Analog and Digital Systems (UEE505)

Lecture # 8
Introduction to Op Amp -II

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Example

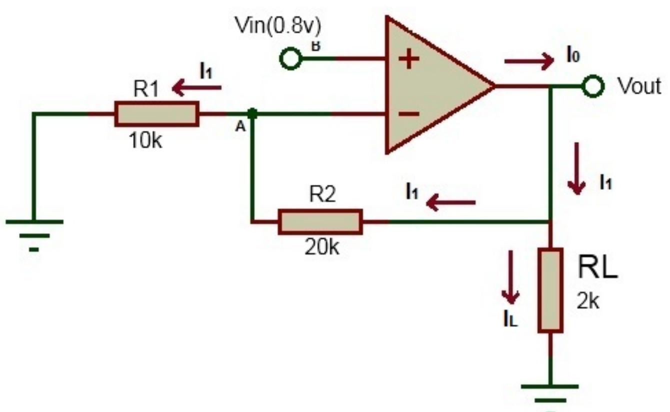
For the non-inverting amplifier shown in the figure below, calculate

i) The gain of the amplifier, A_{CL}

ii) The output voltage, V_O

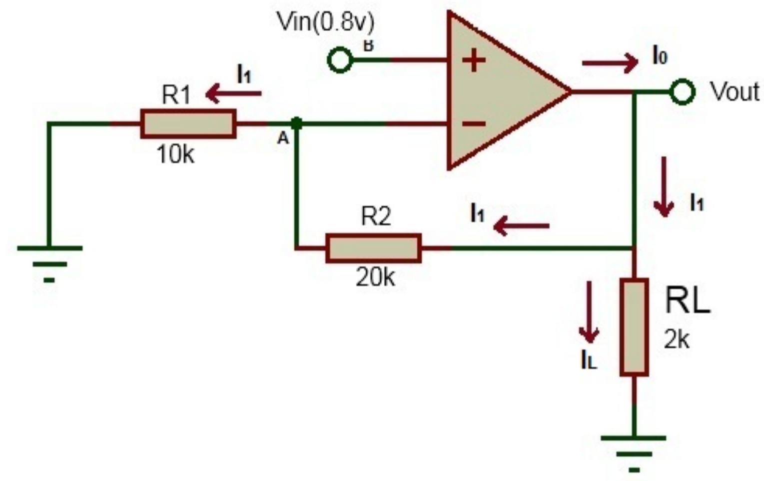
iii) The current through the load resistor, I_L.

iv) The output current, I_O.



