VIVEKANANDA COLLEGE

THAKURPUKUR

KOLKATA-700063

NAAC ACCREDITED 'A' GRADE

Topic	**: Transistor Amplifier**
Course Title	**: Analog Systems and Applications**
Paper	**: PHS-A-CC-4-10-TH**
Unit	**:**
Semester	**: 4th**
Name of the Teacher	**: Somnath Paul**
Name of the Department	**: Physics**

Transistor Amplifier

Introduction:

An amplifier is an electronic device which is capable to enlarge but exact replica of an input signal, i.e. an amplifier receives a signal from some input source and provides a large version of the input signal to some output device or to another amplifier stage. Depending on the nature and level of amplification and the impedance matching requirements, different types of amplifiers can be considered.

Classification of Amplifier:

Amplifier can be classified as follows

1. Based on the transistor configuration
   - 1.1. Common Emitter (CE) Amplifier
   - 1.2. Common-Base (CB) Amplifier
   - 1.3. Common Collector(CC) Amplifier
2. Based on active device
   - 2.1. BJT Amplifier
   - 2.2. FET Amplifier
3. Based on Q-points (Operating points)
   - 3.1. Class A Amplifier
   - 3.2. Class B Amplifier
   - 3.3. Class AB Amplifier
   - 3.4. Class C Amplifier
4. Based on number of stages
   - 4.1. Single Stage Amplifier
   - 4.2. Multi Stage Amplifier
5. Based on output
   - 5.1. Voltage amplifier
   - 5.2. Current amplifier
   - 5.3. Power amplifier
6. Based on frequency responses
   - 6.1. Audio frequency (AF) Amplifier
   - 6.2. Intermediate frequency (IF) Amplifier
   - 6.3. Radio frequency (RF) Amplifier
7. Based on Band width
   - 7.1. Narrow band Amplifier
   - 7.2. Wide band Amplifier

BJT Transistor Amplifier:

CE Amplifier:

Figure 1 shows the circuit of a single stage CE amplifier using an npn transistor. The quiescent point is determined by V_{CC}, R_B and R_C. The input signal is applied to the base emitter circuit and the amplified output signal is taken from the collector emitter circuit.C1 and C2 are coupling (or, blocking) capacitors to provide dc isolation at the input and output of the amplifier.

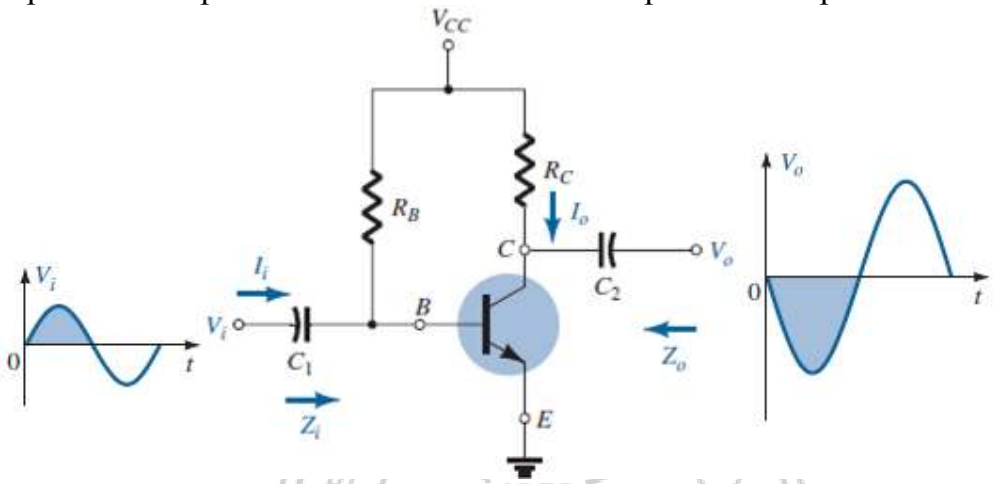


Fig 1

Referring to fig 1, when no ac signal is given, i.e., under dc conditions,

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} \approx \frac{V_{CC}}{R_B}$$

$$I_C = \beta I_B$$

$$V_{CE} = V_{CC} - R_C I_C$$

When a sinusoidal ac signal is applied at the input terminals of the circuit, during the positive half cycle, the forward bias of the base-emitter junction V_{BE} is increased, resulting in an increase in I_B. The collector current is increased by β times the increase in I_B. From the above equation V_{CE} is correspondingly decreased, i.e., the output voltage gets decreased as shown in fig 1.

