OPERATIONAL AMPIFIER

OPAMPs & Applications

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An OPAMP is...

- An Integrated Circuit (IC) Voltage amplifier with two differential inputs and a single output
- A very popular Building block in designing Electronic Circuits.

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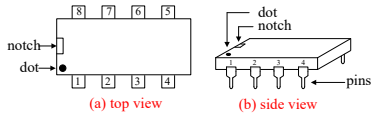
An OPAMP IC



8-pin chip

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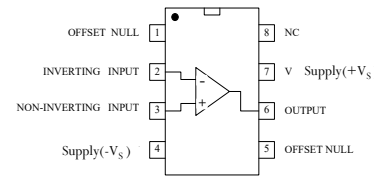
The 741 OPAMP



Pin configuration of op-amp IC 741

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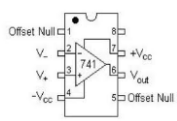
Terminals in a OPAMP

- Inputs
  - Non-inverting input (V^+ or V_1)
  - Inverting input (V^- or V_2)
- Outputs
  - Output (V_{out})
- Power Supply
  - Positive power supply ($+V_S$ or $+V_{CC}$)
  - Negative power supply ($-V_S$ or $-V_{CC}$)



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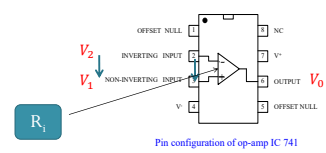
Differential Input and Differential Gain



Pin configuration of op-amp IC 741

$$V_{id} = V_1 - V_2$$
$$V_0 = A_{vd} . (V_{id})$$
$$V_0 = A_{vd} . (V_1 - V_2)$$

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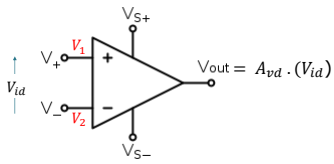
OPAMP Circuit Symbol



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Ideal Op-Amp Characteristics

- Infinite open-loop gain
- Infinite input impedance
- Zero output impedance
- Infinite bandwidth

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The Virtual Short Circuit

$$V_{id} = V_1 - V_2$$

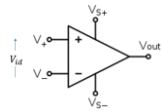
$$V_0 = A_{vd} . (V_{id})$$

$$V_0 = A_{vd} . (V_1 - V_2)$$

$$\frac{V_0}{A_{vd}} = (V_1 - V_2)$$

$$(V_1 - V_2) = 0$$

$$V_1 = V_2$$



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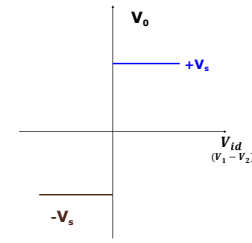
Ideal OPAMP : I/O Characteristics

(a) When $V_{id} = 0$, $V_2 = V_1$, $V_0 = 0$

(b) When $V_{id} > 0$, $V_1 > V_2$, $V_0 = +V_s$

(c) When $V_{id} < 0$, $V_1 < V_2$, $V_0 = -V_s$



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OPAMP Applications

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Application Circuits

1) Voltage Comparator
2) Unity Gain Amplifier/Voltage Follower/Buffer Circuit
3) Non-Inverting Amplifier
4) Inverting Amplifier
5) Scaling Adder
6) Scaling Subtractor
7) Instrumentation Amplifier
8) Integrator
9) Differentiator
10) Constant Current Source
11) Current to Voltage Converter
12) Voltage to Current Converter/Transconductance Amplifier
13) Output Bounding Circuit
14) Schmidt Trigger

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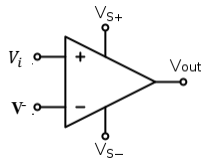
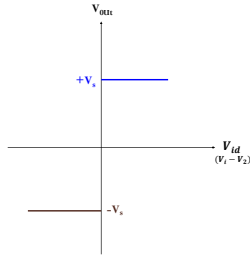
1) Voltage Comparator





If $(V^-) = 0$
It is called a Zero Comparator

If $(V^-) = V_{TH}$
It is called a Threshold Detector or a Level Detector

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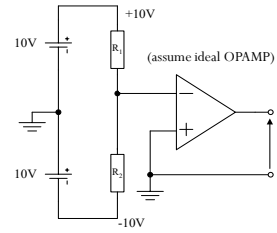
Example



IF R1 = R2 = 10K
What is V_o?

