Operating Signal by Amplifier

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KAIST

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Outline

Structure of Operating Signal

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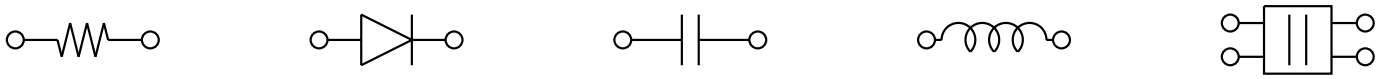
- Signal Operation

Objects used in operation

Resistor Diode Capacitor Coil Transformer



- Resistor

$$I = \frac{V}{R} \tag{1}$$

- Diode

$$I = I_0 e^{kV} \tag{2}$$

- Capacitor

$$I = C\frac{d}{dt}V \tag{3}$$

- Coil

$$I = -\frac{1}{L}\int V dt \tag{4}$$

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$$V_{out} = \frac{N_{in}}{N_{out}} V_{in} \tag{5}$$

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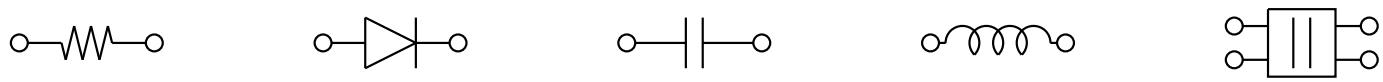

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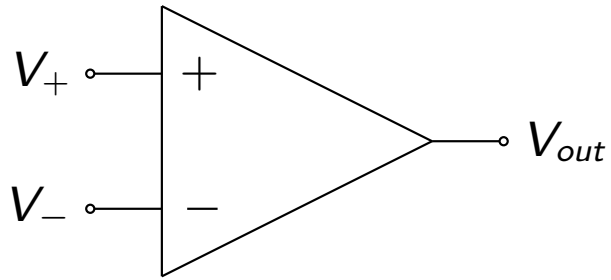
How??

Operational amplifier

As a base of signal operation, Operational amplifier is widely used



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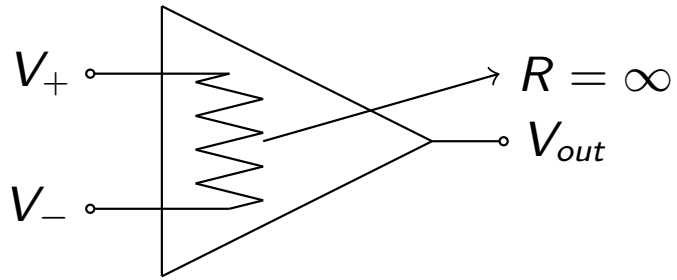

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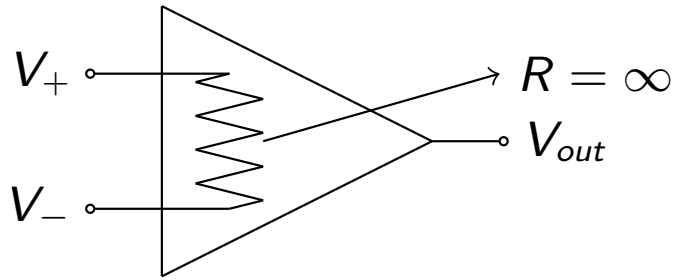

$$V_{out} = \lim_{G \to \infty} G\left(V_+ - V_-\right) \tag{6}$$

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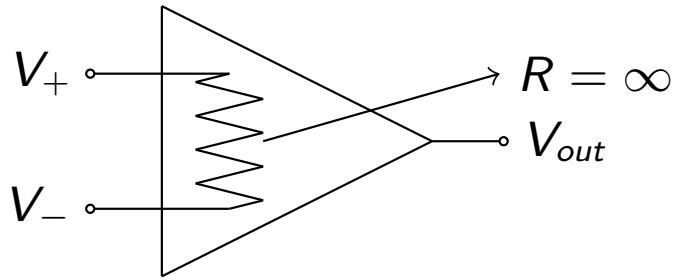