Thus, CE amplifier, a positive going input signal is converted into a negative going output signal, i.e., a 180^0 phase shift is introduced between the output and input signal and further, the output signal is an amplified version of the input signal.

CB Amplifier:

Figure 2 shows the circuit of a single stage CB amplifier using an npn transistor. The emitter-base junction is forward biased by the power supply V_{EE}, and the collector base junction is reverse biased by V_{CC}. The operating point is

determined by dc batteries along with resistors R_E and R_C. The input signal is given to the emitter-base circuit and the output signal is taken from the collector-base circuit.

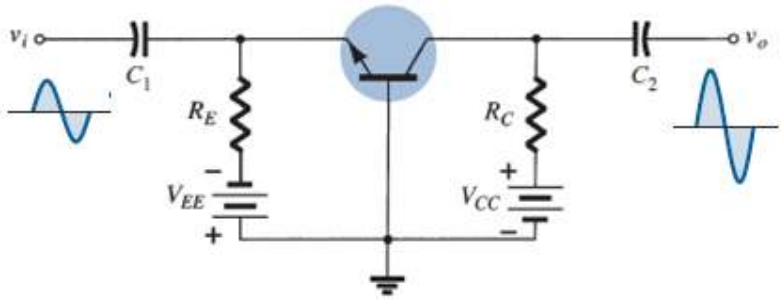


Fig 2

The output voltage is given by the equation

$$V_0 = V_{CB} = V_{CC} - R_C I_C$$

When a sinusoidal ac signal is applied at the input terminals of the circuit, during the positive half cycle, the forward bias of the base-emitter junction V_{BE} is decreased, resulting in a decrease in I_B. As a result I_E ($\approx \beta I_B$) and hence, the collector current I_C also decreases. From the above equation the drop $R_C I_C$ decreases, hence $V_0 = V_{CB}$ correspondingly increases. Thus, a positive half cycle appears at the output without any phase reversal as shown in fig 2.

CC Amplifier:

Figure 3 shows the circuit of a single stage CC amplifier using an npn transistor. The quiescent point is determined by V_{CC}, R_1, R_2 and R_E. The input signal is applied to the base-collector circuit and the output signal is taken from the emitter-collector circuit.

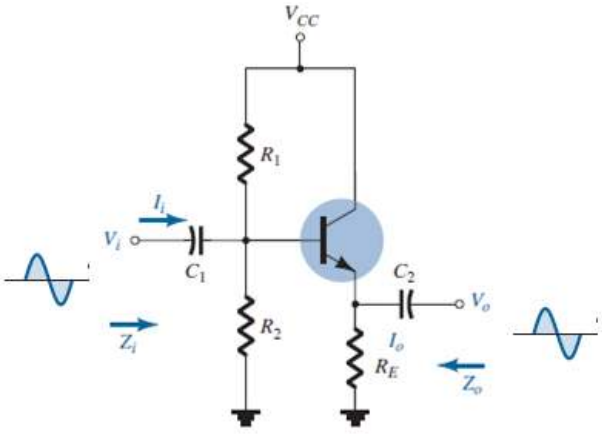


Fig 3

From above figure the output voltage can be written as

$$V_0 = R_E I_E = \beta R_E I_B$$

When a sinusoidal ac signal is applied at the input, during the positive half cycle of the input signal applied, the base potential increases, thereby increasing the base current IB. Hence, emitter current IE increases and voltage drop across RE, i.e., the output voltage increases.

Thus, a positive going input signal results in a positive going output signal as shown in fig 3. Hence, in a CC amplifier, input and output signals are in phase with each other and further, the voltage gain is approximately unity.

As the output signal taken at the emitter terminal almost follows the input signal, the CC amplifier is called the **E*mitter Follower***.

