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.**

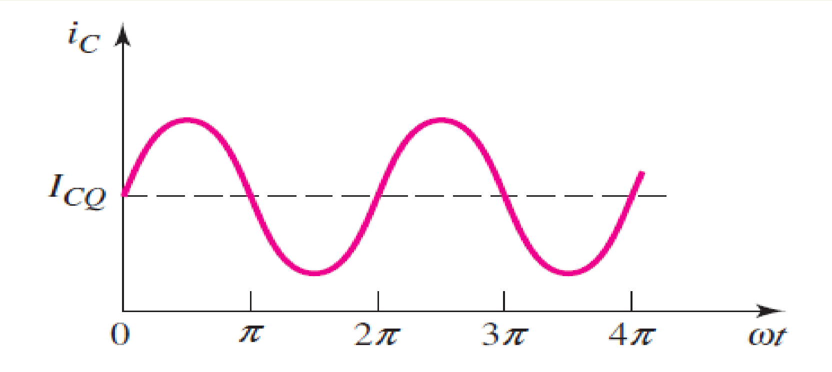
Four of the principal classifications are:
class A, class B, class AB, and class C.

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.

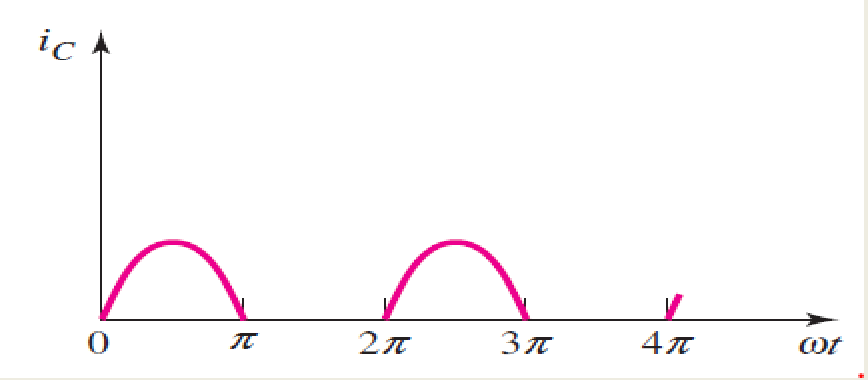
In **class-AB operation,** an output transistor is biased at a small quiescent current *IQ* and conducts for slightly more than half a cycle.

class-A amplifier



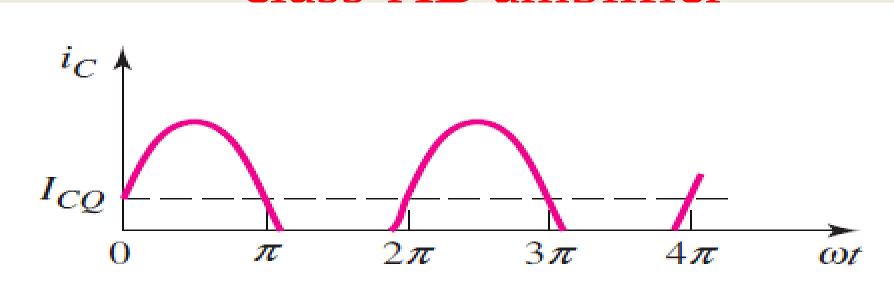
Collector current versus time characteristics

