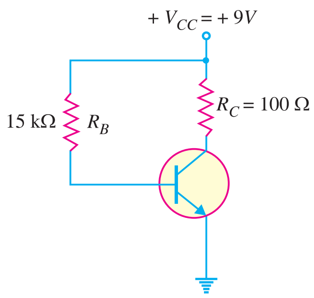


Fig. 9.54

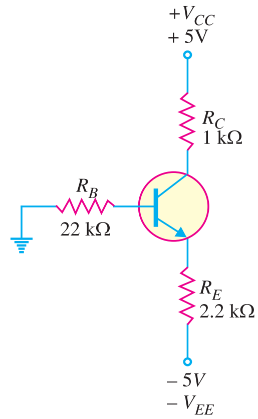


Fig. 9.55

13. To what value can R_E in Fig. 9.55 be reduced without transistor going into saturation ? **[639Ω]**

14. When can the effect of β be neglected in the emitter bias circuit ? **[When $R_E >> R_B/\beta$]**

15. What is the minimum value of β in Fig. 9.56 that makes $R_{in\,(base)} \geq 10\, R_2$? **[69.1]**

16. (*i*) Determine the base voltage V_B in Fig. 9.57.
(*ii*) If R_E is doubled, what will be the value of V_B ? **[(*i*) 1.74V (*ii*) 1.74V]**

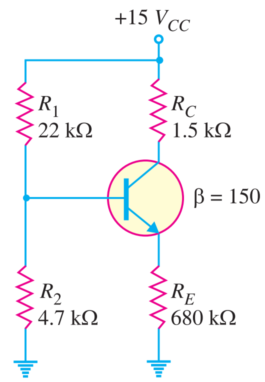


Fig.9.56

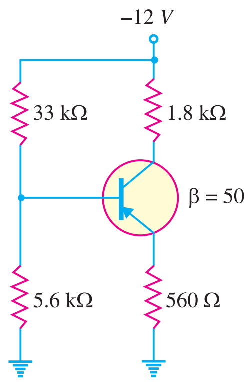


Fig. 9.57

17. (*i*) Find the Q-point values for Fig. 9.57.
(*ii*) Find the minimum power rating of transistor in Fig. 9.57. **[(*i*) 1.41 mA ; – 8.67V (*ii*) 12.2 mW]**

18. A collector-feedback circuit uses an *npn* transistor with V_{CC} = 12V, R_C = 1.2 kΩ, R_B = 47 kΩ. Determine the collector voltage and the collector current if β = 200. **[7.87 mA ; 2.56V]**

Discussion Questions

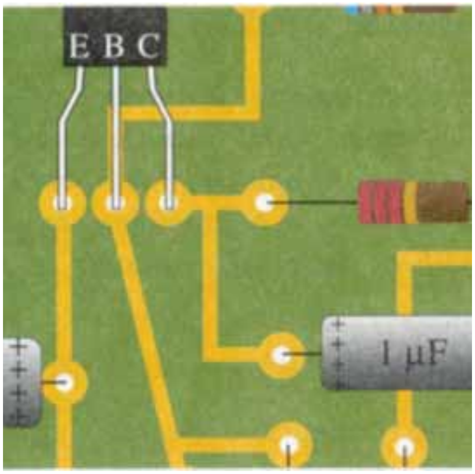
1. Why are transistor amplifiers always operated above knee voltage region ?
2. What is the utility of d.c. load line ?
3. Why have transistors inherent variations of parameters ?
4. Why is $\beta_{d.c.}$ different from $\beta_{a.c.}$?
5. Why has potential divider method of biasing become universal ?

Top

Contents

10

Single Stage Transistor Amplifiers



INTRODUCTION

In the previous chapter, it was discussed that a properly biased transistor raises the strength of a weak signal and thus acts as an amplifier. Almost all electronic equipments must include means for amplifying electrical signals. For instance, radio receivers amplify very weak signals—sometimes a few millionth of a volt at antenna–until they are strong enough to fill a room with sound. The transducers used in the medical and scientific investigations generate signals in the microvolt (μV) and millivolt (mV) range. These signals must be amplified thousands and millions times before they will be strong enough to operate indicating instruments. Therefore, electronic amplifiers are a constant and important ingredient of electronic systems.

Our purpose here will be to discuss *single stage transistor amplifier*. By a *stage* we mean a single transistor with its bias and auxiliary equipment. It may be emphasised here that a practical amplifier is always a multistage amplifier *i.e.* it has a number of stages of amplification. However, it is profitable to consider the multistage amplifier in terms of single stages that are connected together. In this chapter, we shall confine our attention to single stage transistor amplifiers.

10.1 Single Stage Transistor Amplifier

When only one transistor with associated circuitry is used for amplifying a weak signal, the circuit is known as **single stage transistor amplifier.**

A single stage transistor amplifier has one transistor, bias circuit and other auxiliary components. Although a practical amplifier consists of a number of stages, yet such a complex circuit can be conveniently split up into separate single stages. By analysing carefully only a single stage and using this single stage analysis repeatedly, we can effectively analyse the complex circuit. It follows, therefore, that single stage amplifier analysis is of great value in understanding the practical amplifier circuits.