Comparison between CE, CB and CC Amplifier:

Properties	Common Emitter (C-E)	Common Base (C-B)	Common Collector (C-C)
Current Gain	Large	Less than unity	High
Voltage gain	Large	High	Unity
Power gain	Large	Approximately equal to voltage gain	Approximately equal to current gain
Phase shift	180	No phase shift	No phase shift
Input impedance	Moderate	Small	Large
Output impedance	Moderate	Large	Small
Application	Of the three configuration, the CE amplifier along is capable of providing both voltage and current gain. It is widely used for amplification purpose	It used for 1. Matching a very low impedance source 2. Driving high impedance load. 3. As a constant current source	It is widely used as a buffer stage between a high-impedance source and a low impedance load

Classification of Amplifier Based on Q-points:

One method used to categorize amplifier is by Class. Basically, amplifier classes represent the amount of the output signal varies over one cycle of operation for a full cycle of the input signal

According to the position of the operating point there are four different amplifier called Class A, B, AB and C. Now a day there exist another type amplifier called Class D.

A Class-A amplifier is one in which the operating point and the input signal are such that the current in the output circuit flows at all times i.e. the output varies for a full 360^0 of the input cycle. This amplifier operates essentially over a linear portion of its characteristics. In this case preferable choice of operating point is the middle of the load line as shown in fig 4. Fig 5 represents the output voltage variation with time for Class-A amplifier.

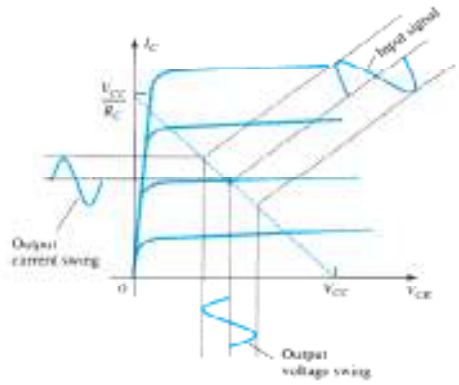


Fig 4

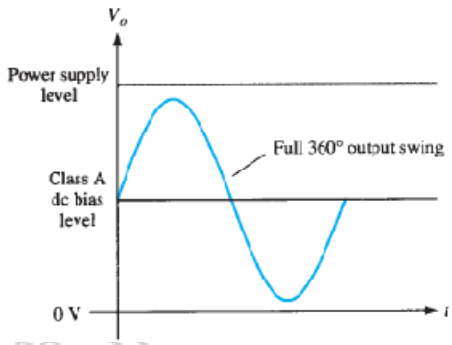


Fig 5

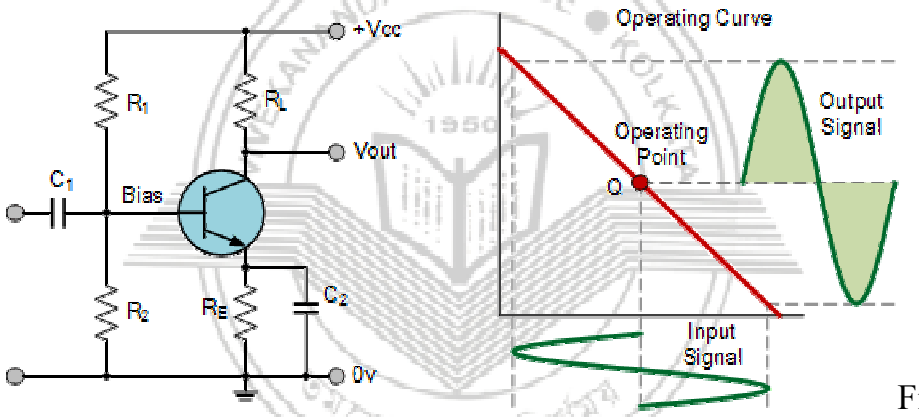


Fig 6

A Class-B amplifier provides an output signal varying over one half the input signal cycle or 180^0 of the input signal. In this case choice of the operating point is at an extreme end of its characteristics as shown in fig 7, so that quiescent power is very small. Hence either the quiescent current or voltage is approximately zero.

