Operational Amplifiers

Op-amp for short

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History

1928 Harold Black invents feedback Amplifier

1947 Ragazzini first uses the term Operational Amplifier in print

1953 First Commercially available Vacuum tube op Amp

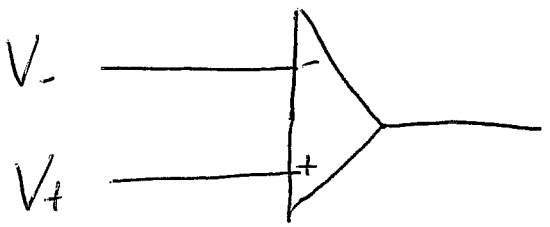
1958 Jack Kilby of Texas Instruments invents the integrated circuit.

1963 Bob Widlar of Fairchild designs the first monolithic IC op-Amp => Single chip.

1947 Bardeen, Brattain, and Shockley of Bell Labs discover the transistor effect

(Transfer of Resistance

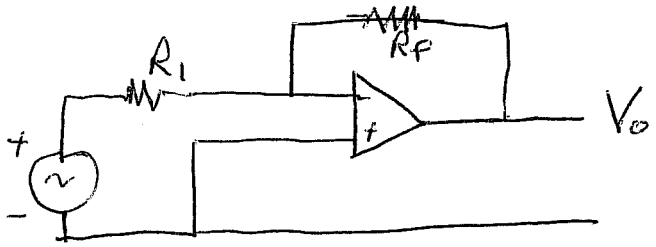
Basic Op Amp



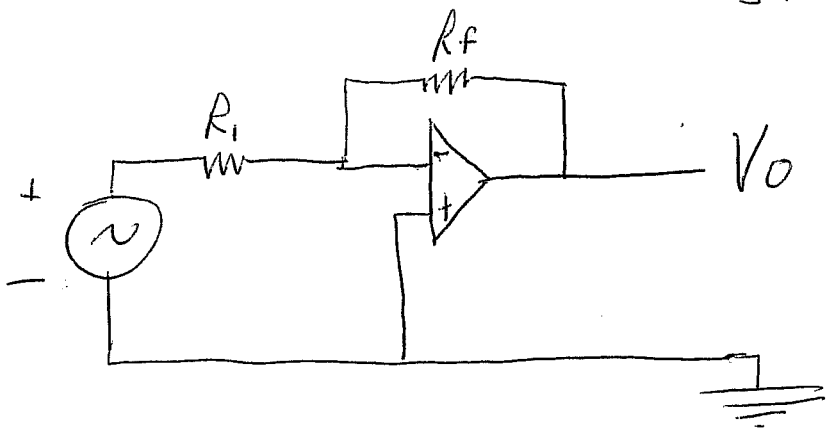
Inputs:
V_+ & V_-

Output:
$A(V_+ - V_-)$
↑ Huge. A = Gain
≃ 100,000

Need to clobber the gain a bit to reduce the instability:



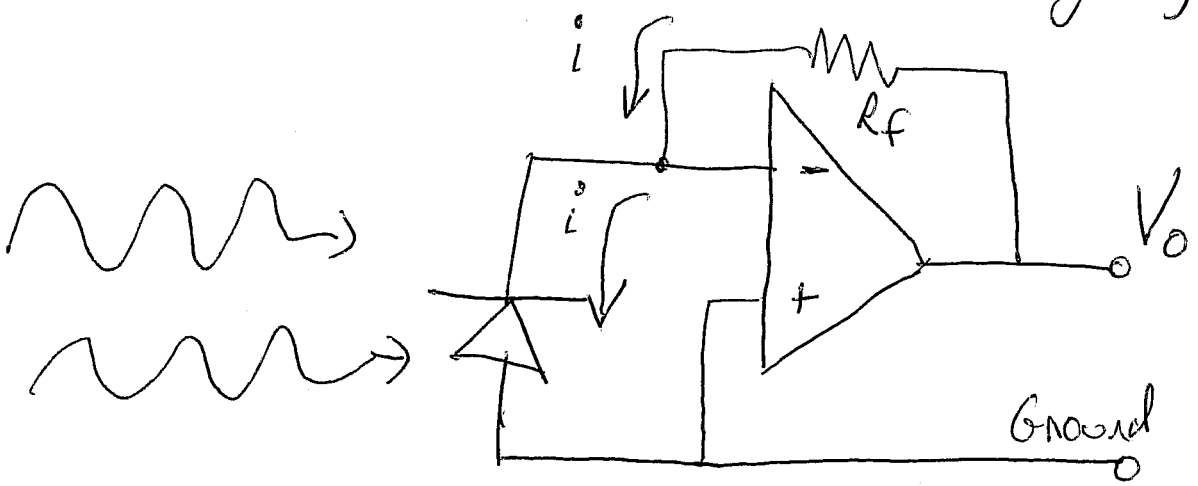
Feedback some of the output to the input to reduce instability



