BEE 403 Linear integrated circuits

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Linear integrated circuits

A linear integrated circuit (linear IC) is a solid-state analog device characterized by a theoretically infinite number of possible operating states. It operates over a continuous range of input levels

APPLICATIONS

Linear ICs are employed in
audio amplifiers,
A/D (analog-to-digital) converters,
averaging amplifiers,
differentiators,
DC (direct-current) amplifiers,
integrators,
multivibrators,
oscillators,
audio filters, and
sweep generators.

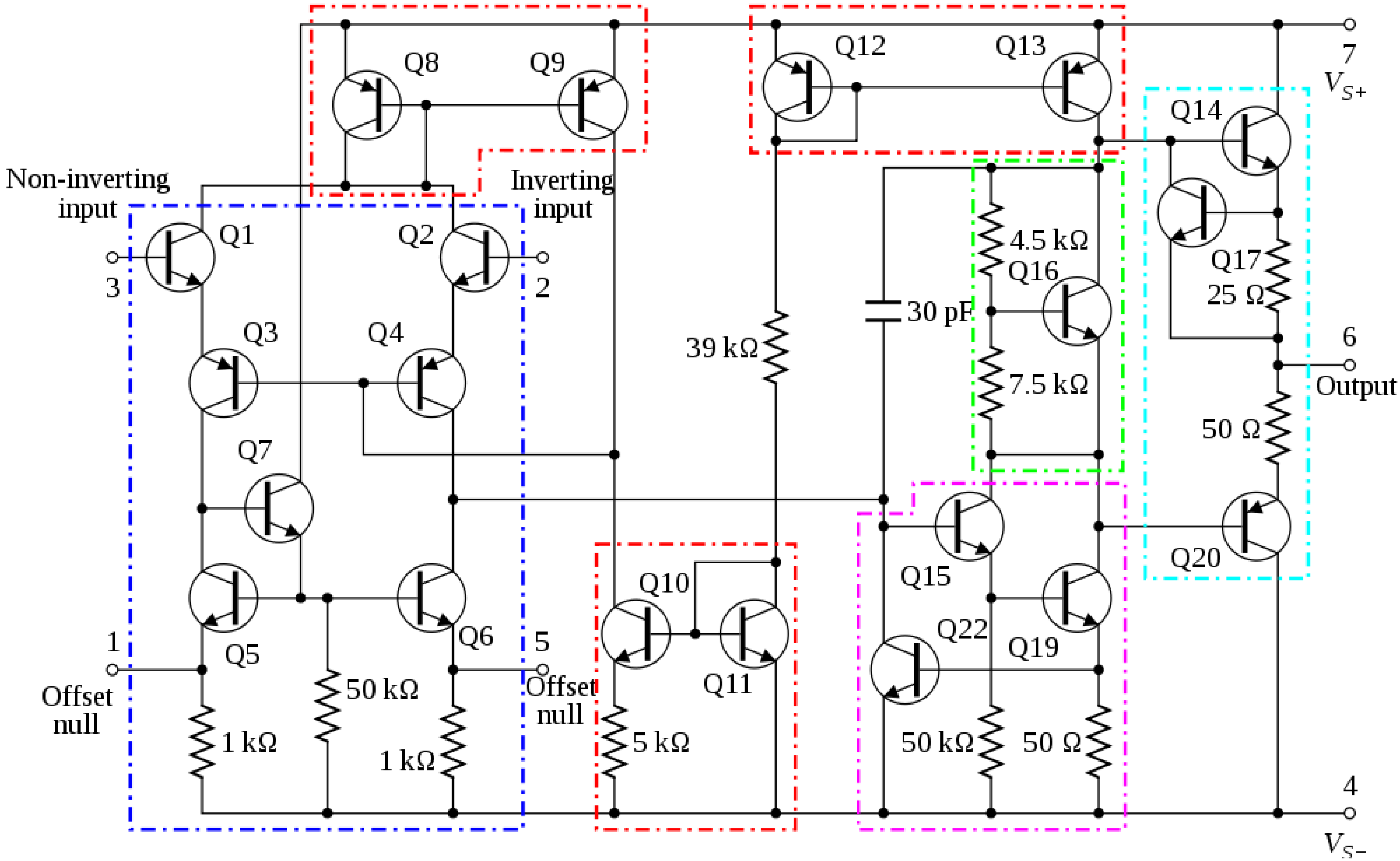
SSI	MSI	LSI	VLSI	ULSI
< 100 active devices	100-1000 active devices	1000-100000 active devices	>100000 active devices	Over 1 million active devices
Integrated resistors, diodes & BJT's	BJT's and Enhanced MOSFETS	MOSFETS	8bit, 16bit Microprocessors	Pentium Microprocessors

