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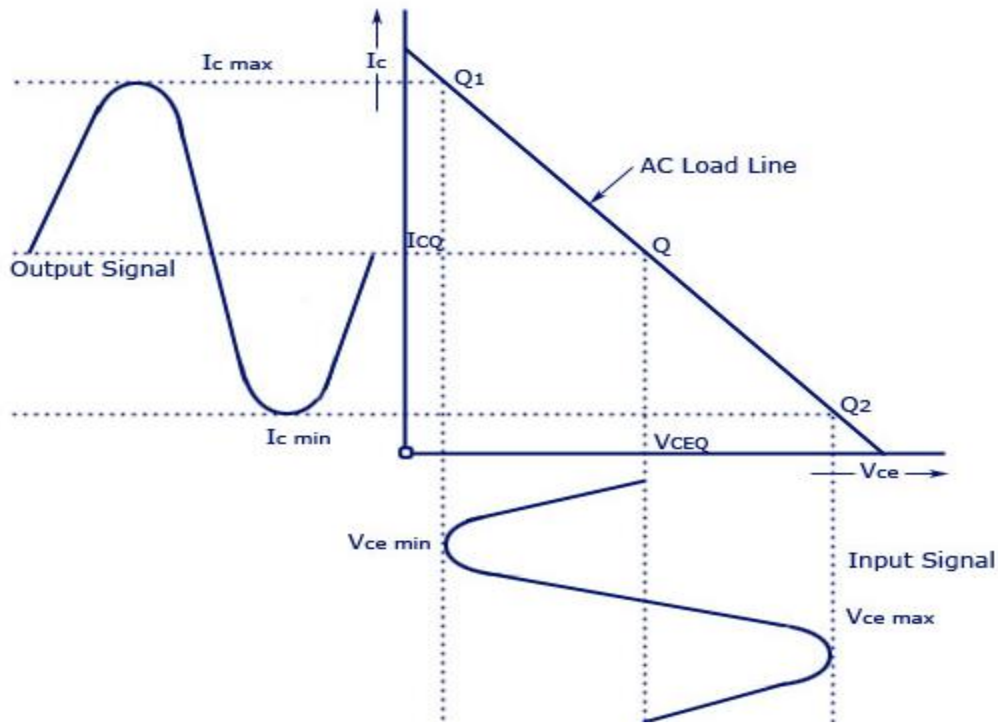
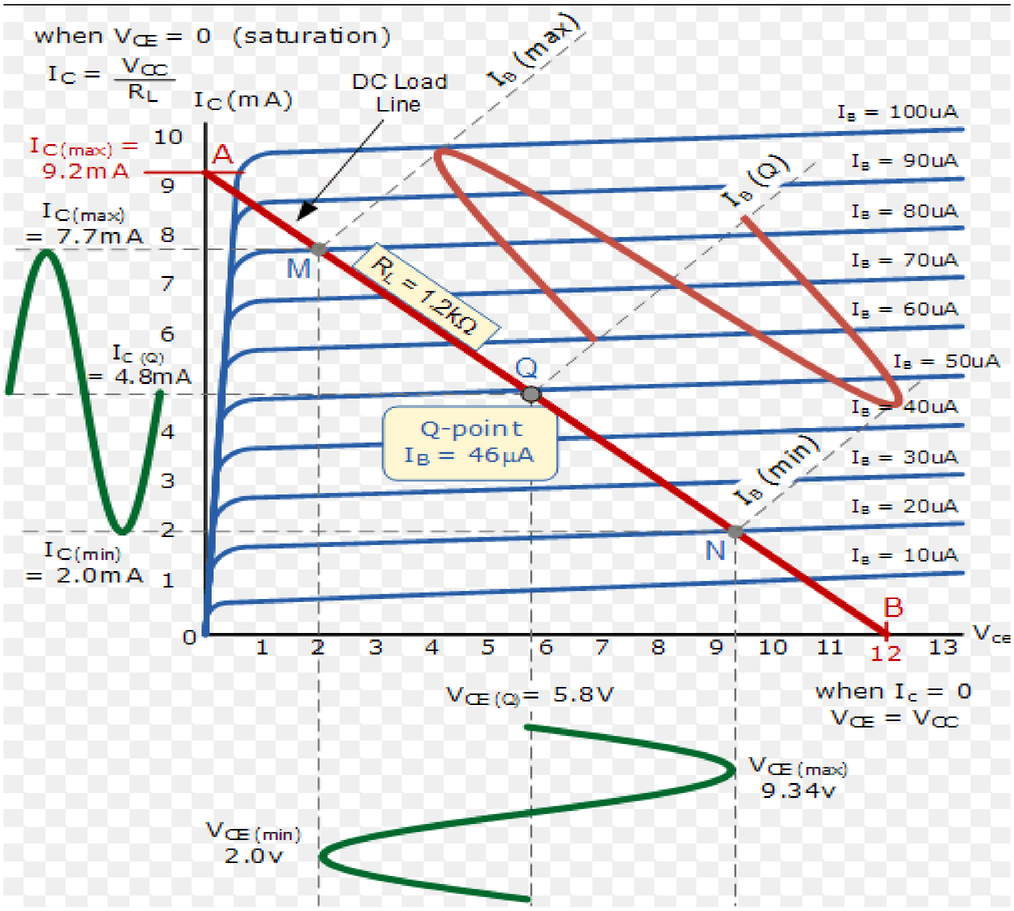
References

