

Basic Electronic Circuits

(IEC-103)

Lecture-03

Operational Amplifiers

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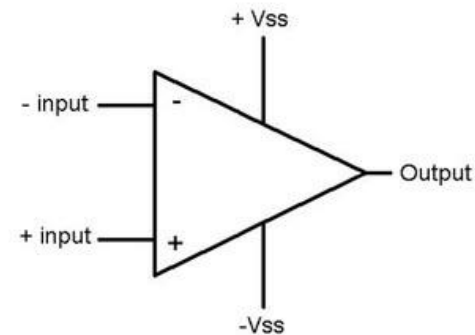
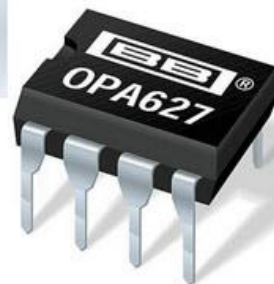
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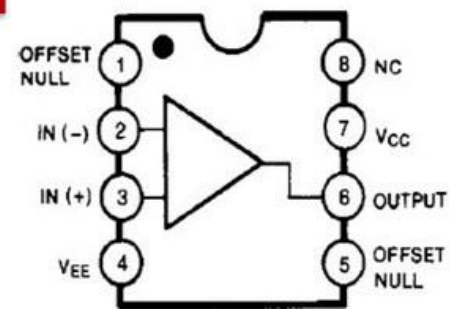
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- ❑ It acts like a voltage controlled voltage source.
- ❑ In combination with other elements it can be made into other dependent sources
- ❑ It performs mathematical operations on analog signals