OPERATION AMPLIFIER

An operational amplifier is a direct coupled high gain amplifier consisting of one or more differential amplifiers, followed by a level translator and an output stage.

It is a versatile device that can be used to amplify ac as well as dc input signals & designed for computing mathematical functions such as addition, subtraction ,multiplication, integration & differentiation

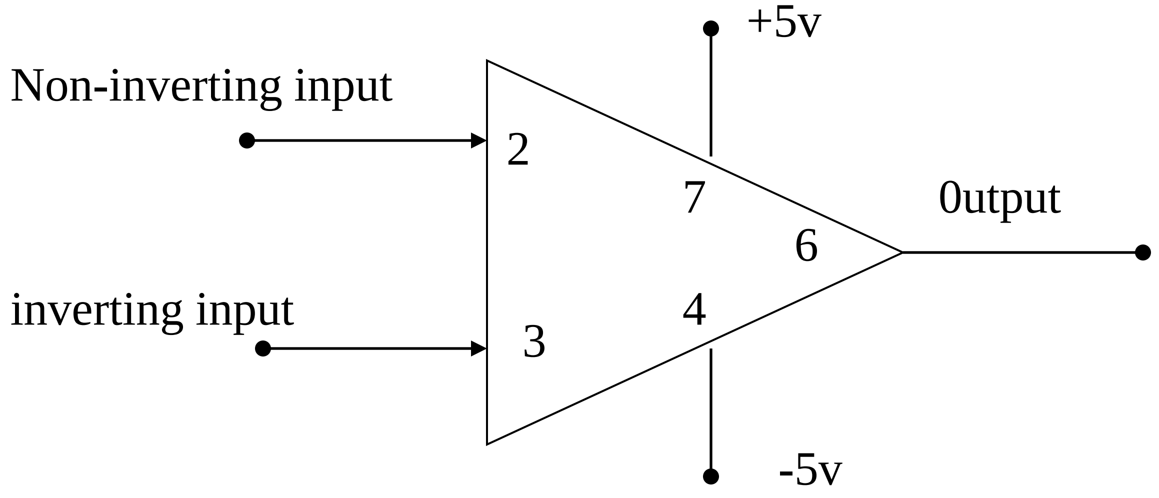
741 Op-Amp Schematic



Ideal characteristics of OPAMP

1. Open loop gain infinite
2. Input impedance infinite
3. Output impedance low
4. Bandwidth infinite
5. Zero offset, ie, Vo=0 when V1=V2=0

Op-amp symbol

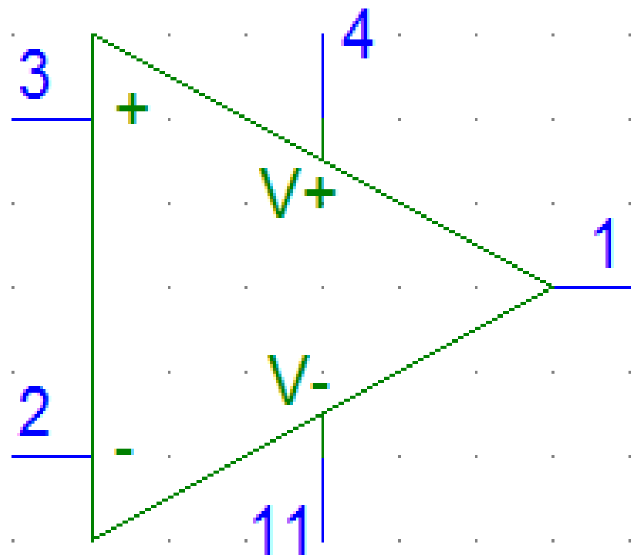


Linear Integrated Circuits − An analog IC is said to be Linear, if there exists a linear relation between its voltage and current. IC 741, an 8-pin Dual In-line Package (DIP)op-amp, is an example of Linear IC.