Solution

i) The gain of the non-inverting amplifier



$A_{CL} = 1 + (R_f/R_1)$

$= 1 + (20k\Omega/10k\Omega)$

$= 3$

ii) The output voltage, $V_O = A_{CL}.\ V_{IN}$

$= 3\ (0.8V)$

$= 2.4\ V$

iii) Current through the load resistor,IL = VO / RL

$= 2.4 / (2 \times 103\Omega)$

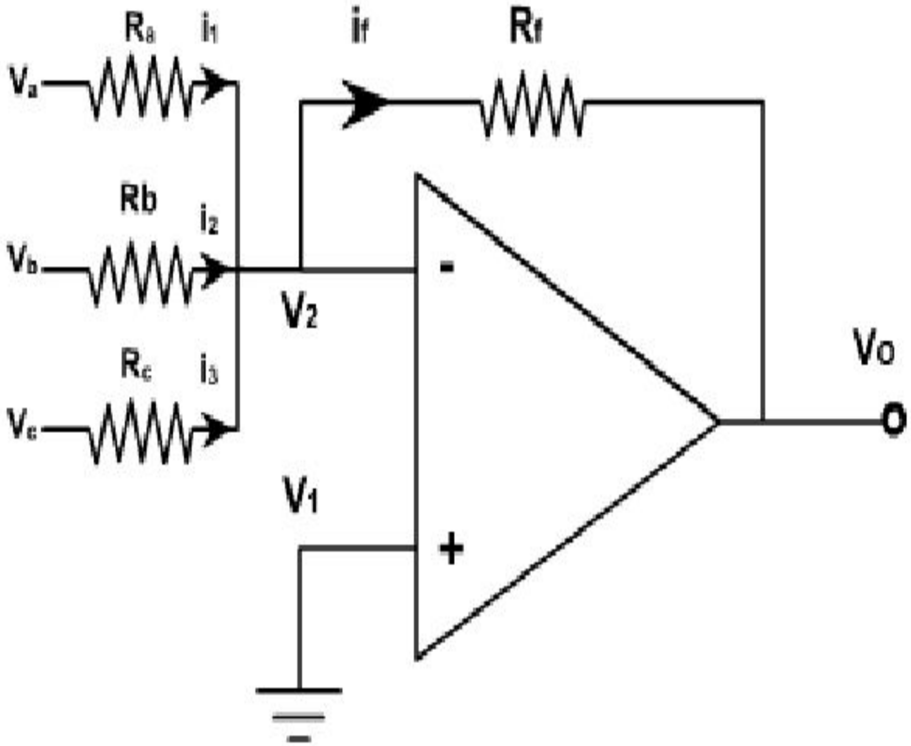
$= 1.2\ mA$

iv) The output current, $I_O = I_1 + I_L$ (KCL)

$= 80\mu A + 1.2\ mA$

$= 1.28mA$

Summing and Averaging Amplifier



Apply KCL at v_2 node:

$$i_1 + i_2 + i_3 = i_f$$

$$\frac{V_a}{R_a} + \frac{V_b}{R_b} + \frac{V_c}{R_c} = \frac{V_o}{R_f}$$

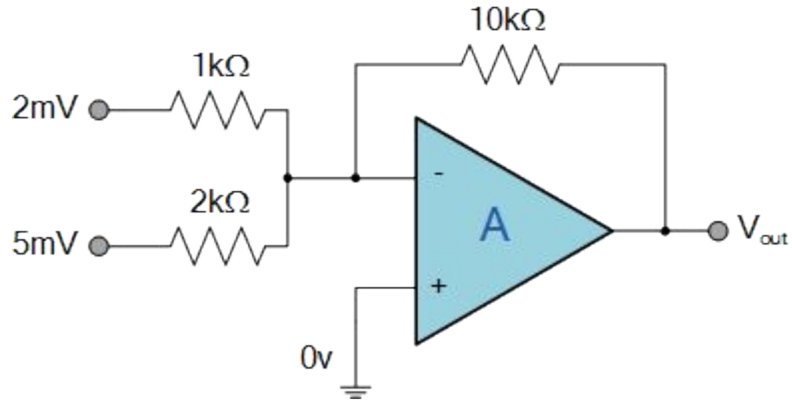
$$V_o = -\left(\frac{R_f}{R_a}V_a + \frac{R_f}{R_b}V_b + \frac{R_f}{R_c}V_c\right)$$

If $R_a = R_b = R_c = R$, then $$\boxed{V_o = -\frac{R_f}{R}(V_a + V_b + V_c)}$$

Note: If $R/R_f = n$ where n is number of inputs then the circuit behave like a averaging amplifier.

Example

Find the output voltage of the following *Summing Amplifier* circuit:



Solution:

