University of Maryland Baltimore County - UMBC
Phys650 - Special Topics in Experimental Atmospheric Physics
(Spring 2009)

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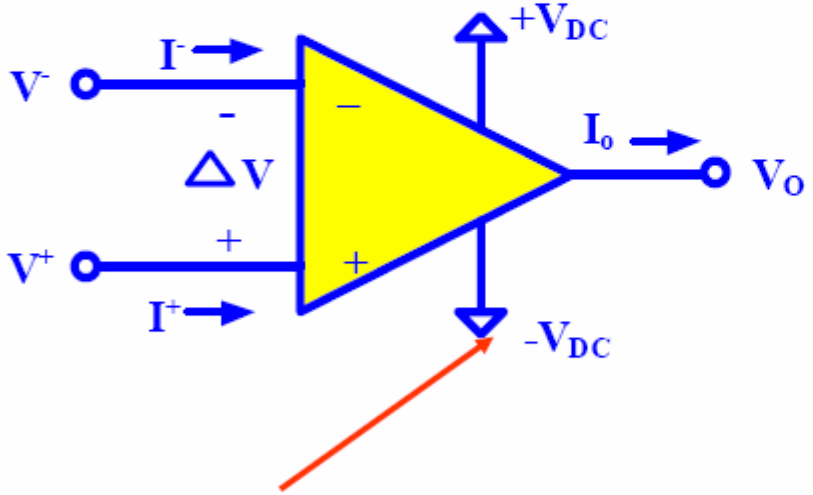
http://userpages.umbc.edu/~martins/PHYS650/

CLASS3 – 2/11/2009

A very brief introduction to operational amplifiers for physicists

Operational Amplifier - An operational amplifier (op amp) is a high gain differential amplifier with nearly ideal external characteristics. Internally the op amp is constructed using many transistors.



Note: Sometimes the supply voltage connections are not shown

Terminology:

V^+ = non-inverting input voltage

V^- = inverting input voltage

V_o = output voltage

I_o = output current

I^+ = non-inverting input current

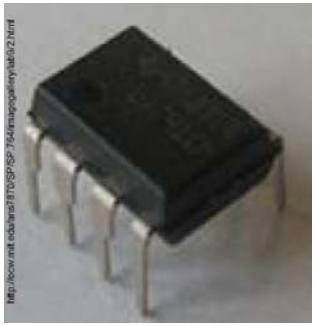
I^- = inverting input current

$\pm V_{DC}$ = positive and negative DC supply voltages used to power the op amp (typically ±5V to ±30V)

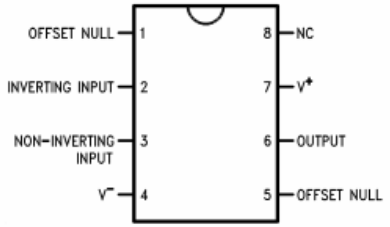
$\Delta V = V^+ - V^-$ = difference voltage