1- **electronic circuit; By Dr. R.S. Sedha**
2- **Principles of Electronics**
3- ***Op Amp Applications Handbook***

Review





Multistage Transistor Amplifiers

Introduction

The output from a single stage amplifier is usually insufficient to drive an output device.Anther words, the gain of a single amplifier is inadequate for practical purposes. Consequently, additional amplification over two or three stages is necessary. To achieve this, the output of each amplifier stage is *coupled* in some way to the input of the next stage. The resulting system is referred to as multistage amplifier. It may be emphasized here that a practical amplifier is always a multistage amplifier. For example, in a transistor radio receiver, the number of amplification stages may be six or more.

In a multistage amplifier, a number of single amplifiers are connected in *cascade arrangement*(means *connected in series*)*i.e.* output of first stage is connected to the input of the second stage through a suitable *couplingdevice* and so on. The purpose of coupling device (*e.g*. a capacitor, transformer etc.) is

(i) To transfer a.c. output of one stage to the input of the next stage.

(ii) To isolate the d.c. conditions of one stagefrom the next stage.

Fig. 1 shows the block diagram of a 3-stage amplifier. Each stage consists ofone transistor and associated circuitry and is coupled to the next stage through a coupling device. Thename of the amplifier is usually given after the type of coupling used. *e.g*

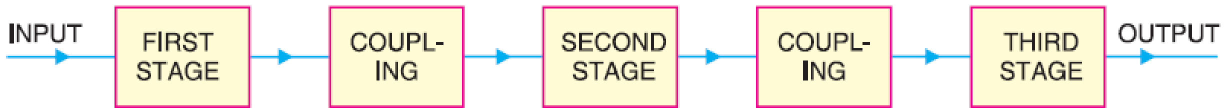


Fig.1: the block diagram of a 3-stage amplifier

Name of coupling Name of multistage amplifier
RC coupling R-C coupled amplifier
Transformer coupling Transformer coupled amplifier
Direct coupling Direct coupled amplifier

(*i*) In *RC* coupling, a capacitor is used as the coupling device. The capacitor connects theoutput of one stage to the input of the next stage in order to pass the ac signal on while blocking the dc bias voltages.

(*ii*) In transformer coupling, transformer is used as the coupling device. The transformer coupling provides the same two functions (*viz*. to pass the signal on and blocking dc) but permits inaddition impedance matching.

(*iii*) In direct coupling or dccoupling, the individual amplifier stage bias conditions are sodesigned that the two stages may be directly connected without the necessity for dcisolation.