class-B amplifier



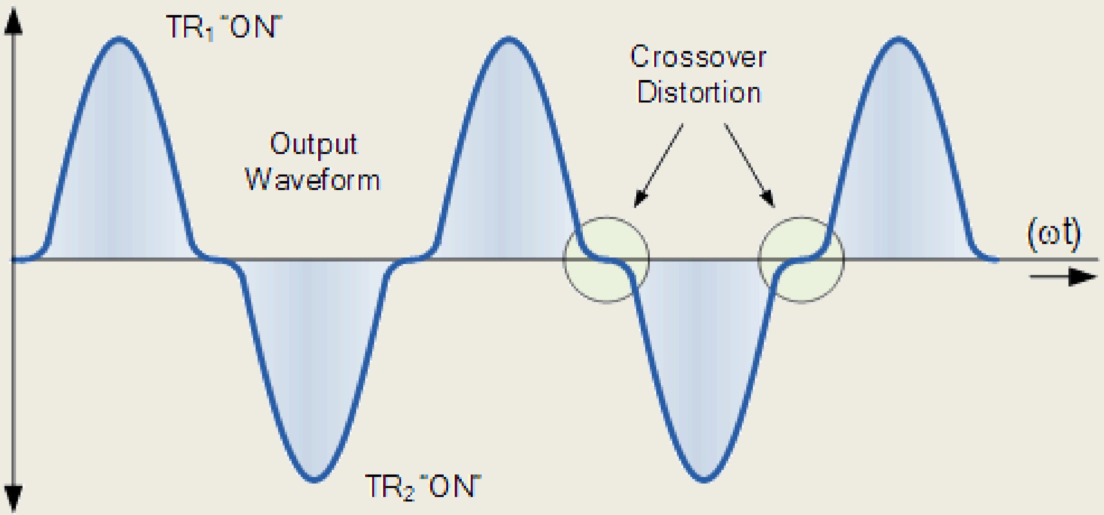
Collector current versus time characteristics

class-AB amplifier



Collector current versus time characteristics

Cross Over Distortion

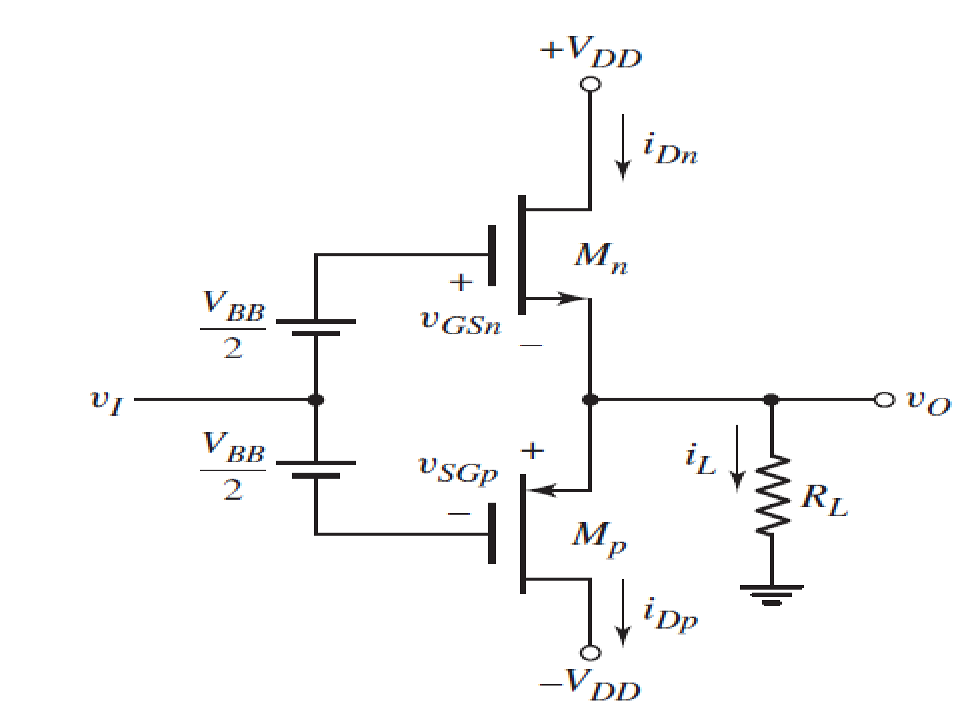


Crossover distortion can be **virtually eliminated by applying small quiescent bias on each transistor** (See Figure)

If Q_n and Q_p are matched, each GATE-SOURCE junction is biased with $V_{BB}/2$ when v_I is zero. Hence v_O is also zero.

MOSFET class-AB output stage

Source:Donald Neamen



A class-AB output stage using enhancement-mode MOSFETs is shown in Figure.

If Mn and Mp are matched, and if $v_I = 0$, then VBB/2 is applied across the gate–source terminals of Mn and the source–gate terminals of Mp.

