Module - 02

MOSFET Power Amplifiers

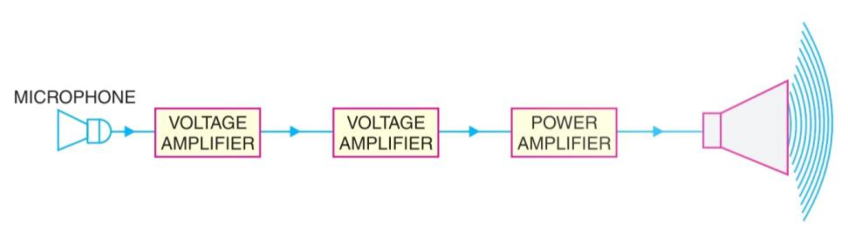
Power Amplifiers, Power Transistors, Classes of Amplifiers, Class A Power Amplifiers, Class B, Class AB Push-Pull Complementary Output Stages.

Power Amplifier

A multistage amplifier may be required to deliver a large amount of power to a passive load.

This power may be in the form of a large current delivered to a relatively small load resistance such as an audio speaker.

The output stage of the power amplifier must be designed to meet the power requirements.



Picture source:Sedha.R.S, “A Text **Book** of Applied **Electronics**”,

Power MOSFET

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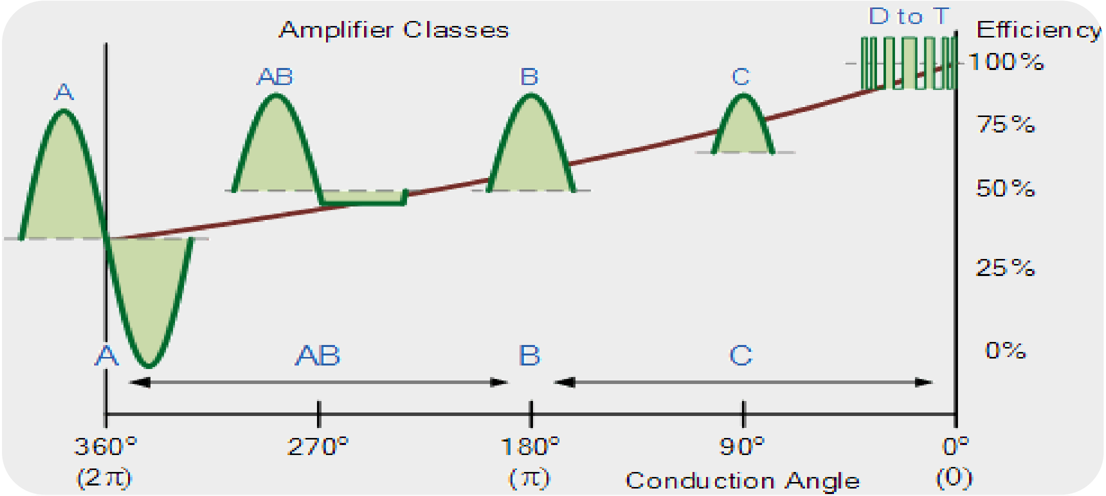
- The superior performance characteristics of power MOSFETs are: **faster switching times, no second breakdown, and stable gain and response time over a wide temperature range.**
- The drain currents are in the ampere range and the breakdown voltages are in the hundreds of volts range.
- These transistors must also operate within a safe operating area

CLASSES OF AMPLIFIERS

Define various classes of power amplifiers, and investigate the characteristics, including power efficiency, of a few of these amplifiers.

Some power amplifiers are classified according to the percent of time the output transistors are conducting, or "turned on."



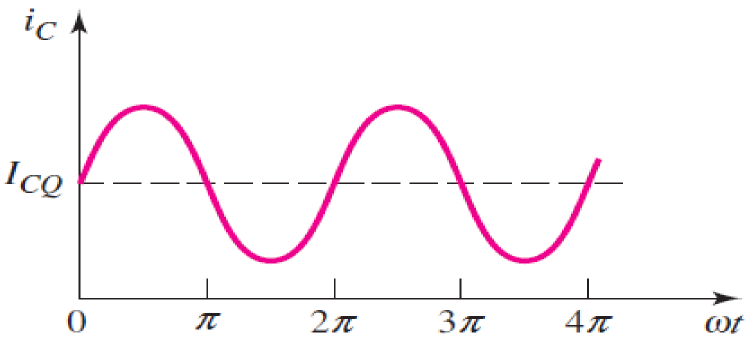
Four of the principal classifications are:
class A, class B, class AB, and class C

. In **class-A operation,** an output transistor is biased at a quiescent current *IQ* and conducts for the entire cycle of the input signal.