$$\text{Gain (Av)} = \frac{V_{out}}{V_{in}} = -\frac{R_f}{R_{in}}$$

$$A_1 = \frac{10k\Omega}{1k\Omega} = -10$$

$$A_2 = \frac{10k\Omega}{2k\Omega} = -5$$

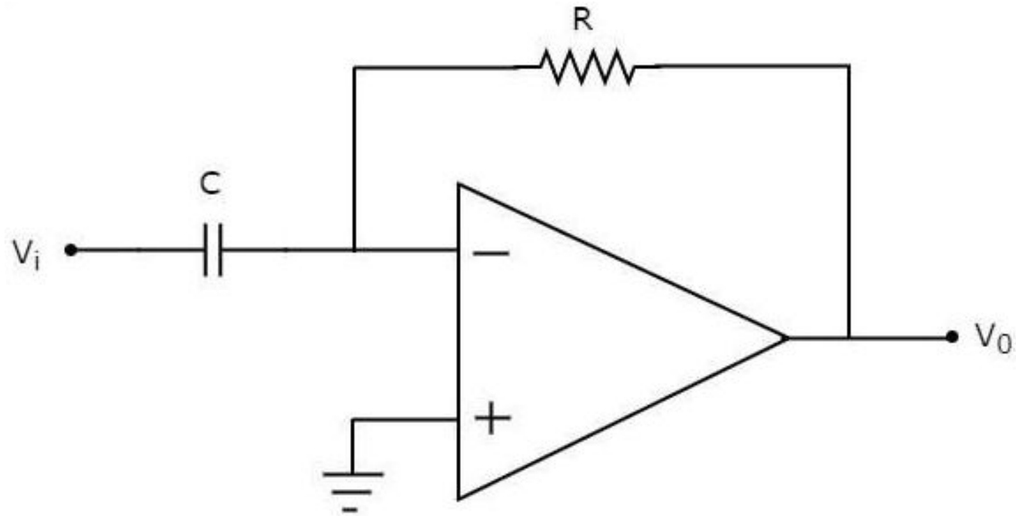
$$Vout = (A_1 \times V_1) + (A_2 \times V_2)$$

$$Vout = (-10(2mV)) + (-5(5mV)) = -45mV$$

Differentiator

A differentiator is an electronic circuit that produces an output equal to the first derivative of its input.

- useful in high-pass filter circuits.
- The nodal equation at the inverting input terminal's node is :



$$C\frac{d(0-V_i)}{dt}+\frac{0-V_0}{R}=0$$

$$-C\frac{dV_i}{dt}=\frac{V_0}{R}$$

$$V_0=-RC\frac{dV_i}{dt}$$

If RC = 1sec, then $V_0=-\frac{dV_i}{dt}$

Integrator

An integrator is an electronic circuit that produces an output that is the integration of the applied input.

- useful in low pass filter circuits and sensor conditioning circuits. The nodal equation at the inverting input terminal is:

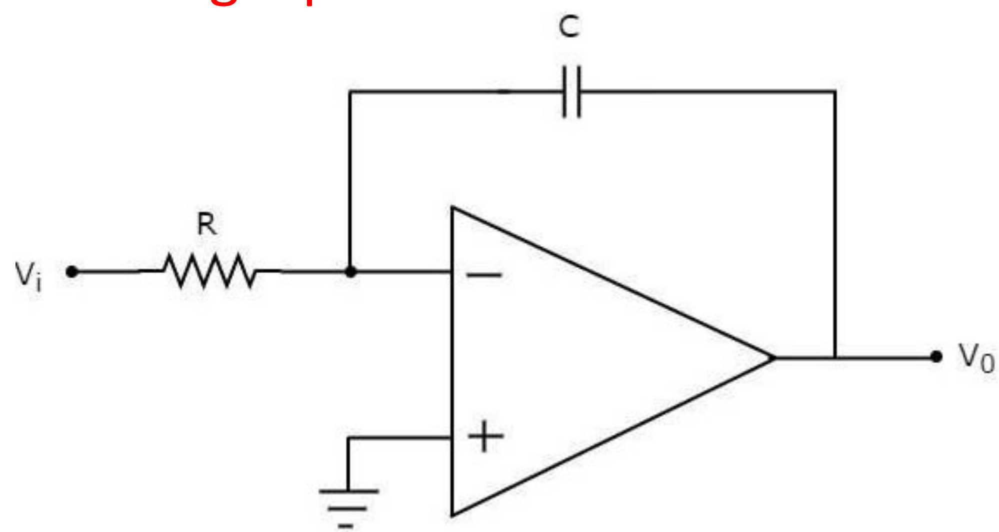
$$\frac{0-V_i}{R}+C\frac{\mathrm{d}(0-V_0)}{\mathrm{d}t}=0$$

