B.SC PHYSICS

SEMESTER IV
PHYCC410

UNIT 3(A): AMPLIFIERS

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POWER AMPLIFIER

Introduction

The transistor amplifier may be classified as to their usage, frequency capabilities, coupling methods and mode of operation.

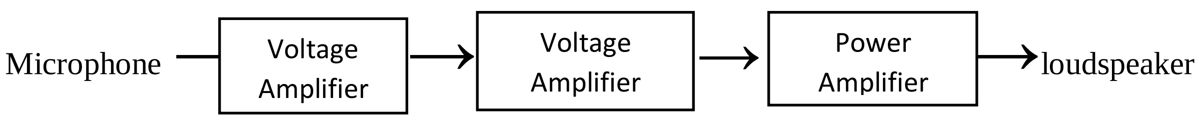
(i) According to use. The classification of amplifiers as to usage are basically voltage amplifiers and power amplifiers. The former primarily increases the voltage level of the signal whereas the latter mainly increases the power level of the signal.

(ii) According to frequency capabilities. According to frequency capabilities amplifiers are classified as audio amplifiers, radio frequency amplifiers etc. The former are used to amplify the signals lying in the audio range i.e 20Hz to 20kHz whereas the latter are used to amplify signals having very high frequency.

(iii) According to coupling methods. The output from a single stage amplifier is usually insufficient to meet the practical requirements. Additional amplification is often necessary. To do this the output of one stage is coupled to the next stage. Depending upon the coupling device used the amplifiers are classified as RC coupled amplifiers, transformer coupled amplifiers etc.

(iv) According to mode of operation. The amplifiers are frequently classified according to their mode of operation as class A, class B, class C amplifiers. The classification depends on the portion of the input signal cycle during which collector current is expected to flow.

A practical amplifier always consists of a number of stages that amplify a weak signal until sufficient power is available to operate a loudspeaker or other output devices. The first few stage is designed to provide maximum power. The final stage is known as power stage.



The early stages build up the voltage level of the signal while the last stage builds up power to a level sufficient to operate the loudspeaker.

Transistor Audio Power Amplifier

A transistor amplifier which raises the power level of the signals that have audio frequency range is known as transistor audio power amplifier. A transistor that is suitable for power amplification is generally called a power transistor. The power transistor is considerably larger in size to provide for handling the great amount of power.

Difference between Voltage and Power Amplifier

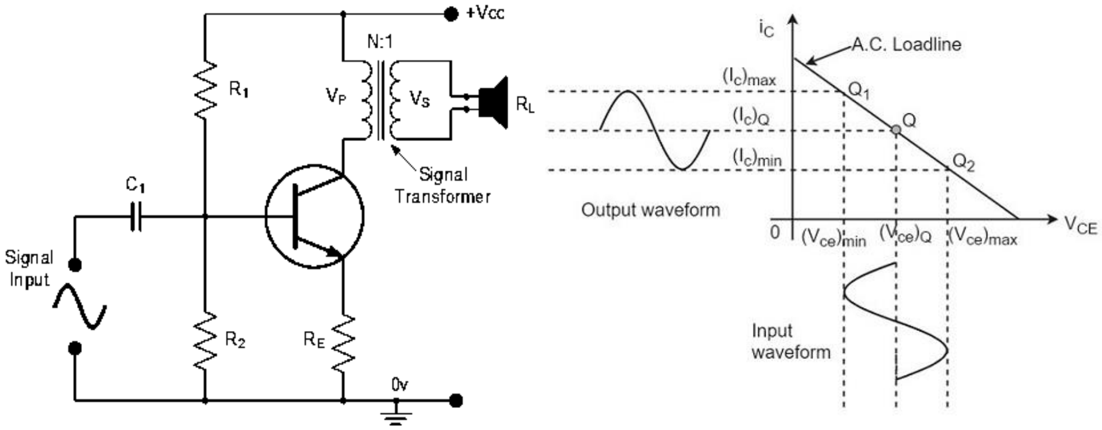
Voltage Amplifier	Power Amplifier
In voltage amplifier the amplitude of input A.C signal is small.	In power amplifier the amplitude of input A.C signal is large.
In voltage amplifier the collector current is low, about 1 mA.	In power amplifier the collector current is very high above greater than 100mA.
The transistor used can dissipate less heat produced during its operation.	The transistor used can dissipate more heat produced as compared to voltage amplifier during its operation.
RC coupling is used in voltage amplifier.	In power amplifier invariably transformer coupling is used.
The transistor used has thin base to handle low current. That means the transistor with high $\beta > 100$ is used in the circuit.	The transistor used has thick base to handle large current. In other words transistor with comparatively smaller β are used.
In voltage amplifier the A.C power output is low.	In power amplifier the A.C power output is high.
The physical size of transistor used is usually small and is known as low or medium power transistor.	The physical size of transistor used is usually large and is known as power transistor.
In voltage amplifier the collector load has high resistance, typically 4kΩ to 10kΩ.	In power amplifier the collector load has low resistance, typically 5Ω to 20Ω.