National Semiconductor

LM741
Operational Amplifier



Dual-In-Line or S.O. Package



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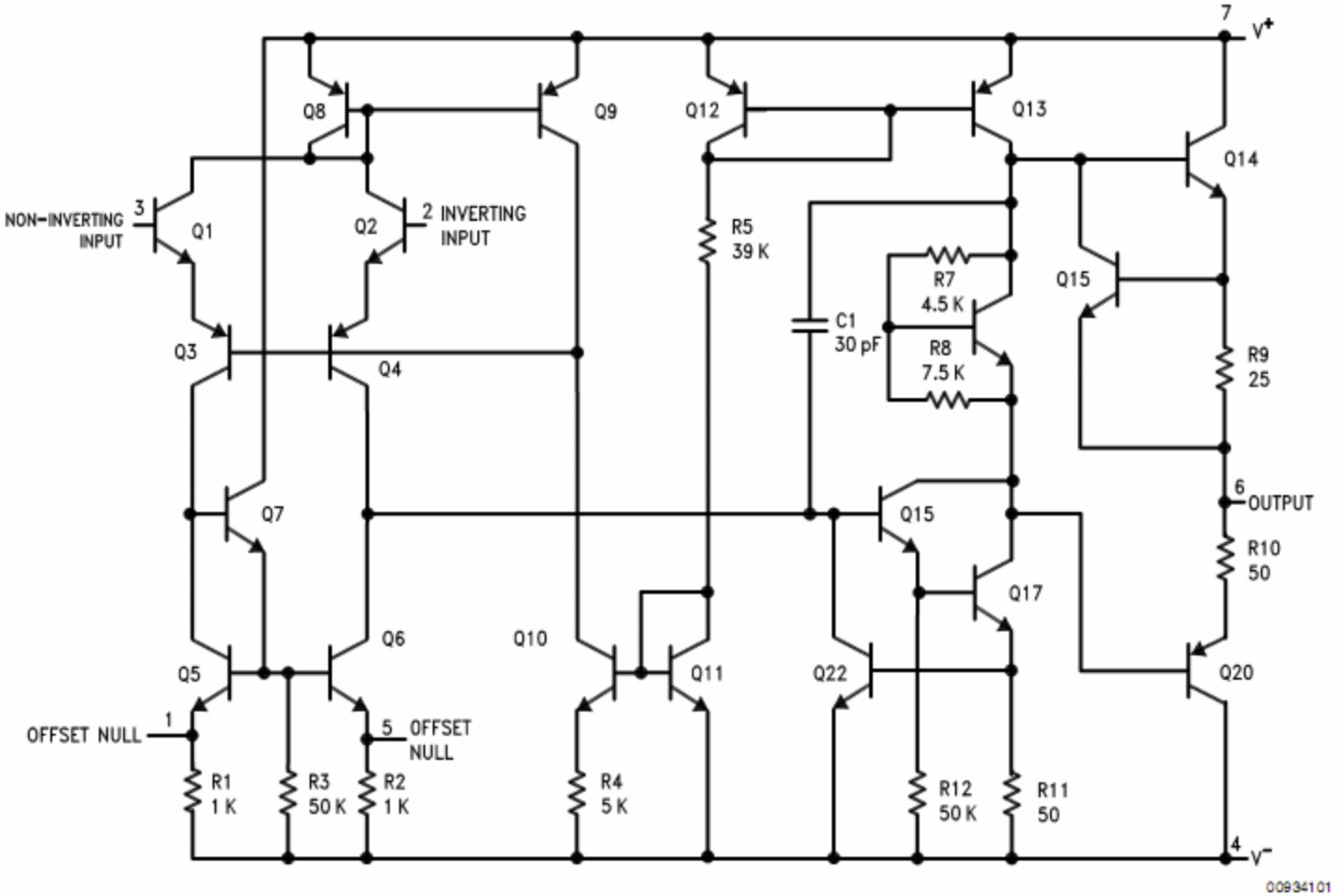
Order Number LM741J, LM741J/883, LM741CN
See NS Package Number J08A, M08A or N08E

Schematic Diagram



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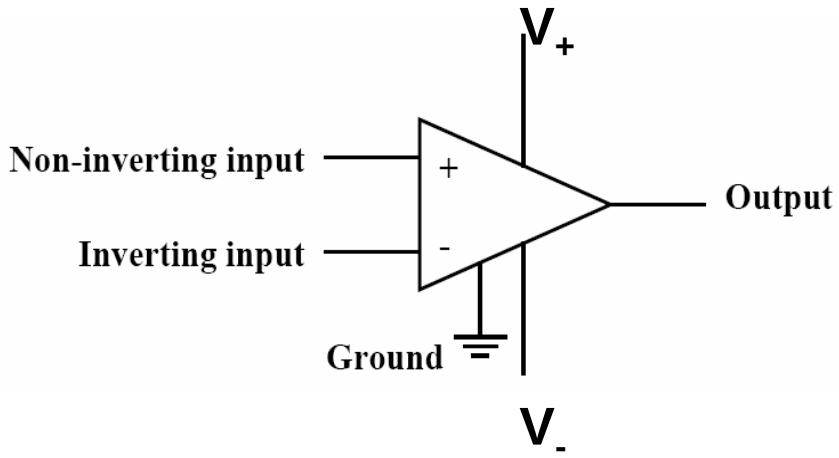
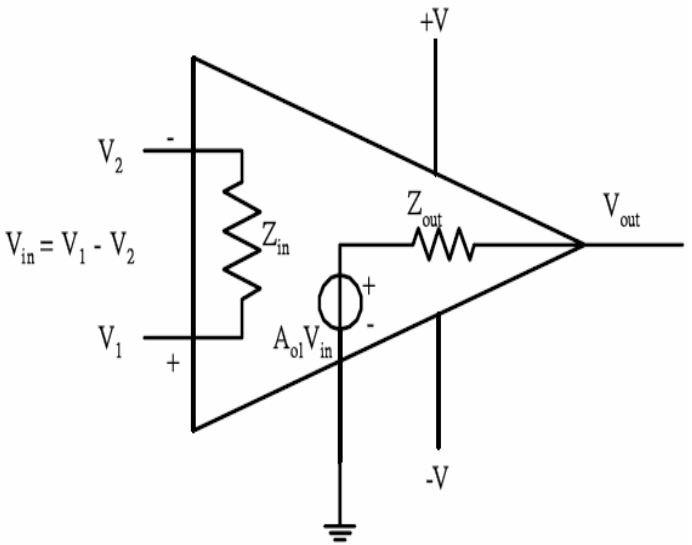
The Op-Amp symbol and internal model