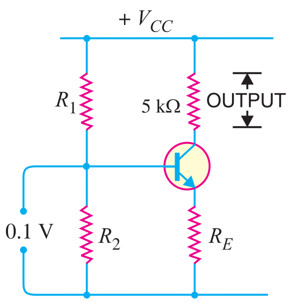


Fig. 10.1

10.2 How Transistor Amplifies ?

Fig. 10.1 shows a single stage transistor amplifier. When a weak a.c. signal is given to the base of transistor, a small base current (which is a.c.) starts flowing. Due to transistor action, a much larger (β times the base current) a.c. current flows through the collector load R_C. As the value of R_C is quite high (usually 4-10 kΩ), therefore, a large voltage appears across R_C. Thus, a weak signal applied in the base circuit appears in amplified form in the collector circuit. It is in this way that a transistor acts as an amplifier.

The action of transistor amplifier can be beautifully explained by referring to Fig. 10.1. Suppose a change of 0.1V in signal voltage produces a change of 2 mA in the collector current. Obviously, a signal of only 0.1V applied to the base will give an output voltage = 2 mA × 5 kΩ = 10V. Thus, the transistor has been able to raise the voltage level of the signal from 0.1V to 10V *i.e.* voltage amplification or stage gain is 100.

10.3 Graphical Demonstration of Transistor Amplifier

The function of transistor as an amplifier can also be explained graphically. Fig. 10.2 shows the output characteristics of a transistor in *CE* configuration. Suppose the zero signal base current is 10 μA *i.e.* this is the base current for which the transistor is biased by the biasing network. When an a.c. signal is applied to the base, it makes the base, say positive in the first half-cycle and negative in the second half-cycle. Therefore, the base and collector currents will increase in the first half-cycle when base-emitter junction is more forward-biased. However, they will decrease in the second half-cycle when the base-emitter junction is less forward biased.

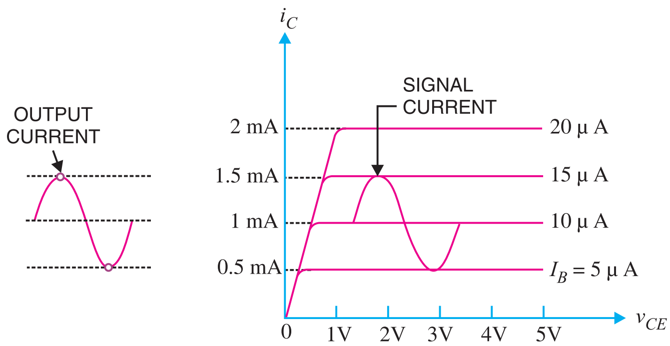


Fig. 10.2

For example, consider a sinusoidal signal which increases or decreases the base current by 5 μA in the two half-cycles of the signal. Referring to Fig. 10.2, it is clear that in the absence of signal, the base current is 10μA and the collector current is 1 mA. However, when the signal is applied in the base circuit, the base current and hence collector current change continuously. In the first half-cycle peak of the signal, the base current increases to 15 μA and the corresponding collector current is 1.5 mA. In the second half-cycle peak, the base current is reduced to 5 μA and the corresponding collector current is 0.5 mA. For other values of the signal, the collector current is inbetween these values *i.e.* 1.5 mA and 0.5 mA.

It is clear from Fig. 10.2 that 10 μA base current variation results in 1mA (1,000 μA) collector current variation *i.e.* by a factor of 100. This large change in collector current flows through collector resistance R_C. The result is that output signal is much larger than the input signal. Thus, the transistor has done amplification.

10.4 Practical Circuit of Transistor Amplifier

It is important to note that a transistor can accomplish faithful amplification only if proper associated circuitry is used with it. Fig. 10.3 shows a practical single stage transistor amplifier. The various circuit elements and their functions are described below :

(*i*) Biasing circuit. The resistances R_1, R_2 and R_E form the biasing and stabilisation circuit. The biasing circuit must establish a proper operating point otherwise a part of the negative half-cycle of the signal may be cut off in the output.

(*ii*) Input capacitor C_{in}. An electrolytic capacitor C_{in} ($\simeq$ 10 μF) is used to couple the signal to the base of the transistor. If it is not used, the signal source resistance will come across R_2 and thus change the bias. The capacitor C_{in} allows only a.c. signal to flow but isolates the signal source from R_2.*

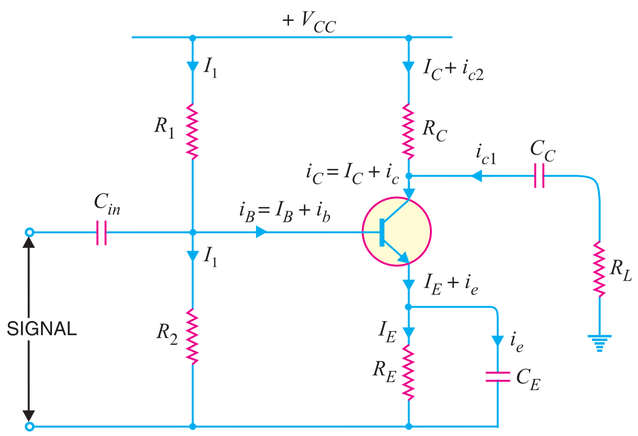


Fig. 10.3

(*iii*) Emitter bypass capacitor C_E. An emitter bypass capacitor C_E ($\simeq 100\mu F$) is used in parallel with R_E to provide a low reactance path to the amplified a.c. signal. If it is not used, then amplified a.c. signal flowing through R_E will cause a voltage drop across it, thereby reducing the output voltage.

(*iv*) Coupling capacitor C_C. The coupling capacitor C_C ($\simeq 10\mu F$) couples one stage of ampli-

* It may be noted that a capacitor offers infinite reactance to d.c. and blocks it completely whereas it allows a.c. to pass through it.