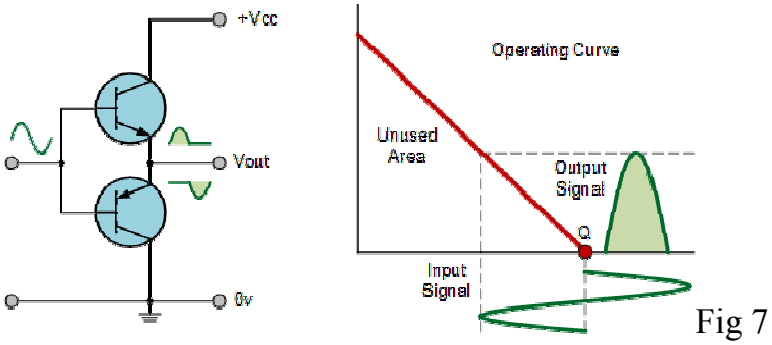


Fig 7

A Class-AB amplifier is one which operating between two extremes defined for Class-A and Class-B. In this case the output signal swings occurs between 180^0 and 360^0. The choice of the operating point and circuit diagram of a Class AB amplifier represent as shown in fig 8.

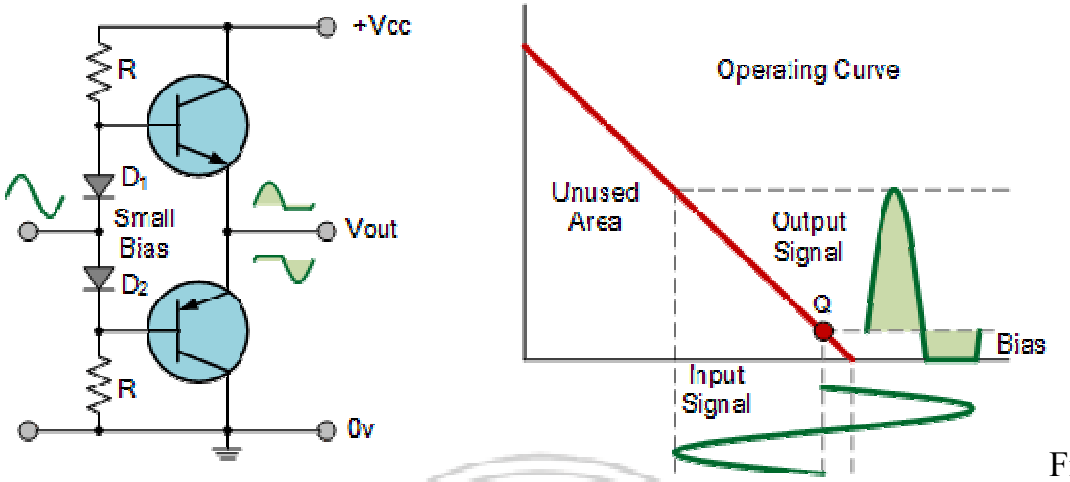


Fig 8

A Class-C amplifier provides an output signal varying less than half the input signal cycle or below of the 180^0 of the input signal and will operates only with a tuned (resonant) circuit, which provides a full cycle of operation for the tuned or resonant frequency. This operating class is therefore used in special areas of tuned circuits, such as radio or communications. The choice of the operating point and circuit diagram of a Class C amplifier represent as shown in fig 9.

