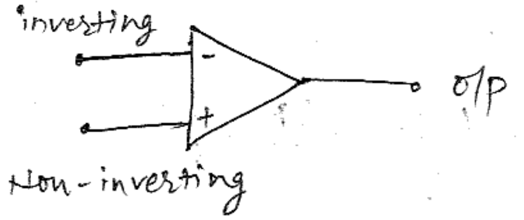
UNIT-II

Applications of op-amplifier

op-amp: symbol → linear / Non-linear

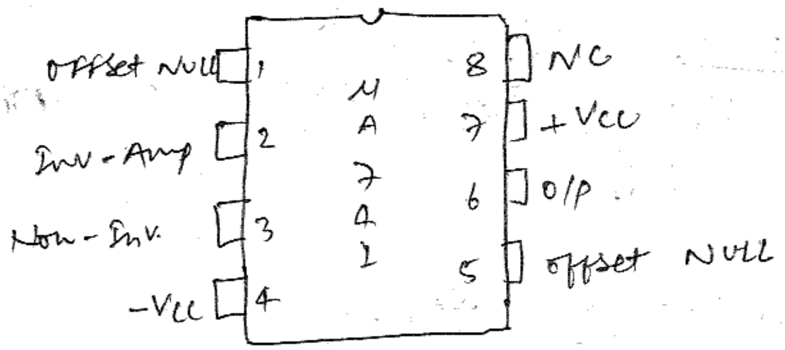


Offset voltage - External applying voltage.

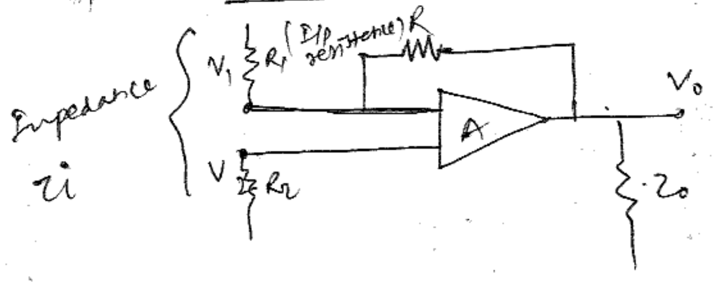
Packages

1. Metal can
2. Dip (Dual ~~compatt~~ inline package)
3. Flat

PIN diagram. ±5V to ±20V.

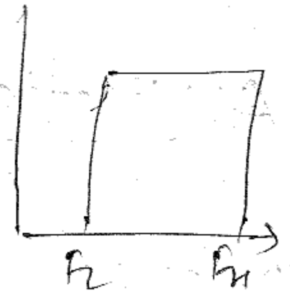


Characteristics:



AOL (open loop gain)

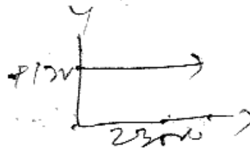
ACL (closed loop gain)



B.W = $f_H - f_L$

2 ii) Input offset voltage (V_{ioff})

Linear - Inverting, Non - inverting, voltage follower, adder, Subtractor, differentiator, integrator, instrumentation amplifier



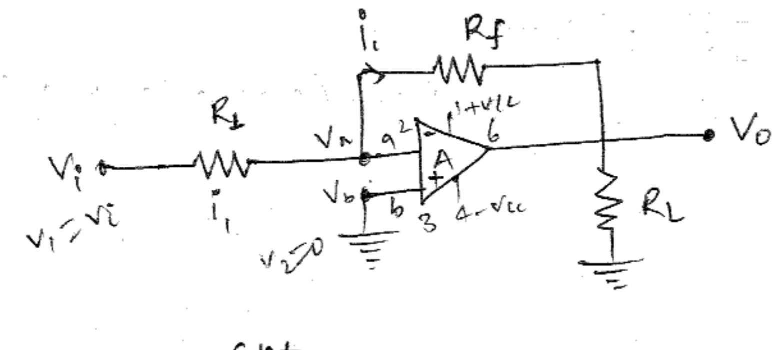
Non-linear : Eg. RPS

~~I/p vol~~ V_{in} = 230V but setting 12V

precision Rectifier : log amplifier, anti-log amplifier, Comparator, ~~schemitrigger~~ sclemitrigger.

