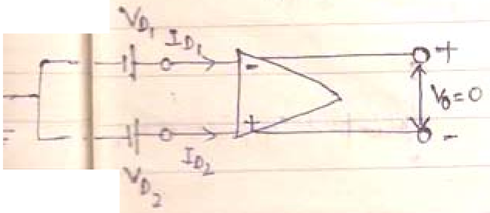
Electronics 20.2.95.

Q. (I). Define (a) Input bias Current (b) Input offset current (c) input offset voltage (d) Output offset voltage and (e) Slew rate of an OP-AMP. Show with circuit diagram how CMRR of an OP-AMP is measured. [Page: 615].

In order to compare the merits of various OP-AMP circuits the above parameters are defined:

(I) Input bias Current: Due to mismatch of input transistors unequal bias current flows through the input terminals when the two inputs are identical and output is zero ($V_1 = V_2$; $V_0 = 0$). Thus input bias current is the current flowing into each of the two input terminals when they are biased to same voltage levels.



In otherwords the average of currents into two input terminals with output at zero voltes is input bias current.

i.e $$I_{bias} = \frac{I_{D_1} + I_{D_2}}{2}$$

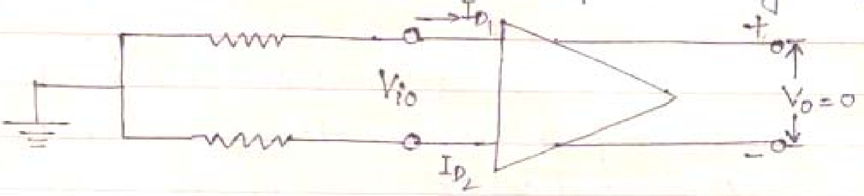
(II) Input Off set Current: It is defined as the difference of the currents into two input terminals with the output at zero volts ($V_0 = 0$). Thus;

$$I_{io} = I_{D_1} - I_{D_2} \quad \text{with } V_0 = 0$$

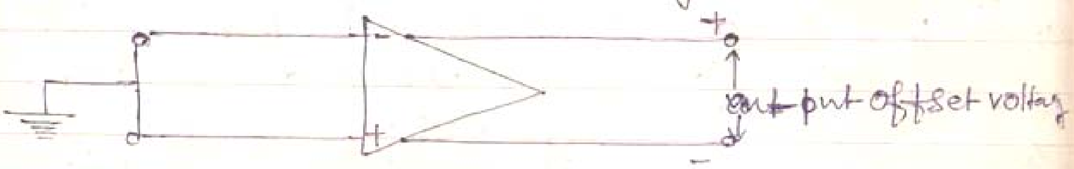
It is found $20\,mA < I_{io} < 60\,mA$ & it drifts with the temp. change. Input off set current drift $= \frac{\Delta I_{io}}{\Delta T}$

(iii) Input Offset voltage: (V_{io}) The input voltage which must be applied across the input terminals to obtain zero output voltage is called input offset voltage. (Fig ②)

It is found even when $V_1 = V_2$, $V_0 \neq 0$ due to inherent imbalance in the circuits. Hence to make $V_0 = 0$; Input offset voltage V_{io} ($1mV \leq V_{io} \leq 4mV$) is to be applied. It also temp. dependent hence Input offset voltage drift $= \frac{\Delta V_{io}}{\Delta T}$



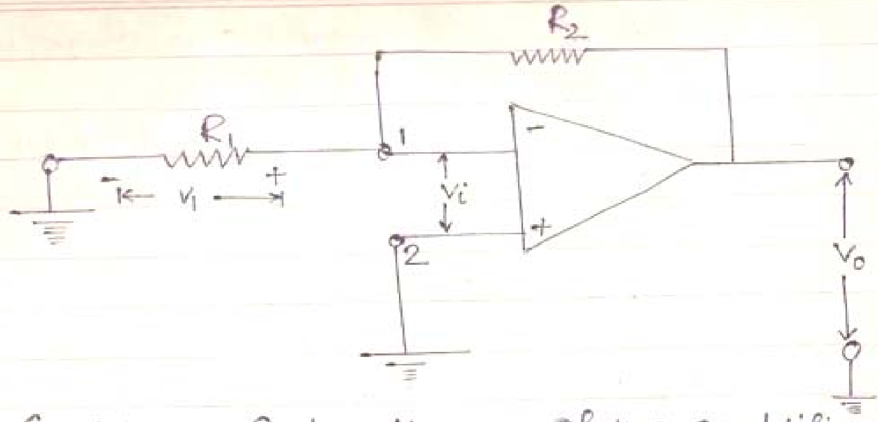
(iv) Output offset voltage: It is the difference between the D.C voltages present at the two input terminals (or at the output terminal and ground for an amplifier with one output) when the two input terminals are grounded.