Regardless of the manner in which a capacitor is connected in a transistor amplifier, its behaviortowards dc and acis as follows. *A capacitor blocks dc i.e. a capacitor behaves as an "open*"to dc*Therefore, for dc analysis, we can remove the capacitors from the transistor amplifier circuit.

A capacitor offers reactance (= $1/2\pi fC$) to ac depending upon the values of f and C. In practical transistor circuits, the size of capacitors is so selected that they offer negligible (ideally zero) reactance to the range of frequencies handled by the circuits. Therefore, *for ac analysis, we can* *replacethe capacitors by a short i.e. by a wire.* The capacitors serve the following two roles in transistor amplifiers:

1. As coupling capacitors

2. As bypass capacitors

1. As coupling capacitors. In most applications, you will not see a single transistor amplifier. Rather we use a multistage amplifier *i.e.* a number of transistor amplifiers are connected in series or cascaded. The capacitors are commonly used to connect one amplifier stage to another. When a capacitor is used for this purpose, it is called a *coupling capacitor*. Fig.2 shows the coupling capacitors (*CC*1; *CC*2;*CC*3 and *CC*4) in a multistage amplifier. A coupling capacitor performs the following two functions:

(*i*) It blocks dc*i.e.* it provides dcisolation between the two stages of a multistage amplifier.

(*ii*) It passes the ac signal from one stage to the next with little or no distortion.

*$X_C = 1/2\pi fC$. For dc $f = 0$ so that $X_C \to \infty$. Therefore, a capacitor behaves as an open to dc

