Ideal Voltage Transfer Curve of Op Amp

Ideal Voltage Transfer Curve of Op Amp – The ideal op-amp produces the output proportional to the difference between the two input voltages. The graphical representation of this statement gives the voltage transfer curve. It is the graph of output voltage V_o plotted against the difference input Voltage V_d, assuming gain constant. This graph is called **transfer characteristics** of the op-amp.

Now the output voltage is proportional to difference input voltage but only up to the positive and negative saturation voltages of op-amp. These saturation voltages are specified by the manufacturer in terms of output voltage swing rating of an ap-amp, for given value of supply voltages. These saturation voltages are slightly less than the supply voltages.

Thus, the voltage transfer curve is a straight line till output reaches saturation voltage level. Thereafter output remains constant. The Ideal Voltage Transfer Curve is shown in the Fig.

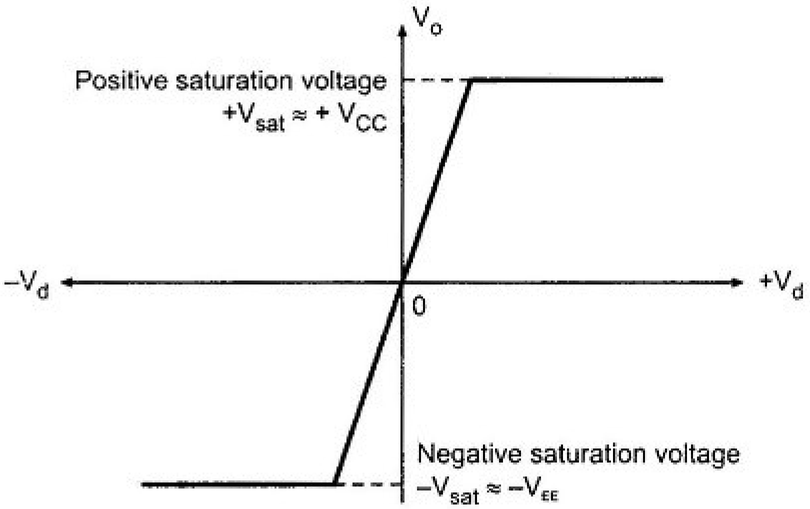


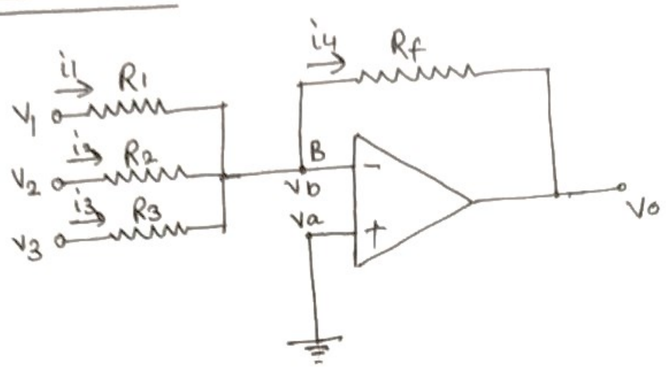
Fig. Ideal voltage transfer curve

The curve is not drawn to the scale. If drawn to the scale, the curve would be almost vertical due to large values of op-amp gain.

Thus note that the op-amp output voltage gets saturated at $+V_{CC}$ and $-V_{EE}$ and it can not produce output voltage more than $+V_{CC}$ and $-V_{EE}$. Practically saturation voltages $+V_{sat}$ and $-V_{sat}$ are slightly less than $+V_{CC}$ and $-V_{EE}$.

Operational Amplifier Application

1. Adder



From this circuit $V_a = 0$ V.

$$V_b = V_a = 0\text{ V}$$

Apply KCL at node B

$$i_1 + i_2 + i_3 = i_4$$

$$\frac{V_1 - V_b}{R_1} + \frac{V_2 - V_b}{R_2} + \frac{V_3 - V_b}{R_3} = \frac{V_b - V_o}{R_f}$$