Z_{in} is the input impedance (very large ≈ 2 M Ω)
Z_{out} is the output impedance (very small ≈ 75 Ω)
A_{ol} is the open loop gain (very high ≈ 10^{10})

therefore:

I_{in} ≈ *zero.* *Impedance is so high, the input current is negligible*

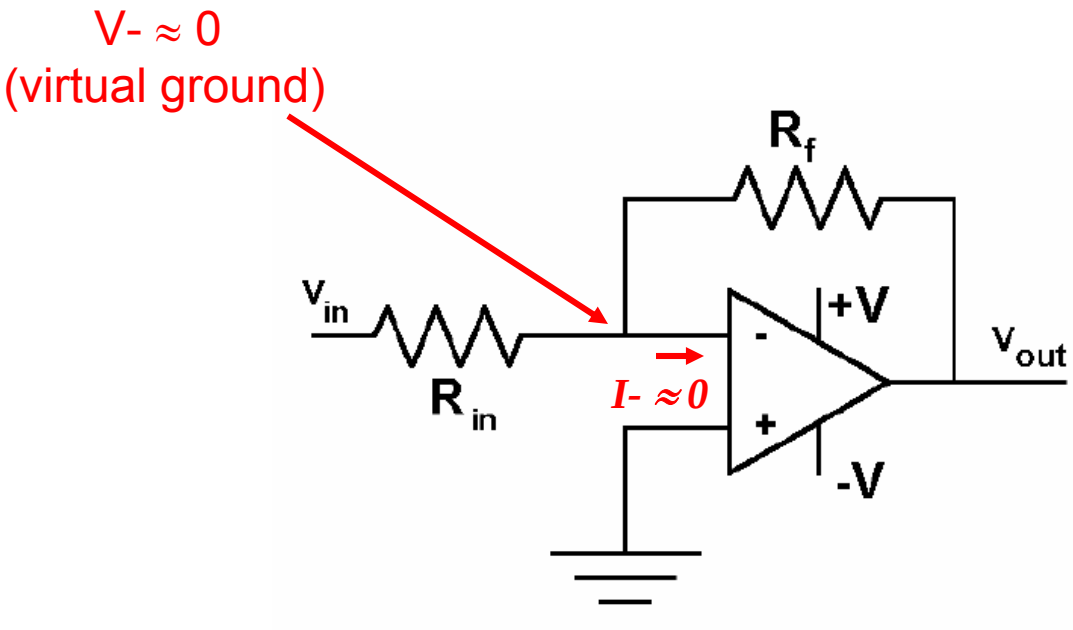
$V_2 - V_1 = 0$ *Gain is so high, the circuit attempts to zero the input voltage difference*