For **class-B operation,** an output transistor conducts for only one-half of each sine wave input cycle.

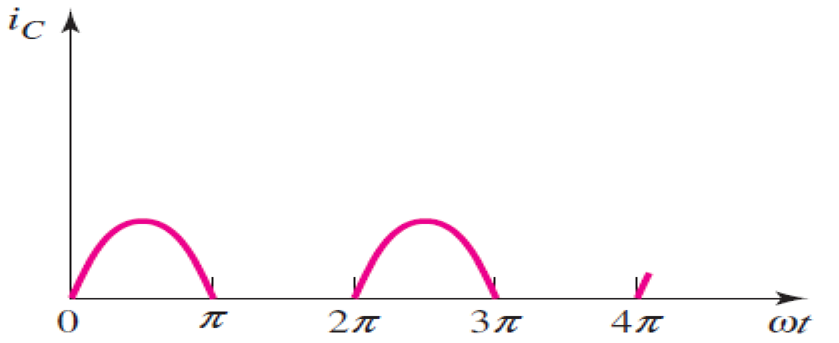
In **class-AB operation,** an output transistor is biased at a small quiescent current *IQ* and conducts for slightly more than half a cycle.

class-A amplifier



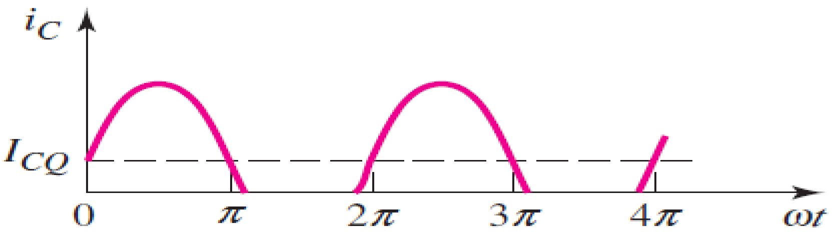
Collector current versus time characteristics

class-B amplifier



Collector current versus time characteristics

class-AB amplifier



Collector current versus time characteristics

Why the efficiency of class A power amplifier is less

In class A amplifier the transistor is biased such that the output current flows i.e. the transistor is on for full cycle of the input ac signal.

As class A operates in the linear region of the of the DC load line and the output device is always on at all times it is constantly carrying current, which represent the continuous loss of power in the amplifier.

Due to this continuous loss of power class A amplifiers create tremendous amounts of heat adding to their very low efficiency of around 30 %.

CLASS A

The Class A Amplifier more suitable for outdoor musical systems, since the transistor reproduces the entire audio waveform without ever cutting off.

As a result, the sound is very clear and more linear, that is, it contains much lower levels of distortion.

They are usually very large, heavy and they produce nearly 4-5 watts of heat energy per a watt of output.

Therefore, they run very hot and neec they are not at all ideal for a car and r home.

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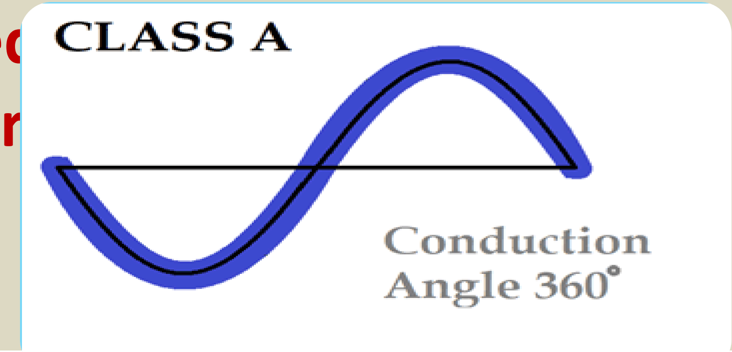


Features: Poor

Excellent:Medium

Advantages:

It has high fidelity because of output exact replica of the input signal

It has improved high frequency response, because the active device is full ON time.