(Same circuit redrawn larger)

Transimpedance Amplifier

(Turn the current produced by an LED with light shining on it, into a measureable voltage)



Analyze this circuit using the Op-Amp Golden Rules

1) V_o feedback keeps the voltage the same at the - and + terminals of the Op-Amp.
2) The - and + terminals have extremely high input impedance: No current flows into either terminal.

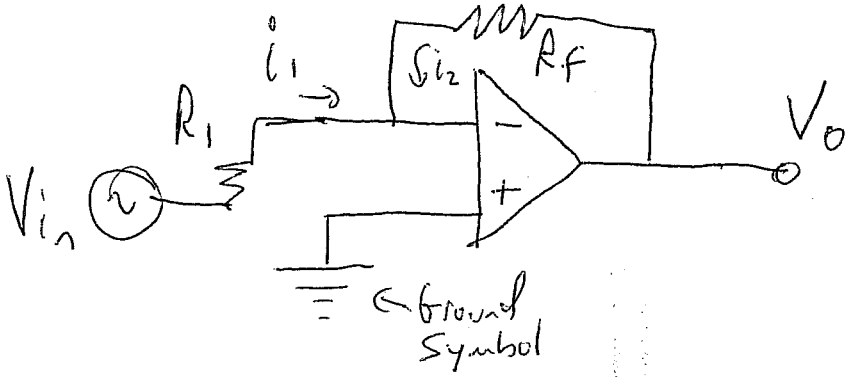
Analysis: i = current generated by the LED when light shines on it.

From rule 2, i is the current flowing through R_f also. From rule 1, - and + terminals are both at ground voltage. Ohms Law gives $V_o = i R_f$ or $i = 1\ \mu a$, $R_f = 1 M\Omega$

$V_o = 1$ Volt

Simple Circuits

1) Inverting Amplifier:



Output is measured from V_o to Ground.

Goal: Amplify V_{in} by turning it into V_{out}.

V_o is the output voltage
V_{in} is the input voltage.

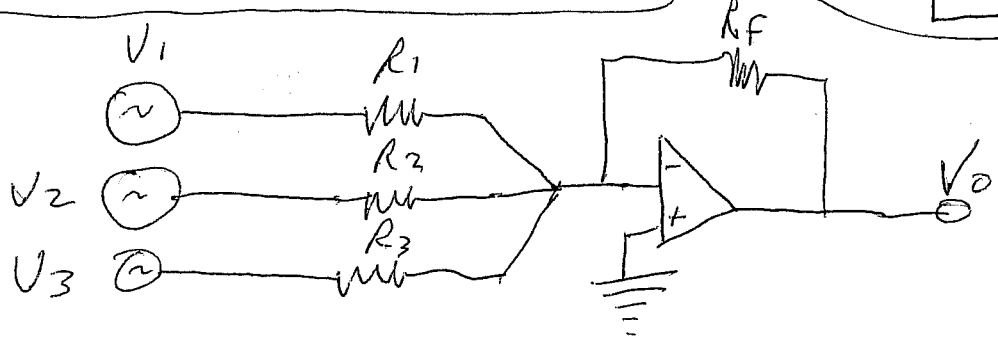
− Sign ⇒ inversion.

Gain $= R_f/R_1$

Rule 2: $i_1 + i_2 = 0$,

Rule 1 & Ohm's Law: $\frac{V_{in}}{R_1} + \frac{V_o}{R_f} = 0$

So $\boxed{\frac{V_o}{V_{in}} = -\frac{R_f}{R_1}}$



Mixer Circuit

$\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} + \frac{V_o}{R_f} = 0$. With $R_1 = R_2 = R_3$,

$$\boxed{V_o = -(V_1 + V_2 + V_3)\left(\frac{R_f}{R_1}\right)}$$

Gain $= R_f/R_1$

input voltages are Summed & Amplified