NEPAL ENGINEERING COUNCIL

Concept of Basic Electrical and Electronics Engineering

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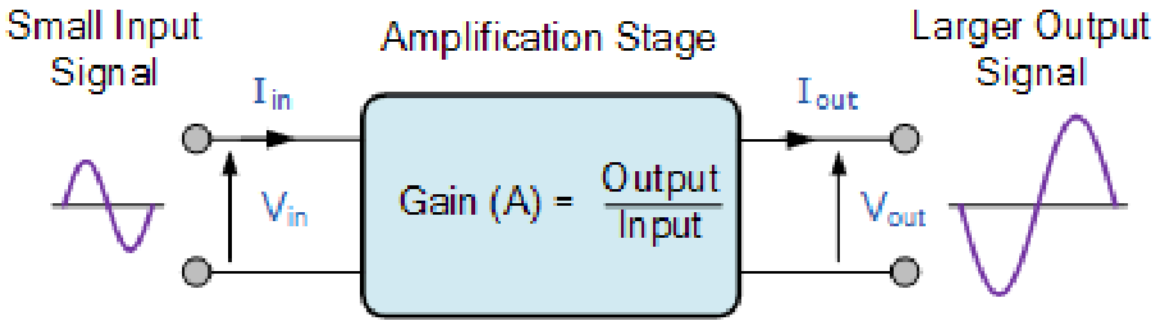
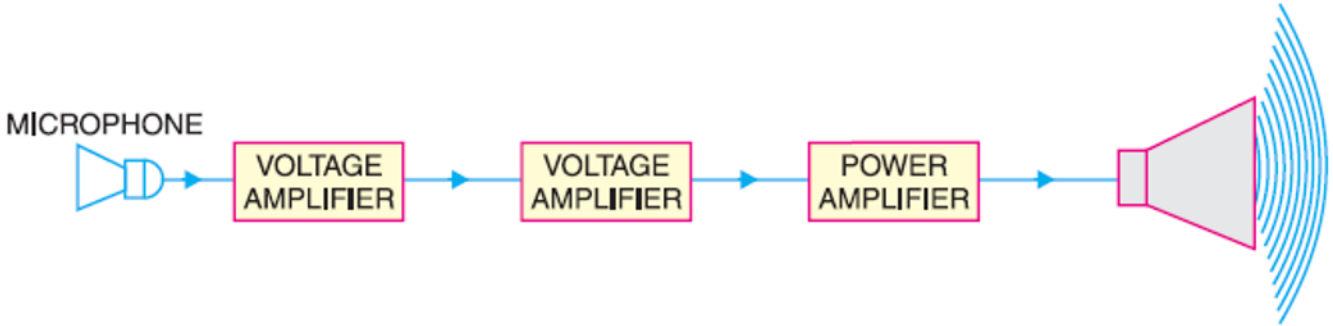
2024

Contents

1.6 Amplifiers: Classification of Output Stages, Class A Output Stage, Class B Output Stage, Class AB Output Stage, Biasing the Class AB Stage, Power BJTs, Transformer-Coupled Push-Pull Stages, and Tuned Amplifiers, op-amps.

Amplifier


Small Input Signal
Amplification Stage
Larger Output Signal
I_{in}
V_{in}
Gain (A) = Output / Input
I_{out}
V_{out}


MICROPHONE
VOLTAGE AMPLIFIER
VOLTAGE AMPLIFIER
POWER AMPLIFIER

Voltage amplifier

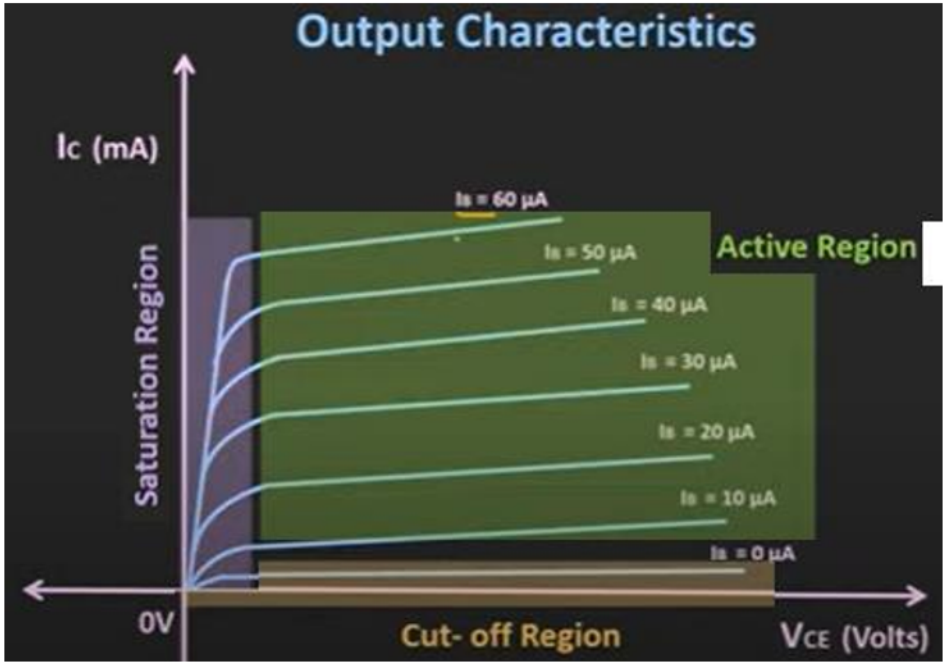
- Voltage amplifier is used to raise voltage level of weak signal.
- No need of heat sink in voltage amplifier.
- Distortion in output will be minimum.
- Size of transistor used is small.
- RC coupling is widely used.
- Used as first stage of amplifier.
- Output impedance is high.