Classification of Power Amplifier

Transistor power amplifiers handle large signals. Many of them are driven so hard by the input large signal that collector current is either cut-off or is in the saturation region during a large portion of the input cycle. Therefore , such amplifiers are generally classified according to their mode of operation i.e the portion of the input cycle during which the collector current is expected to flow.. On the basis, they are classified as:

(i)class A power amplifier (ii) class B power amplifier (iii) class C power amplifiers

Class A power amplifier : If the collector current flows at all times during the full cycle of the signal the power amplifier is known as class A power amplifier.



The operating point of this amplifier is present in the linear region. It is so selected that the current flows for the entire ac input cycle. The power amplifier must be biased in such a way that no part of the signal is cut off. As the output wave shape is exactly similar to the input wave shape, therefore such amplifiers have least distortion.They have the disadvantage of low power output and low collector efficiency.

Advantages of Class A Amplifiers

The advantages of Class A power amplifier are as follows −

- The current flows for complete input cycle
- It can amplify small signals
- The output is same as input
- No distortion is present

Disadvantages of Class A Amplifiers

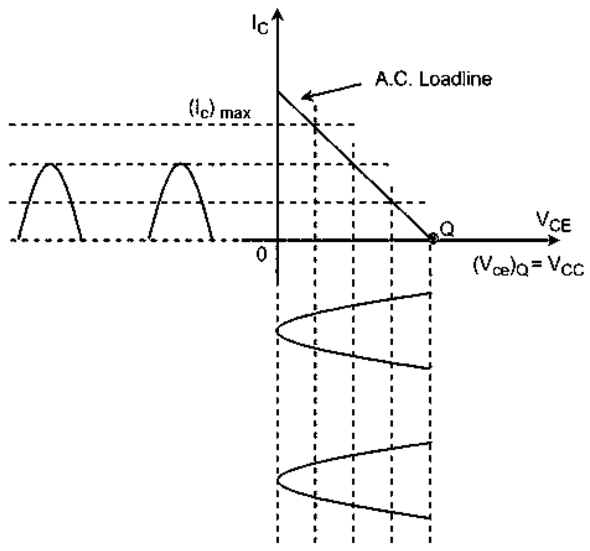
The advantages of Class A power amplifier are as follows −

- Low power output
- Low collector efficiency

Class B power Amplifiers: If the collector current flow only during the positive half cycle of the input signal it is called a class B power amplifier.

In class B operation, the transistor bias is so adjusted that zero signal collector current is zero i.e no biasing circuit is needed at all. During the positive half-cycle of the signal the input circuit is forward biased and hence collector current flows. However during the negative half cycle of the signal the input circuit is reversed bias and no collector current flows. The operating point Q is located at collector cut off voltage. The output from a class B amplifier is amplified half-wave rectification. In a class B amplifier, the negative half cycle of the signal is cut off and hence a severe distortion occurs. However, class B amplifiers provide higher power output and collector efficiency (50% - 60%). Such amplifiers are mostly used for power amplification in push pull arrangement in order to minimize the disadvantages and achieve low distortion, high efficiency and high output power.

The figure below shows the input and output waveforms during class B operation.



(iii) **Class C power Amplifiers**: If the collector current flows for less than half-cycle of the

input signal, it is called class C amplifiers. In class C amplifier the base is given some negative bias so that collector current does not flow just when the positive half cycle of the signal starts. Such amplifiers are never used for power amplification. They are used as tuned amplifiers.

Expression for Collector Efficiency

For comparing power amplifiers, collector efficiency is the main criterion. The greater the collector efficiency,the better is the power amplifiers.