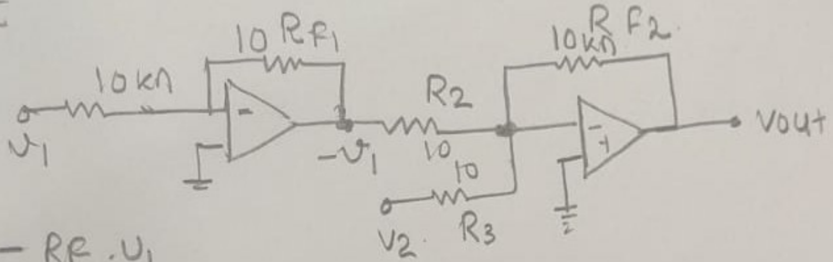
$$\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} = \frac{-V_o}{R_f}$$

$$V_o = -\left[\frac{R_f}{R_1} V_1 + \frac{R_f}{R_2} V_2 + \frac{R_f}{R_3} V_3\right]$$

if $R_f = R_1 = R_2 = R_3$

so $V_o = -\left[V_1 + V_2 + V_3\right]$

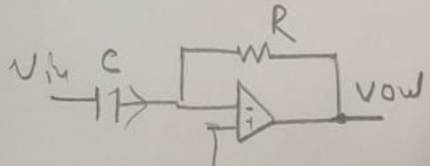
Subtracter



$$V_0 = -\frac{R_f}{R_1} \cdot v_1$$
$$= -v_1$$

$$V_{out} = -(-v_1 + v_2)$$
$$V_{out} = (v_1 - v_2)$$

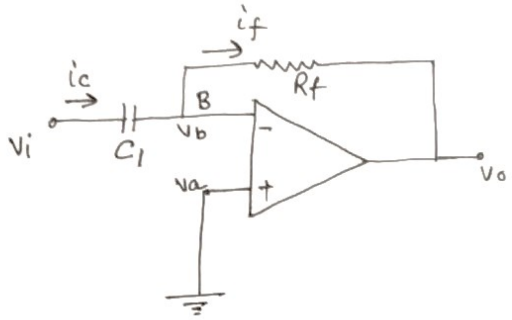
Integrator



$$q = CV$$
$$\frac{dq}{dt} = C\frac{dv}{dt}$$
$$i = C\,dv/dt$$

$$\frac{C\,d(V_{in} - 0)}{dt} = -\frac{V_{out} - 0}{R}$$
$$V_{out} = -CR\,\frac{dv_{in}}{dt}$$

3. Differentiator



$V_a = V_b = 0$

Current through capacitor C_1 $\quad i_c = C_1 \dfrac{d(V_i - V_b)}{dt}$

$$= C_1 \cdot \frac{dV_i}{dt}$$

Apply KCL at node B

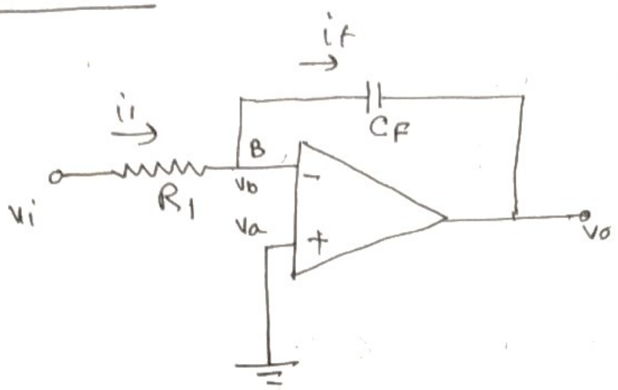
$$i_c = i_f$$

$$C_1 \frac{dV_i}{dt} = \frac{V_b - V_o}{R_f}$$

$$C_1 \cdot \frac{dV_i}{dt} = \frac{-V_o}{R_f}$$

$$\boxed{V_o = - R_f \cdot C_1 \cdot \frac{dV_i}{dt}}$$

4. Integrator



$$V_a = 0$$

$$V_b = V_a = 0$$

$$i_f = C_F \cdot \frac{d(V_b - V_o)}{dt}$$

Apply KCL at node B

$$i_1 = i_f$$

$$\frac{V_i - V_b}{R_1} = C_F \cdot \frac{d(V_b - V_o)}{dt}$$

$$\frac{V_i}{R_1} = -C_F \cdot \frac{dV_o}{dt}$$

$$\frac{dV_o}{dt} = -\frac{1}{R_1 C_F} \cdot V_i$$

$$\boxed{V_o = -\frac{1}{R_1 C_F} \int V_i \, dt + V_o(0)}$$