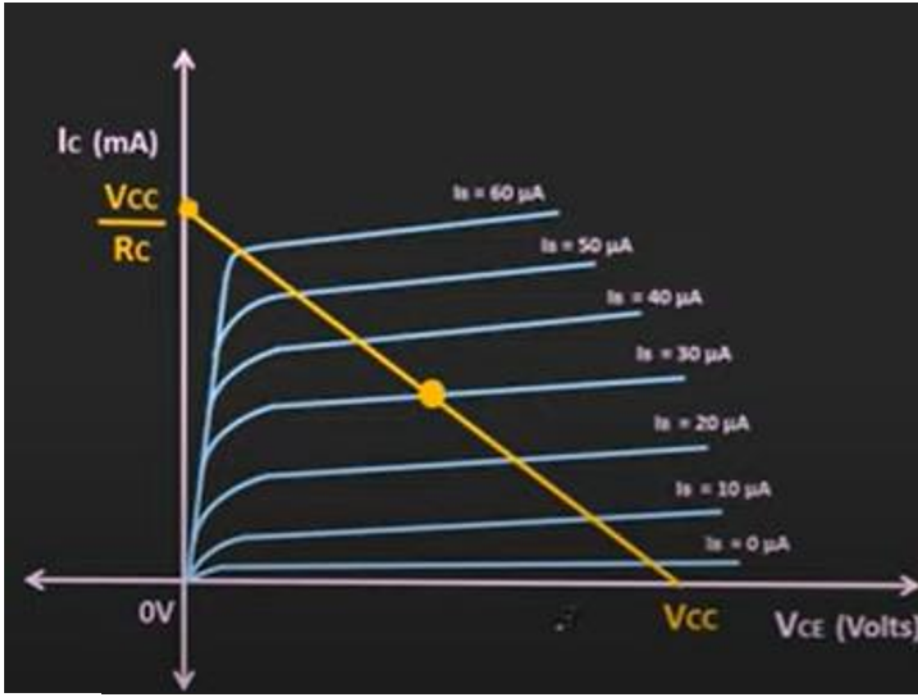
Power amplifier

- Power amplifier is used to raise power level of weak signal.
- Heat sink are used in power amplifier.
- Distortion in output will be minimum.
- Size of power transistor is large.
- Transformer coupling is widely used.
- Used as last stage of amplifier.
- Output impedance is low.

Rev: Load Line and Q point

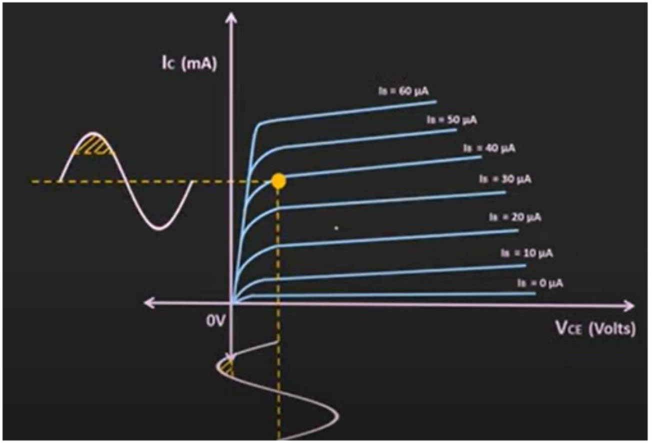
- For most commonly used CE configuration

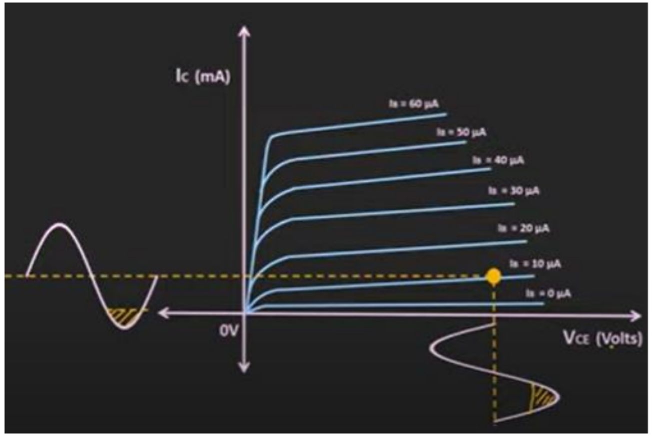


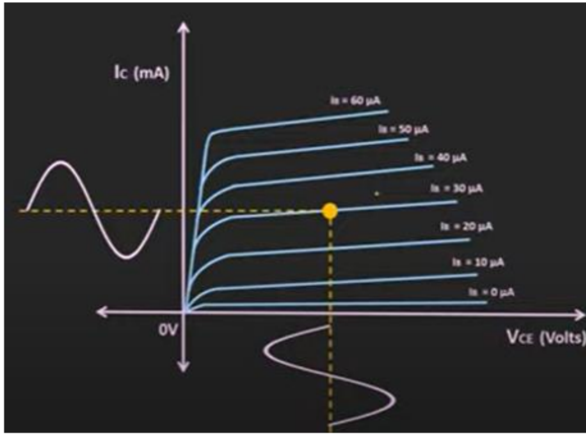


Rev: Position of Q point and Distortion

- If Q point is near to other region(Saturation or Cutoff), and AC is given input output AC signal of the amplifier can be distorted. Fig 1 and 2.
- But for Q point should be as fig 3 has no distortion