The quiescent drain currents established in each transistor

$$I_{DQ} = 0.05 = K\left(\frac{V_{BB}}{2} - |V_T|\right)^2$$

Source:Donald Neamen

As v_I increases, the voltage at the gate of Mn increases and v_O increases. Transistor Mn operates as a source follower, supplying the load current to RL.

Since i_{Dn} must increase to supply the load current, v_{GSn} must also increase. Assuming V_{BB} remains constant, an increase in v_{GSn} implies a decrease in v_{SGp} and a resulting decrease in i_{Dp}.

As v_I goes negative, the voltage at the base of Mp decreases and v_O decreases. Transistor Mp then operates as a source follower, sinking current from the load.

Source:Donald Neamen

Design Equations

The output voltage v_o is

$$v_o = R_L i_L$$

The quiescent drain currents established in each transistor are given by

$$i_{Dn} = i_{Dp} = I_{DQ} = K\left(\frac{V_{BB}}{2} - |V_T|\right)^2$$

The input voltage for v_o positive is

$$v_I = v_O + v_{GSn} - \frac{V_{BB}}{2}$$

The source-to-gate voltage of *Mp* is

$$v_{GSn} = \sqrt{\frac{i_{Dn}}{K}} + |V_T|$$

The source-to-gate voltage of M_p is

$$v_{SGp} = V_{BB} - V_{GSn}$$

Source:Donald Neamen

– Class-AB Operation

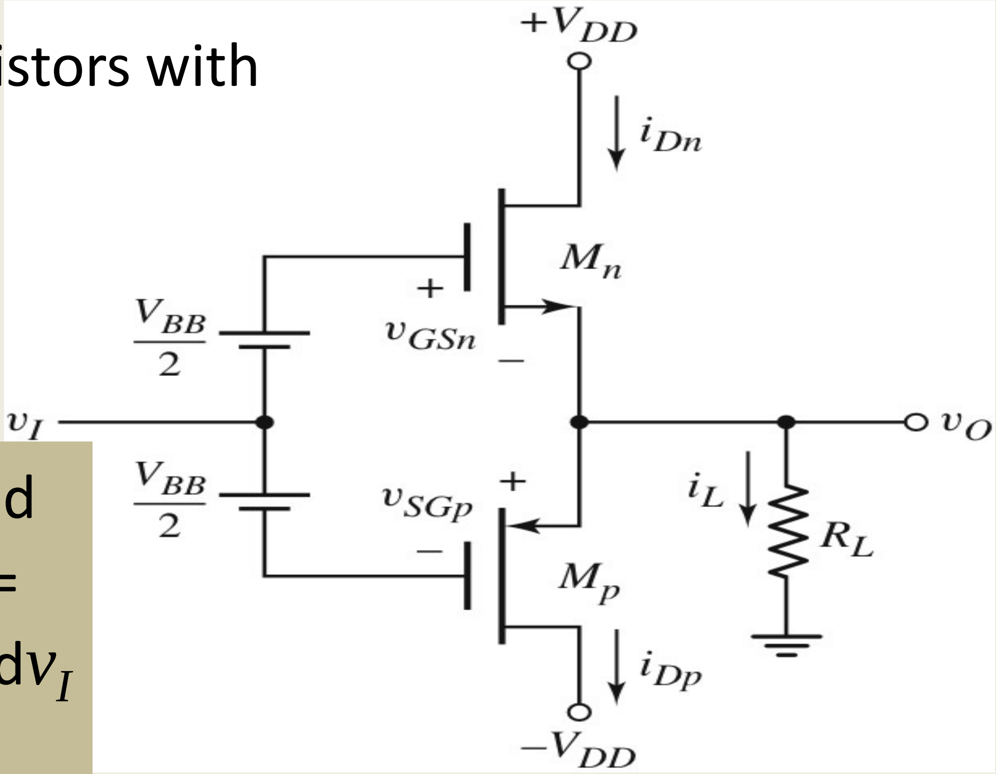
Numerical

M_n and M_p are matched transistors with the following parameters;

$$|V_T| = 1\,\text{V};$$

$$K = 0.20\ \text{A/V}^2$$

If V_{DD} = 10 V and R_L = 20Ω, find the bias voltage $V_{BB}/2$ for I_{DQ} = 0.05 A. Find also V_{GSn}, V_{SGp} and v_I if v_O = 5 V.