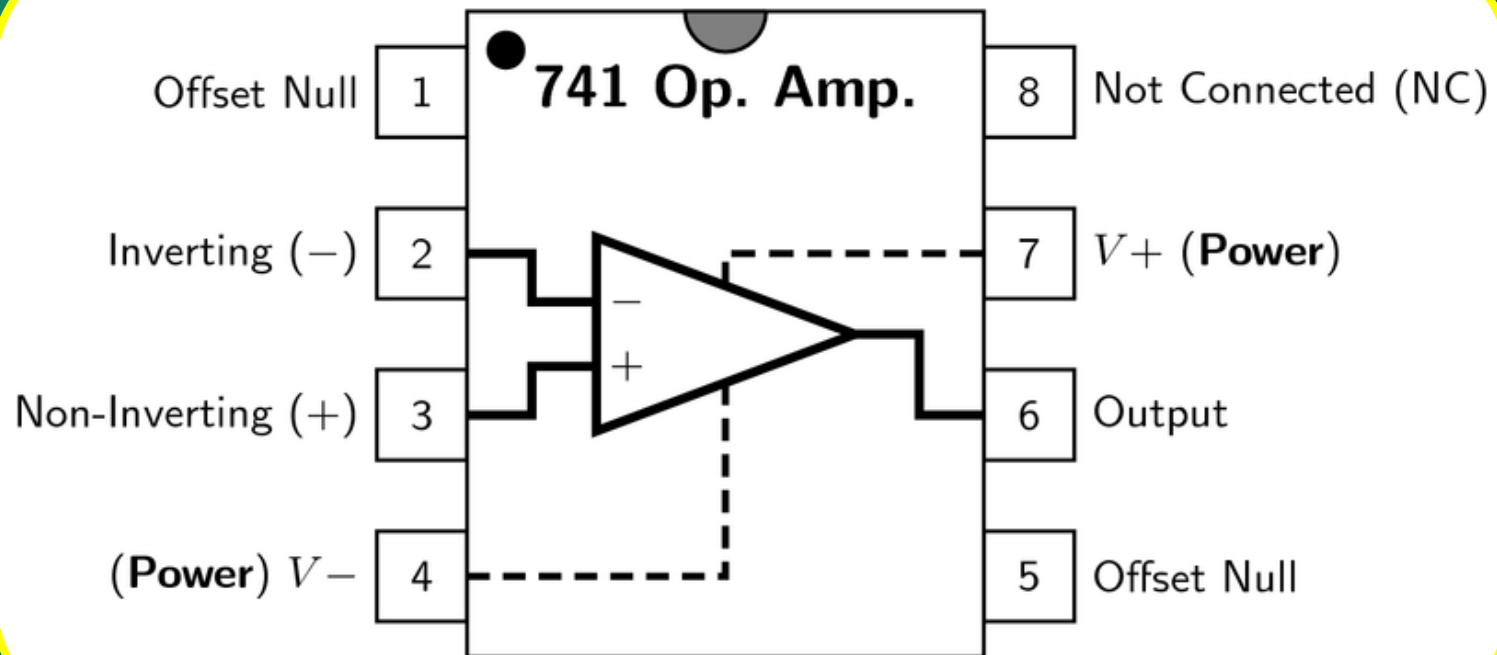
741 Op Amp IC



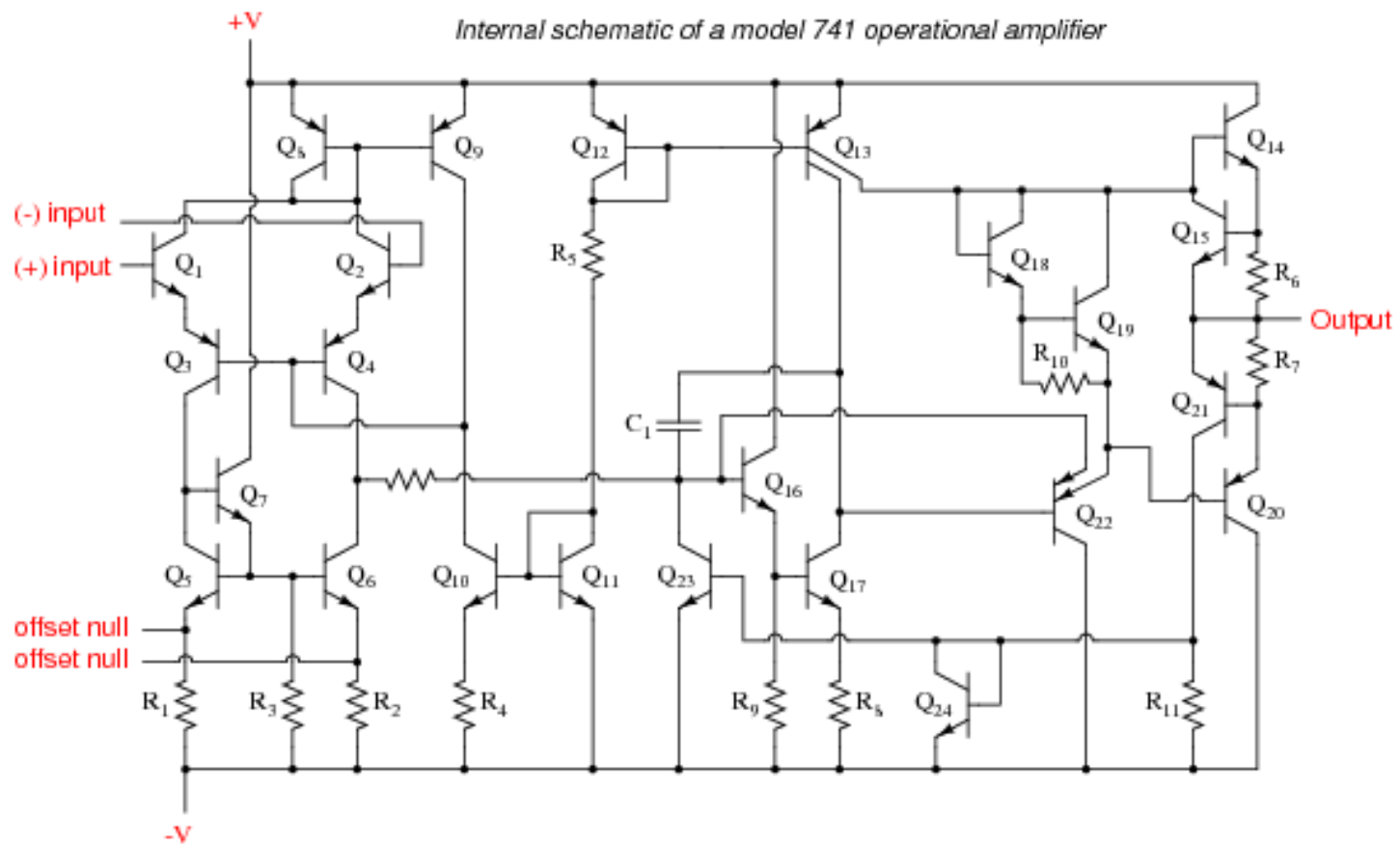
OP-AMP



741 Op Amp IC (Pin Diagram)



741 Op Amp IC (Circuit Diagram)



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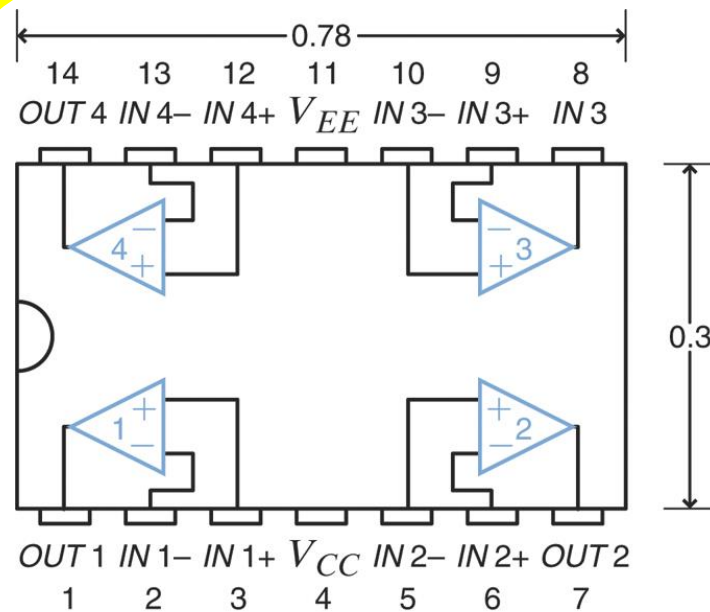
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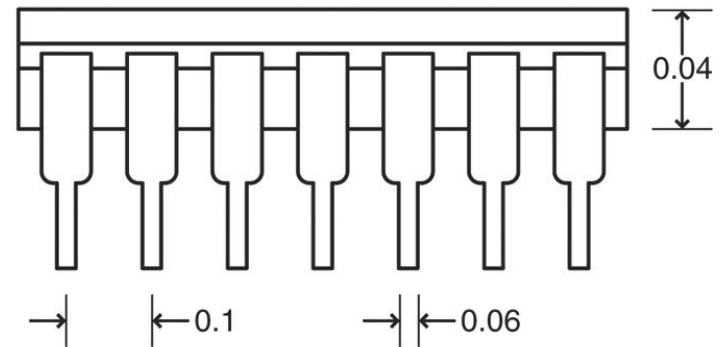
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- ❑ Available in 2 configurations – 8 pin and 14 pin.

14 Pin Op-amp Chip

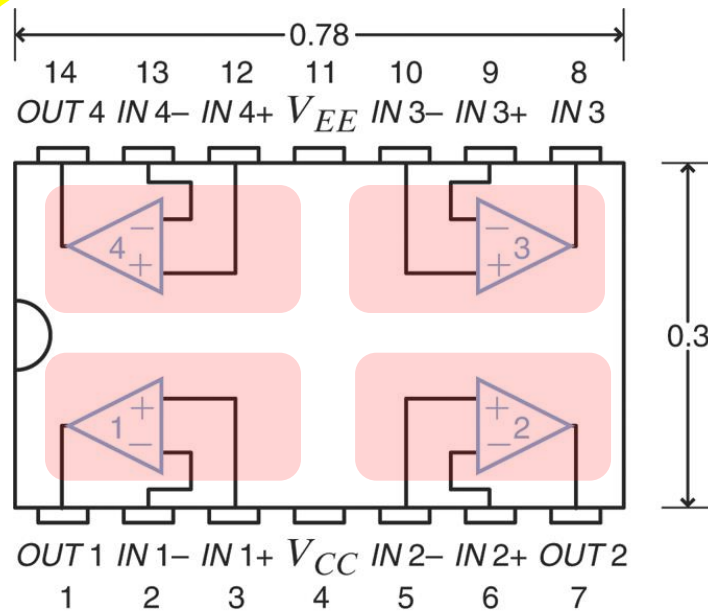


(a)

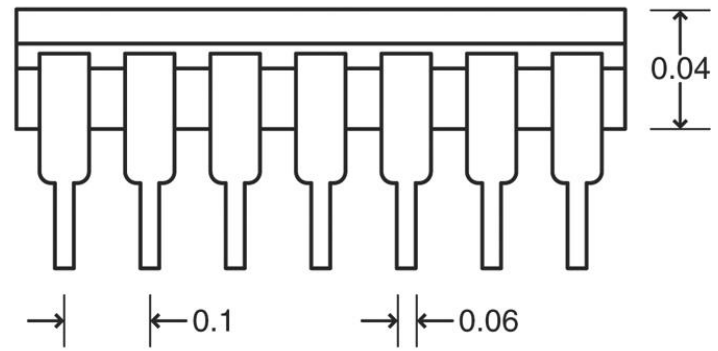


(b)

14 Pin Op-amp Chip



(a)



(b)

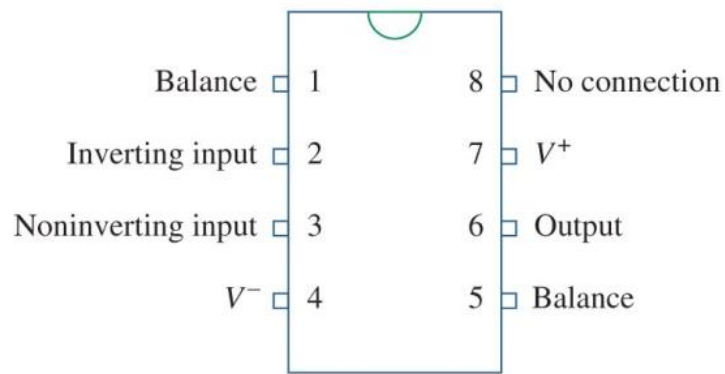
Operational Amplifiers

The op amp amplifier is capable of many math operations, such as addition, subtraction, multiplication, differentiation, integration, etc...

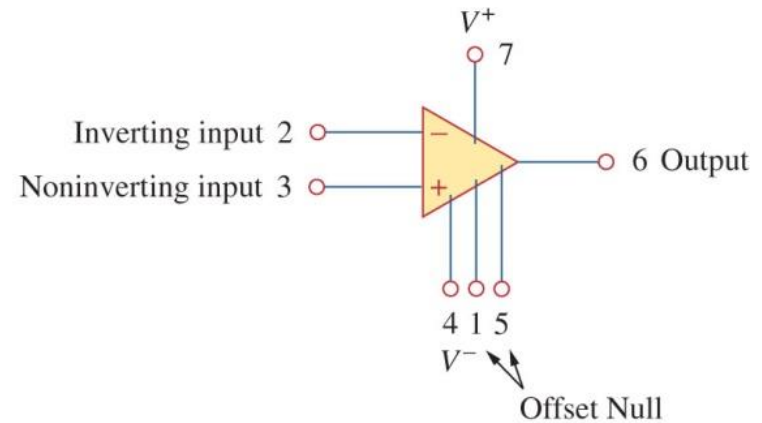
Five important terminals of operational amplifier

- **The inverting input**
- **The noninverting input**
- **The output**
- **The positive and negative power supplies.**

Operational Amplifier



(a)



(b)