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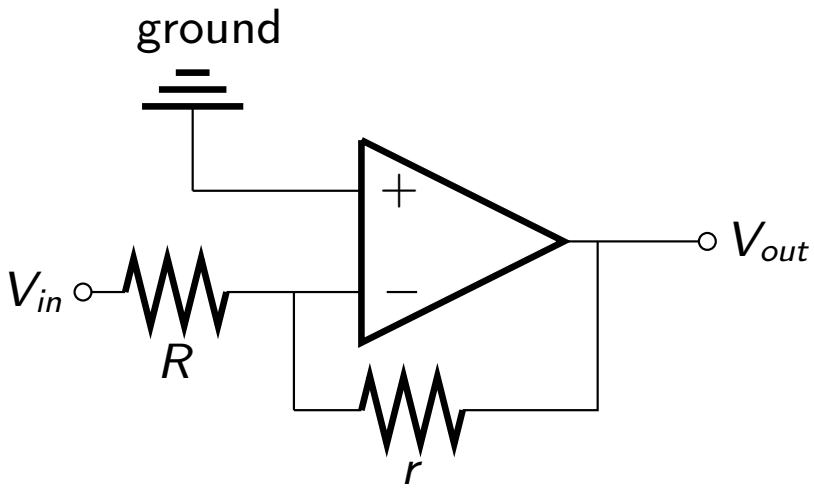
- OP-amp amplify input voltage with Gain G
- In ideal case, G is infinitely large number

Simple OP-amp circuit : Inverting amplifier



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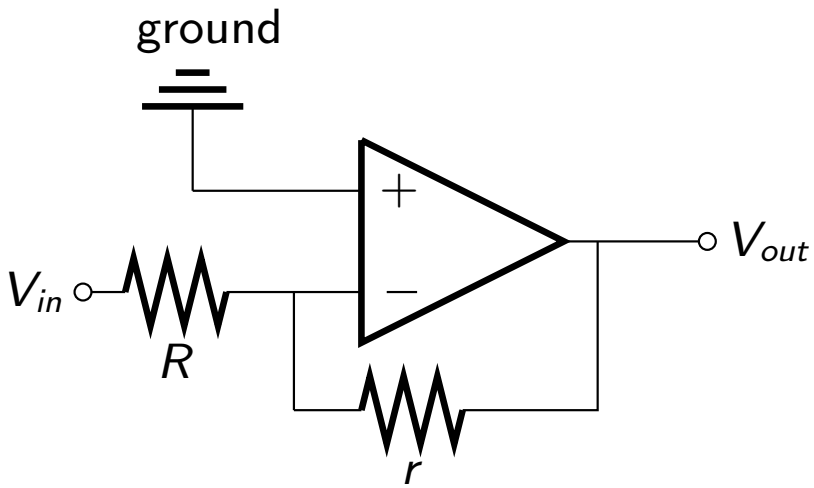

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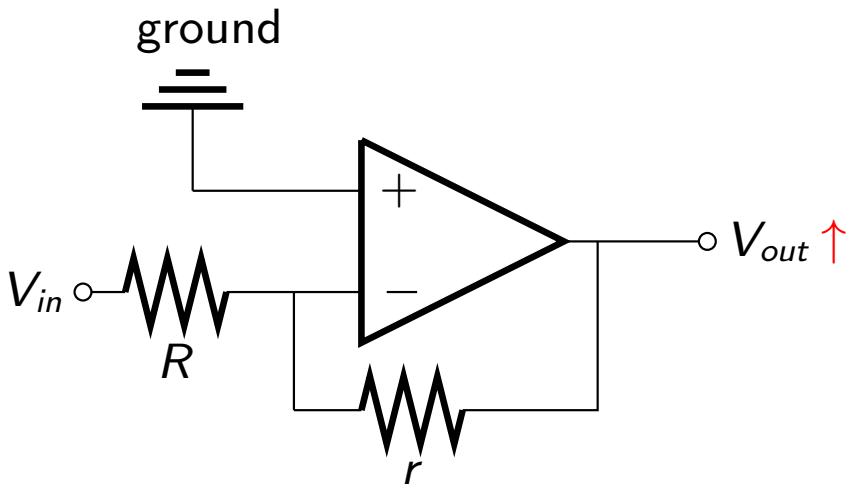