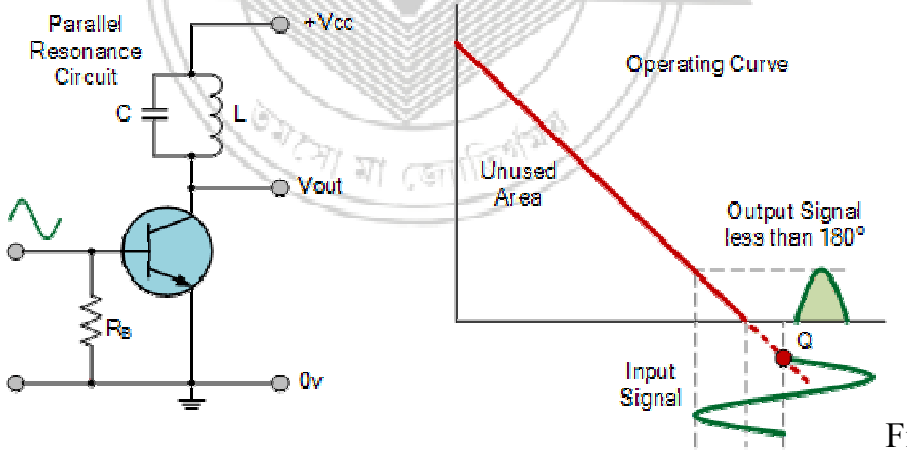
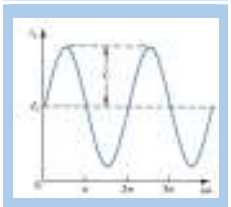
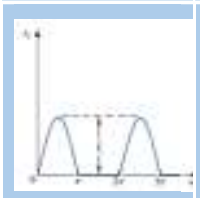
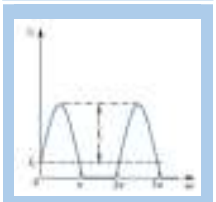
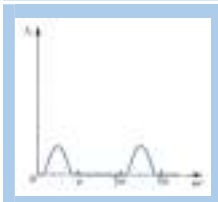


Fig 9

A Class-D is a form of amplifier operation using pulse (digital) signals, which are on for a short interval and off for a longer interval. Using digital techniques makes it possible to obtain a signal that varies over the full cycle (using sample and-hold circuitry) to recreate the output from many pieces of input signal. The major advantage of class D operation is that the amplifier is

"on" (using power) only for short intervals and the overall efficiency can practically be very high.

	Class-A	Class-B	Class-AB	Class-C	Class-D
Operating Cycle	360°	180°	180° to 360°	Less than 180°	Pulse operation
Power Efficiency	25% with a direct or series-fed load connection 50% with a transformer connection to the load	78.5%	Between 25%(50%) and 78.5%	≈ 100%	Typically over 90%
Collector current with time					
Where used	Low-power amplifier where efficiency is not important	Output power amp; may use Darlington configurations and diodes for biasing	Output power amp; may use Darlington configurations and diodes for biasing	Tuned RF power amplifier; final amp stage in communications circuits	Class-D amplifiers use some form of pulse-width modulation to control the output devices

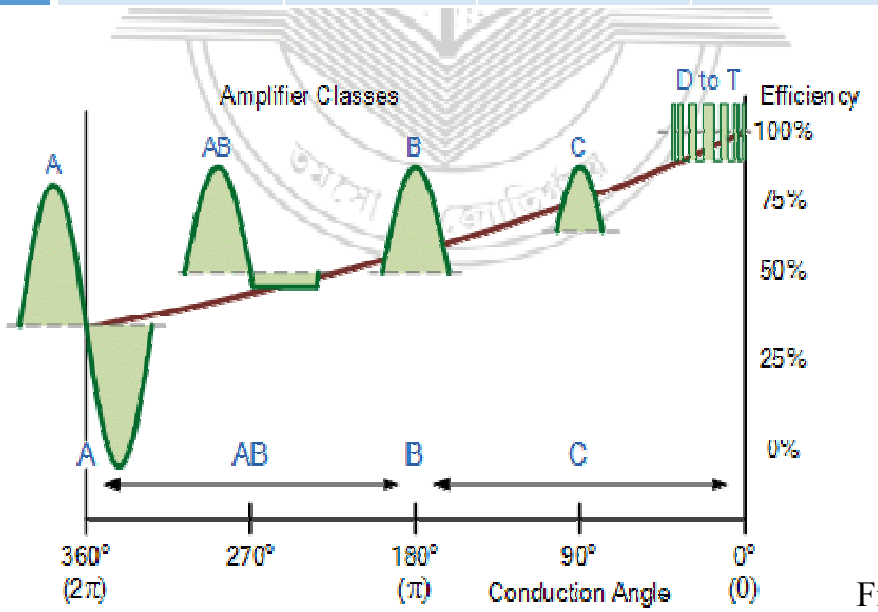


Fig 10

Figure 10 represent the summary of various Amplifier Classes.