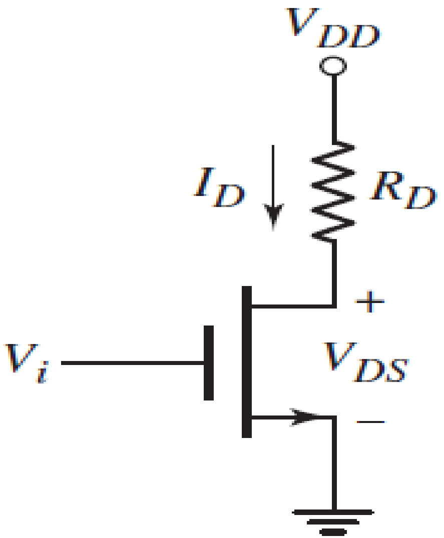
No Cross Over Distortion

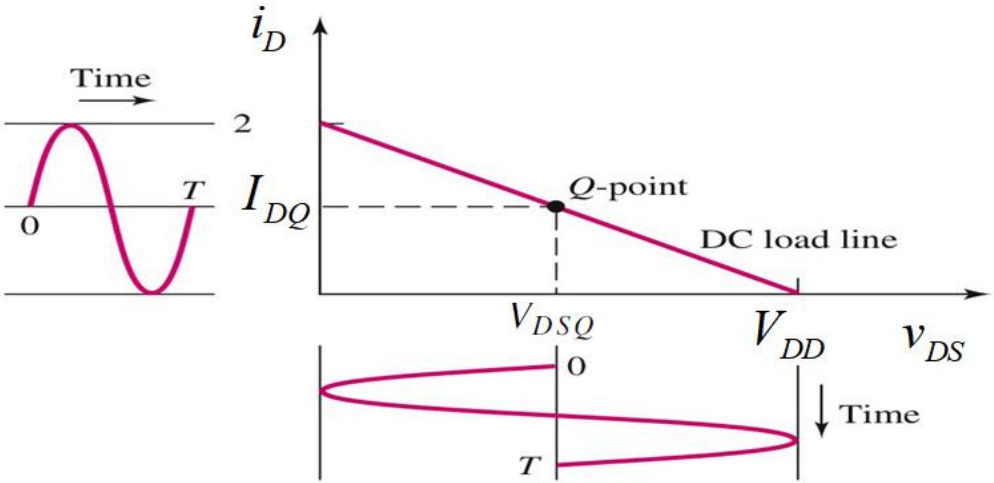
Due to large power supply and heat sink, amplifier is costly and bulky.

Poor Efficiency

Disadvantages

class-A amplifier

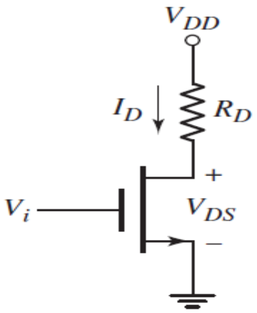




At the transition point,

$$\boxed{V_{DS}(\text{sat}) = V_{GS} - V_{TN}}$$

class-A amplifier



The load line is given by

$$V_{DS} = V_{DD} - I_D R_D$$

The drain current is given by

$$I_D = K_n(V_{GS} - V_{TN})^2$$

Combining these expression

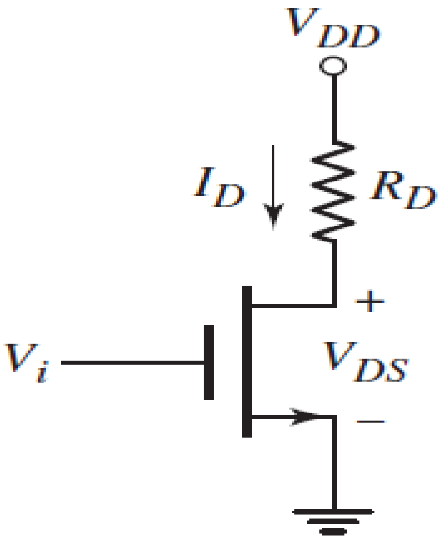
$$V_{DS}(\text{sat}) = V_{DD} - K_n R_D V_{DS}^2(\text{sat})$$

$$V_{DS}(\text{sat}) = V_{GS} - V_{TN}$$

class-A amplifier

The average power supplied by the V_{DD} source is

$$P_s = V_{DD} I_{DQ}$$



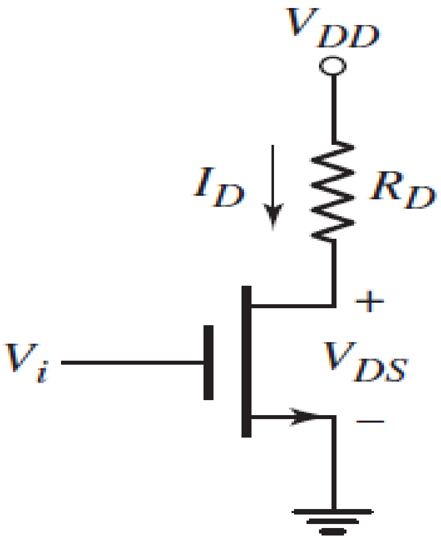
For sinusoidal input signals,
the average ac power delivered to the load is

