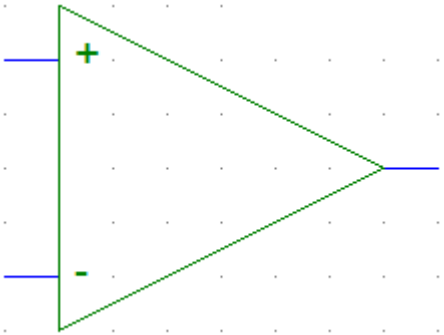
CG1111: Engineering Principles and Practice I

Operational Amplifier

Operational Amplifier (Op-Amp)

- An operational amplifier (op-amp) is a DC-coupled high-gain electronic voltage amplifier with a differential input and, usually, a single-ended output

Input Terminals

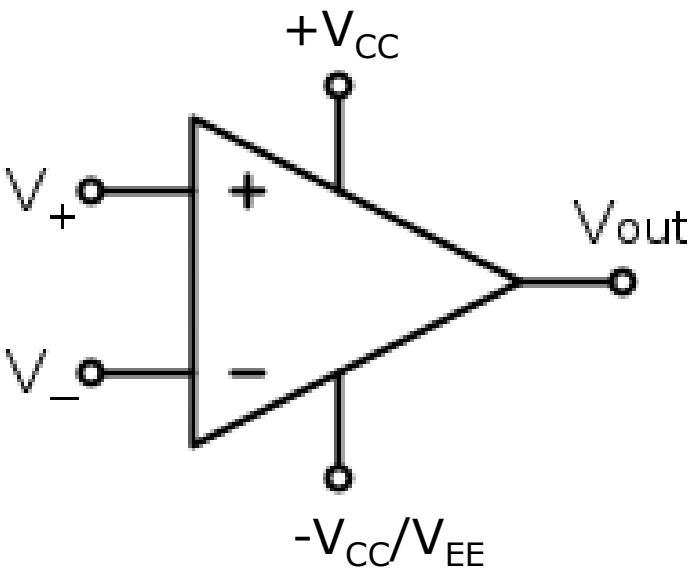


Output Terminal

Op-Amp Terminals

Positive Power Supply (Positive Rail)

Non-Inverting Input Terminal

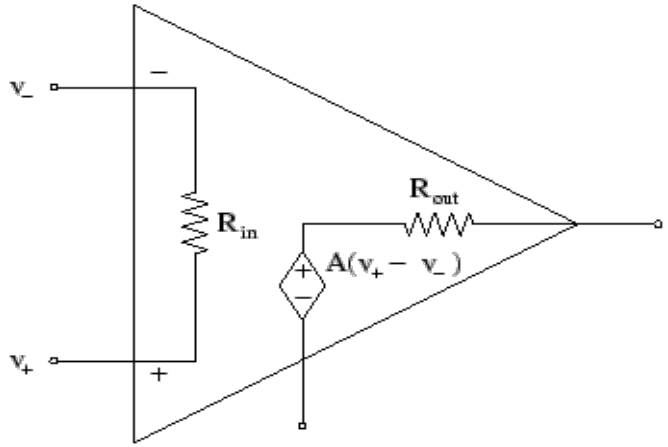


Output Terminal

Inverting Input Terminal

Negative Power Supply (Negative Rail)

Op-Amp Equivalent Circuit



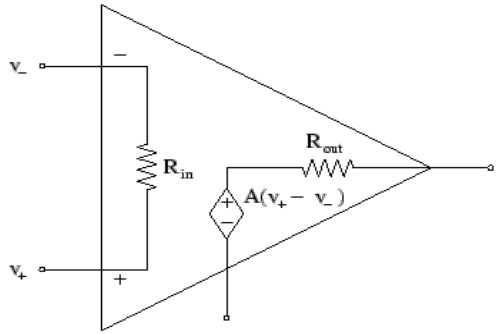
- A is the open loop voltage gain
  - The open-loop gain, *A*, is very large, approaching infinity
- R_i is the input impedance & R_{out} is the output impedance

Typical Op Amp Parameters

Parameter	Variable	Typical Ranges	Ideal Values
Voltage Gain	A	10^5 to 10^8	∞
Input Resistance	R_{in}	10^5 to 10^8 Ω	∞ Ω
Output Resistance	R_{out}	10 to 100 Ω	0 Ω
Supply Voltage	V_{cc}/V^+ $-V_{cc}/V^-$	5 to 30 V -30 to 0 V	N/A N/A