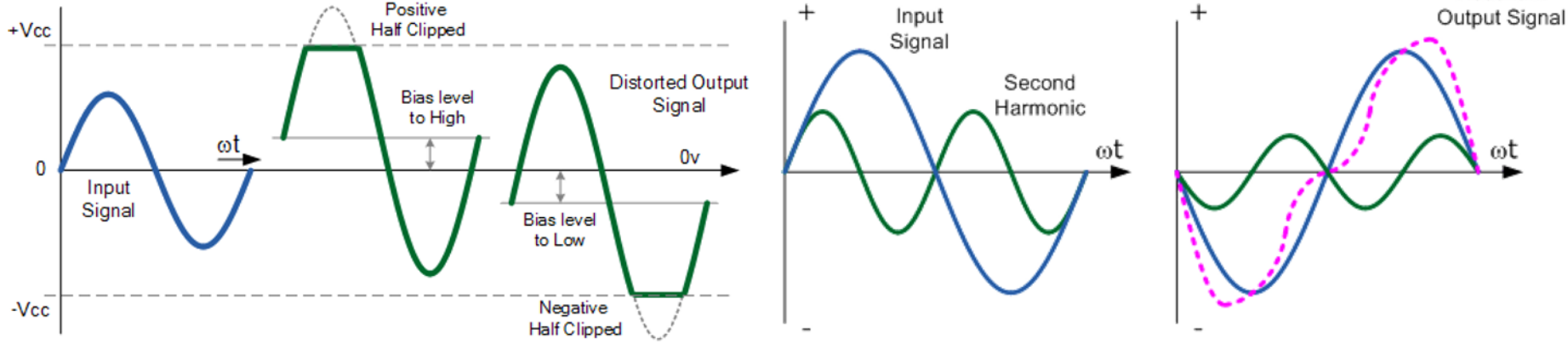






Distortion

Amplifier Distortion can take on many forms such as Amplitude, Frequency and Phase Distortion



Amplifier Class

Amplifier Classes is the term used to differentiate between the different amplifier types.

On the basic of **Conduction angle (Position of Q point)** which are defined by the length of their conduction state over some portion of the output waveform:

Class A

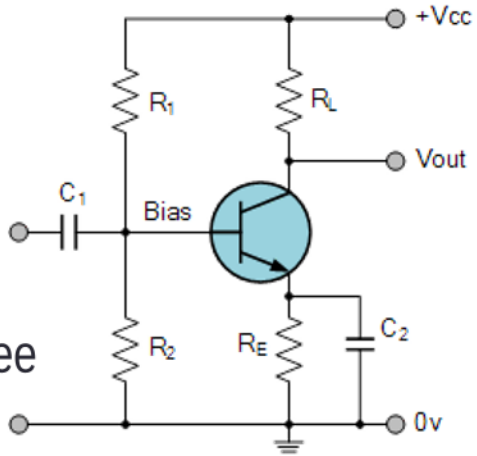
Class B

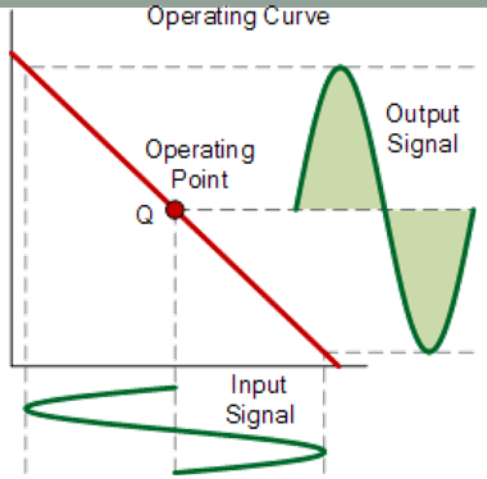
Class AB

Class C

Class A Amplifier

- Q point lies on middle of load line (Active region)
- Angle of conduction 360degree
- No distortion
- On all the time means carries current all the time so more power loss so low efficiency (25%)
- Can be extended upto 50% by modification