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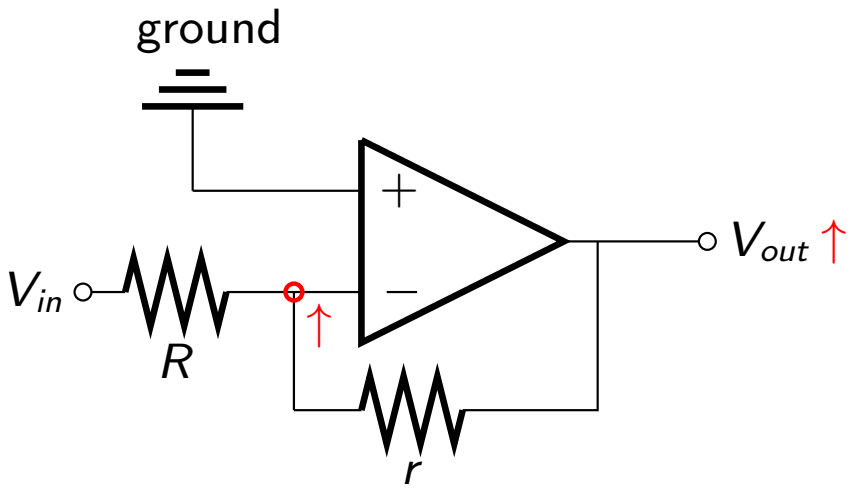

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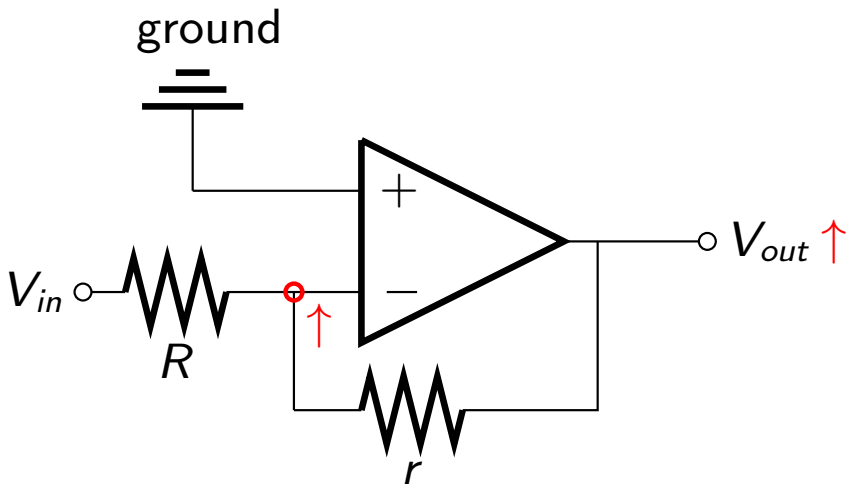

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  - $V_{out} \rightarrow$ Finite

