Semiconductor Devices, Analog and Digital Electronics

BLOCK – I SEMICONDUCTOR DIODES, TRANSISTORS AND AMPLIFIERS

UNIT 5: RC Coupled amplifier

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Content

1. Amplifier
2. Amplifier Classification
3. RC Coupling Amplifier
4. Construction of RC Coupling Amplifier
5. Operation of RC Coupling Amplifier
6. Frequency Response of RC Coupled Amplifier
7. Advantages of RC Coupled Amplifier
8. Disadvantages of RC Coupled Amplifier
9. Application of RC Coupled Amplifier

Objective

After studying this unit students can:

- Define Amplifier
- Classified amplifier based on different types
- Define RC Coupling Amplifier
- Define operation and construction of RC Coupling Amplifier
- Describe frequency Response of RC Coupled Amplifier
- Define advantages, disadvantages and applications of RC Coupled Amplifier
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Amplifiers

An Amplifier circuit is one which strengthens the signal. The amplifier action and the important considerations for the practical circuit of transistor amplifier were also detailed in previous chapters.

Amplifiers Classification

Let us now try to understand the classification of amplifiers. Amplifiers are classified according to many considerations.

Based on number of stages

Depending upon the number of stages of Amplification, there are Single-stage amplifiers and Multi-stage amplifiers.

Single-stage Amplifiers – This has only one transistor circuit, which is a single stage amplification.

Multi-stage Amplifiers – This has multiple transistor circuit, which provides multi-stage amplification.

Based on its output

Depending upon the parameter that is amplified at the output, there are voltage and power amplifiers.

Voltage Amplifiers – The amplifier circuit that increases the voltage level of the input signal, is called as Voltage amplifier.

Power Amplifiers – The amplifier circuit that increases the power level of the input signal, is called as Power amplifier.

Based on the input signals

Depending upon the magnitude of the input signal applied, they can be categorized as Small signal and large signal amplifiers.

Small signal Amplifiers – When the input signal is so weak so as to produce small fluctuations in the collector current compared to its quiescent value, the amplifier is known as Small signal amplifier.

Large signal amplifiers – When the fluctuations in collector current are large i.e. beyond the linear portion of the characteristics, the amplifier is known as large signal amplifier.

Based on the frequency range

Depending upon the frequency range of the signals being used, there are audio and radio amplifiers.

Audio Amplifiers – The amplifier circuit that amplifies the signals that lie in the audio frequency range i.e. from 20Hz to 20 KHz frequency range, is called as audio amplifier.

Power Amplifiers – The amplifier circuit that amplifies the signals that lie in a very high frequency range, is called as Power amplifier.

Based on Biasing Conditions

Depending upon their mode of operation, there are class A, class B and class C amplifiers.

Class A amplifier – The biasing conditions in class A power amplifier are such that the collector current flows for the entire AC signal applied.

Class B amplifier – The biasing conditions in class B power amplifier are such that the collector current flows for half-cycle of input AC signal applied.

Class C amplifier – The biasing conditions in class C power amplifier are such that the collector current flows for less than half cycle of input AC signal applied.

Class AB amplifier – The class AB power amplifier is one which is created by combining both class A and class B in order to have all the advantages of both the classes and to minimize the problems they have.

Based on the Transistor Configuration

Depending upon the type of transistor configuration, there are CE CB and CC amplifiers.

CE amplifier – The amplifier circuit that is formed using a CE configured transistor combination is called as CE amplifier.

CB amplifier – The amplifier circuit that is formed using a CB configured transistor combination is called as CB amplifier.

CC amplifier – The amplifier circuit that is formed using a CC configured transistor combination is called as CC amplifier.

Based on the Coupling method

Depending upon the method of coupling one stage to the other, there are RC coupled, Transformer coupled and direct coupled amplifier.

RC Coupled amplifier – A Multi-stage amplifier circuit that is coupled to the next stage using resistor and capacitor (RC) combination can be called as a RC coupled amplifier.

Transformer Coupled amplifier – A Multi-stage amplifier circuit that is coupled to the next stage, with the help of a transformer, can be called as a Transformer coupled amplifier.

Direct Coupled amplifier – A Multi-stage amplifier circuit that is coupled to the next stage directly, can be called as a direct coupled amplifier.