– Class-AB Operation

$$i_D = K\left(v_{GS} - |V_T|\right)^2$$

Since the MOSFETs are matched, at quiescent point;

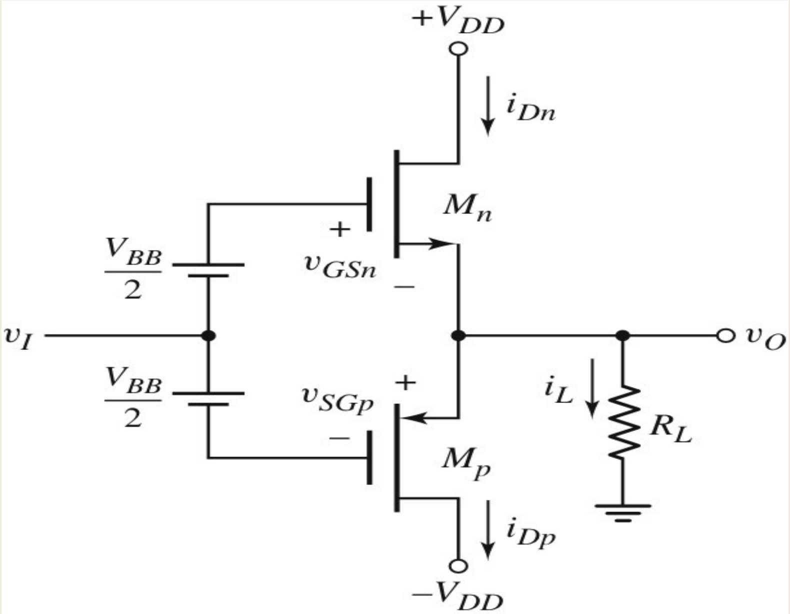
$$i_D = I_{DQ}$$

and

$$v_{GS} = V_{GSQ} = V_{SGQ} = \frac{V_{BB}}{2}$$

Hence;

$$I_{DQ} = K\left(\frac{V_{BB}}{2} - |V_T|\right)^2$$



– Class-AB Operation

Substituting values;

$$0.05 = 0.2\left(\frac{V_{BB}}{2} - 1\right)^2$$

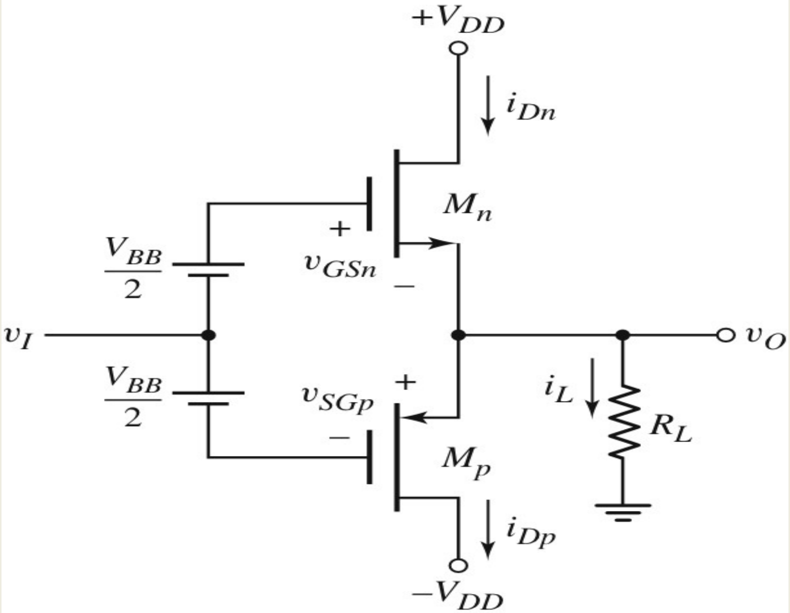
which yields; $$\frac{V_{BB}}{2} = 1.5\ \text{V}$$