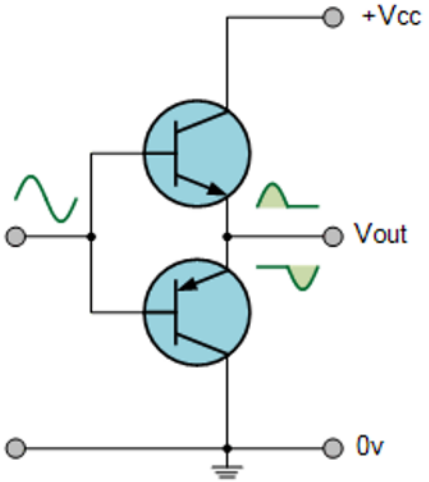


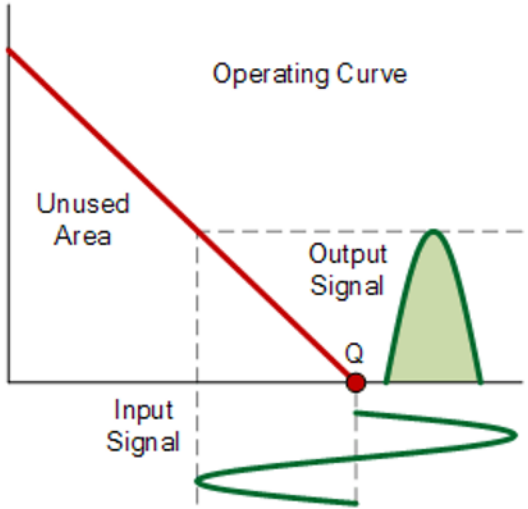


Therefore, due to the low efficiency and over heating problems of Class A amplifiers, more efficient amplifier classes have been developed.

Class B Amplifier

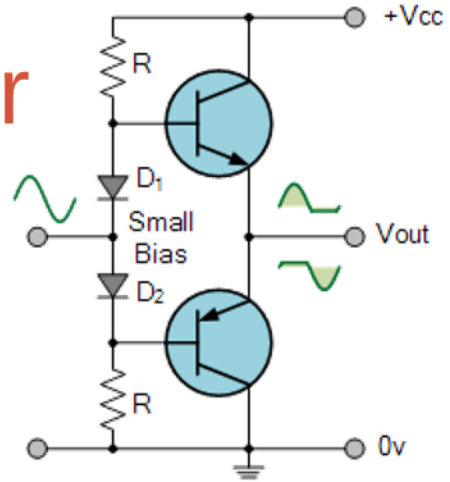
- Q point lies on X axis of load line (Cut off region/Saturation region)
- Angle of conduction 180 degree
- Distortion
- Maximum possible efficiency is 78.5%

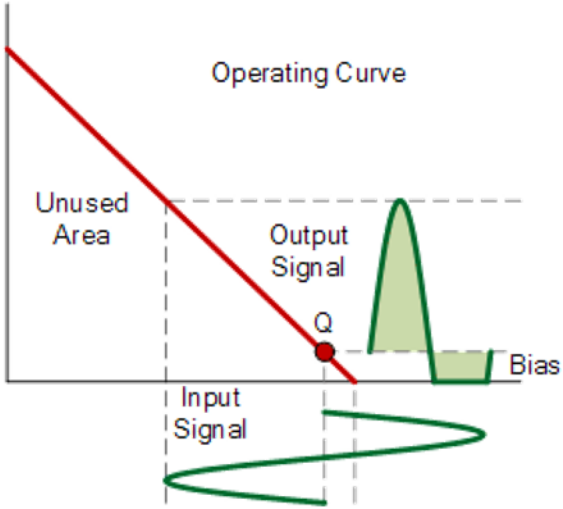




Class AB Amplifier

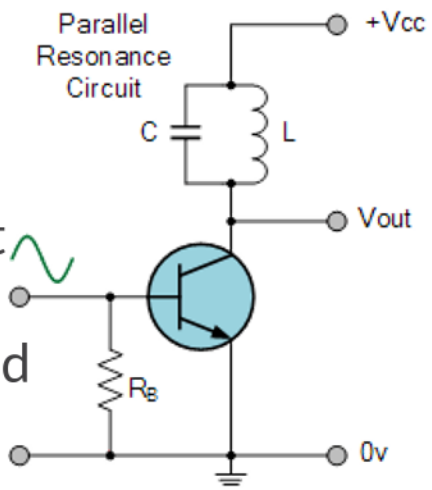
- Q point lies near to X axis of load line
- Angle of conduction between 180 degree to 360 degree
- Distortion
- Maximum possible efficiency is les than 78.5%