Op Amp

Positive power supply
(Positive rail)

Non-inverting
Input terminal

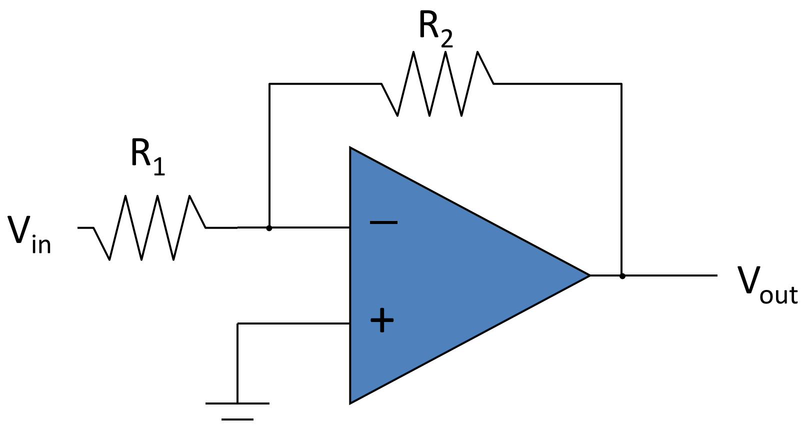


Output terminal

Inverting input
terminal

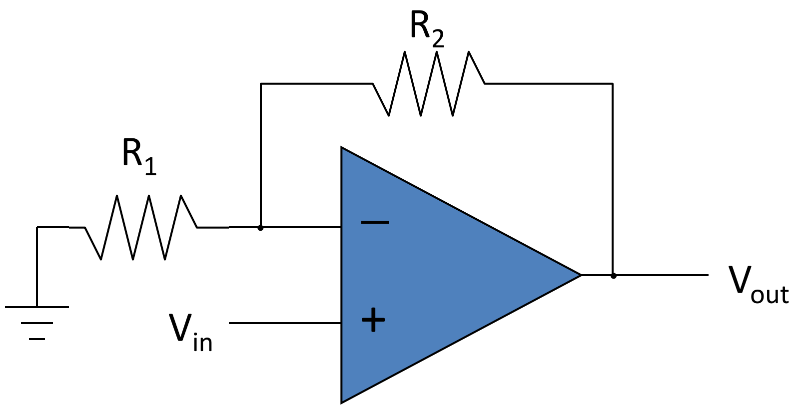
Negative power supply
(Negative rail)

Inverting amplifier example



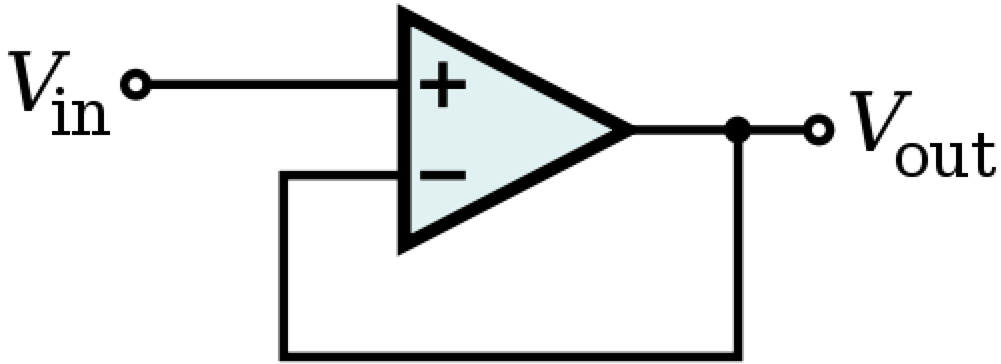
- Applying the rules: – terminal at "virtual ground"
  - so current through R_1 is $I_f = V_{in}/R_1$
- Current does not flow into op-amp (one of our rules)
  - so the current through R_1 must go through R_2
  - voltage drop across R_2 is then $I_f R_2 = V_{in}\times(R_2/R_1)$
- So $V_{out} = 0 - V_{in}\times(R_2/R_1) = -V_{in}\times(R_2/R_1)$
- Thus we amplify V_{in} by factor $-R_2/R_1$
  - negative sign earns title "inverting" amplifier
- Current is *drawn into* op-amp output terminal

