Unit - 2

Differential Amplifier:-

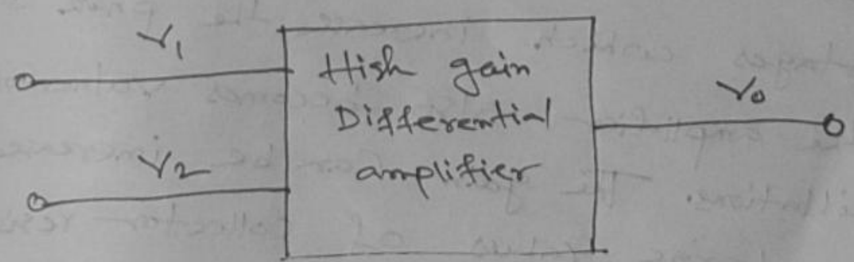
The function of a differential amplifier is to amplify the difference betⁿ two signals. The need for differential amplifier arises in many physical measurements where response from DC to many MHZ of frequency is required. This forms the basic i/P stage of an integrated amplifier.

The basic differential amplifier has the following important properties of

* Excellent stability
* High versality &
* High immunity to interference Signals.

The differential amplifier as a building block of the op-amp has the advantages of

* Lower cost
* Easier fabrication as IC component &
* closely matched components



The above figure shows the basic block diagram of a differential amplifier, with two i/P terminals and one o/P terminal. The o/P signal of the differential amplifier is proportional to the difference betⁿ the two i/p signals.

$$V_o = A_{dm}(V_1 - V_2)$$

if $V_1 = V_2$, then the o/p voltage is zero. A non-zero output voltage V_o is obtained when V_1 & V_2 are not equal. The difference mode i/p is defined as

$V_m = V_1 - V_2$ and the common mode i/p voltage is defined as

$$V_{CM} = \frac{V_1 + V_2}{2}$$

These equ show that if $V_1 = V_2$, then the differential mode i/p signal is zero & common mode i/p signal is $V_{cm} = V_1 = V_2$

Differential Amplifier with Active Load:-

Differential amplifier is designed with active loads to increase the differential mode voltage gain. The open circuit voltage gain of an op-amp is needed to be as large as possible. This is got by cascading the gain stages which increase the phase shift and the amplifier also becomes vulnerable to oscillations. The gain can be increased by using large values of collector resistance. For such a circuit, the voltage gain is given by

$$A_{dm} = g_m R_C$$

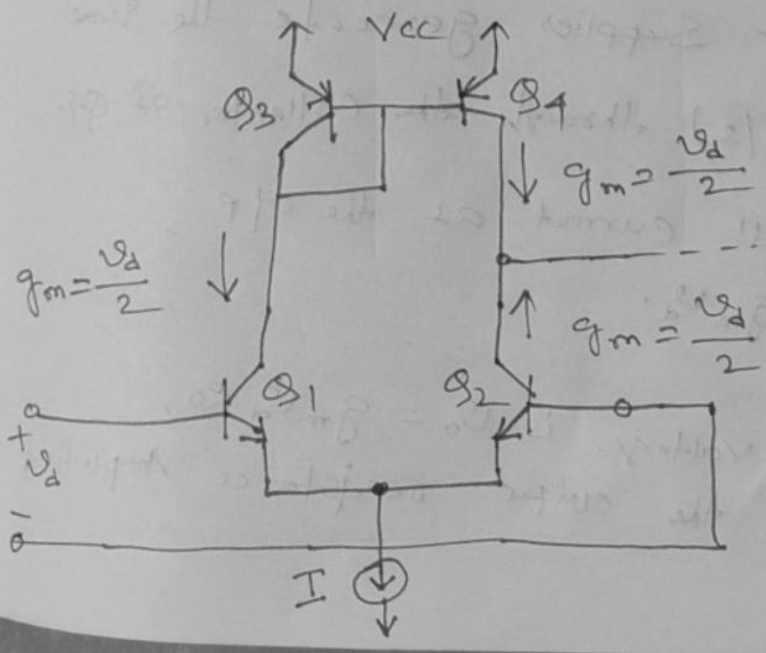
To increase the gain the IC RC product must be made very large. However, there are limitations in IC fabrication such as.

1. A large value of resistance needs a large chip area
2. For large RC, the quiescent drop across the resistor increase and a large power supply will be required to maintain a given operating current.

3.

The BJT differential AMP with an active load:-

* Many IC amplifiers use BJT loads in place of the load resistance, Rc.
* BJT load resistor is usually connected as a constant-current source with a very high resistance load (o/p resistance of the current source)
* Higher load resistance, higher o/p gain.



* Q_3 & Q_4 are connected in a current mirror configuration.

* If no i/p signal is applied that both bases are grounded. I is split into equal between Q_1 & Q_2

* Assume $\beta >> 1$. the mirror supplies an equal current $I/2$ through the collector of Q_4.

* Since this current is equal to the current through Q_2, no o/p current flows through the o/p terminal.

* When a differential signal v_d is applied, current signal $g_m(v_d/2)$ will result in the collector Q_1 & Q_2.