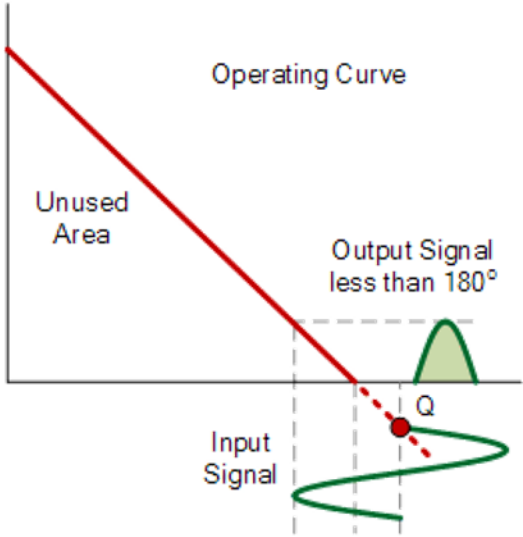




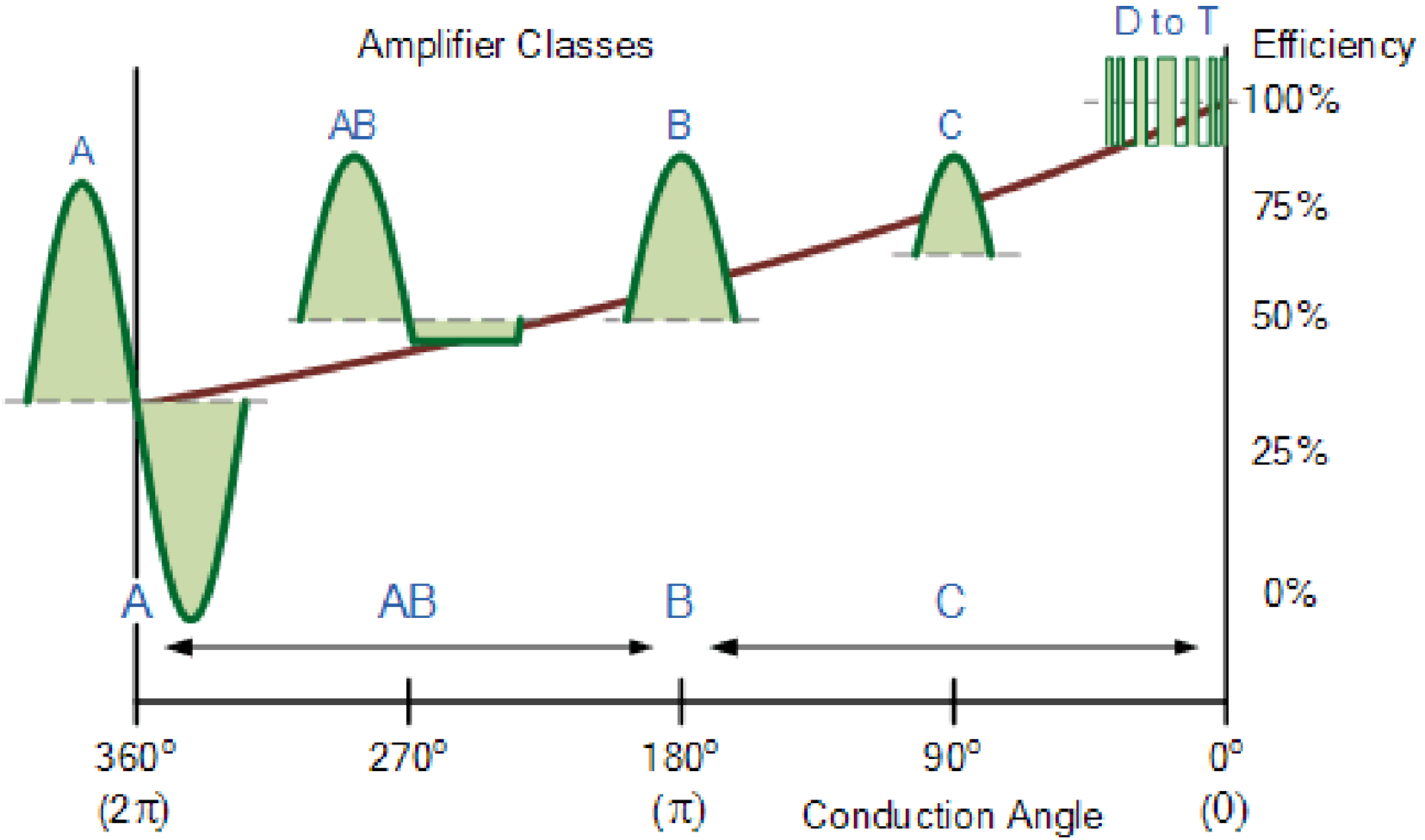
Class C Amplifier

- The **Class C Amplifier** design has the greatest efficiency but the poorest linearity of the classes of amplifiers mentioned here.





- Q point lies below the X axis of load line
- Angle of conduction less than 180 degree
- Heavy Distortion so not used in Audio amplifier, instead used in high frequency certain types of radio frequency amplifiers
- Maximum possible efficiency 95%


Amplifier Classes
D to T
Efficiency
100%
75%
50%
25%
0%
A
AB
B
C
A
AB
B
C
360°
(2π)
270°
180°
(π)
90°
Conduction Angle
0°
(0)

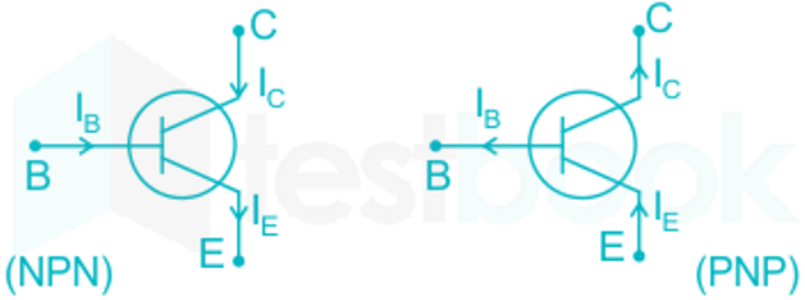
Index	Class A	Class B	Class AB	Class C
Angle of Conduction	360	180	180<Angle<360	Angel<180
Efficiency	25% Can be extended upto 50%	78.5%	78.5%	95%
Q point position	Center of Load line (Active region)	On X axis	Just above X axis	Below X axis
Distortion	No distortion	Less than C and more than A ,AB	Less than C,B and More than A	Heavy distortion
Application	Audio	Audio	Audio	Tuned amplifier (RF)