Non-inverting Amplifier



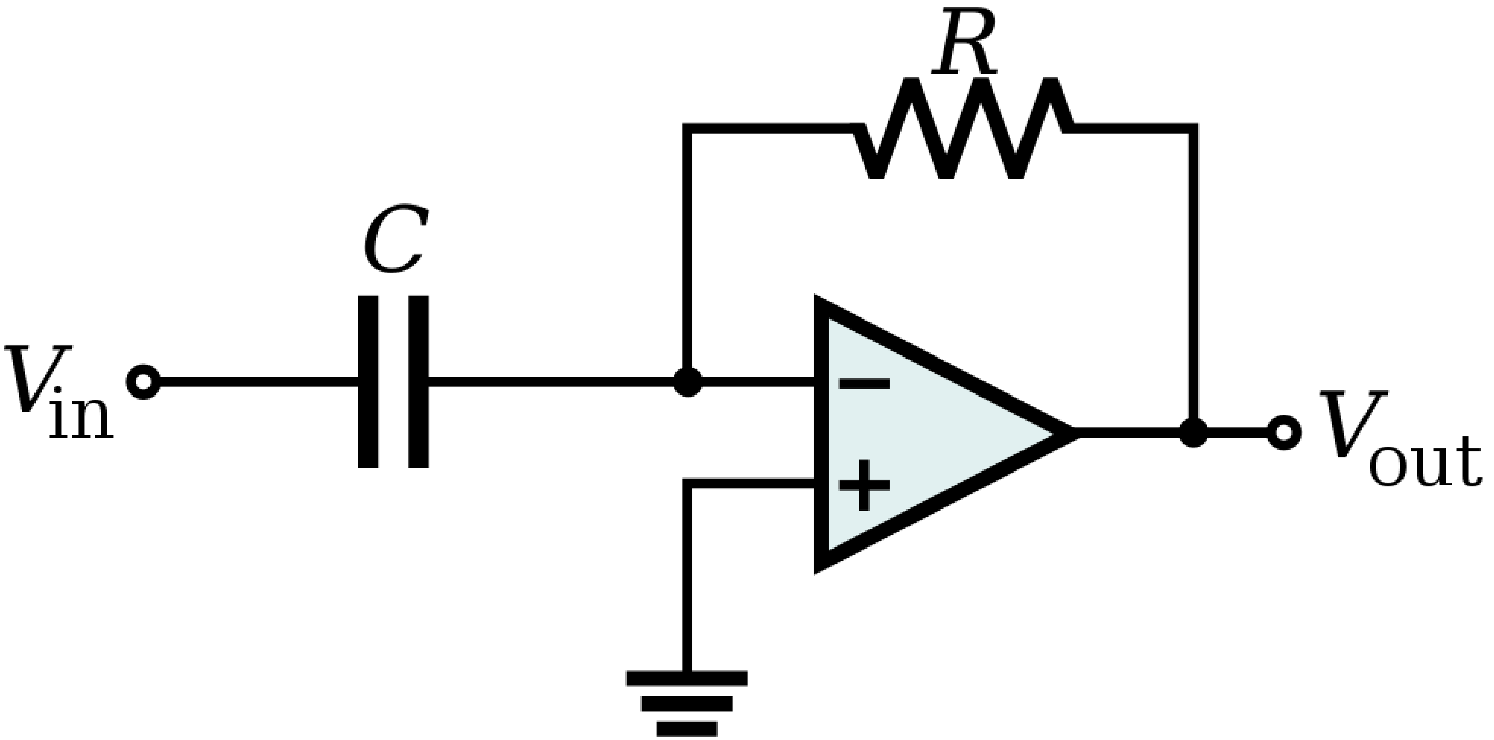
- Now neg. terminal held at V_{in}
  - so current through R_1 is $I_f = V_{in}/R_1$ (to left, into ground)
- This current cannot come from op-amp input
  - so comes through R_2 (delivered from op-amp output)
  - voltage drop across R_2 is $I_f R_2 = V_{in} \times (R_2/R_1)$
  - so that output is higher than neg. input terminal by $V_{in} \times (R_2/R_1)$
  - $V_{out} = V_{in} + V_{in} \times (R_2/R_1) = V_{in} \times (1 + R_2/R_1)$
  - thus gain is $(1 + R_2/R_1)$, and is positive
- Current is sourced from op-amp output in this example