http://blog.ncut.edu.tw/userfile/3120/08_IntroductiontoOperationalAmplifier.pdf

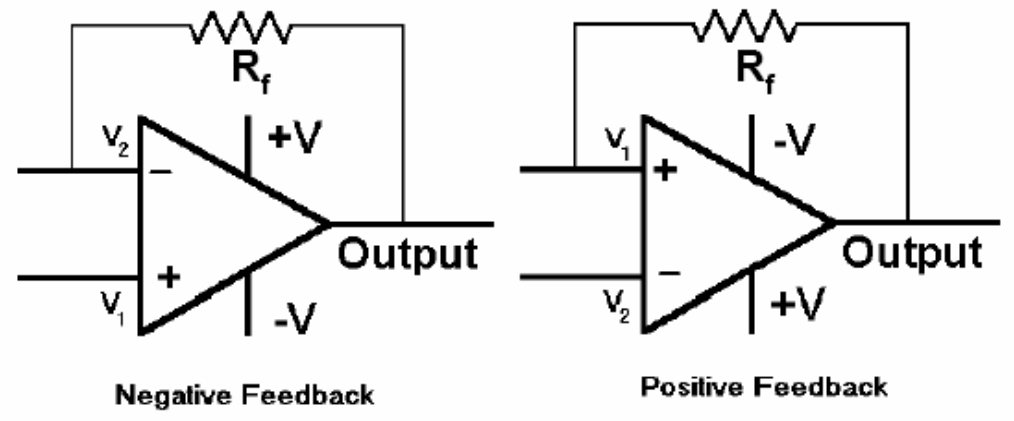
The Op-Amp inverting amplifier

$I_{in} \approx$ *zero.* *Impedance is so high, the input current is negligible*

$V_2 - V_1 = 0$ *Gain is so high, the circuit attempts to zero the input voltage difference*



Types of feedback



Negative Feedback

As information is fed back reversely, the output reacts to the input and becomes more stable. Output tends to stay in the desired range. Examples: cruise control, heating/cooling systems, amplifier, oscillator.

Positive Feedback

As information is fed back positively, the output destabilizes and my saturate. Examples: Guitar feedback, stock market crash.

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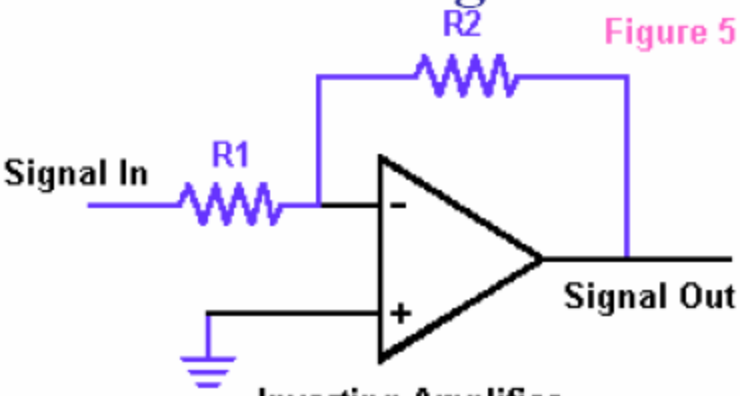
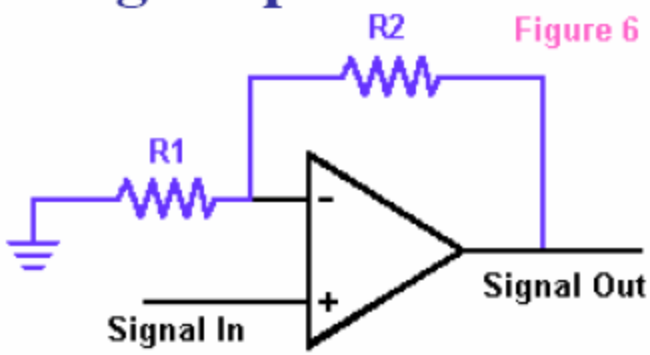
Inverting and Non-inverting amplifiers