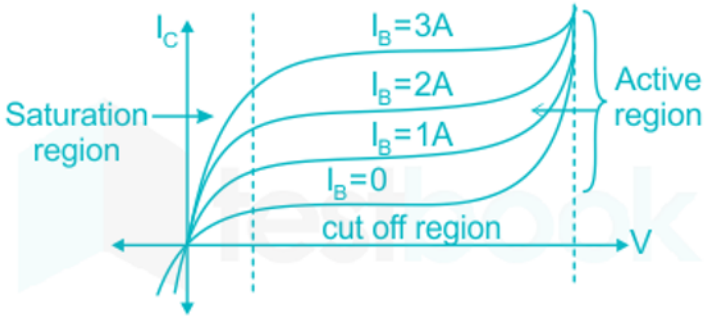
MCQs

- Separate file

Power BJTs

- They are used in high power amplification application.
- It is designed specifically to control high current – voltage ratings and very high power in the circuit.
- The power transistor is a three-layer NPN and PNP device.





Characteristics curve of common Emitter transistor

- In this type of transistors collector current I_c is the function of base current I_B i.e. a change in the base current giving a corresponding amplified change in the collector current for a given collector-emitter voltage V_{CE}.

Construction

The n+ and n− layers form the collector of the transistor. The n+ layer has high doping concentration and acts as a substrate; while the n− layer has a low doping concentration called the drift region.

The substrate provides a mechanical support and a low resistance path between the active collector region and the collector contact. The p-type base is thin and has moderate doping concentration. The n+ emitter region possesses a very high doping concentration

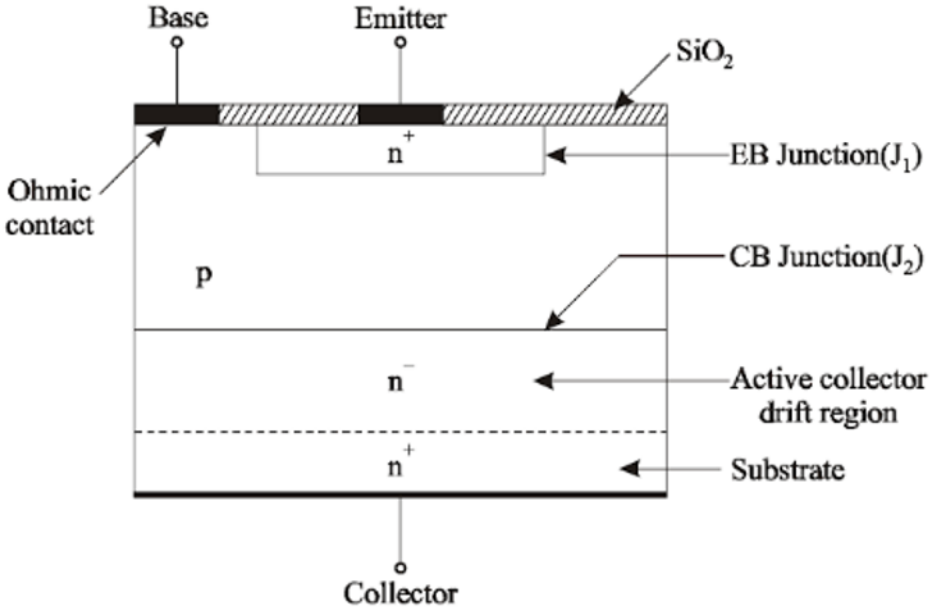


Figure 2 Cross-sectional view of n-p-n power transistor.

Power BJT vs Power MOSFET

Power BJT	Power MOSFET
It is a bipolar device	It is a unipolar device
Current Controlled Device	Voltage Controlled Device
BJT cannot operate at very high frequency.	MOSFET's can operate at very high frequency.
Negative temperature Coefficient	Positive temperature Coefficient
Drive circuit is complex	Drive circuit is simple
Switching losses are more.	Switching losses are less.

In a power transistor _____ is controlling parameter

1. V_{BE}
2. V_{CE}
3. I_B
4. I_C

Ans: 3

A power transistor is a _____
a) three layer, three junction device
b) three layer, two junction device
c) two layer, one junction device
d) four layer, three junction device

Answer: b
Explanation: A power BJT has three layers, p-n-p or n-p-n forming two junctions. p-n-p: two positive (p) layers and one negative (n) layers in between them. n-p-n: two negative(n) layers and one positive(p) layers.

Which one is the most suitable power device for high frequency (>100 kHz) switching application?
a) BJT
b) Power MOSFET
c) Schottkey diode
d) Microwave transistor

Answer B

For a power transistor, if base current I_B is increased keeping V_{ce} constant; then_____
a) I_C increases
b) I_C decreases
c) I_C remains constant
d) I_C changes sinusoidal

Answer: a
Explanation: I_B is directly proportional to I_c. The I_C curve is linearly distributed when using I_B as a parameter, and exponentially distributed using V_{BE} as a parameter. So when V_{BE} is constant, the transistor current I_C is almost linear with respect to I_B.

