COLLEGE OF ENGINEERING AND TECHNOLOGIES
ALMUSTAQBAL UNIVERSITY

Electronics Circuits

CTE 204

Lecture 8

- OP AMP CIRCUITS -

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OP-AMP CIRCUITS

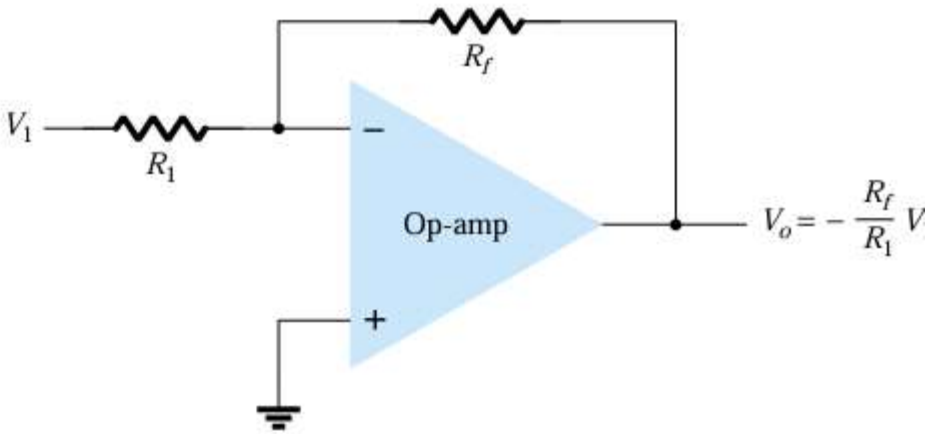
- The op-amp can be connected in a large number of circuits to provide various operating characteristics.

- In this section, we cover a few of the most common of these circuit connections.

Inverting Amplifier

- In this and the following sections, we consider some useful op amp circuits that often serve as modules for designing more complex circuits.

- The first of such op amp circuits is the inverting amplifier shown in Figure below.



Inverting Amplifier

- In this circuit, the noninverting input is grounded, vi is connected to the inverting input through R1, and the feedback resistor Rf is connected between the inverting input and output.

- Our goal is to obtain the relationship between the input voltage vi and the output voltage vo.

Inverting Amplifier

- Applying KCL at node 1,

$$i_1 = i_2 \quad \Rightarrow \quad \frac{v_i - v_1}{R_1} = \frac{v_1 - v_o}{R_f}$$

- But v1 = v2 = 0 for an ideal op amp, since the noninverting terminal is grounded.
- Hence,

$$\frac{v_i}{R_1} = -\frac{v_o}{R_f}$$

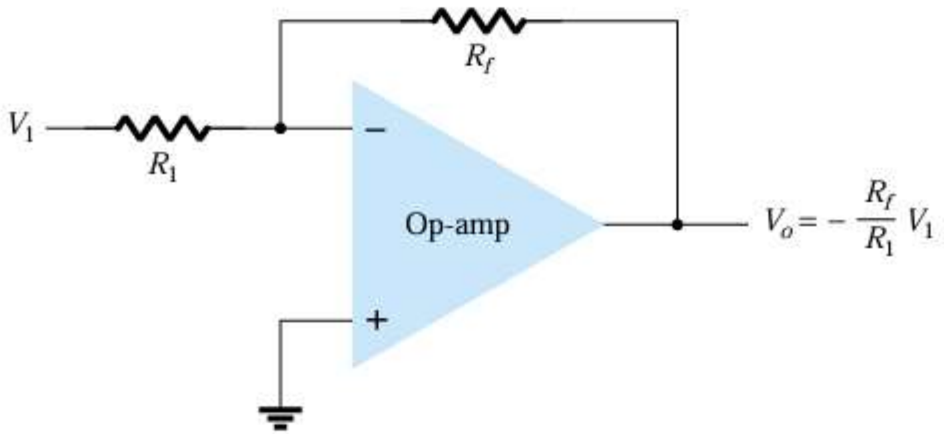
$$\boxed{v_o = -\frac{R_f}{R_1} v_i}$$

Inverting Amplifier

- An inverting amplifier reverses the polarity of the input signal while amplifying it.