From the expression

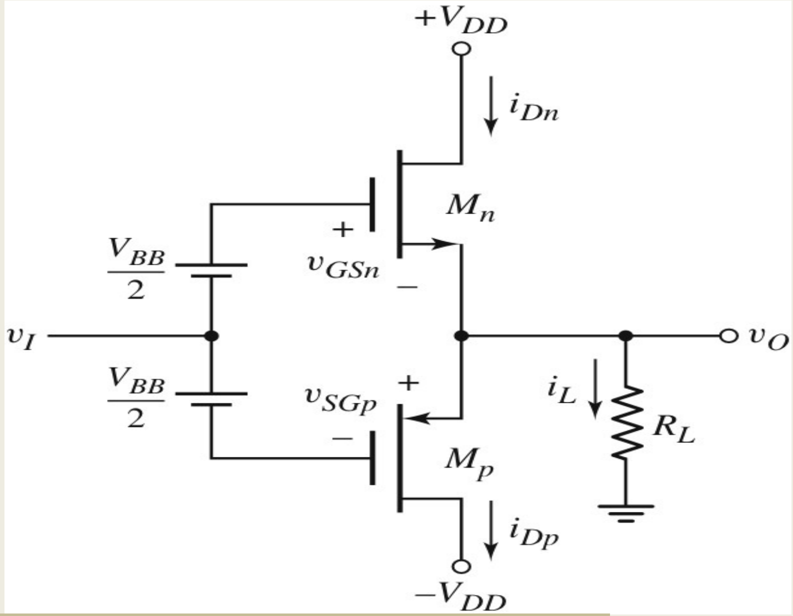
$$i_{Dn} = K\left(v_{GSn} - |V_T|\right)^2$$

we have;

$$v_{GSn} = \sqrt{\frac{i_{Dn}}{K}} + |V_T|$$



– Class-AB Operation



When $v_O = 5\text{ V};$

$$i_{Dn} \cong i_L = \frac{v_O}{R_L}$$

$$= \frac{5}{20} = 0.25\text{ A};$$

and

$$v_{GSn} = \sqrt{\frac{i_{Dn}}{K}} + |V_T| = \sqrt{\frac{0.25}{0.2}} + 1 = 2.12\text{ V}$$

Source:Donald Neamen

– Class-AB Operation

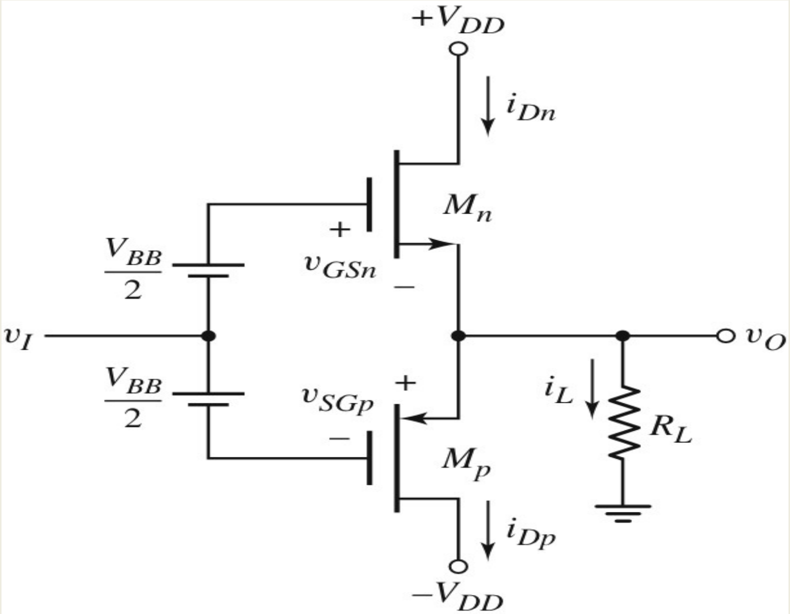
Since;

$$V_{BB} = v_{GSn} + v_{SGp}$$

then;

$$v_{SGp} = V_{BB} - v_{GSn}$$

$$= 3 - 2.12 = 0.88\,\text{V}$$



And;

$$v_I = v_O + v_{GSn} - \frac{V_{BB}}{2} = 5 + 2.12 - \frac{3}{2} = 5.62\,\text{V}$$