Voltage follower



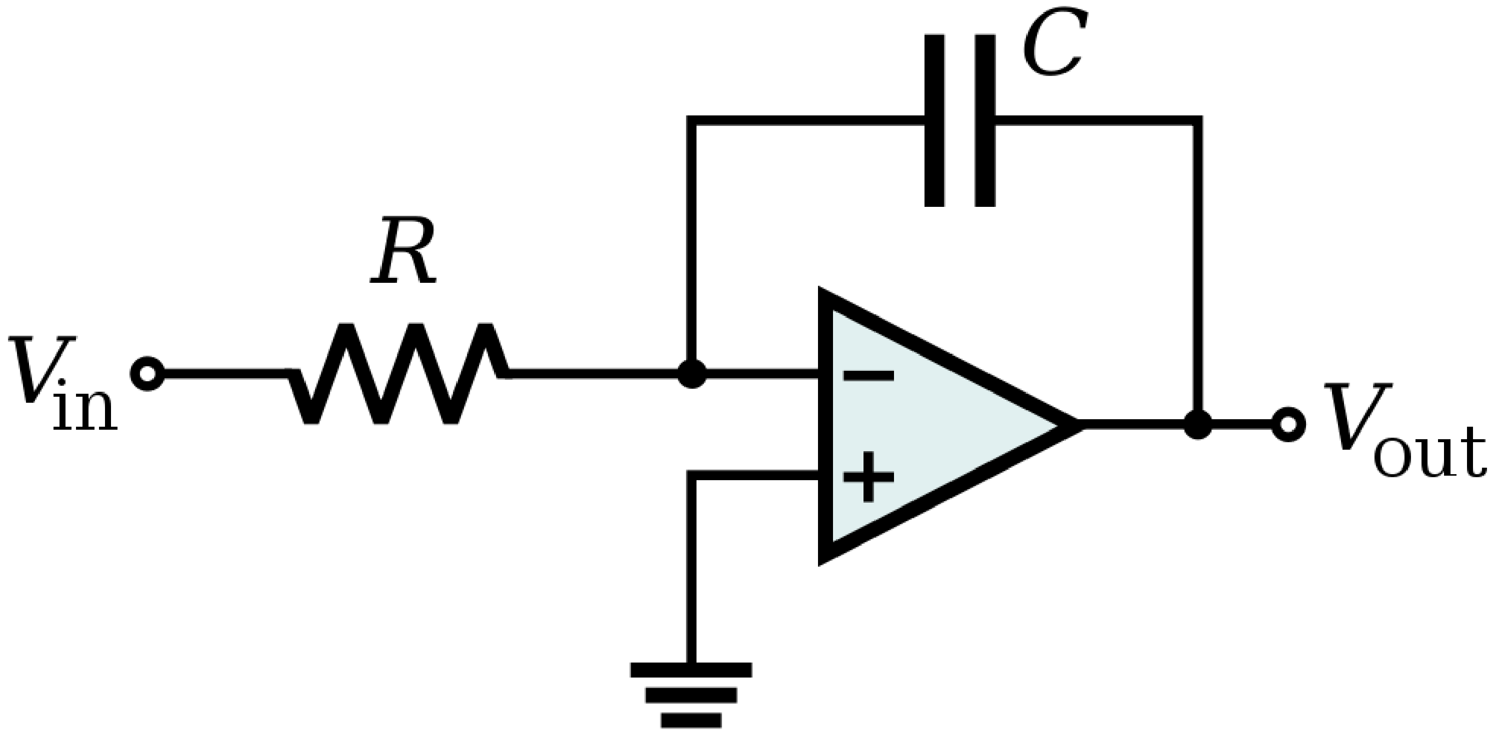
$$V_{OUT} = V_{IN}$$

Differentiator



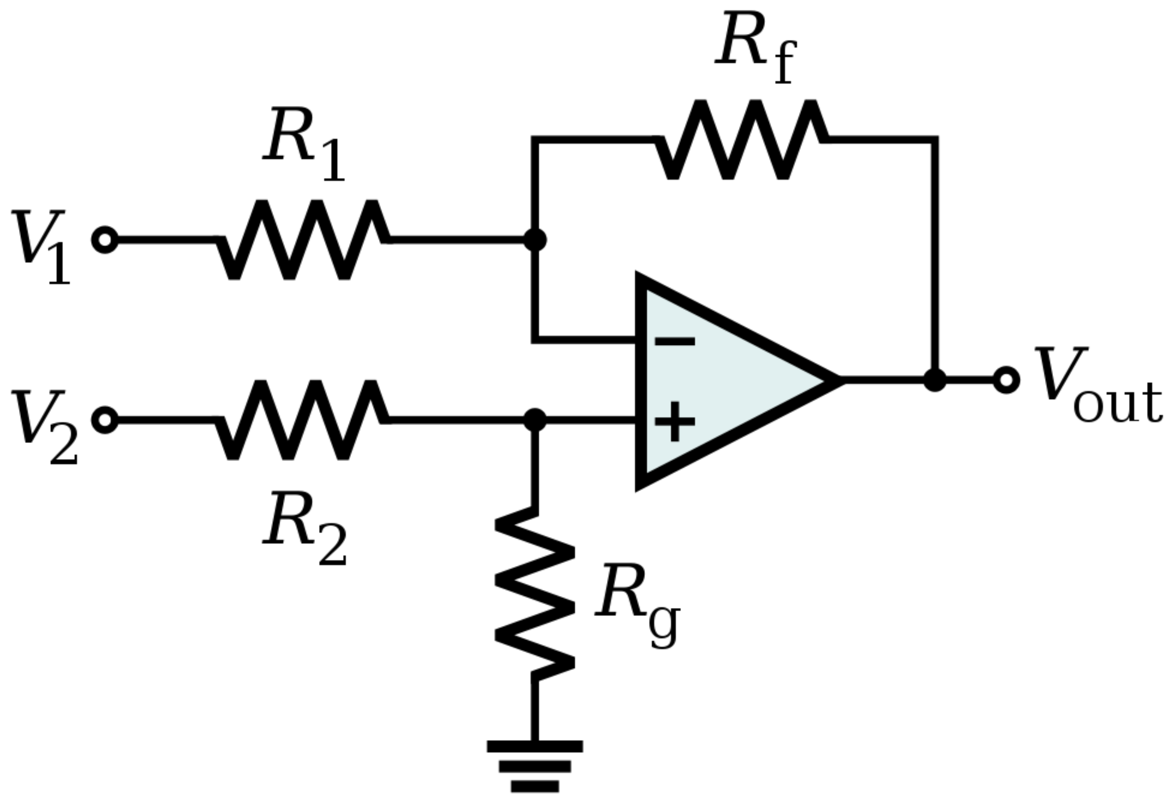
$$V_{out} = -RC\frac{dV_{in}}{dt}$$

Integrator



$$V_{out} = -\int_0^t \frac{V_{in}}{RC}\,dt + V_{initial}$$

Differential Amplifier

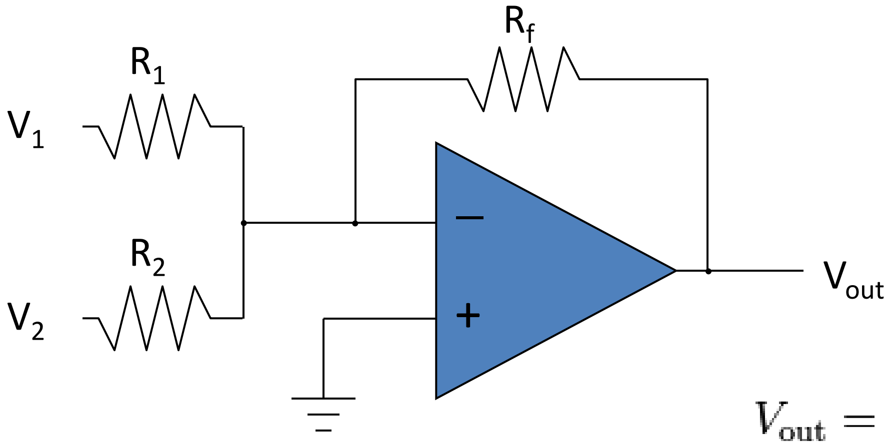


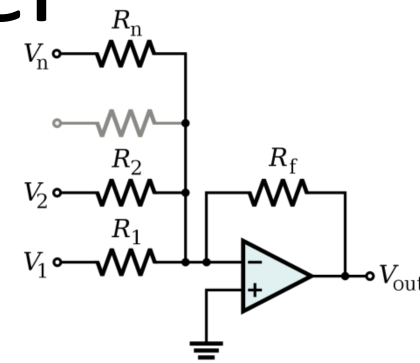