Powering an Op-amp

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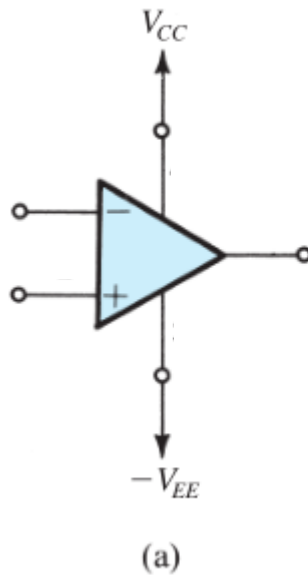
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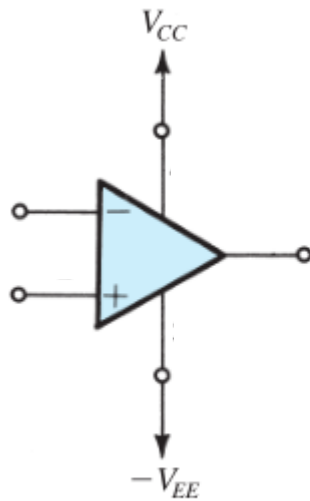
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- ☐ **Most op-amps use two voltage sources, with a ground reference between them.**

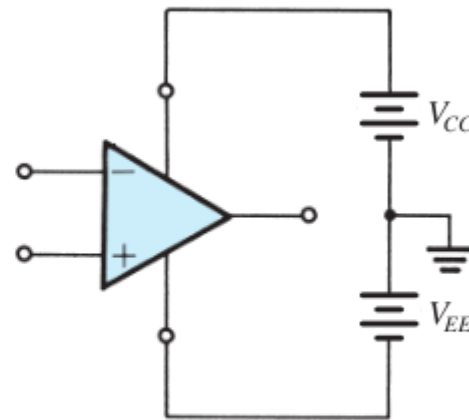
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(a)



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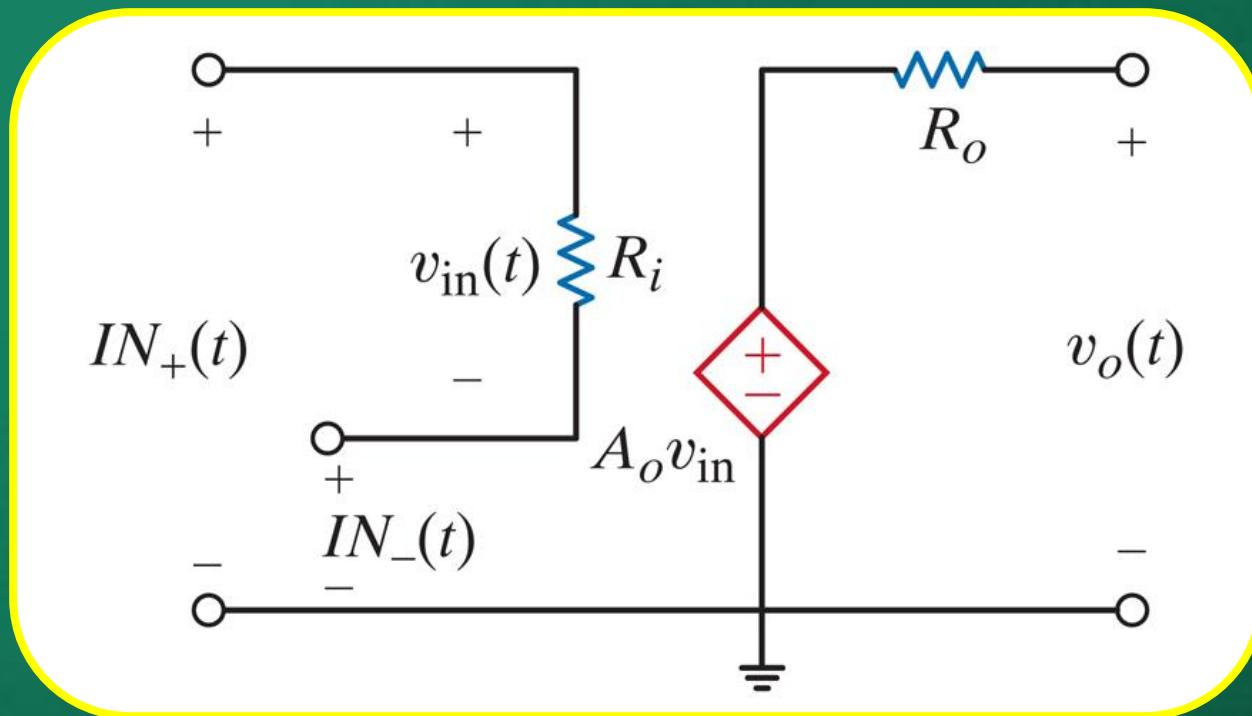
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- In real devices, it is still high: 10^5 to 10^8 volts/volt.

Equivalent Circuit of an Op-amp



Typical Values of Op-amp Params

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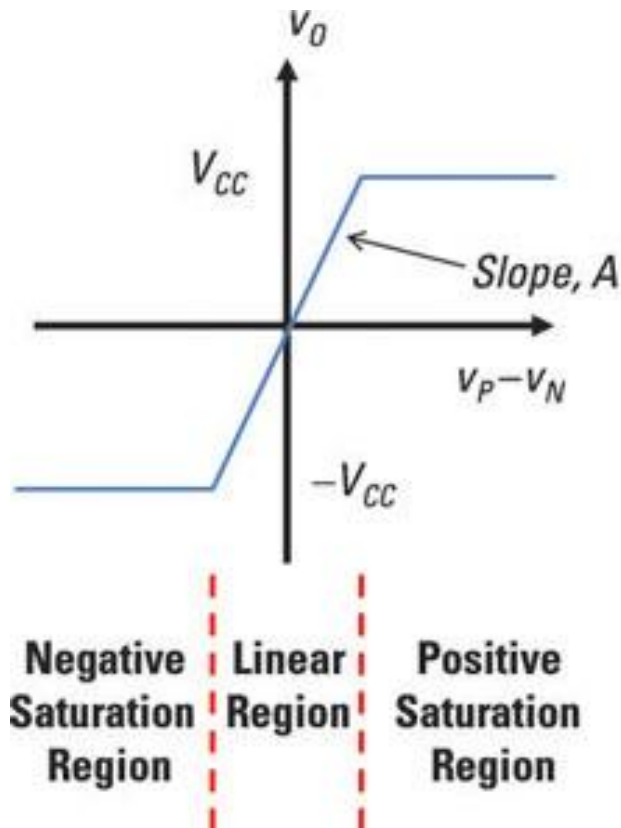
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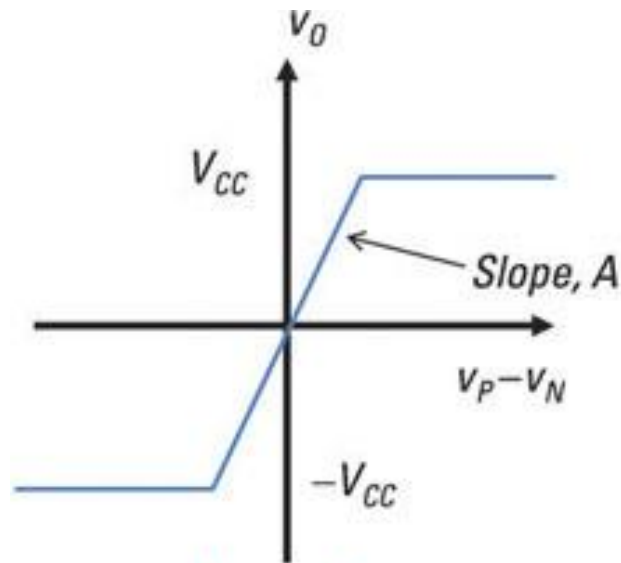
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Supply voltage, V_{CC}	5 to 24 V	