$$\frac{-V_i}{R}=C\frac{\mathrm{d}V_0}{\mathrm{d}t}$$

$$\frac{\mathrm{d}V_0}{\mathrm{d}t}=-\frac{V_i}{RC}$$

$$dV_0=\left(-\frac{V_i}{RC}\right)\mathrm{d}t$$

$$\int dV_0=\int\left(-\frac{V_i}{RC}\right)\mathrm{d}t$$

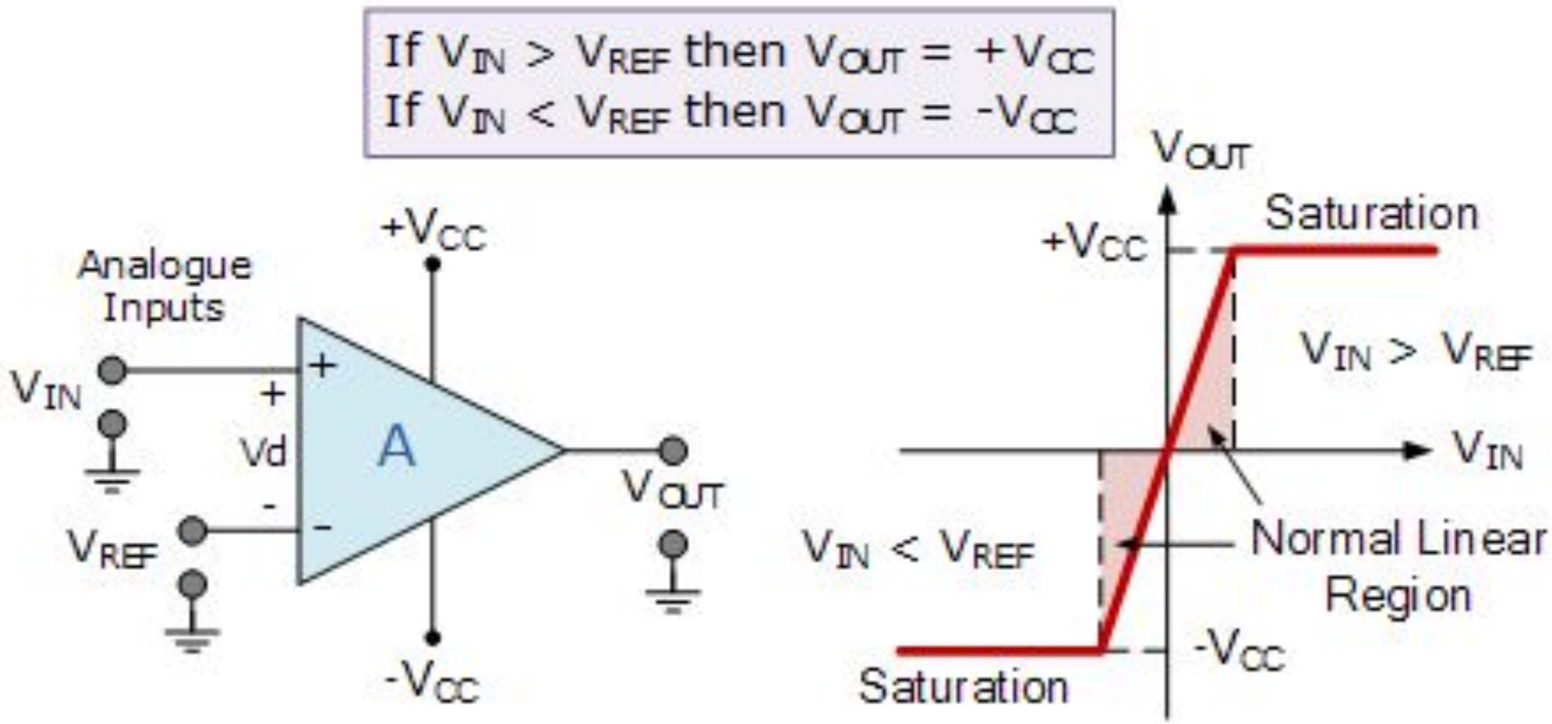


Therefore, $V_0=-\frac{1}{RC}\int V_t\mathrm{d}t$

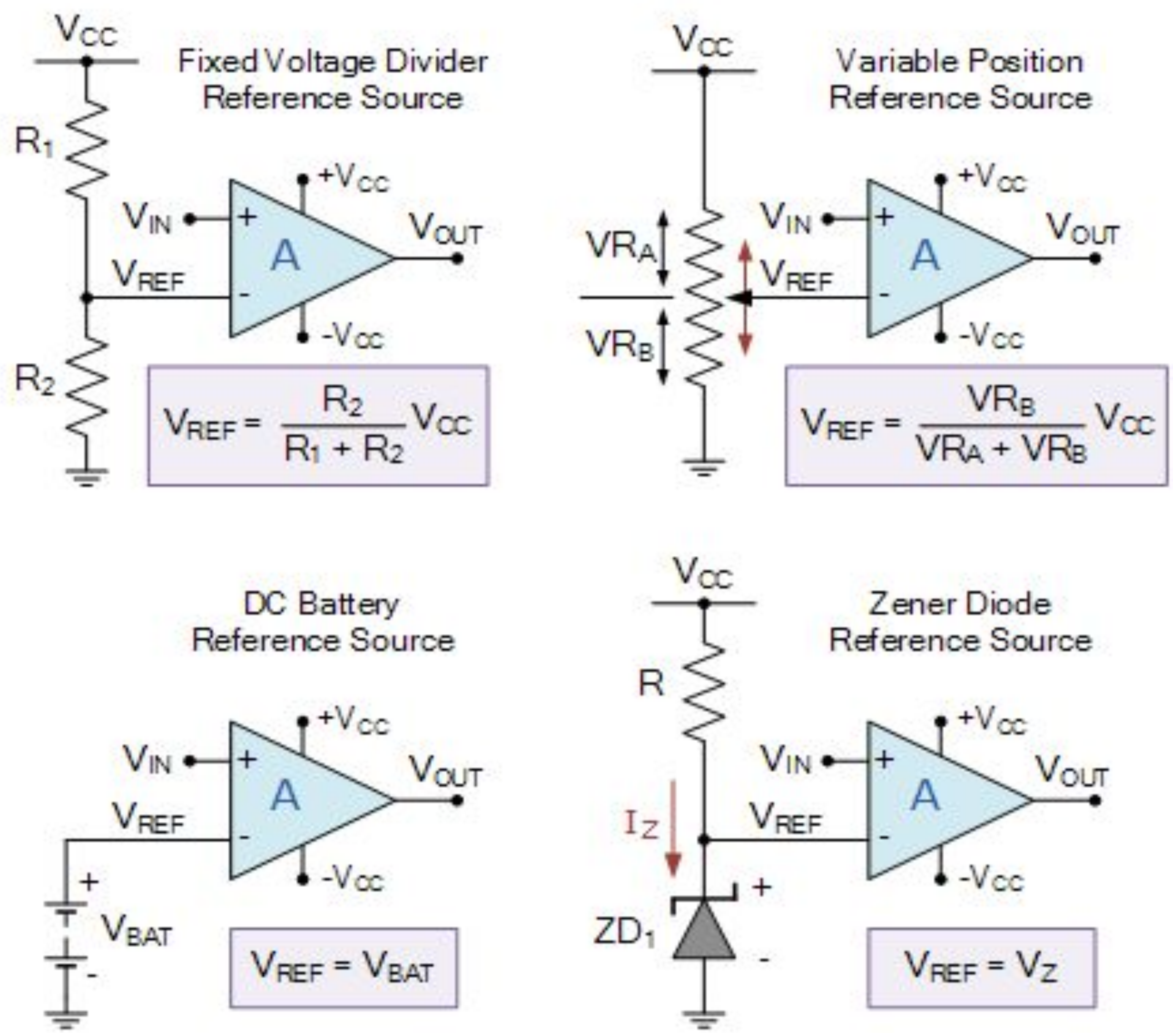
For RC = 1sec, $V_0=-\int V_i\mathrm{d}t$

