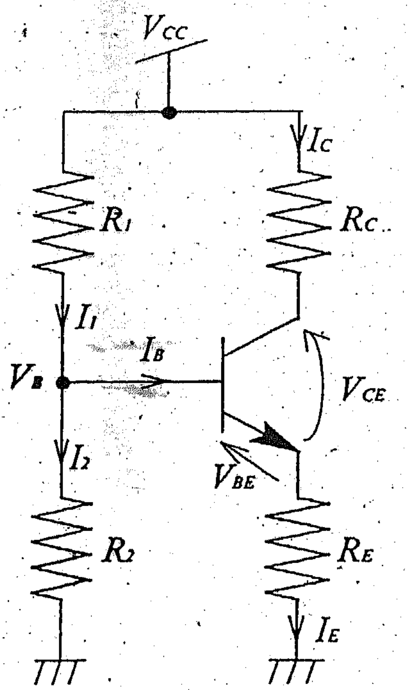


Fig 4. 30

$$V_E = 0.1\,V_{CC}$$
$$= 0.1\,(25V)$$
$$= 2.5V$$

$$I_E \cong I_C$$
$$I_E = 4mA$$

$$R_E = \frac{V_E}{I_E} = \frac{2.5V}{4mA} = 625\Omega$$

ii) Calculate R_2. Given in the data sheet β=200, we could calculate R_2 using $\beta R_E = 10\,R_2$.

$$R_2 = \frac{\beta R_E}{10} = \frac{(200)(625\Omega)}{10} = 12.5\ k\Omega$$

iii) Calculate R_1.

$$V_B = V_{BE} + V_E$$
$$= 0.7V + 2.5V$$
$$= 3.2V$$

$$V_B = \frac{R_2}{R_1 + R_2} V_{CC}$$

$$R_1 = \frac{(V_{CC} - V_B)R_2}{V_B}$$
$$= \frac{(25V - 3.2V)(12.5k\Omega)}{3.2V}$$
$$= 85.16k\Omega$$

iv) Lastly, calculate R_C from the output loop equation.

$$V_{CC} = V_{RC} + V_{CE} + V_E$$
$$= I_C R_C + V_{CE} + V_E$$

$$R_C = \frac{V_{CC} - V_{CE} - V_E}{I_C}$$
$$= \frac{25V - 12.5V - 2.5V}{4mA}$$
$$= 2.5\ k\Omega$$

The design is now completed as shown in Fig 4. 31.

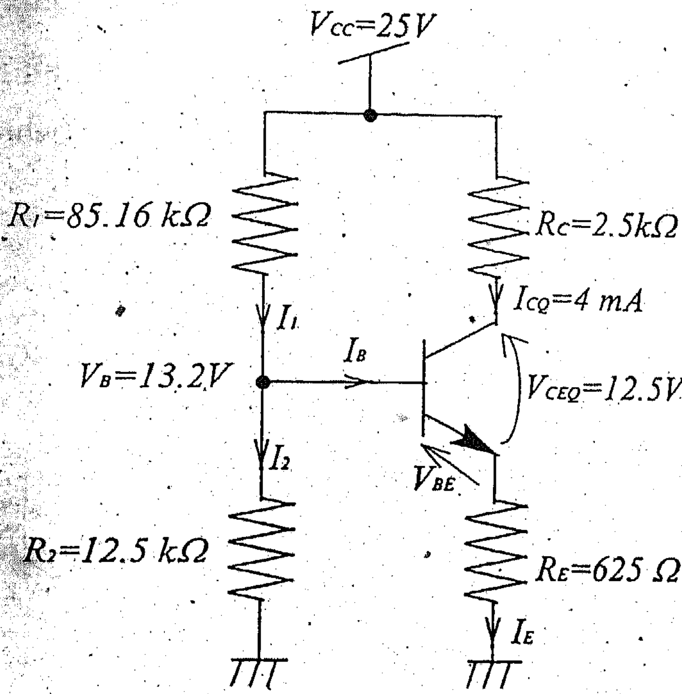


Fig 4. 31

Through proper design, transistor can be used as an electronic switch for computer and control applications. The network of Fig 4. 32 can be employed as an <u>*inverter*</u> in computer logic circuitry (which will be studied in detail in Digital Electronics Module).