Op-amp Golden Rules

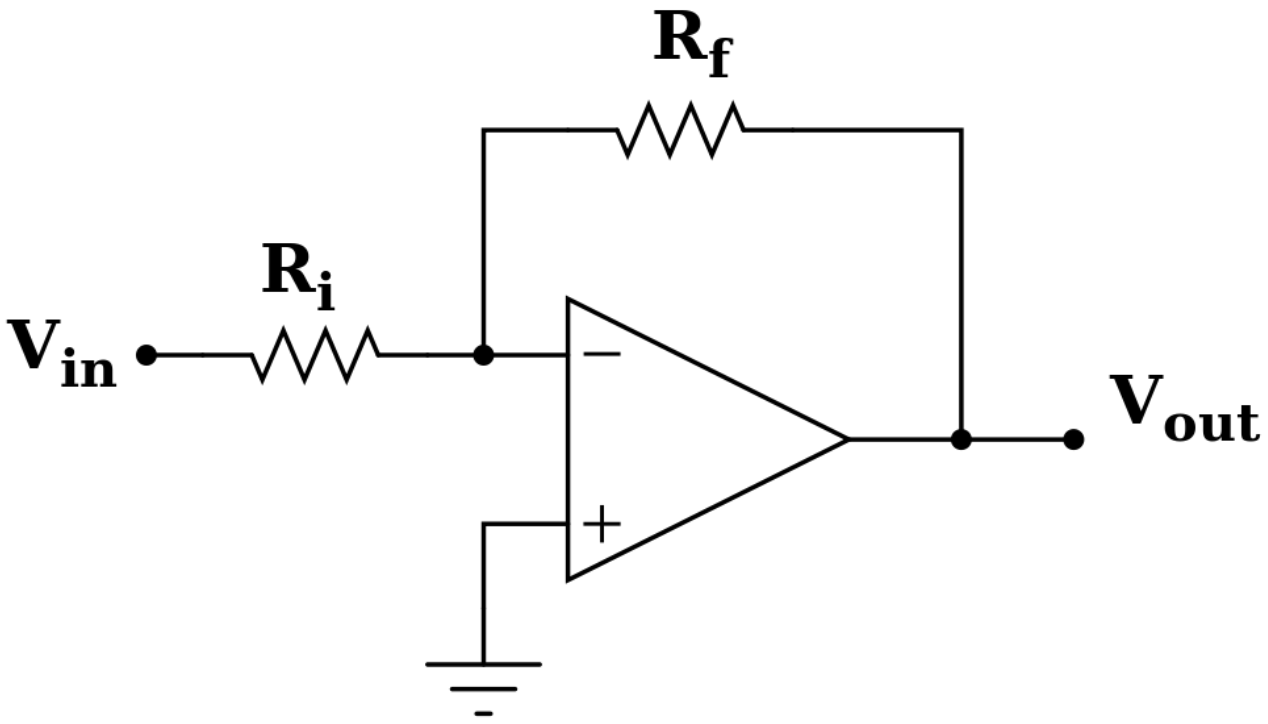
- Rule 1: The output attempts to do whatever is necessary to make the voltage difference between the inputs zero
  - The voltage gain of a real op-amp is so high that a fraction of a millivolt input will swing the output over its full range
- Rule 2: The inputs draw no current
  - The ideal op-amp has an infinite input resistance (R_{in}). Thus, the current drawn at the two terminals is zero



Inverting Amplifier

- For an ideal op-amp, the inverting amplifier gain is given simply by

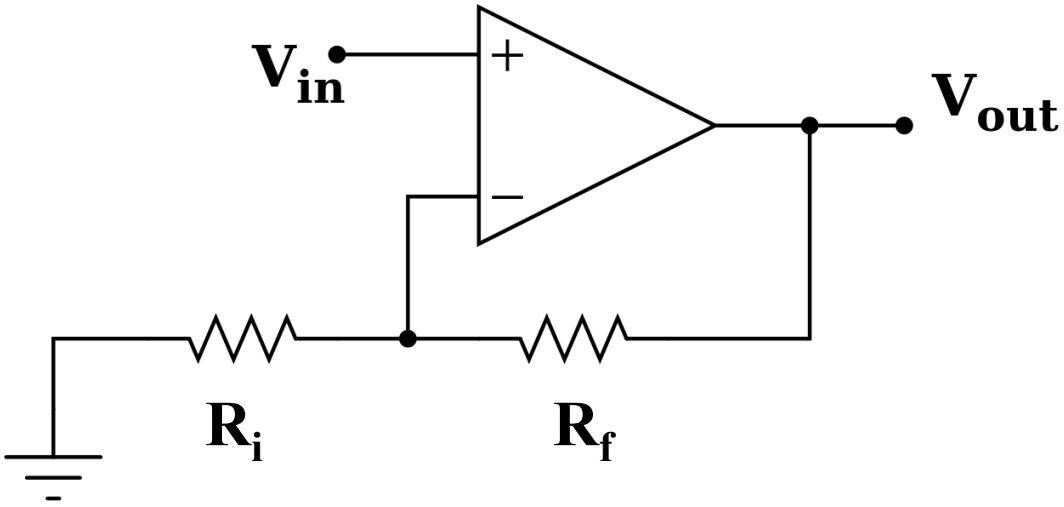
$$\frac{V_{out}}{V_{in}} = -\frac{R_f}{R_i}$$