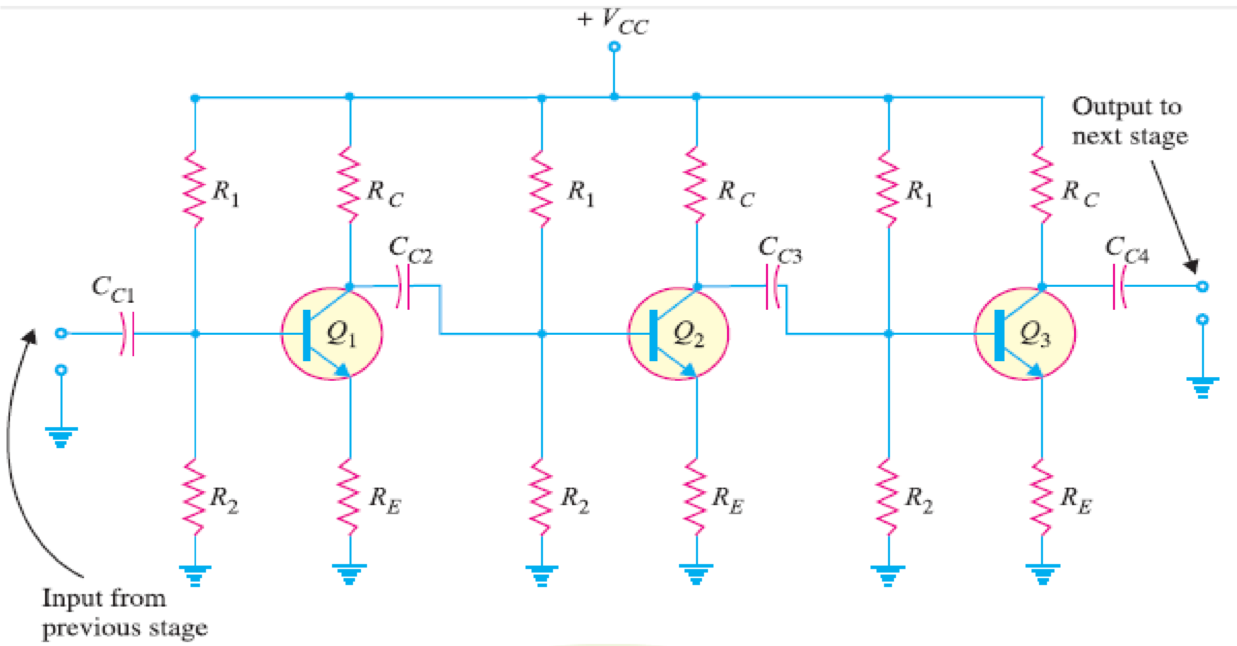


Fig.2: the coupling Capacitors in a multistage amplifier

2. As bypass capacitors

Like a coupling capacitor, a bypass capacitor also blocks dcand behaves as a short or wireto an ac signal. But it is used for a different purpose. A bypass capacitor is connected in parallel with a circuit component (*e.g.* resistor) to bypass the ac signal. Fig.3 shows a bypass capacitor *CE* connected across the emitter resistance *RE*. Since *CE* behaves as a short to the ac signal, the whole of ac signal (*ie*) passes through it. Note that *CE* keeps the emitter at ac ground. Thus for acpurposes, *RE* does not exist. *CE*plays an important role in determining the voltage gain of the amplifier circuit. If *CE* is removed, the voltage gain of the amplifier is greatly reduced. Note that *Cin*is the coupling capacitor in this circuit.

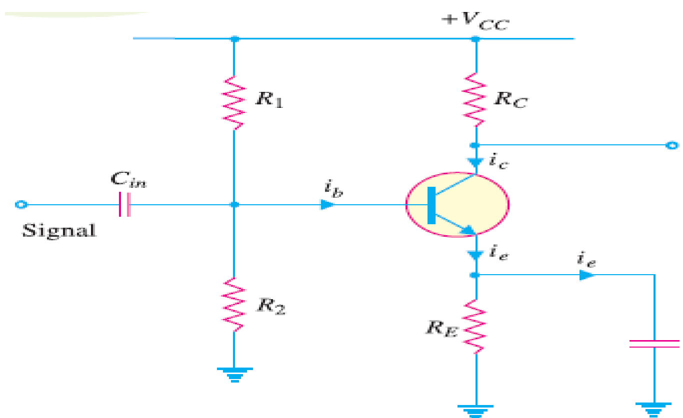


Fig.3: a bypass capacitor *CE* connected across the emitter resistance *RE*

Important Terms

In the study of multistage amplifiers, we shall frequently come across the terms *gain, frequency response, decibel gain* and *bandwidth.* These terms stand discussed below:

(*i*) Gain. Meaning *The ratio of the output electrical quantity to the input one of the amplifier***(**it can becurrent gain or voltage gain or power gain).

The gain of a multistage amplifier is equal to the product of gains of individual stages. For instance, if *G*1, *G*2 and *G*3 are the individual voltage gains of a three-stage amplifier, then total voltage gain G is given by:

G = G1xG2xG3

This can be easily proved. Suppose the input to first stage is *V*.

Output of first stage = *G*1*V*

Output of second stage = (*G*1*V*) *G*2 = *G*1*G*2*V*

Output of third stage = $(G1G2V)G3 = G1G2G3V$

Total gain, $G = \frac{\text{Output of third stage}}{\text{V}}$

or $G = \frac{G1G2\ G3V}{V} = G1 \times G2 \times G3$

(*ii*) Frequency response

The voltage gain of an amplifier varies with signal frequency. It is because reactance of the capacitors in the circuit changes with signal frequency and hence affects the output voltage. The curve between voltage gain and signal frequency of an amplifier is known as *frequency response*.Fig.4 shows the frequency response of a typical amplifier. The gain of the amplifier increases as the frequency increases from zero till it becomes maximum at *fr*, called *resonant frequency*. If the frequency of signal increases beyond *fr*, the gain decreases.

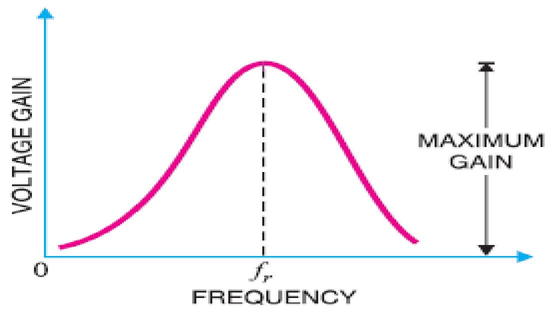


Fig.4: frequency response of a typical amplifier