Transfer Characteristics of an Op-amp



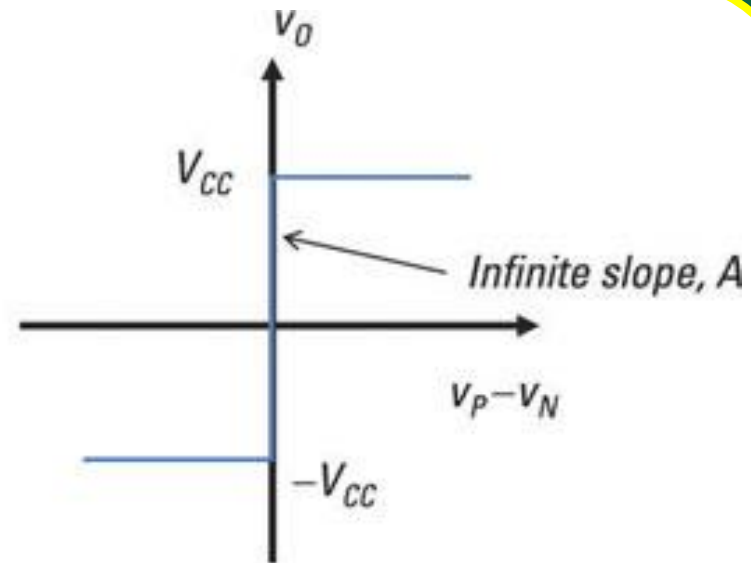
Transfer Characteristics of an Op-amp



Negative
Saturation
Region

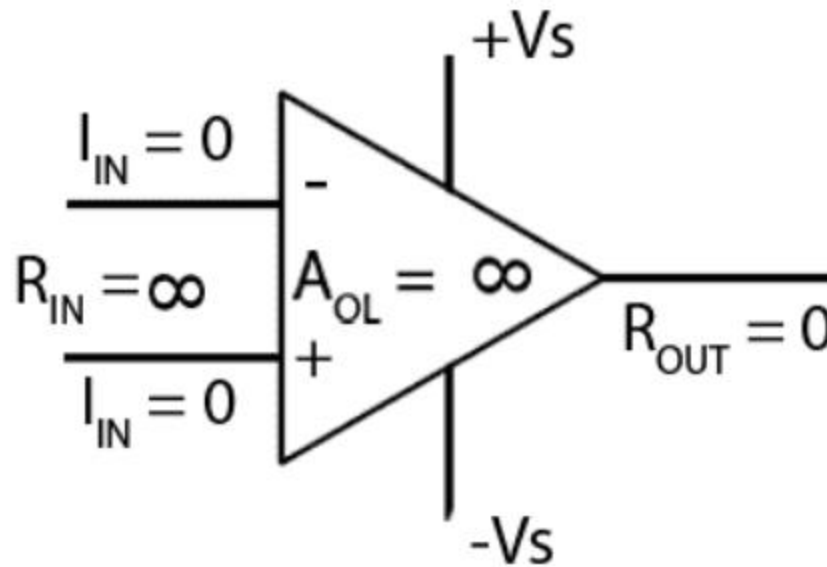
Linear
Region

Positive
Saturation
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Transfer Characteristic
of an Ideal Op Amp

Ideal Op-amp



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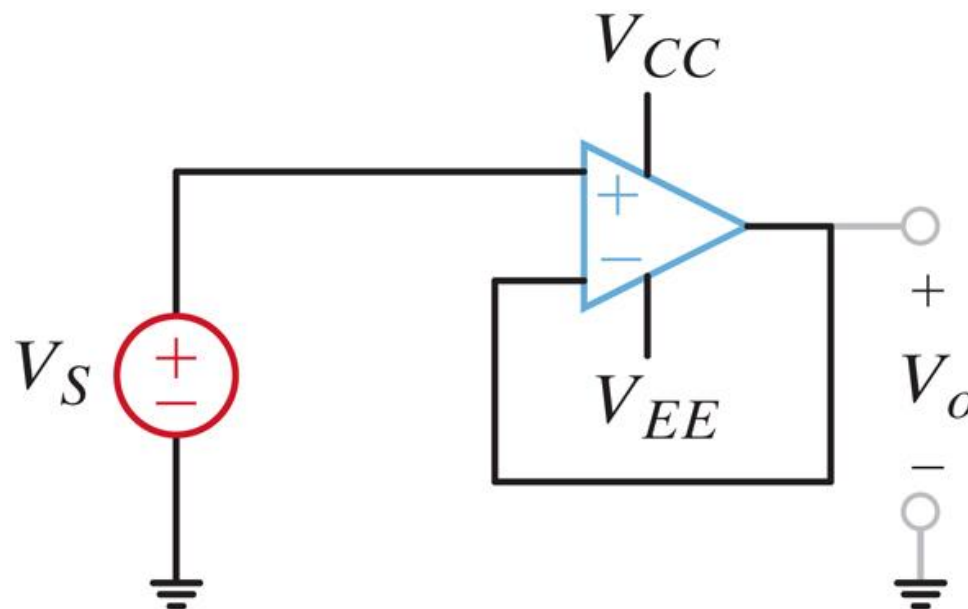
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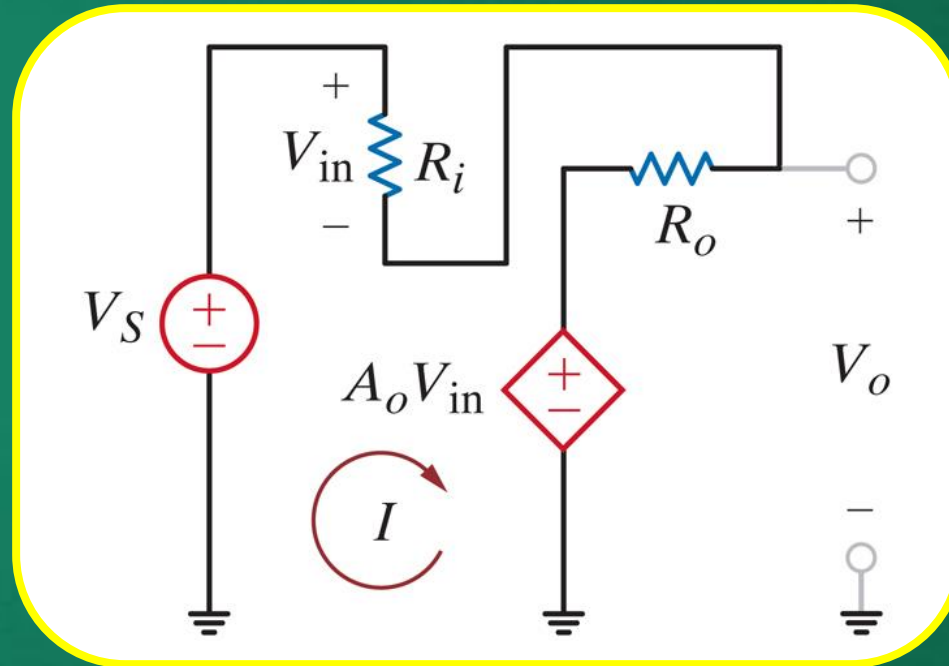
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- ❑ **Positive feedback would lead to oscillations.**