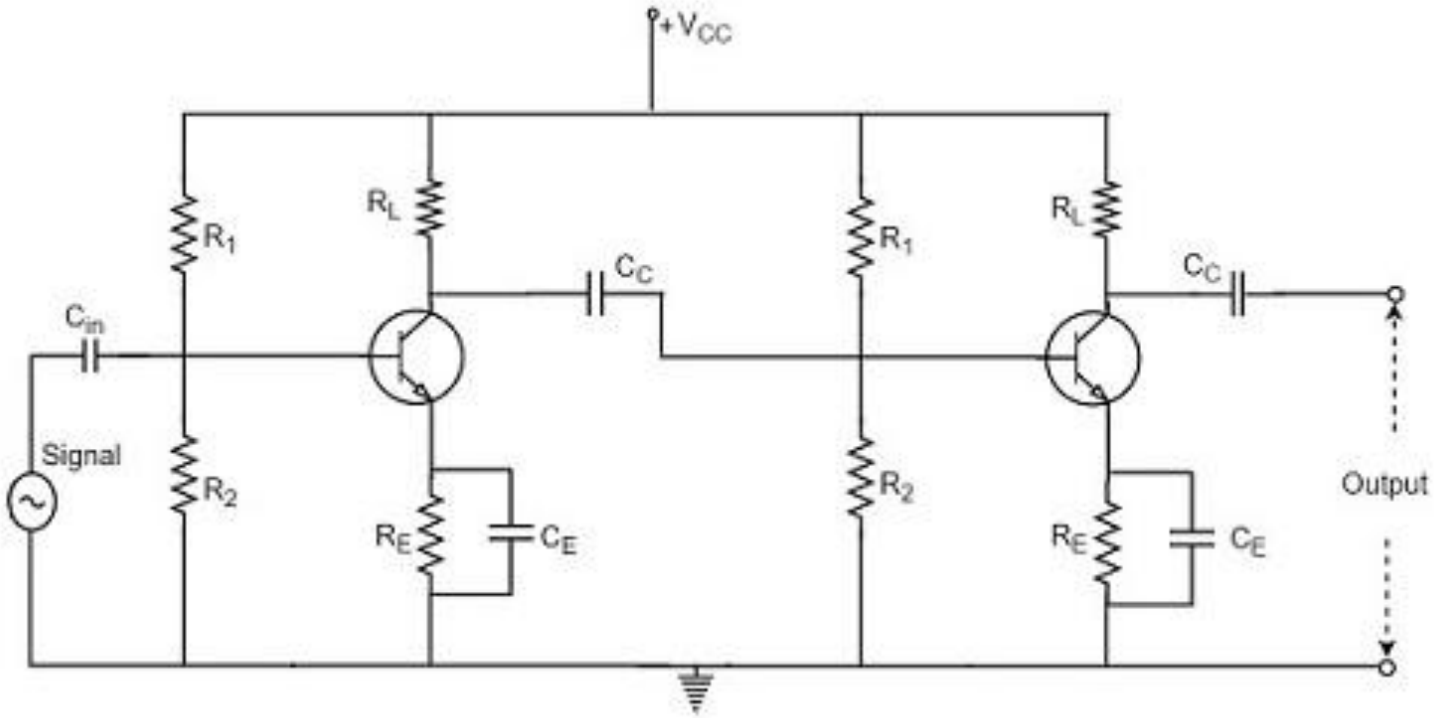
RC Coupling Amplifier

The resistance-capacitance coupling is, in short termed as RC coupling. This is the mostly used coupling technique in amplifiers.

Construction of a Two-stage RC Coupled Amplifier

The constructional details of a two-stage RC coupled transistor amplifier circuit are as follows. The two stage amplifier circuit has two transistors, connected in CE configuration and a common power supply V_{CC} is used. The potential divider network R_1 and R_2 and the resistor R_e form the biasing and stabilization network. The emitter by-pass capacitor C_e offers a low reactance path to the signal.

The resistor R_L is used as a load impedance. The input capacitor C_{in} present at the initial stage of the amplifier couples AC signal to the base of the transistor. The capacitor C_C is the coupling capacitor that connects two stages and prevents DC interference between the stages and controls the shift of operating point. The figure below shows the circuit diagram of RC coupled amplifier.