LM 745 - provides only +5V.

Inverting amplifier :



Ckt.

~~AOL~~ ~~ACLo~~ For ACL

Applying KCL,

$$i_1 = \frac{V_i}{R_1} \quad — (1)$$

$$V_b = V_a = 0 \quad — (2)$$

$$i_1 = \frac{V_a - V_o}{R_f} \quad — (3)$$

from (1), (2) & (3)

$$\frac{V_i}{R_1} = \frac{-V_o}{R_f}$$

$$\boxed{V_o = -\frac{V_i R_f}{R_1}}$$

~~$\frac{V_o}{V_i} = \frac{R_f}{R_f}$~~ $$\boxed{\frac{V_o}{V_i} = -\frac{R_f}{R_1}}$$

(Prob. 1) Design an amplifier circuit with the gain of −10 with the i/p ~~ress~~ resistance $R_1 = 10\,k\Omega$.

$$A_{CL} = \frac{V_o}{V_i} = -10$$

$$R_f = -\frac{V_o}{V_i} \times R_1 = -\left(\frac{-10}{1}\right) \times 10 = 100\,k\Omega$$

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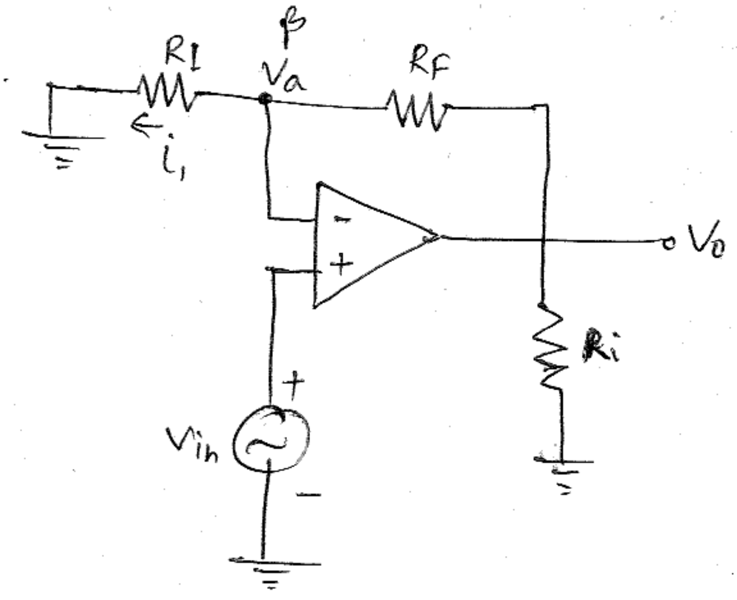
Non-Inverting Amplifier



Applying KCL

$$\frac{V_i - V_a}{R_1} = \frac{V_o - V_i}{R_f}$$

$$\frac{V_i}{R_1} = \frac{V_o - V_i}{R_f} \quad [\because V_a = 0]$$

$$\frac{V_i}{R_1} + \frac{V_i}{R_f} = \frac{V_o}{R_f}$$

$$V_i\left(\frac{1}{R_1} + \frac{1}{R_f}\right) = \frac{V_o}{R_f}$$

$$\frac{V_o}{V_i} = R_f\left(\frac{1}{R_1} + \frac{1}{R_f}\right)$$

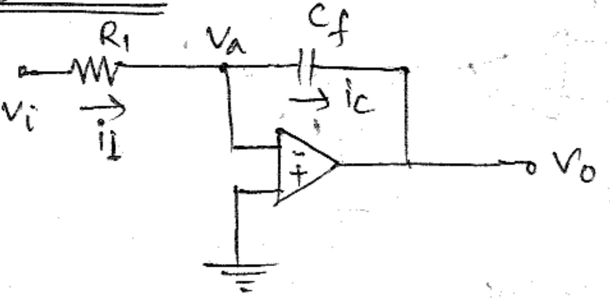
$$\frac{V_o}{V_i} = R_f\left(\frac{R_f + R_i}{R_1 R_f}\right)$$