- Notice that the gain is the feedback resistance divided by the input resistance which means that the gain depends only on the external elements connected to the op amp.

Example 1 : If the circuit of Figure below has R1 = 100 k and Rf = 500 k , what output voltage results for an input of v1 = 2v?



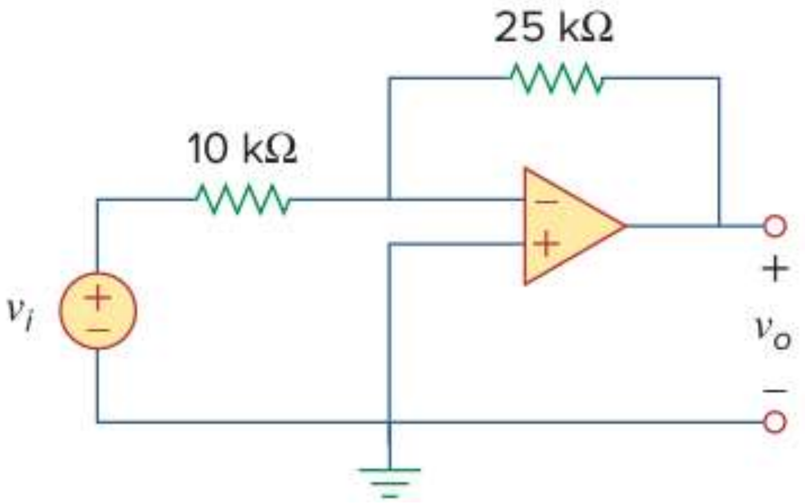
Solution

$$V_o = -\frac{R_f}{R_1} V_1 = -\frac{500\text{ k}\Omega}{100\text{ k}\Omega}(2\text{ V}) = \mathbf{-10\text{ V}}$$

Example 2 : Refer to the op amp in Figure below. If vi = 0.5 V, calculate:

(a) The output voltage vo.

(b) The current in the 10-kΩ resistor.



Inverting Amplifier

Solution:

(a)

$$\frac{v_o}{v_i} = -\frac{R_f}{R_1} = -\frac{25}{10} = -2.5$$

$$v_o = -2.5v_i = -2.5(0.5) = -1.25 \text{ V}$$

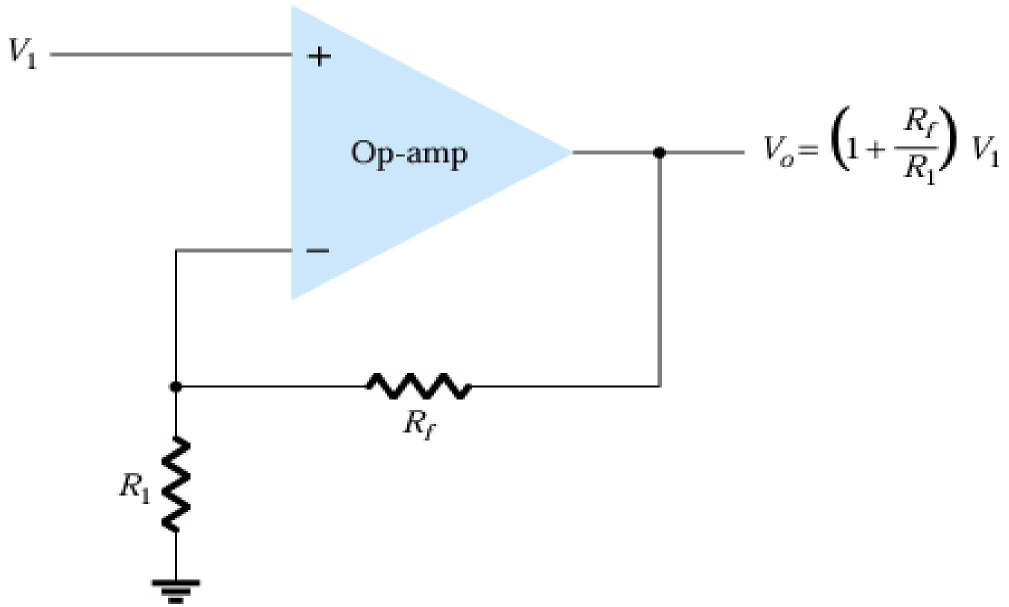
(b) The current through the 10-kΩ resistor is