(v) Slew rate: The slew rate is the time rate of change of the closed loop amplifier output voltage under large signal conditions.

It is the maximum rate of change of output voltage for a step input.

Detail: Considering that a step function of large amplitude is applied as V_i; a finite time is required for V_0 to respond to step



input (. Since Capacitances of the amplifier Can not change voltage rapidly). Further as the feedback voltage applied through R_2 to input, is proportional to V_o, the f.b is delayed in return to the input & the amplifier input voltage(V_i) is momentarily large. As a result until the f.b voltage responds, input voltage V_i drives the amplifier into saturation & a distorted output waveform appears as a transient.

The maximum rate of change of output voltage is defined as slew rate

Thus:

$$S = \left(\frac{dV_o}{dt}\right)_{max}$$

for Sinusoidal voltage $V_o = |V_o| \sin \omega t$

$$\therefore \frac{dV_o}{dt} = \omega |V_o| \cos \omega t$$

or

$$\boxed{\left(\frac{dV_o}{dt}\right)_{max} \geq \omega |V_o|}$$

So max^m possible amplitude at frequency 'f' is

$$|V_o| = \frac{(dV_o/dt)_{max}}{\omega} = \frac{S}{\omega}.$$

N.B Slew rate is determined by capacitance of the amplifier.

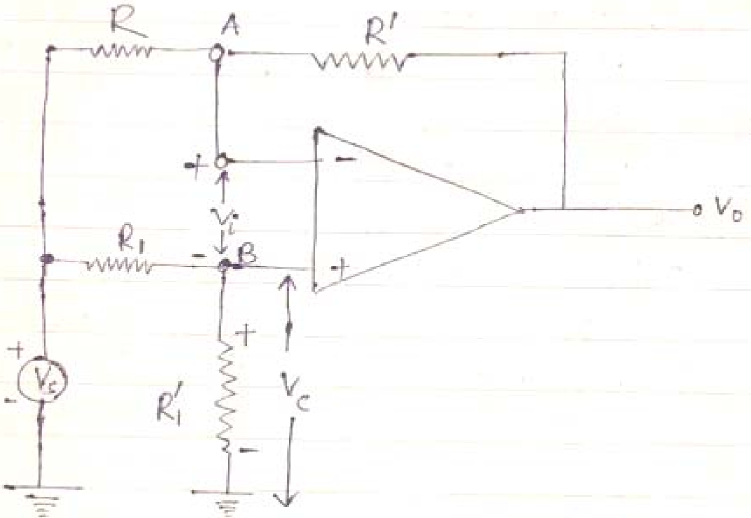
Measurement of Common Mode Rejection Ratio

The common mode rejection ratio is defined as:

$$\rho = \left| \frac{A_d}{A_c} \right|$$

where A_d is the differential voltage gain.

A_c is the common mode voltage gain.



$R \sim 100\Omega$
$R' \sim 100K$
$R_1 \sim 100\Omega$
$R_1' \sim 100K$

The signal at the point A or B is essentially the common mode signal V_c, where

$$V_c = \frac{R_1'}{R_1 + R_1'} \cdot V_s = \frac{R'}{R + R'} V_s \simeq V_s$$

assuming $R_1' > R_1$ & $R' > R$.

If the resistors are matched ($R = R_1$ & $R' = R_1'$), then $V_i = V_o = 0$, provided that $A_c = 0$. Since $A_c \neq 0$, there is an

Output error voltage V_o.
Thus the differential input voltage : $V_i = \frac{V_o}{A_d}$

Thus

$$\rho = \frac{A_d}{A_c} = \frac{V_o/V_i}{V_o/V_c} = \frac{V_c}{V_i}$$

Since $V_c \simeq V_s$, then V_i is effectively across R
&

$$\therefore V_o = [(R+R')/R]\,V_i$$

or

$$\rho = \frac{R+R'}{R}\,\frac{V_s}{V_o}$$

Since $A_c = \frac{V_o}{V_c}$ is non linear function of the magnitude V_c hence the above measurement must be done at the rated.