$$\frac{V_o}{V_i} = \frac{R_i + R_f}{R_i}$$

$$\boxed{V_o = \left(\frac{R_i + R_f}{R_i}\right) V_i}$$

$$\therefore \boxed{\beta = \frac{R_i}{R_i + R_f}}$$

Integrator



Applying KCL in the ckt :

$$\frac{V_i - V_a}{R_1} = \frac{C\, d(V_a - V_o)}{dt}$$

$$\therefore \frac{V_i}{R_1} = + \frac{C dV_o}{dt} \quad [\because V_a = 0]$$

Now, taking integration, on both sides

$$\int \frac{V_i}{R_1} dt = -C \int \frac{dV_o}{dt}$$

$$\int \frac{V_i}{R_1} dt = -CV_o$$

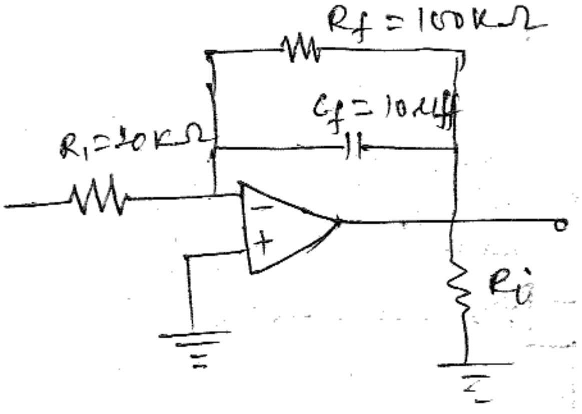
$$\boxed{V_o = -\frac{1}{R_1 C_f} \quad V_i\, dt}$$

Applications:

1] Analog to digital converter.
2] Analog computer.
3] RAM generator.
4] Frequency Response of capacitor.

Q] consider a ~~partial~~ practical integrated ckt for the component values $R_1 = 10k\Omega$, $R_f = 100k\Omega$, $C_f = 10\,\mu F$. Determine the lower frequency limit of integration and the response of the ~~output~~. input.

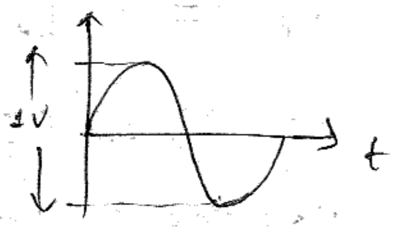
i) sine wave
ii) step I/P
iii) square wave.



1] Sine wave input

For the i/p of one voltage peak value, the o/p is,

$$V_o = \frac{1}{R_1 C_f} \int V_i(t)\, dt$$



$$= \frac{1}{10\times10^3 \times 10\times10^{-6}}$$

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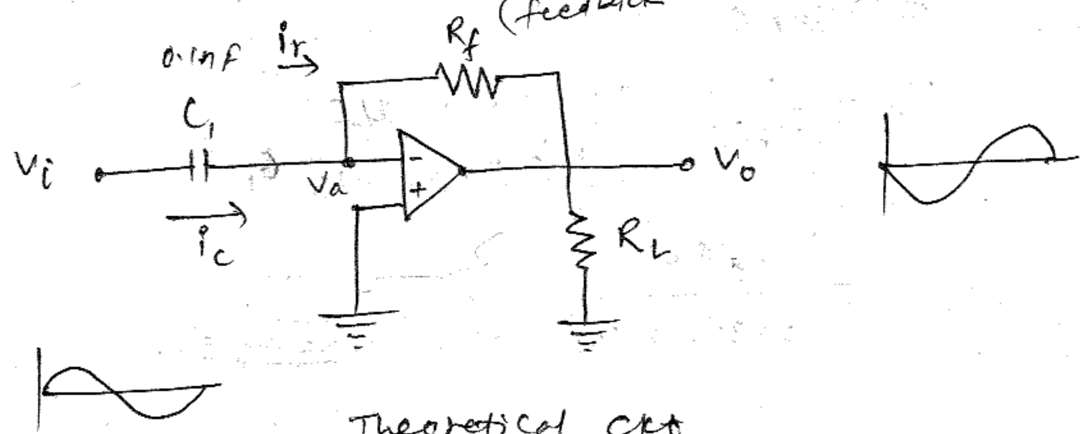
Differentiator



Theoretical ckt.