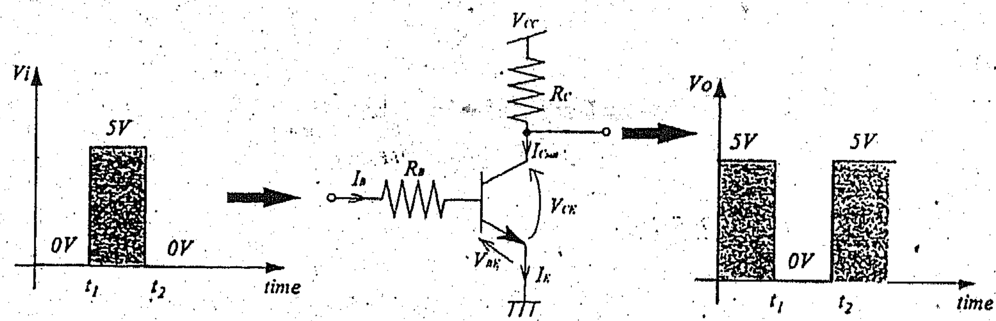


Fig 4. 32

During t_1 and t_2 from the circuit above, the transistor is turn "ON". With V_i equal to 5V, there will be I_B flows into the base terminal. Hence V_{BE} is equal to 0.7V. The collector current will be at its saturation level I_{Csat}. The output terminal connected to the collector has a voltage equals to V_{CEsat} which is approximately zero volt as shown in the output waveform of Fig 4. 32. The transistor during this period is like a closed switch where current passing through it with zero voltage drop across.

Before t_1 and after t_2, the transistor is at its "OFF" state. No V_i voltage therefore no I_B. Thus there will not be any I_C flowing. According to the output loop equation, the output voltage is equal to the supply V_{CC}. Just like a open switch, the voltage at the open circuit is equal to the supply without any current passing through it.

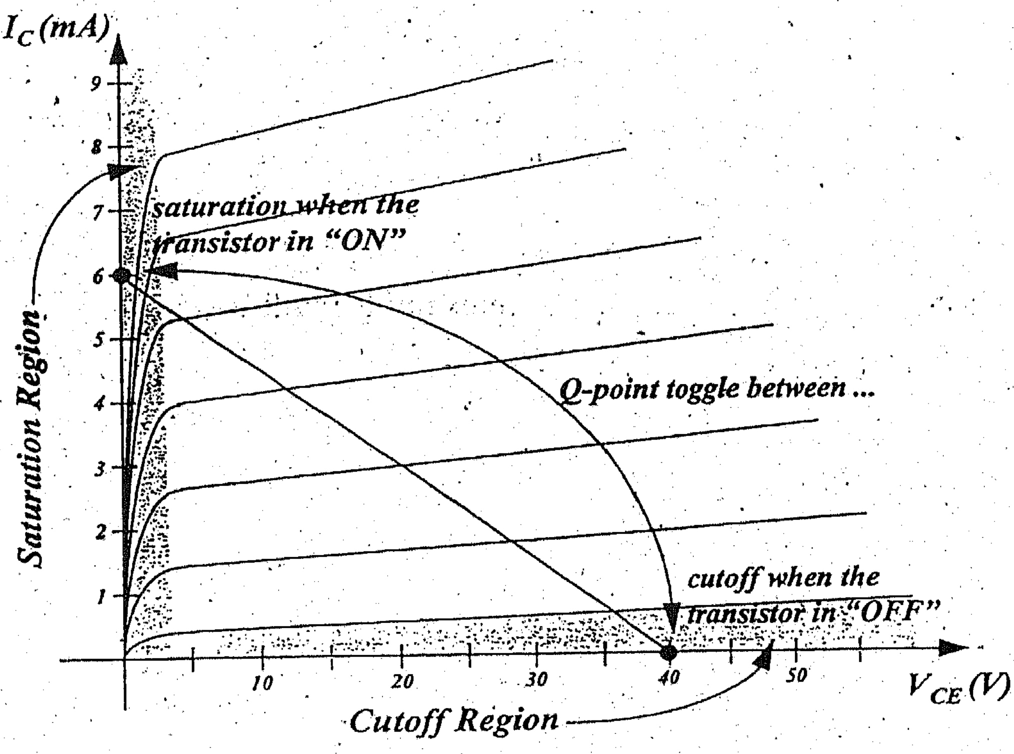


Fig 4. 33

When the transistor is designed to operate like a switch, the Q-point toggles between the *saturation region* and *cutoff region*.

Very important points to note when designing a transistor switch. You ought to ensure that the base current is sufficiently large to drive the transistor into its <u>*saturation*</u> to turn it "ON". Meaning that the base current must be

$$I_B > \frac{I_{Csat}}{\beta_{dc}}$$

so that the V_{CE} will reach it saturation (V_{CEsat}) giving approximately zero volt.

To design transistor switch and more examples will be shown during your tutorial discussion.