Op-amp Analysis

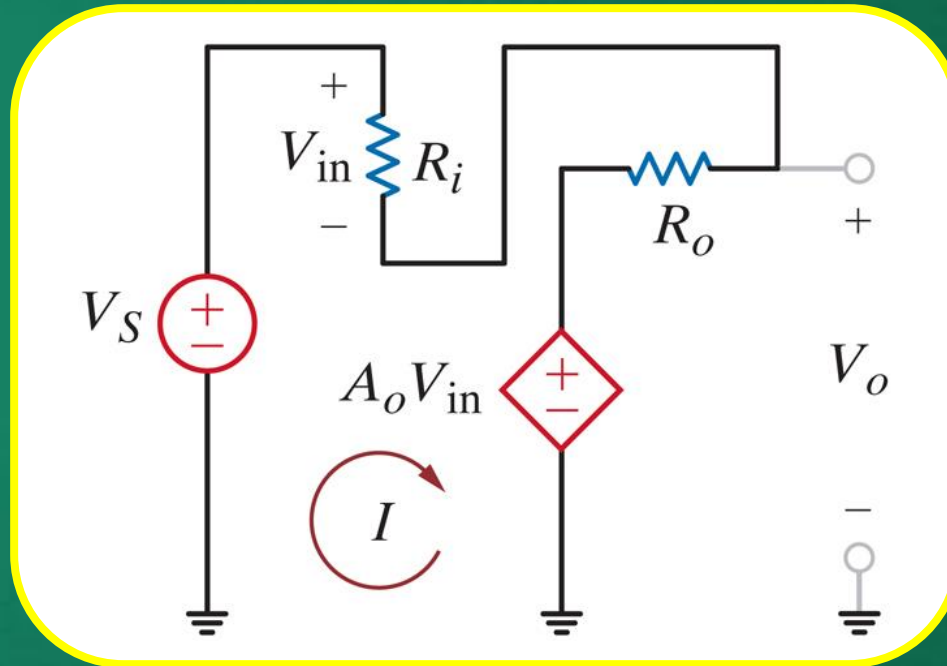
Unity Gain Buffer



Analysis using Circuit Model



Analysis using Circuit Model



$$\frac{V_o}{V_s} = \frac{1}{1 + \frac{R_i}{R_o + A_o R_i}}$$

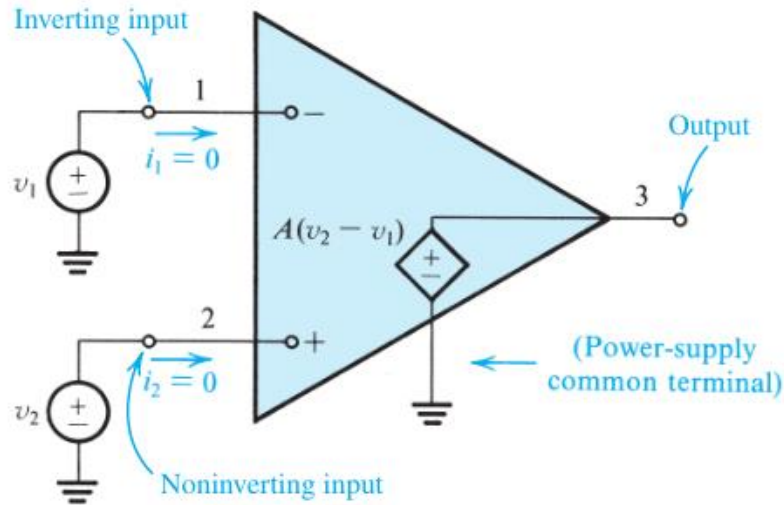
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- No current ever flows into either of the input terminals.**

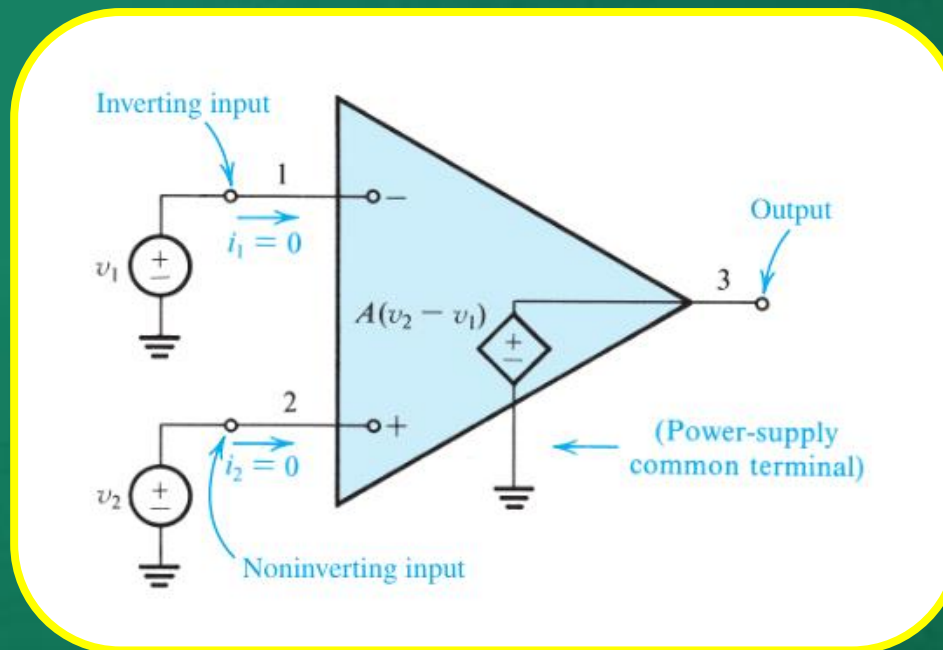
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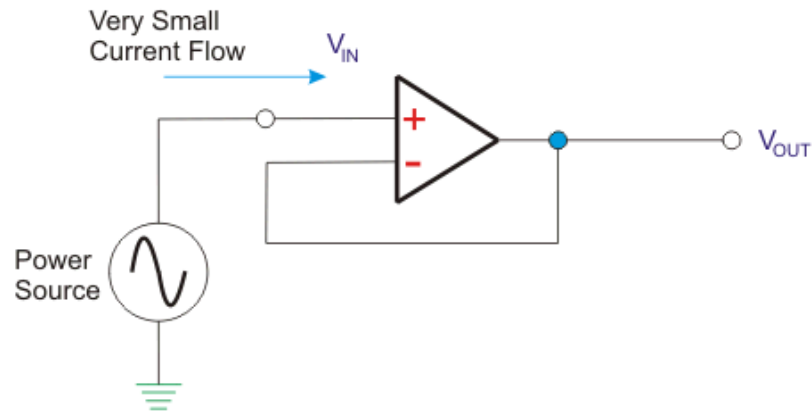
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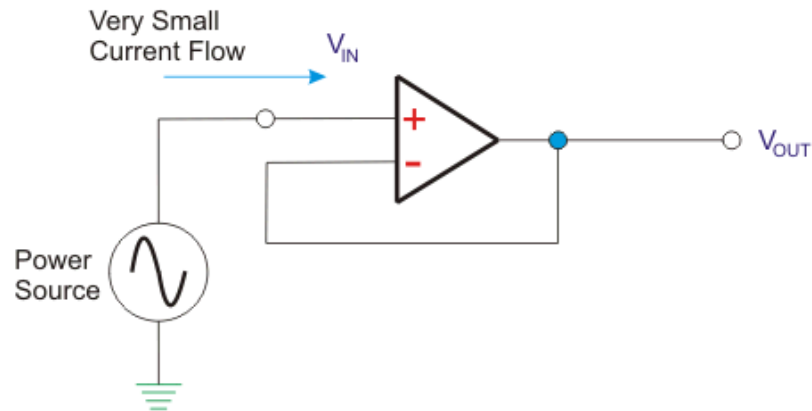


- ❑ There is no voltage difference between the two input terminals.