* The mirror supplies generate the same current $g_m(v_d/2)$ through the collector of Q_4.

* The overall current at the o/p terminal is $g_m v_d$.

* The o/p voltage is $v_o = g_m v_d R_o$, where R_o is the output resistance amplifier.

(*) R_o is the parallel of O/P resistance of

Q_2 & Q_4:

$$R_o = r_{o2} \| r_{o4}$$

In case $r_{o2} = r_{o4} = r_o$, we have

$$R_o = r_o/2$$

The O/P voltage $v_o = g_m v_d (r_o/2)$

The voltage gain

$$A_d = \frac{v_o}{v_d} = g_m (r_o/2)$$

Considering $g_m = I_c/V_T$ and

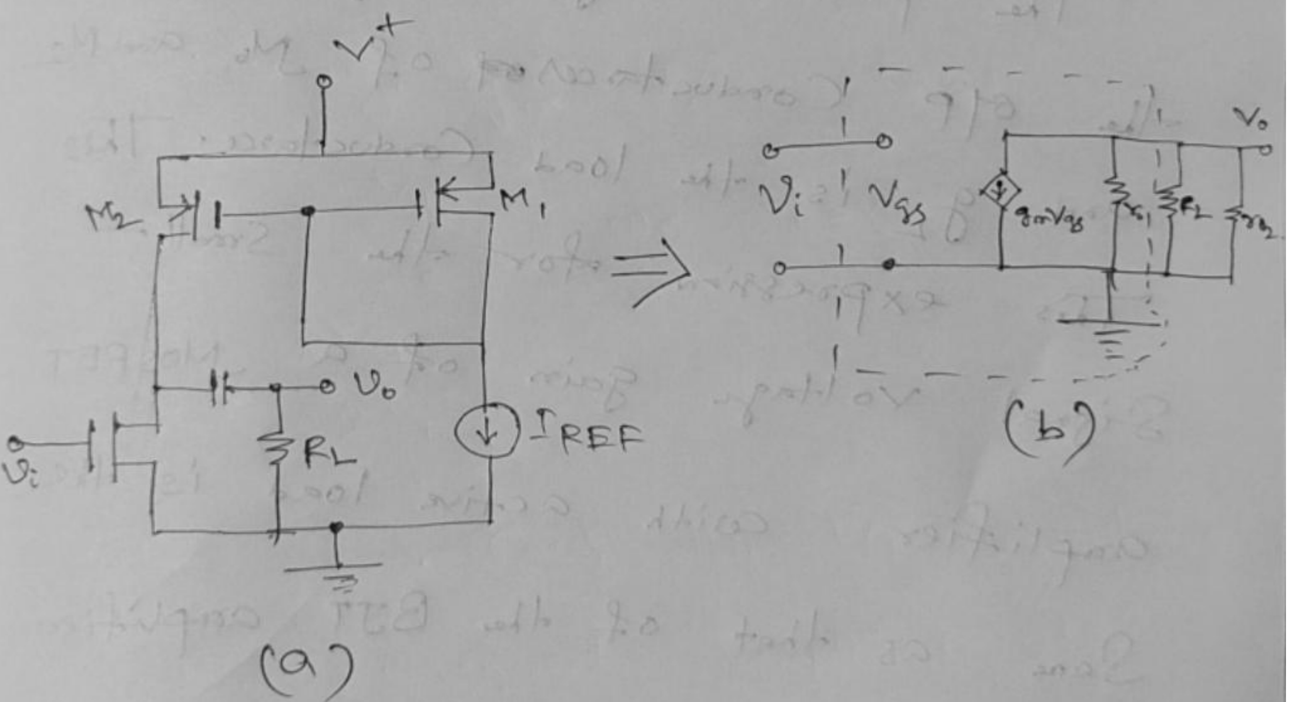
$$r_o = \frac{V_A}{I_c} \quad \text{we have}$$

$$A_d = \frac{V_A}{2V_T}$$

In some cases the I/P resistance of the subsequent amplifier stage may be of the same order as R_o and must be taken into account in determining voltage gain.

MOSFET Differential AMP with active load:-

A simple MOSFET amplifier with an active load and a load resistor R_L capacitively coupled to the output is shown in fig(a). Fig(b) shows the small-signal equivalent circuit, in which the load R_L, the active load resistance r_{o2}, and the o/p resistance r_o of transistor M_o are included.



The output voltage is

$$V_o = -g_m V_{gs} (r_o \parallel R_L \parallel r_{o2})$$

and Since $V_{gs} = V_i$ where V_i is the ac voltage, the Small-Signal voltage gain is

$$A_v = \frac{V_o}{V_i} = -g_m (r_o \parallel R_L \parallel r_{o2})$$

$$= \frac{-g_m}{g_o + g_L + g_{o2}}$$

The parameters g_o and g_{o2} are the O/P Conductances ~~of~~ of M_o and M_2 and g_L is the load Conductance. This

This expression for the Small-Signal voltage gain of a MOSFET amplifier with active load is the Same as that of the BJT amplifier