Now, Collector efficiency,

$$\eta = \frac{a.c\ power\ output}{dc\ power\ input}$$

$$= \frac{P_{ac}}{P_{dc}}$$

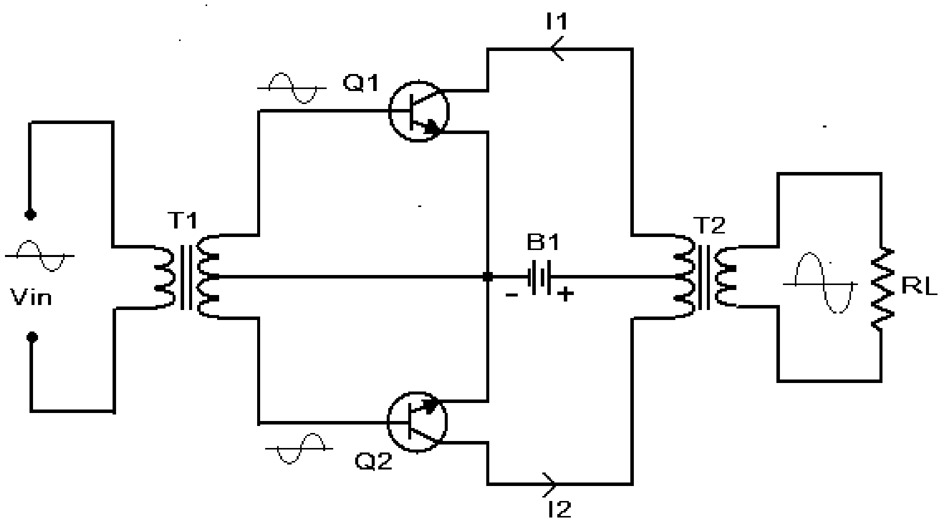
where,

$$P_{dc} = V_{cc} I_c$$

$P_{ac} = V_{ce} I_c$ wher V_{ce} is the rms value of signal output voltage and I_c is the rms value of output signal current.

Push-Pull Amplifier

The push pull amplifier is a power amplifier and is frequently employed in the output stages of electronic circuits. It is used whenever low distortion, high efficiency and high output power are required. A push pull amplifier is an amplifier which has an output stage that can drive a current in either direction through the load. The output stage of a typical push pull amplifier consists of of two identical BJTs one sourcing current through the load while the other one sinking the current from the load. Figure shows the circuit of a push pull amplifier. T wo transistor Q1 and Q2 placed back to back are employed . Both transistor are operated in class B operation i.e collector current is nearly zero in the absence of the signal. The centre tapped secondary of driver transformer T1 supplies equal and opposite voltages to the base circuits of two transistors. The output transformer T2 has the centre tapped primary winding. The supply voltage Vcc is connected between the bases and this centre tap. The loudspeaker is connected across the secondary of this transformer.



Circuit operation: The input signal appears across the secondary coil of driver transformer. Suppose during the first half cycle (upper portion of Vin i.e positive half) of the signal upper part of secondary of the transformer T1 becomes positive and lower part of secondary of the transformer T1 becomes negative. This will make the base emitter junction of Q1 reversed bias and that of Q2 forward biased. The circuit will conduct current due to Q2 only. Therefore this half cycle of the signal is amplified byQ2 and appears in the lower half of the primary of output transformer. In the next half cycle of the signal Q1 is forward bias whereas Q2 is reversed bias .Therefore Q1 conducts. Consequently, this half cycle of the signal is amplified by Q1and appears in the upper half of the output transformer primary. The centre-tapped primary of the output transformer combines two collector currents to form a sine wave output in the secondary. The push pull arrangement also permits a maximum transfer of power to the load through the impedance matching. If R_L is the resistance across secondary of output transformer, then resistance $R`_L$ of primary shall become:

$$R`_L = \left(\frac{2N1}{N2}\right)^2 R_L$$

where , N_1 = Number of turns between either end of primary winding and centre tap

N_2 = Number of secondary turns

Advantages

(i) The efficiency of the circuit is quite high due to class B operation.
(ii) Ahigh ac output power is obtained.

Disadvantage

(i) Two transistors have to be used.
(ii) It requires two equal and opposite voltages at the input. Therefore push pull circuit requires the use of driver stage to furnish these signals.
(iii) If the parameters of the two transistor ate not same, there will be unequal amplification of the two halves of the signal.
(iv) The circuit gives more distortion.
(v) Transformers used are bulky and expensive.

Power Efficiency of Class B Push-Pull Amplifier

The current in each transistor is the average value of half sine loop.

For half sine loop, I_{dc} is given by

$$I_{dc}=(I_C)_{max}\pi I_{dc}=(IC)max\pi$$

Therefore,

$$(p_{in})_{dc}=2\times[(I_C)_{max}\pi\times V_{CC}](pin)dc=2\times[(IC)max\pi\times VCC]$$

Here factor 2 is introduced as there are two transistors in push-pull amplifier.

R.M.S. value of collector current = $(I_C)_{max}/\sqrt{2}$ (IC)max/2
R.M.S. value of output voltage = $V_{CC}/\sqrt{2}$ VCC/2

Under ideal conditions of maximum power

Therefore,

$$(P_O)_{ac} = \frac{(I_C)_{max}}{\sqrt{2}} \times \frac{V_{CC}}{\sqrt{2}} = \frac{(I_C)_{max} \times V_{CC}}{2}$$ (PO)ac=(IC)max2×VCC2=(IC)max×VCC2

Now overall maximum efficiency

$$\eta_{overall} = \frac{(P_O)_{ac}}{(P_{in})_{dc}}$$ ηoverall=(PO)ac(Pin)dc

$$= \frac{(I_C)_{max} \times V_{CC}}{2} \times \frac{\pi}{2 (I_C)_{max} \times V_{CC}}$$ =(IC)max×VCC2×π2(IC)max×VCC

$$= \frac{\pi}{4} = 0.785 = 78.5\%$$ =π4=0.785=78.5%

The collector efficiency would be the same.

Hence the class B push-pull amplifier improves the efficiency than the class A push-pull amplifier.