POWER AMPLIFIERS

- In practice, any amplifier consists of few stages of amplification. If we consider audio amplification, it has several stages of amplification, depending upon our requirement.

General Concepts:

- A **power amplifier** is one that is designed to deliver a large amount of power to a load. To perform this function, a power amplifier must itself be capable dissipating large amounts of power; so that the heat generated when it is operated at high current and voltage levels is released into the surroundings at a rate fast enough to prevent destructive temperature buildup.
- Power amplifiers typically contain bulky components having large surface areas to enhance heat transfer to the environment. A power transistor is a discrete device with a large surface area and a metal case.
- A power amplifier is often the last stage of an amplifier system designed to modify signal characteristics referred to as signal conditioning. It is designed at least one of its semiconductor components, typically a power transistor, can be operated over substantially the entire range of its output characteristics, from saturation to cutoff. This mode of operation is called **large-signal operation**.
- The term "large-signal operation" is also applied to devices used in digital switching circuits. In these applications, the output level switches between "high" and "low" (cutoff and saturation), but remains in those states most of the time. Power dissipation is therefore not a problem.
- On the other hand, the variations in the output level of a power amplifier occur in the active region, between the two extremes of saturation and cutoff, so a substantial amount of power is dissipated. Large signal amplifiers also known as power amplifiers are capable of providing large amount of power to the load**.** They are used as last

stage in electronic systems. A power amplifier takes the d.c. power supply connected to the output circuit and converts it into a.c. signal power. Output power is controlled by input signal.

Power Amplifier

- After the audio signal is converted into electrical signal, it has several voltage amplifications done, after which the power amplification of the amplified signal is done just before the loud speaker stage. This is clearly shown in the below figure.

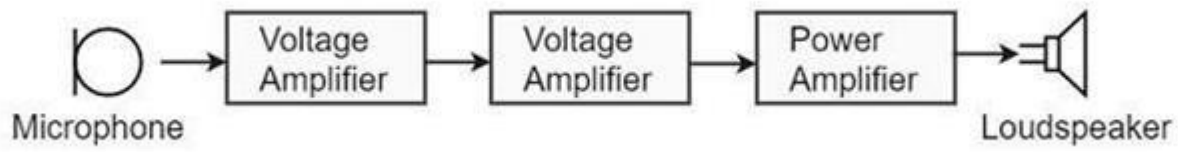

Fig.1 power amplification

(Source: Microelectronics byJ. Millman and A. Grabel, Page-484)

- While the voltage amplifier raises the voltage level of the signal, the power amplifier raises the power level of the signal. Besides raising the power level, it can also be said that a power amplifier is a device which converts DC power to AC power and whose action is controlled by the input signal.
- The DC power is
  distributed according to the ,
  DC power i/p = AC o/p + losses

Power Transistor

- For such Power amplification, a normal transistor would not do. A transistor that is manufactured to suit the purpose of power amplification is called as a **Power transistor**. A Power transistor differs from the other transistors, in the following factors.
  - It is larger in size, in order to handle large powers.

- The collector region of the transistor is made large and a heat sink is placed at thecollector-base junction in order to minimize heat generated.
- The emitter and base regions of a power transistor are heavily doped.
- Due to the low input resistance, it requires low input power.
- Hence there is a lot of difference in voltage amplification and power amplification. So, let us now try to get into the details to understand the differences between a voltage amplifier and a power amplifier.

Difference between Voltage and Power Amplifiers:

Let us try to differentiate betweenvoltage and power amplifier.

Voltage Amplifier

- The function of a voltage amplifier is to raise the voltage level of the signal. A voltageamplifier is designed to achieve maximum voltage amplification. The voltage gain of an amplifier is given by

$$Av=\beta(Rc/Rin)$$

The characteristics of a voltage amplifier are as follows −

- The base of the transistor should be thin and hence the value of β should be greaterthan 100.
- The resistance of the input resistor R_{in} should be low when compared to collectorload R_C.
- The collector load R_C should be relatively high. To permit high collector load, thevoltage amplifiers are always operated at low collector current.
- The voltage amplifiers are used for small signal voltages.

Power Amplifier

- The function of a power amplifier is to raise the power level of input signal. It is required todeliver a large amount of power and has to handle large current.