$$V_{out} = \frac{(R_f + R_1)\,R_g}{(R_g + R_2)\,R_1} V_2 - \frac{R_f}{R_1} V_1$$

If $R_1 = R_2$ and $R_f = R_g$:

$$V_{out} = \frac{R_f}{R_1}(V_2 - V_1)$$

Summing Amplifier

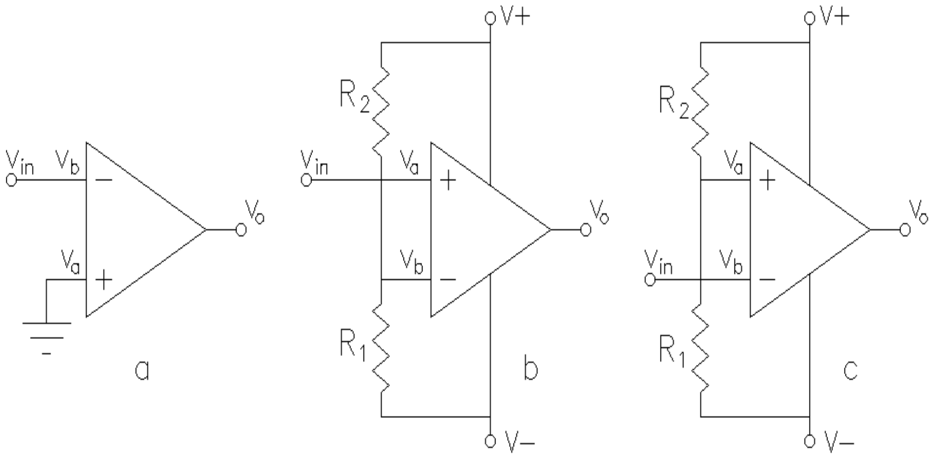




$$V_{\text{out}} = -R_{\text{f}} \left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \cdots + \frac{V_n}{R_n} \right)$$

- Much like the inverting amplifier, but with two input voltages
  - inverting input still held at virtual ground
  - I_1 and I_2 are added together to run through R_f
  - so we get the (inverted) sum: $V_{out} = -R_f \times (V_1/R_1 + V_2/R_2)$
    - if $R_2 = R_1$, we get a sum proportional to $(V_1 + V_2)$

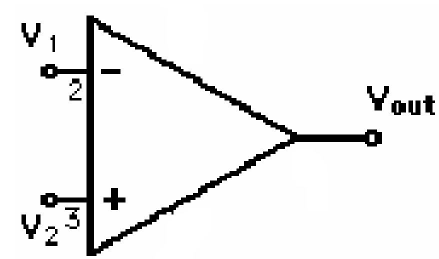
Comparator



V_1 is V_{ref}

V_2 is V_{in}

$$v_{out} = \begin{cases} +V_{max} & v_+ > v_- \\ -|V_{min}| & v_+ < v_- \end{cases}$$