$V_0 = 0$

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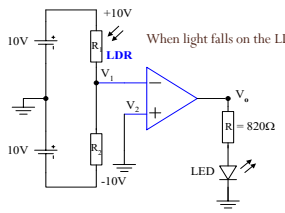
Example (Cont.)



When light falls on the LDR, the LED turns off.

When there is no light falling on the LDR, the LED turns on.

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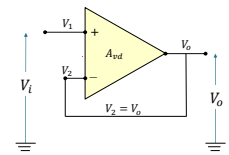
2) Unity Gain Amplifier



$$V_0 = A_{vd} \cdot (V_{id})$$
$$V_0 = A_{vd} \cdot (V_1 - V_2)$$
$$V_0 = A_{vd} \cdot (V_i - V_o)$$
$$\frac{V_0}{A_{vd}} = (V_i - V_o)$$
$$(V_i - V_o) = 0$$
$$V_i = V_o$$

- 100% negative feedback.
- So gain is unity
- Pass both dc and ac
- Takes no current from input
- High current dives available to the load

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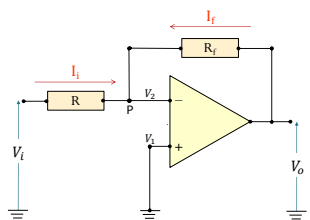
3) Inverting Amplifier



$V_1 = V_2 = 0$
$V_P = 0$

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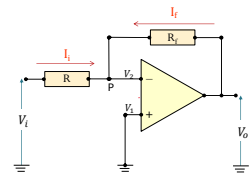
Inverting Amplifier



$$A_v = -\left(\frac{R_f}{R}\right)$$

$$I_i + I_f = 0$$
$$\left(\frac{V_i - V_P}{R}\right) + \left(\frac{V_o - V_P}{R_f}\right) = 0$$
$$\left(\frac{V_i - 0}{R}\right) + \left(\frac{V_o - 0}{R_f}\right) = 0$$

$$\left(\frac{V_i}{R}\right) + \left(\frac{V_o}{R_f}\right) = 0$$
$$\left(\frac{V_i}{R}\right) = -\left(\frac{V_o}{R_f}\right)$$
$$A_v = \frac{V_o}{V_i} = -\left(\frac{R_f}{R}\right)$$

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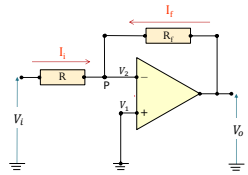
Inverting Amplifier



$$A_v = -\left(\frac{R_f}{R}\right)$$

- Vol. gain totally depend on the two resistors.
- Opamp provides the virtual short circuit and current drive
- Amplify ac and dc components of input signal by same gain.
- If $R_f < R$, the circuit can act as an inverting attenuator

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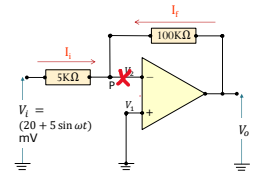
Tutorial 1, Question 4.



$$A_v = -\left(\frac{R_f}{R}\right)$$

$$A_v = -\left(\frac{100}{5}\right)$$

$$A_v = -20$$

$$V_o = A_v V_i$$

$I_i = (4 + \sin \omega t)\mu A$

$I_f = -(4 + \sin \omega t)\mu A$

$V_o = -20(20 + 5 \sin \omega t)$

$V_o = -(400 + 100 \sin \omega t)\ mV$

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