Non-Inverting Amplifier

- For an ideal op-amp, the inverting amplifier gain is given simply by

$$\frac{V_{out}}{V_{in}} = 1 + \frac{R_f}{R_i}$$

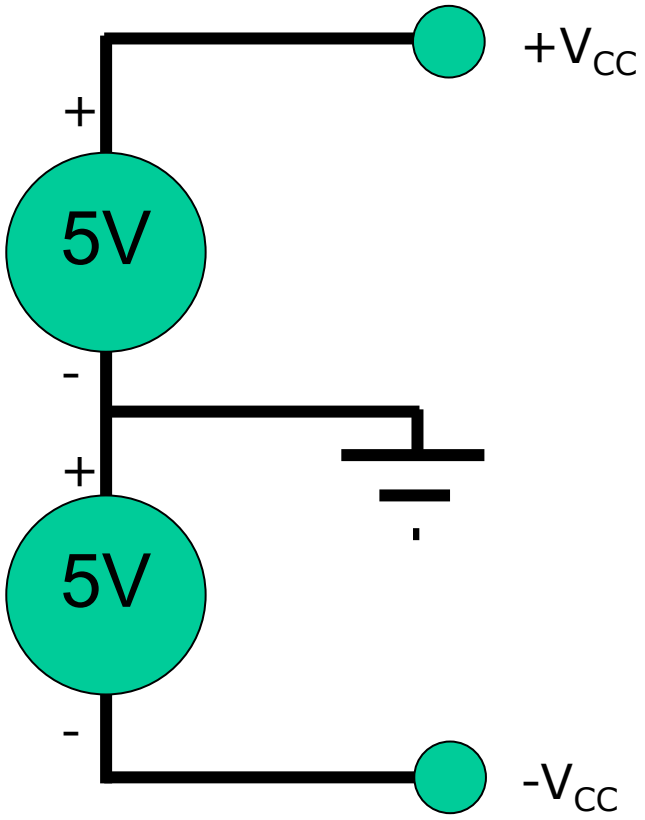


Single Supply Vs Dual Supply

- An op-amp can be powered either by a Single Power Supply or a Dual Power Supply
- Single Supply: Provide a positive voltage to the V^+ terminal of the op-amp and connect the ground to the V^- terminal of the op-amp
- Dual Supply: Provide a positive voltage to the V^+ terminal of the op-amp and provide a negative voltage to the V^- terminal of the op-amp

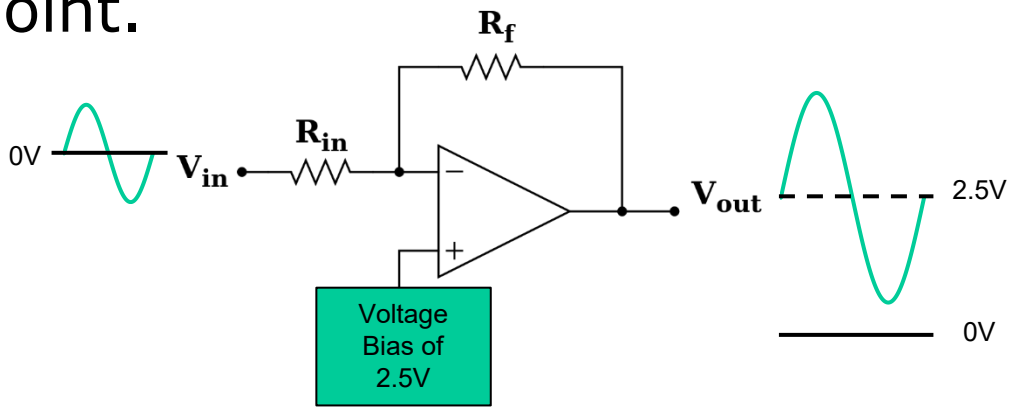
Dual Supply

- Create a dual supply with a positive and negative voltage by connecting two power sources as below
- Connect the negative terminal of first source to the positive terminal of the second source
- The positive terminal of the first source gives a positive voltage
- The negative terminal of the second source gives a negative voltage



Op-Amp Bias

- Bias, in an electronic circuit, describes the steady state operating characteristics with no input signal
- In an op-amp circuit, the operating characteristic we are concerned with is the output voltage of our op-amp
- If an op-amp is biased to 2.5V, it means that, for no incoming signal, the output voltage will rest at 2.5V
- Bias is strictly a DC value. Once an AC signal is applied, the output will then begin to move about the bias point.



THANK YOU