The characteristics of a power amplifier are as follows −

- The base of transistor is made thicken to handle large currents. The value of β being(β > 100) high.
- The size of the transistor is made larger, in order to dissipate more heat, which isproduced during transistor operation.
- Transformer coupling is used for impedance matching.
- Collector resistance is made low.

The comparison between voltage and power amplifiers is given below in a tabular form.

S.No	Particular	Voltage Amplifier	Power Amplifier
1	B	High (>100)	Low (5 to 20)
2	RC	High (4-10 KΩ)	Low (5 to 20 Ω)
3	Coupling	Usually R-C coupling	Invariably transformer coupling
4	Input voltage	Low (a few m V)	High (2-4 V)
5	Collector current	Low (≈ 1 mA)	High (> 100 mA)
6	Power output	Low	High
7	Output impendence	High (≈ 12 K Ω)	Low (200 Ω

- The Power amplifiers amplify the power level of the signal. This amplification is done in the last stage in audio applications. The applications related to radio frequencies employ radio power amplifiers. But the **operating point** of a transistor plays a very important role in determining the efficiency of the amplifier. The **main classification** is done based on this mode of operation. The classification is done based on their frequencies and also based on their modeof operation.

Classification Of Amplifiers

Classification Based on Frequencies

Power amplifiers are divided into two categories, based on the frequencies they handle. They are as follows.

- **Audio Power Amplifiers** − The audio power amplifiers raise the power level of signals that have audio frequency range (20 Hz to 20 KHz). They are also known as **Small signal power amplifiers**.
- **Radio Power Amplifiers** − Radio Power Amplifiers or tuned power amplifiers raise the power level of signals that have radio frequency range (3 KHz to 300 GHz). They are also known as **large signal power amplifiers**.

Classification Based on Mode of Operation

On the basis of the mode of operation, i.e., the portion of the input cycle during which collector current flows, the power amplifiers may be classified as follows.

- **Class A Power amplifier** − When the collector current flows at all times during the full cycle of signal, the power amplifier is known as **class A power amplifier**.
- **Class B Power amplifier** − When the collector current flows only during the positive half cycle of the input signal, the power amplifier is known as **class B power amplifier**.
- **Class C Power amplifier** − When the collector current flows for less than half cycle of the input signal, the power amplifier is known as **class C power amplifier**.
- **Class AB amplifier-** There forms another amplifier called Class AB amplifier, if we combine the class A and class B amplifiers so as to utilize the advantages of both. Before going into the details of these amplifiers, let us have a look at the important terms that have to be considered to determine the efficiency of an amplifier.

Terms Considering Performance

- The primary objective of a power amplifier is to obtain maximum output power. In order to achieve this, the important factors to be considered are collector efficiency, power dissipation capability and distortion. Let us go through them in detail.

Collector Efficiency

- This explains how well an amplifier converts DC power to AC power. When the DC supply is given by the battery but no AC signal input is given, the collector output at such a condition is observed as **collector efficiency**.
- The collector efficiency is defined as

η=average a.c power output / average d.c power input to transistor

- The main aim of a power amplifier is to obtain maximum collector efficiency. Hence thehigher the value of collector efficiency, the efficient the amplifier will be.

Power Dissipation Capacity

- Every transistor gets heated up during its operation. As a power transistor handles large currents, it gets more heated up. This heat increases the temperature of the transistor, which alters the operating point of the transistor. So, in order to maintain the operating point stability, the temperature of the transistor has to be kept in permissible limits. For this, the heat produced has to be dissipated. Such a capacity is called as Power dissipation capability.

- **Power dissipation capability** can be defined as the ability of a power transistor to dissipate the heat developed in it. Metal cases called heat sinks are used in order to dissipate the heat produced in power transistors.

Distortion

- A transistor is a non-linear device. When compared with the input, there occur few variations in the output. In voltage amplifiers, this problem is not pre-dominant as small currents are used. But in power amplifiers, as large currents are in use, the problem of distortion certainly arises. **Distortion** is defined as the change of output wave shape from the input wave shape of the amplifier. An amplifier that has lesser distortion, produces a better output and hence considered efficient. We have already come across the details of transistor biasing, which is very important for the operation of a transistor as an amplifier. Hence to achieve faithful amplification, the biasing of the transistor has to be done such that the amplifier operates over the linear region.