Operation of RC Coupled Amplifier

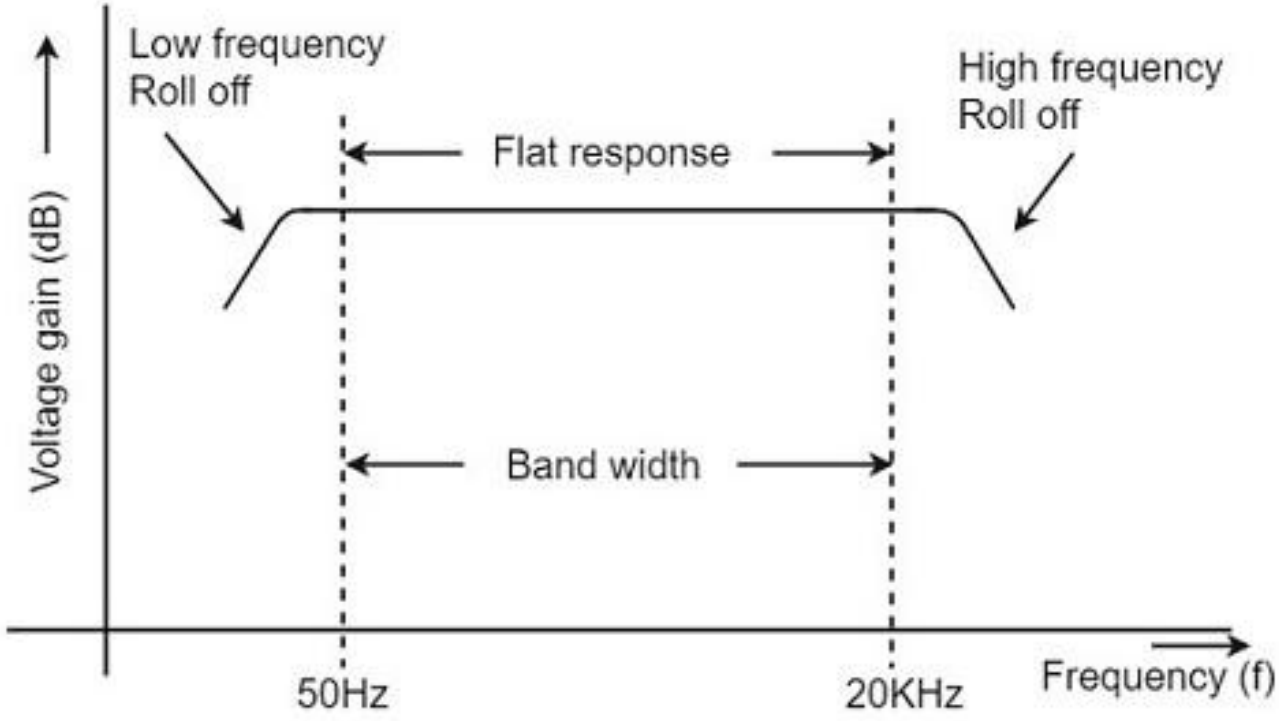
When an AC input signal is applied to the base of first transistor, it gets amplified and appears at the collector load R_L which is then passed through the coupling capacitor C_C to the next stage. This becomes the input of the next stage, whose amplified output again appears across its collector load. Thus the signal is amplified in stage by stage action.

The important point that has to be noted here is that the total gain is less than the product of the gains of individual stages. This is because when a second stage is made to follow the first stage, the **effective load resistance** of the first stage is reduced due to the shunting effect of the input resistance of the second stage. Hence, in a multistage amplifier, only the gain of the last stage remains unchanged.

As we consider a two stage amplifier here, the output phase is same as input. Because the phase reversal is done two times by the two stage CE configured amplifier circuit.

Frequency Response of RC Coupled Amplifier

Frequency response curve is a graph that indicates the relationship between voltage gain and function of frequency. The frequency response of a RC coupled amplifier is as shown in the following graph.



From the above graph, it is understood that the frequency rolls off or decreases for the frequencies below 50Hz and for the frequencies above 20 KHz. whereas the voltage gain for the range of frequencies between 50Hz and 20 KHz is constant.

$$X_C=1/2\pi f_c$$

It means that the capacitive reactance is inversely proportional to the frequency.

At Low frequencies (i.e. below 50 Hz)

The capacitive reactance is inversely proportional to the frequency. At low frequencies, the reactance is quite high. The reactance of input capacitor C_{in} and the coupling capacitor C_C are so high that only small part of the input signal is allowed. The reactance of the emitter by pass capacitor C_E is also very high during low frequencies. Hence it cannot shunt the emitter resistance effectively. With all these factors, the voltage gain rolls off at low frequencies.

At High frequencies (i.e. above 20 KHz)

Again considering the same point, we know that the capacitive reactance is low at high frequencies. So, a capacitor behaves as a short circuit, at high frequencies. As a result of this, the loading effect of the next stage increases, which reduces the voltage gain. Along with this, as the capacitance of emitter diode decreases, it increases the base current of the transistor due to which the current gain (β) reduces. Hence the voltage gain rolls off at high frequencies.

At Mid-frequencies (i.e. 50 Hz to 20 KHz)

The voltage gain of the capacitors is maintained constant in this range of frequencies, as shown in figure. If the frequency increases, the reactance of the capacitor C_C decreases which tends to increase the gain. But this lower capacitance reactive increases the loading effect of the next stage by which there is a reduction in gain.

Due to these two factors, the gain is maintained constant.

Advantages of RC Coupled Amplifier

The following are the advantages of RC coupled amplifier.

•The frequency response of RC amplifier provides constant gain over a wide frequency range, hence most suitable for audio applications.

•The circuit is simple and has lower cost because it employs resistors and capacitors which are cheap.

•It becomes more compact with the upgrading technology.

Disadvantages of RC Coupled Amplifier

The following are the disadvantages of RC coupled amplifier.

- The voltage and power gain are low because of the effective load resistance.
- They become noisy with age.
- Due to poor impedance matching, power transfer will be low.

Applications of RC Coupled Amplifier

The following are the applications of RC coupled amplifier.

- They have excellent audio fidelity over a wide range of frequency.
- Widely used as Voltage amplifiers.
- Due to poor impedance matching, RC coupling is rarely used in the final stages.

Some Useful links

https://www.youtube.com/watch?v=BSR26SU3R2U

https://www.youtube.com/watch?v=uwvg5VfHiYE

https://www.youtube.com/watch?v=-B00z6cBnnQ

Thanks