Analysis using Ideal Op-amp

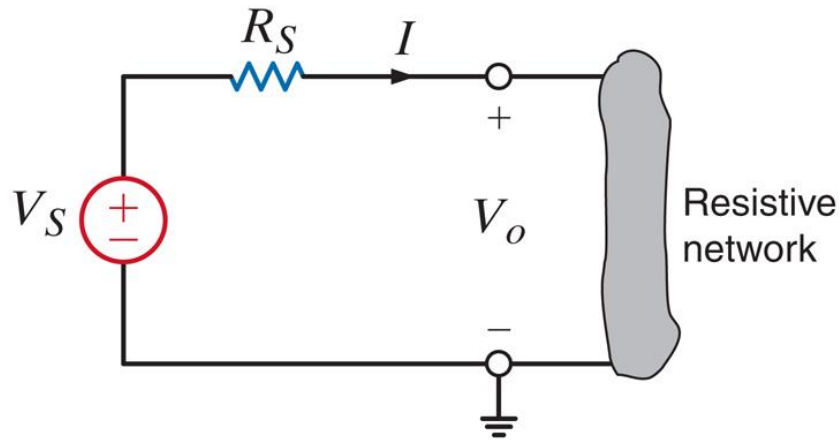


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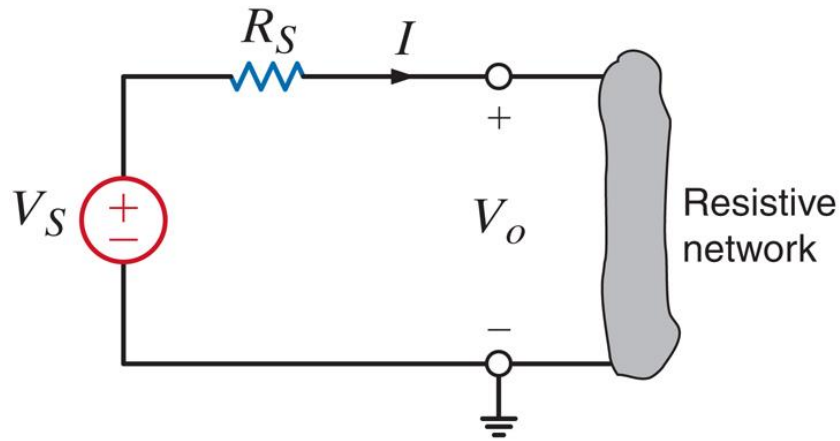


$$\frac{V_{OUT}}{V_{IN}} = 1$$

Advantages of Buffer

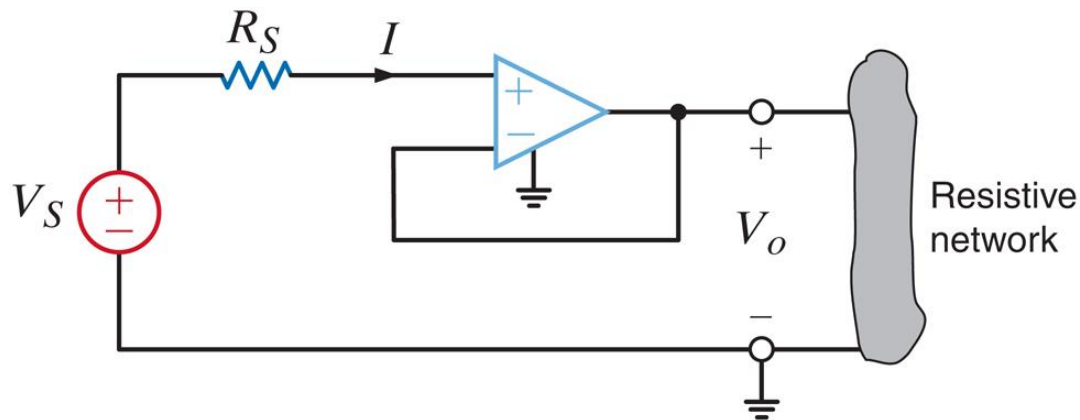


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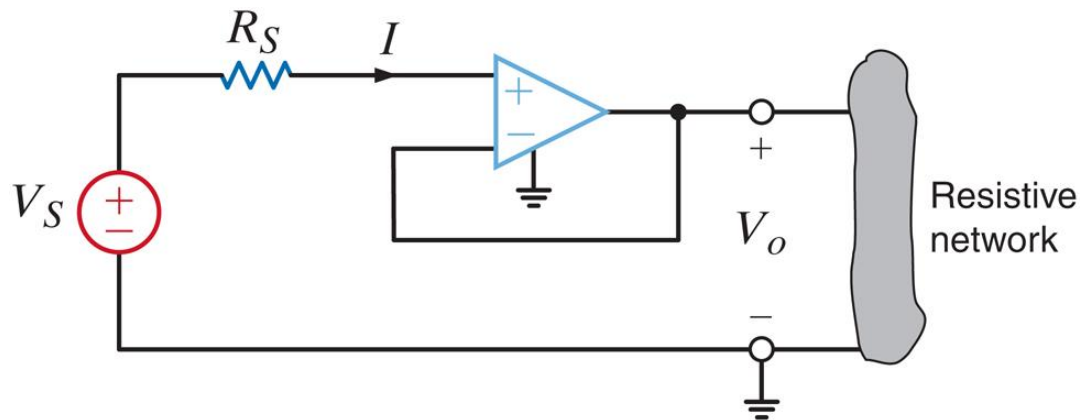


$$V_o = V_s - R_s I$$

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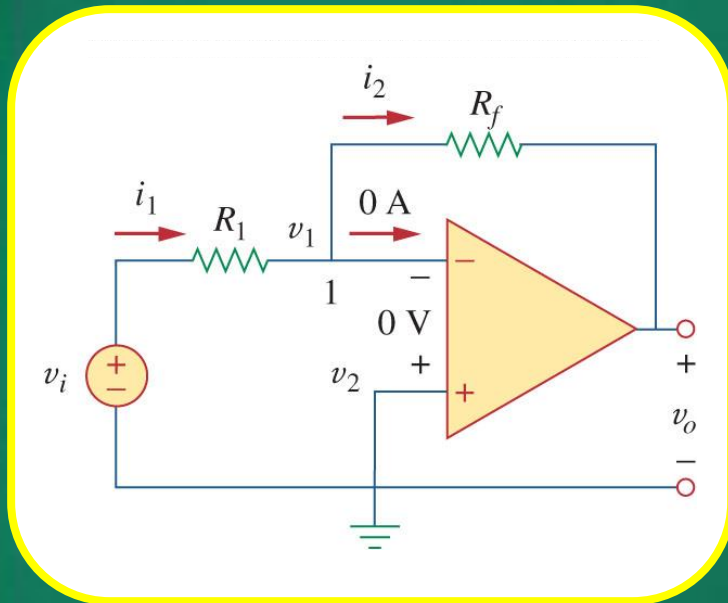


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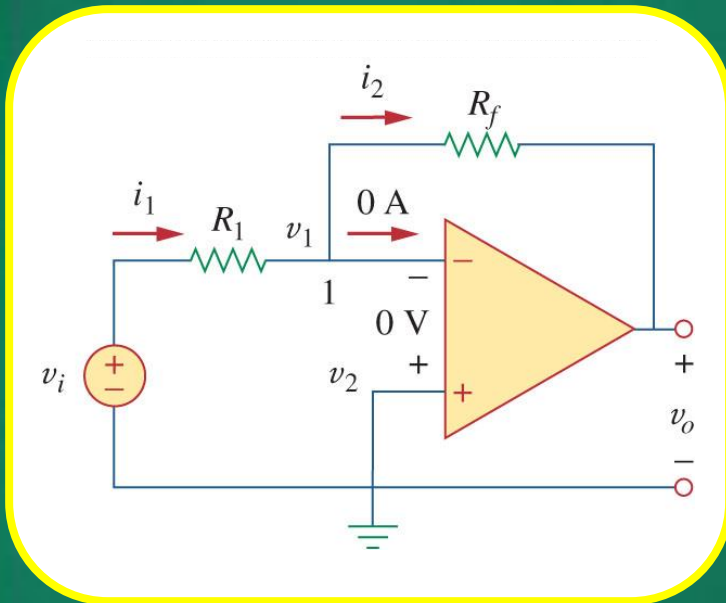
$$V_o = V_s$$