$$P_L = \frac{1}{2}\frac{(Vp)^2}{R_D}$$

The quiescent drain current is found to be

$$I_{DQ} = \frac{V_{DD} - V_{DSQ}}{R_D}$$

The power conversion efficiency



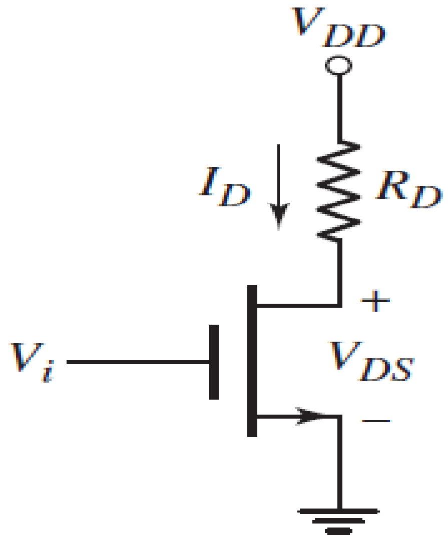
$$\eta = \frac{P_L}{P_S} \times 100 \approx 25\%$$

$$P_L = \frac{1}{2} V_p I_p = \frac{1}{2}\left(\frac{V_{CC}}{2}\right) I_{DQ} = \frac{V_{CC} I_{DQ}}{4}$$

P_L = average ac power to the load
P_S = average power supplied by the source (V_{DD})

Consider the common-source circuit in Figure The circuit parameters are $V_{DD} = 10$ V and $R_D = 5$ k, and the transistor parameters are: $K_n = 1\ mA/V^2$, $V_{TN} = 1$ V, and λ=0

Assume the output voltage swing is limited to the range between the transition point and $v_{DS} = 9$ V, to minimize nonlinear distortion.



Formula:

$$\boxed{V_{DS} = V_{DD} - I_D R_D}$$

$$\boxed{V_{DS}(\text{sat}) = V_{GS} - V_{TN}}$$

$$\boxed{I_D = K_n (V_{GS} - V_{TN})^2}$$

$$\boxed{V_{DS}(\text{sat}) = V_{DD} - K_n R_D V_{DS}^2(\text{sat})}$$

$$(1)(5)V_{DS}^2(\text{sat}) + V_{DS}(\text{sat}) - 10 = 0$$

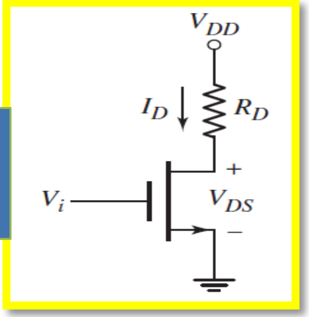
which yields

$$V_{DS}(\text{sat}) = 1.32\ \text{V}$$

To obtain the maximum symmetrical swing under the conditions specified, we want the *Q-point midway between V_{DS} = 1.32 V and V_{DS} = 9 V*

V_{DSQ}= 5.16V

Class A
Power MOSFET



The maximum ac component of voltage across the load resistor is then

vr = 3.84 sinωt

$$V_{DSQ} = \frac{V_{DS} + V_{DS(sat)}}{2} = \frac{9+1.32}{2} = 5.16$$

$$v_p = V_{DS} - V_{DSQ} = 9 - 5.16 = 3.84 \sin\omega t$$

Efficiency; $\eta = \frac{P_L}{P_S}$

the average power delivered to the load is

$$\bar{P}_L = \frac{1}{2} \cdot \frac{(3.84)^2}{5} = 1.47 \text{ mW}$$

$$\eta = \frac{\bar{P}_L}{P_S} = \frac{1.47}{9.68} \Rightarrow 15.2\%$$

The quiescent drain current is found to be

$$I_{DQ} = \frac{10 - 5.16}{5} = 0.968 \text{ mA}$$

The average power supplied by the V_{DD} source is

$$\bar{P}_S = V_{DD} I_{DQ} = (10)(0.968) = 9.68 \text{ mW}$$