Comparator

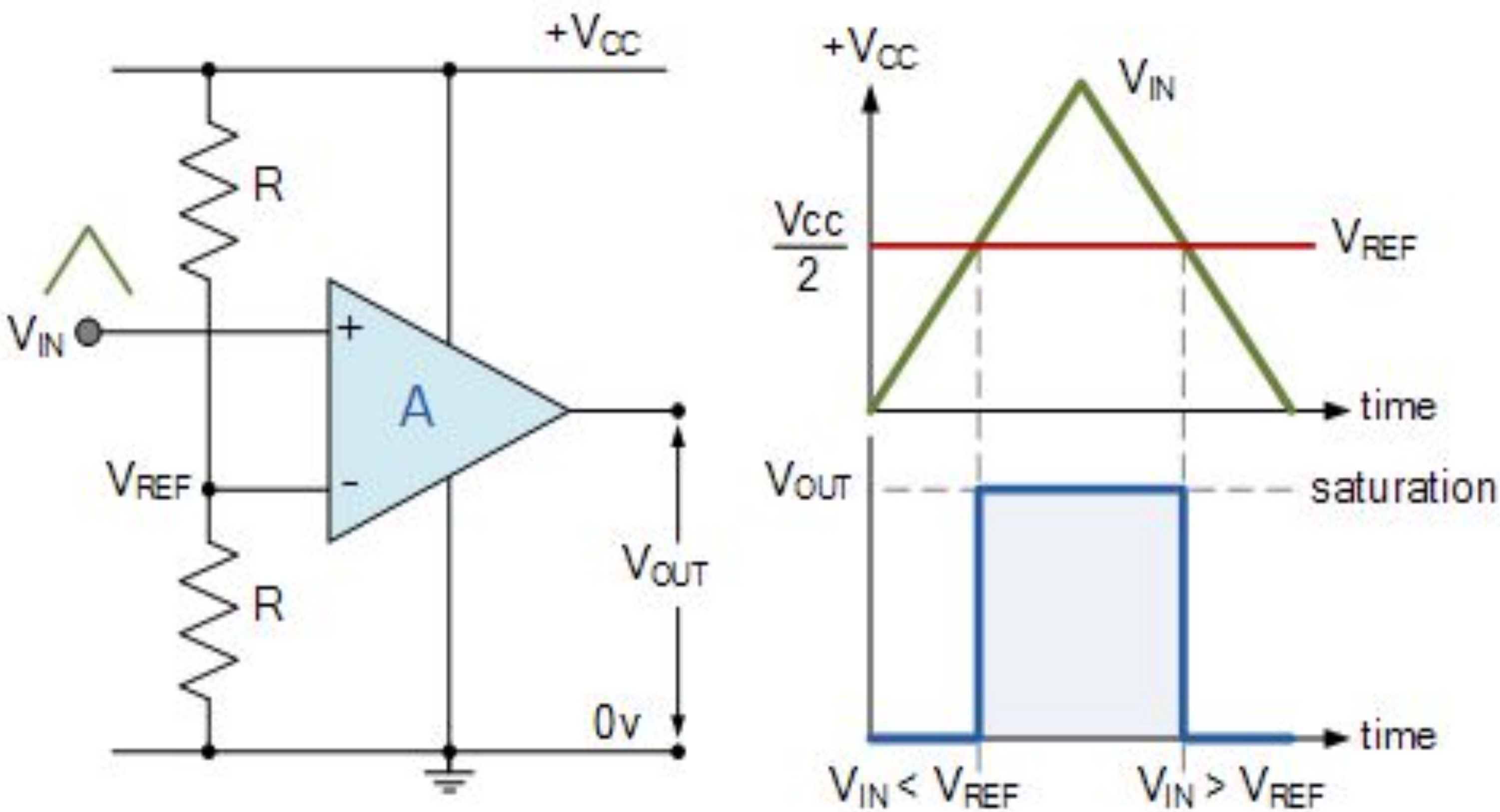
- Type of op-amp that compares two input voltage and produces an output in either of two states



Comparator Reference Voltage



Non inverting Comparator Circuit



References

❖ For more details, refer to:

-- *Boylestad R. L., Electronic Devices and Circuit Theory, Pearson Education*

-- *Op-Amps and Linear Intergrated Circuits , Ramakant A. Gayakwad*

-- https://www.electronics-tutorials.ws/opamp