Inverting Amplifier

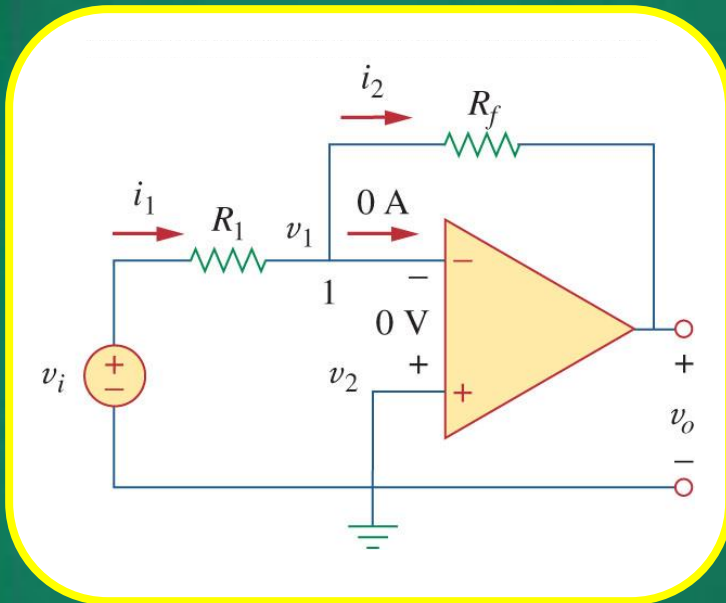


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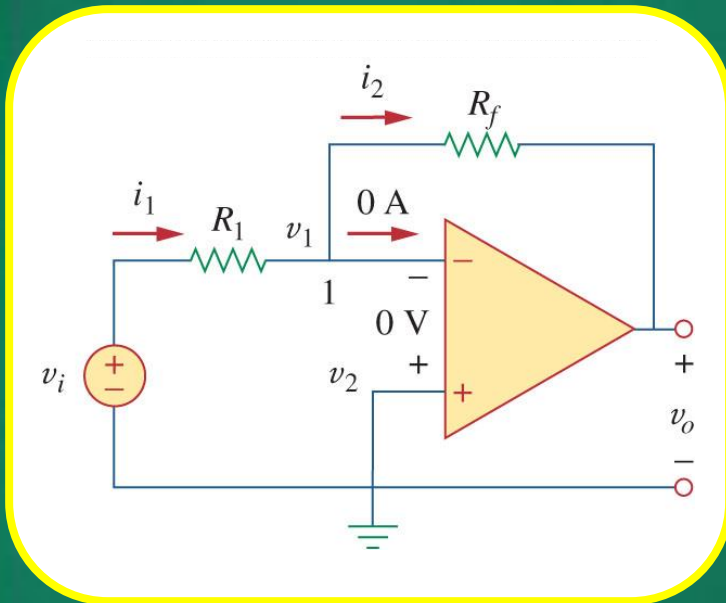


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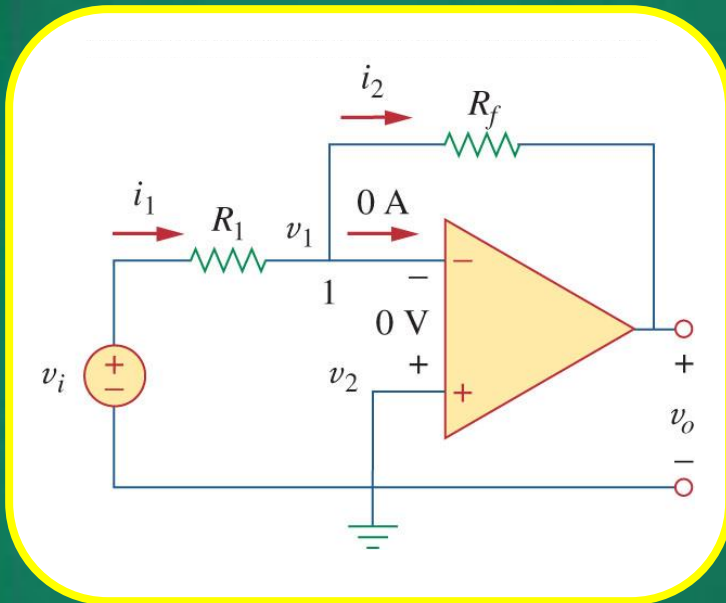
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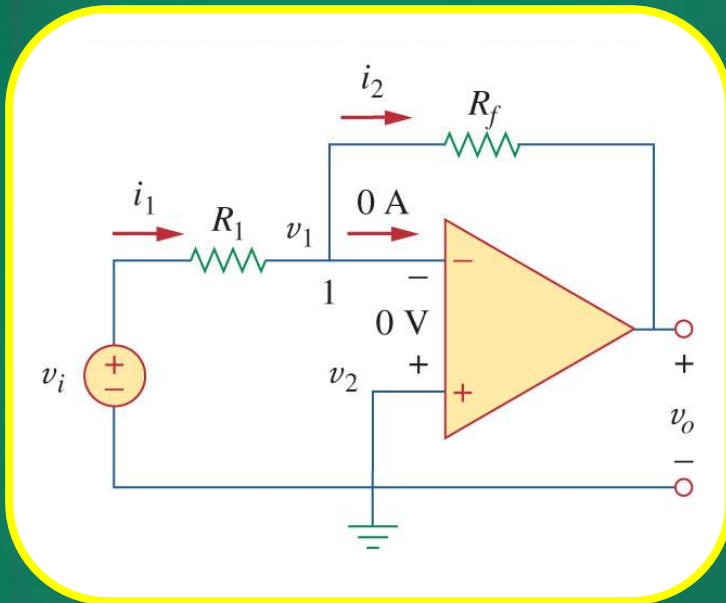
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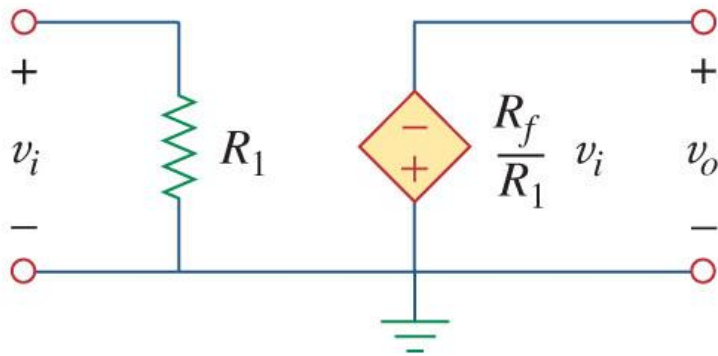
Inverting Amplifier



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

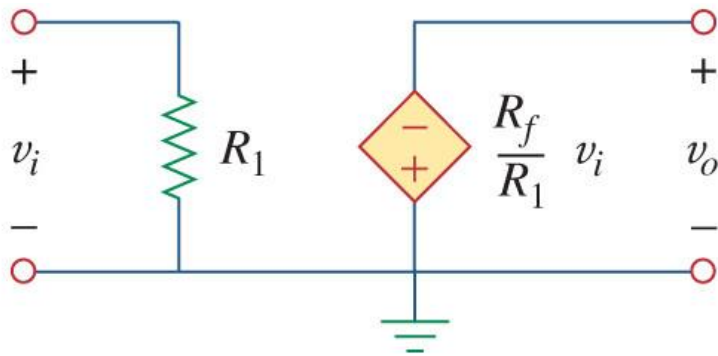
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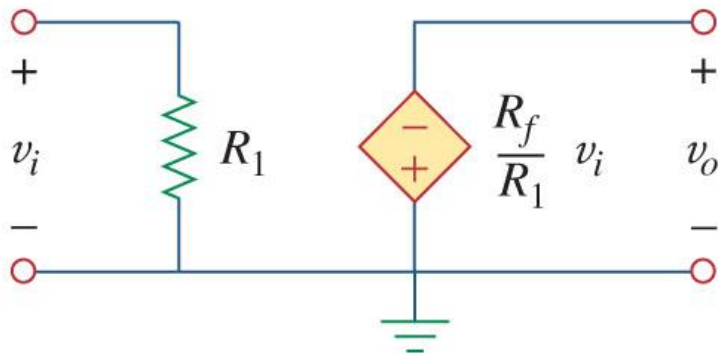
Inverting Amplifier

- The inverting amplifier's equivalent circuit is shown here.