Figure 5



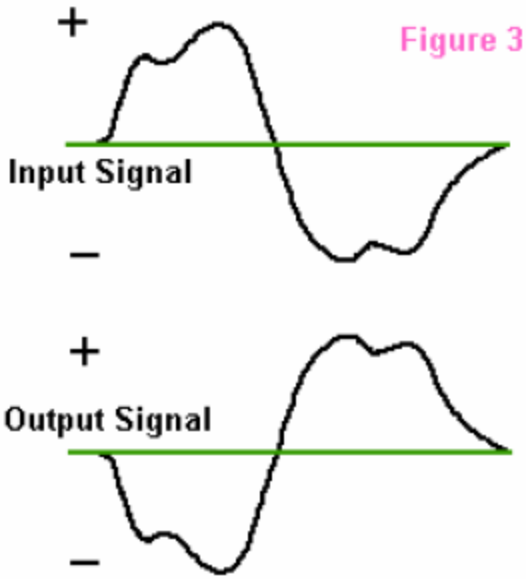
Inverting Amplifier

Figure 6



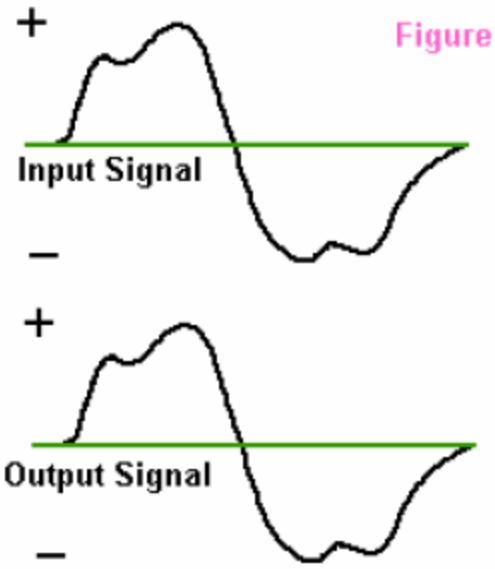
Non-Inverting Amplifier

Figure 3



Inverted Amplifier - Unity Gain

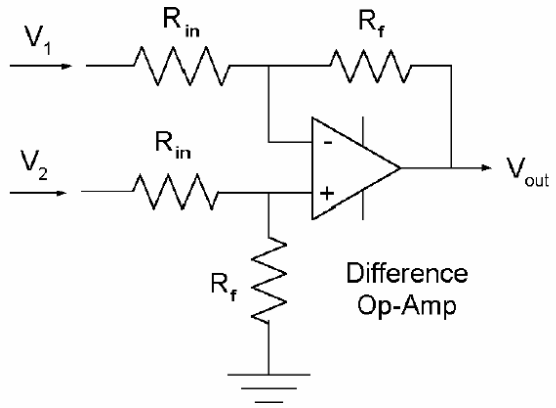
Figure 4



Non-Inverted Amplifier - Unity Gain

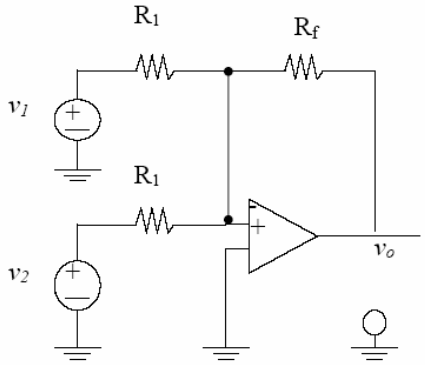
http://www.colomar.com/Shavano/intro_opamp.html

Differential (or Difference) Amplifier



$$V_{out} = \left(\frac{R_f}{R_{in}}\right)(V_2 - V_1) \qquad A = \frac{R_f}{R_{in}}$$

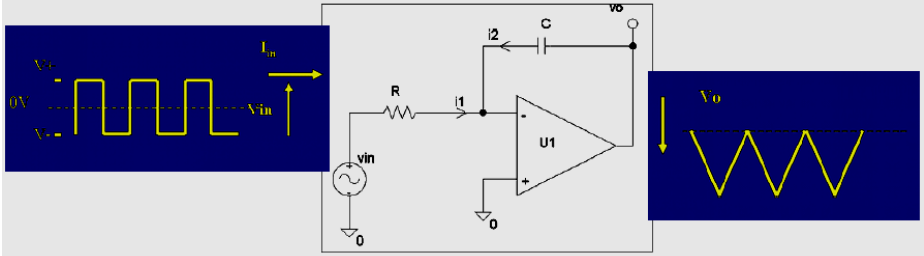
Summing amplifier



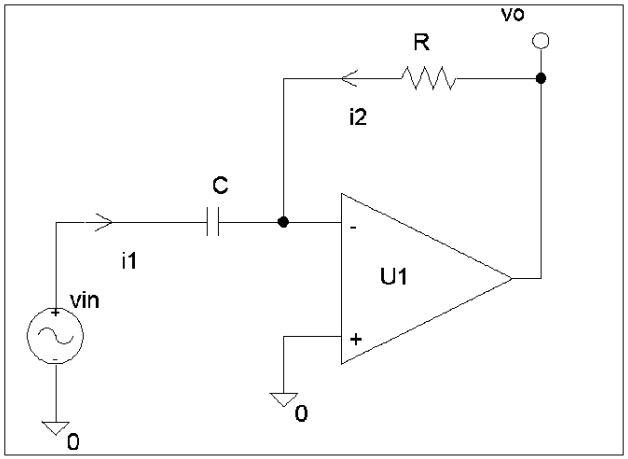
$$I_i = \frac{v_i}{R_i}$$

$$v_o = -R_f(I_1 + I_2) = -\frac{R_f}{R_1}v_1 - \frac{R_f}{R_1}v_2$$

Integrator



Differentiator



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