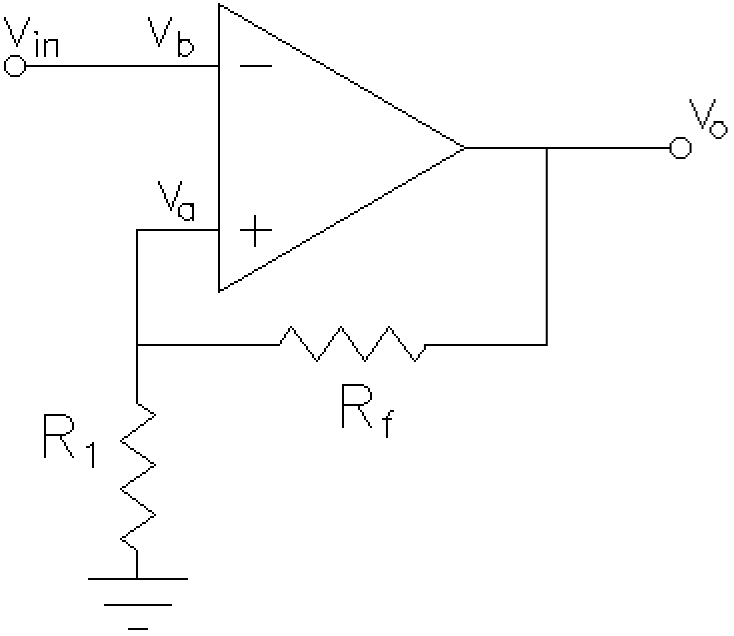


Determines if one signal is bigger than another

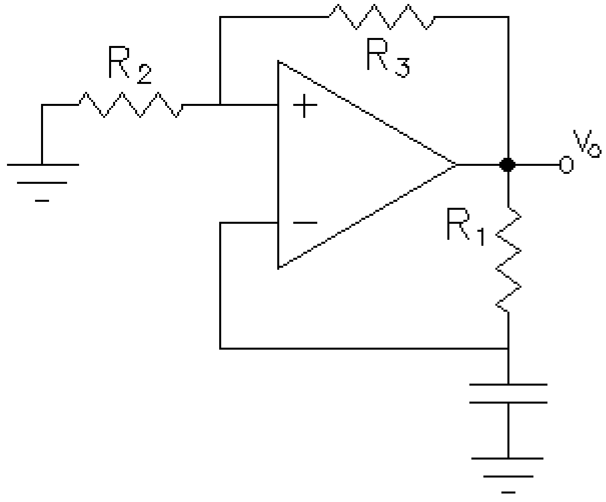
Applications of comparator

1. Zero crossing detector
2. Window detector
3. Time marker generator
4. Phase detector

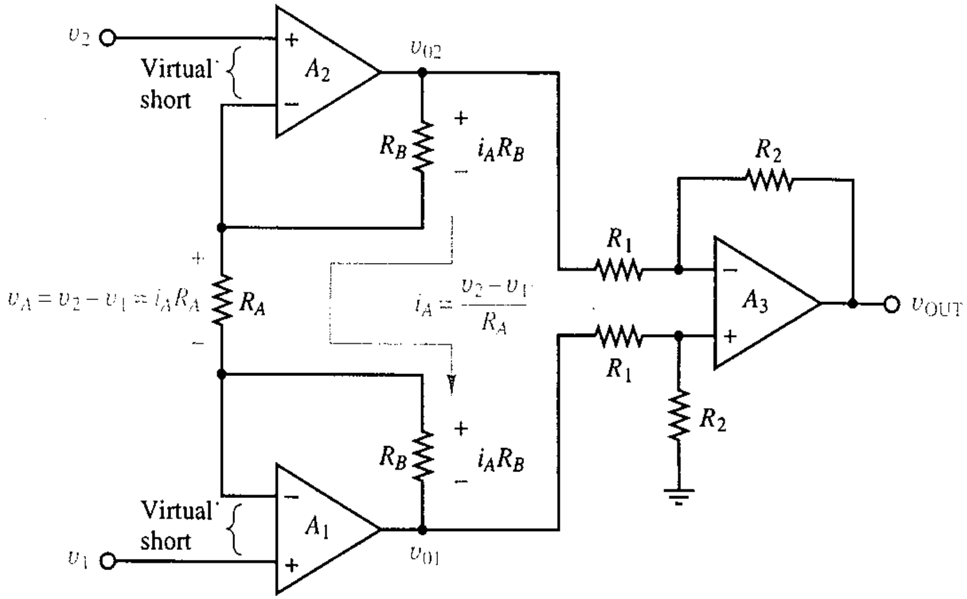
Schmitt trigger



square wave generator



Instrumentation Amplifier



v_{OUT} = (R2/R1)(1 + [2R_B/R_A])(v1 – v2)

By adjusting the resistor R_A, we can adjust the gain of this instrumentation amplifier

Application:Strain Gauge