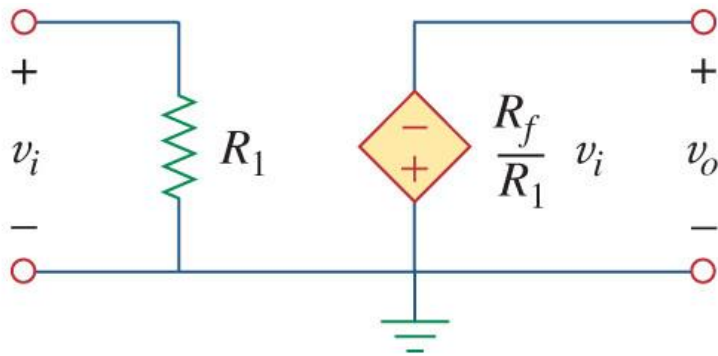


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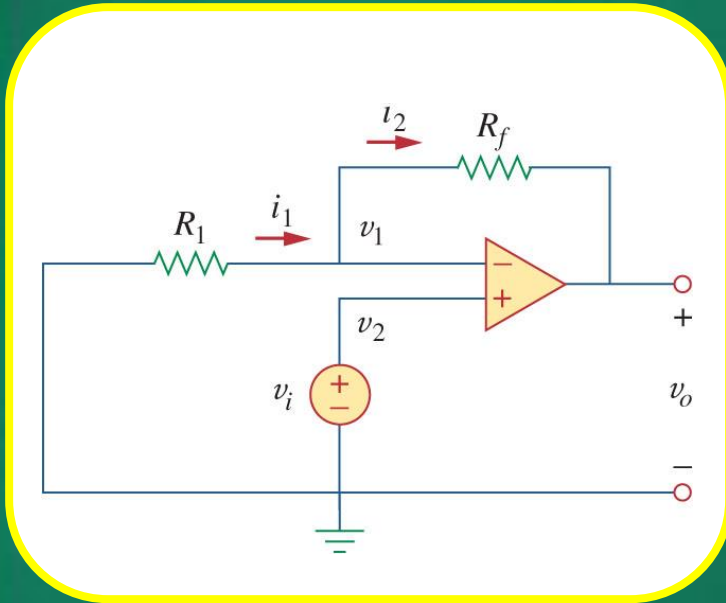


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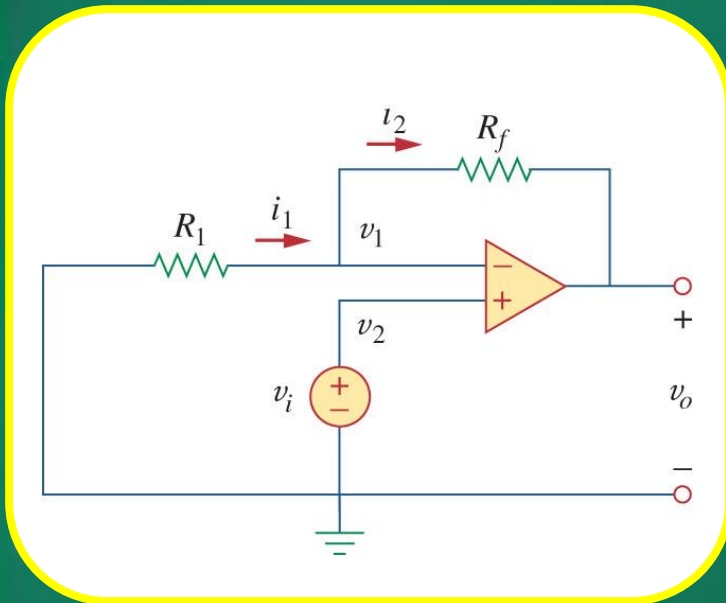


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- Note that it has a finite input resistance.
- It is also a good candidate for making a current-to-voltage converter

Non-Inverting Amplifier

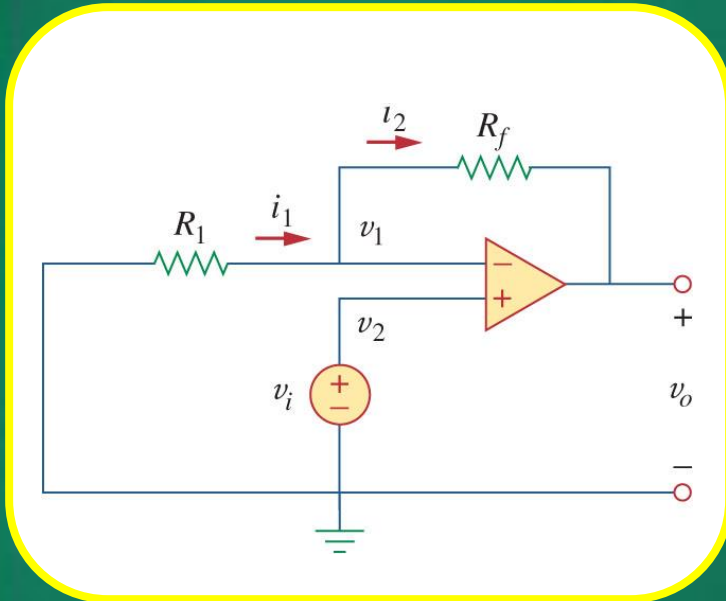


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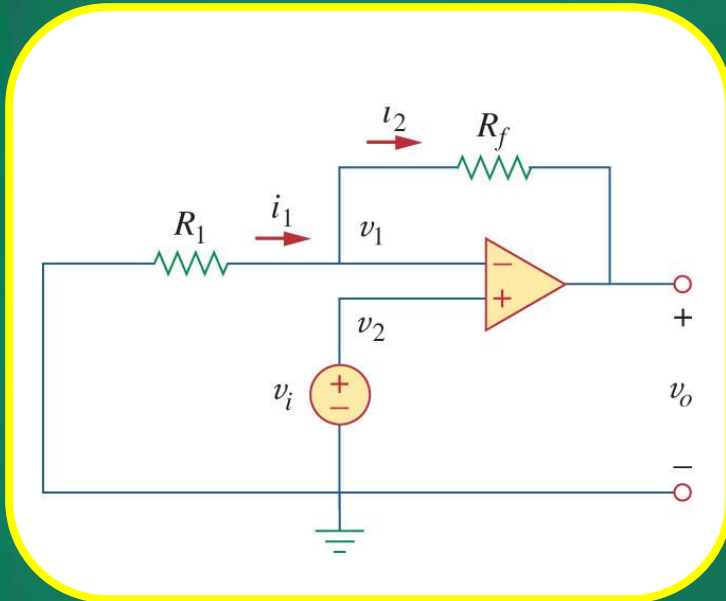
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Non-Inverting Amplifier



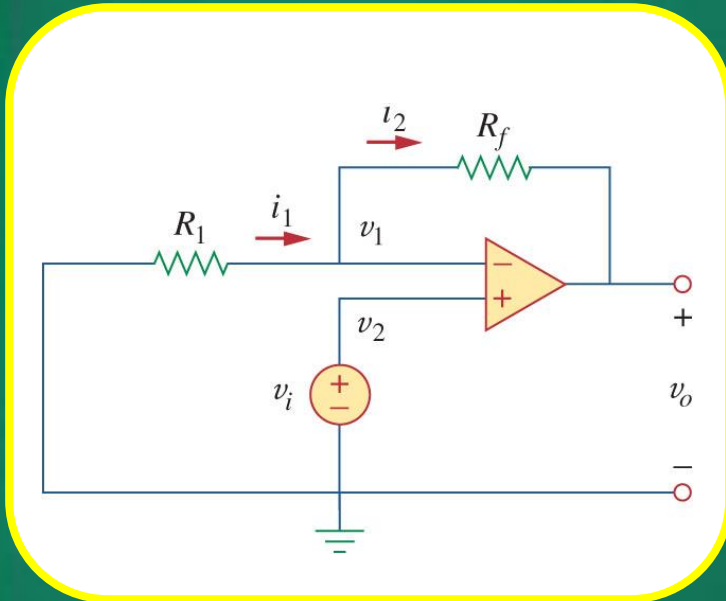
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- **This amplifier retains the infinite input impedance of the op-amp.**
- **One aspect of this amplifier's gain is that it can never go below 1.**
- **One could replace the feedback resistor with a wire and disconnect the ground and the gain would be 1 (voltage follower).**