$$i = \frac{v_i - 0}{R_1} = \frac{0.5 - 0}{10 \times 10^3} = 50\ \mu\text{A}$$

Noninverting Amplifier

- Another important application of the op amp is the noninverting amplifier shown in Figure below.

- In this case, the input voltage vi is applied directly at the noninverting input terminal, and resistor R1 is connected between the ground and the inverting terminal.



Noninverting Amplifier

- We are interested in the output voltage and the voltage gain.

- Application of KCL at the inverting terminal gives

$$i_1 = i_2 \quad \Rightarrow \quad \frac{0 - v_1}{R_1} = \frac{v_1 - v_o}{R_f}$$

Noninverting Amplifier

But $v_1 = v_2 = v_i$.

$$\frac{-v_i}{R_1} = \frac{v_i - v_o}{R_f}$$

or

$$v_o = \left(1 + \frac{R_f}{R_1}\right) v_i$$

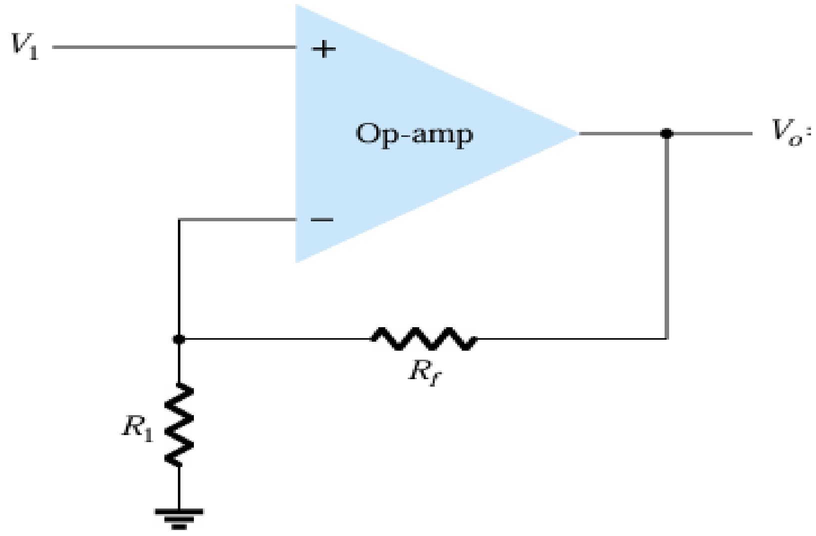
Noninverting Amplifier

- A noninverting amplifier is an op amp circuit designed to provide a positive voltage gain.

- Again we notice that the gain depends only on the external resistors.

- Notice that if feedback resistor $R_f = 0$ (short circuit) or $R_1 = \infty$ (open circuit) or both, the gain becomes 1.

Example 3 : Calculate the output voltage of a noninverting amplifier (as shown in Figure below) for values of V1 = 2 V, Rf 500 k, and R1 100 k.



Solution

$$V_o = \left(1 + \frac{R_f}{R_1}\right)V_1 = \left(1 + \frac{500\ \text{k}\Omega}{100\ \text{k}\Omega}\right)(2\ \text{V}) = 6(2\ \text{V}) = \mathbf{+12\ V}$$