Push Pull Amplifier

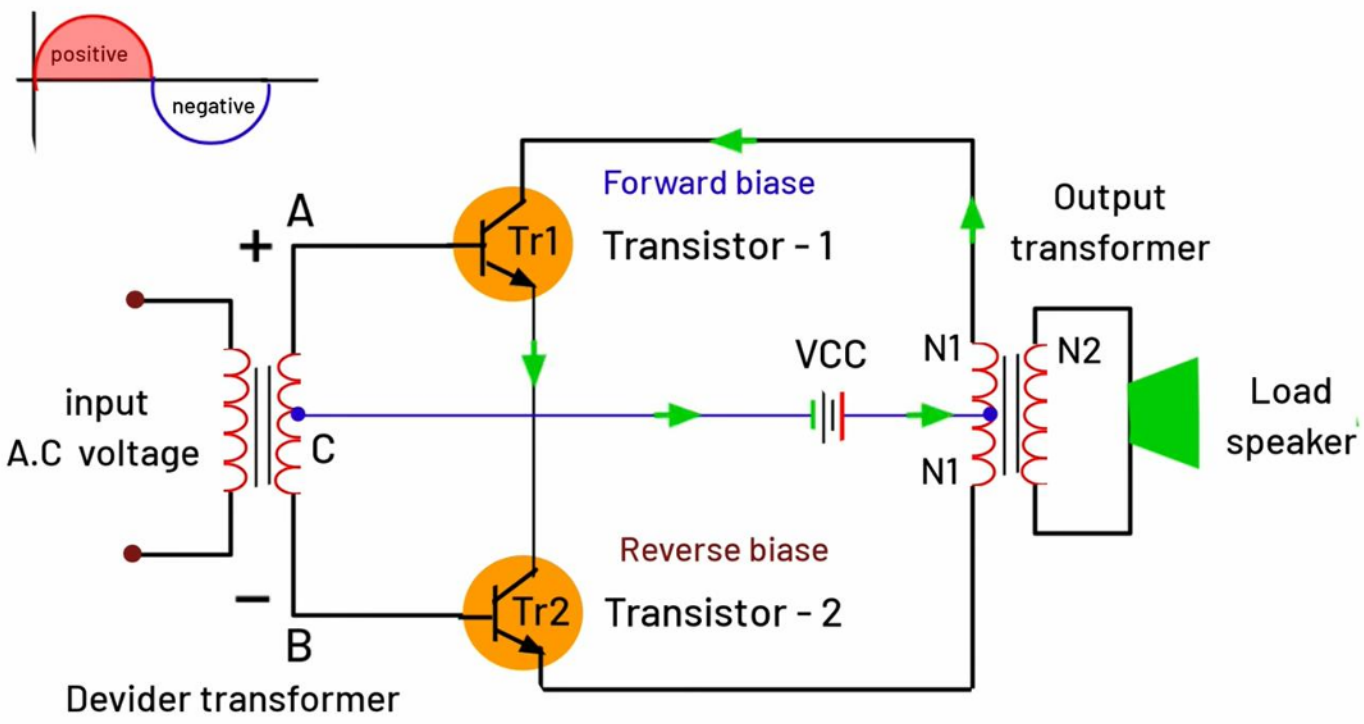
- It contains a pair of active devices such as a complementary pair of transistors. One of the transistors push the current towards output during positive half-cycle of the input signal The other transistor pulls the current towards the output during the negative half-cycle of the input signal .

- This amplifier can be constructed in different configurations such as Class-A, Class-B, and Class-AB Push-pull amplifiers.
- Reduces even harmonics
- In long-distance communication systems where low distortion is required, these amplifiers are used so, These amplifiers are used in RF systems.

Push Pull Amplifier Class B

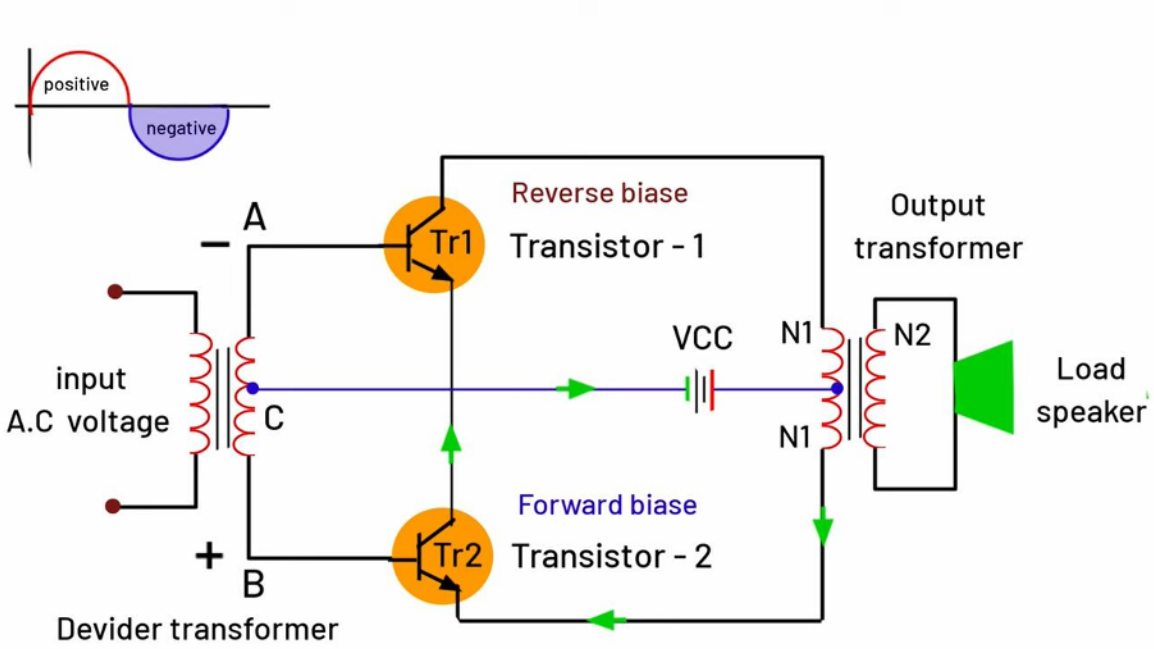
For Positive half cycle:

T1 forward biased and circuit as shown



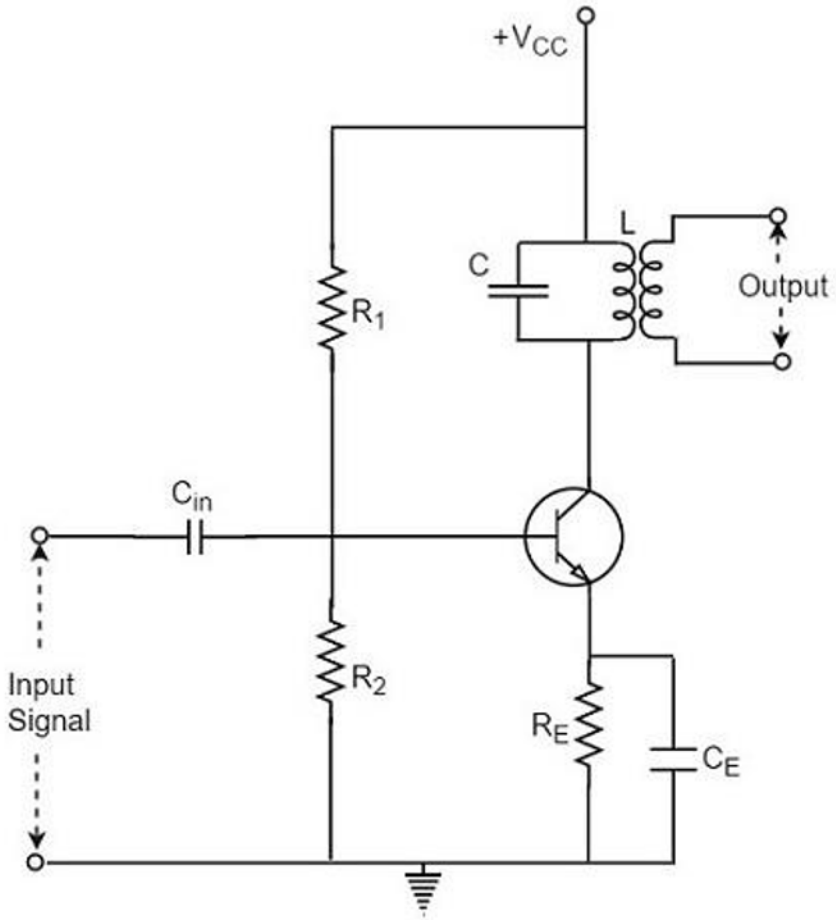
For Negative half cycle:

T2 forward biased and circuit as shown



Tuned Amplifier

- These amplifiers are one kind of amplifier that selects the particular range of frequencies and rejects the undesired frequencies by employing a tuned circuit at its load.
- The tuner circuit is nothing but a LC circuit which is also called as resonant or tank circuit. It selects the frequency.
- Condition of parallel resonance is applicable like fr, Z…



A push pull amplifier

a) Reduces odd harmonies in the output
b) Is the first stage of audio amplifier?
c) Reduces even harmonies in the output
d) Uses single transistor

Answer: C

What is the conduction angle for Class B push-pull amplifier?

a) 0
b) 90
c) 180
d) 270

Answer: c

Explanation: For class B push-pull amplifier, the conduction angle is 180 degree that is it amplifies only one half cycle of the input in one time period

Tuned amplifier is _____ type of amplifier?

a) Electronic
b) Mechanical
c) Electrical
d) Both a and b

Answer a

Amplifiers are classified based on ___ parameters?

a) Power
b) Current
c) Voltage
d) All the above

Answer D

_____ type of amplifier considers certain frequencies and rejects certain frequencies?

a) Current amplifier
b) Voltage amplifier
c) Tuned amplifier
d) All the above

Answer e

Which of the following type of frequencies does a tuned amplifier amplifies?

a) Higher frequencies
b) Radio frequencies
c) Lower frequencies
d) Both a and b

____ is a combination of tuned amplifiers?

a) RL
b) LC
c) RC
d) RLC

Ans: b

Which of the following is the formula of resonant impedance?

a) L/CR
b) RLC
c) R/LC
d) 1/RLC

Ans: a