Applying KCL, $V = IR$

$$i_c = i_r$$

$$C\frac{dv}{dt} = \frac{V_o - V_a}{R_f} \quad [\because V_a = 0]$$

$$C\frac{d(V_a - V_i)}{dt} = \frac{V_o}{R_f}$$

$$-C\frac{dV_i}{dt} = \frac{V_o}{R_f}$$

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

Q: Design an op-amp diffr that will differentiate i/p signal with $f_{max} = 100\text{ Hz}$.

i) Draw the O/p waveform for a sine wave 1v peak at 100 Hz applied to the differentiator.

Soln:

we know,

$$f = \frac{1}{2\pi RC}$$

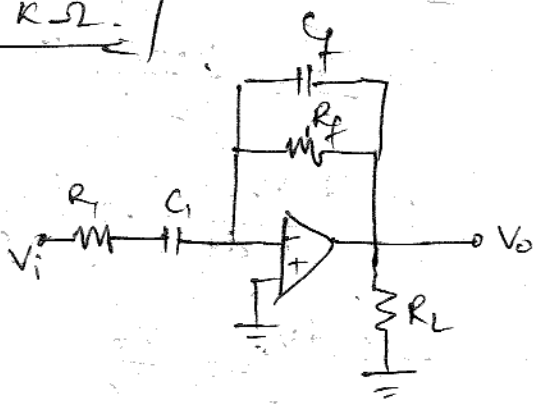
$$R = \frac{1}{2\pi f C} \quad [\because C = 0.1\,\mu f] \quad [C = 0.1 \times 10^{-6} F]$$

$$= \frac{10^{6}}{2 \times 3.14 \times 100 \times 0.1} = \frac{10^{6}}{62.8}$$

$$= 15923.56$$

$$= 15.9 \times 10^{3}$$

$$\boxed{R = 15.9\,K\Omega.}$$



Practical ckt.

again,

$$f = 10 f_a$$
$$= 10 \times 100\,Hz$$
$$f = 1\,KHz$$

$$f = \frac{1}{2\pi R_1 C_1}$$

$$R_1 = \frac{10^{6}}{2\pi \times 1000 \times 0.1} = \frac{10^{6}}{628}$$

$$= 1592.35$$

$$= 1.59235 \times 10^{3}$$

$$\boxed{R_1 = 1.59\,K\Omega.}$$

//.

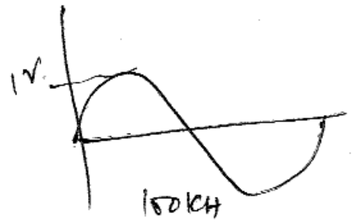
$R_1 C_1 = R_f C_f$

$(1.5\times10^3)(0.1\mu F) = (15.9\times10^3)\ C_f$

$$\boxed{C_f = 0.01 k\Omega}$$

$V_o = -R_f C_1 \frac{dv_i}{dt}$ — (*)

$= -(15.9\times10^3)(0.1\mu F)\ \frac{d\ \sin 200\pi t}{dt}$



$1\sin(2\pi\times100)t$.

$= -15.9\times10^3\times0.1\times10^{-6}\cos 200\pi t.$

$= -1.59\times10^{-3}\cos 200\pi t\times200\pi$

$= -0.9985\cos 200\pi t.$

$= -0.999\cos 2\pi 100t$

$$\boxed{V_o = 1\cos 2\pi 100 t.}$$ //.