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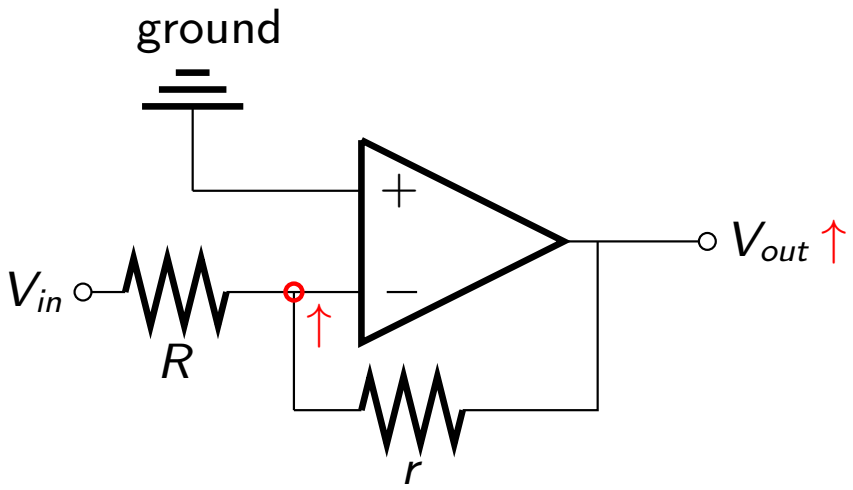

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  - Finite $V_{out} \rightarrow V_- = V_+ = 0$ [Remind $\lim_{G\rightarrow\infty} G(V_+ - V_-)$]

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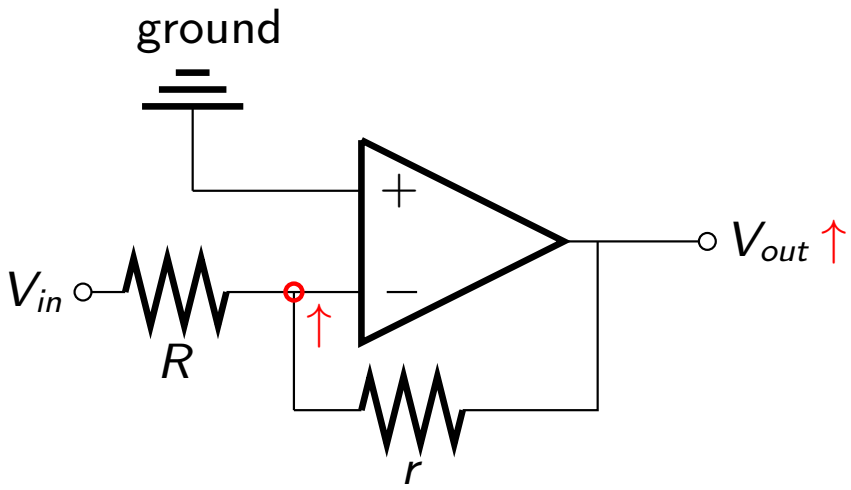

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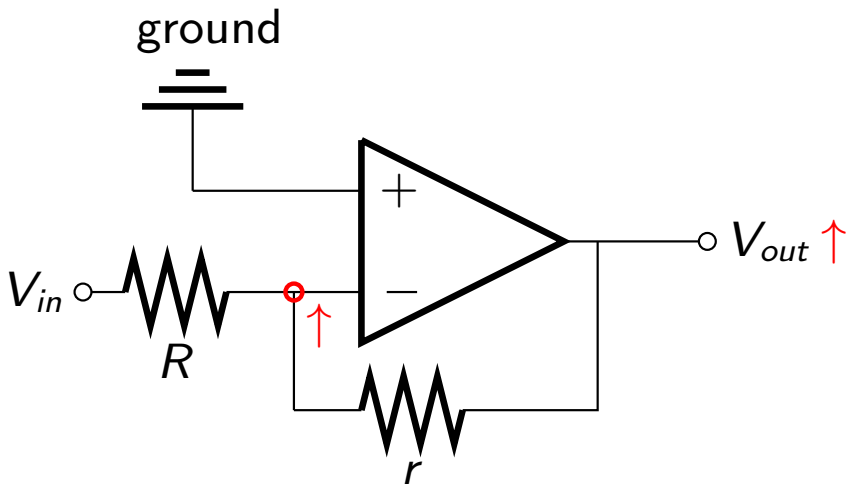

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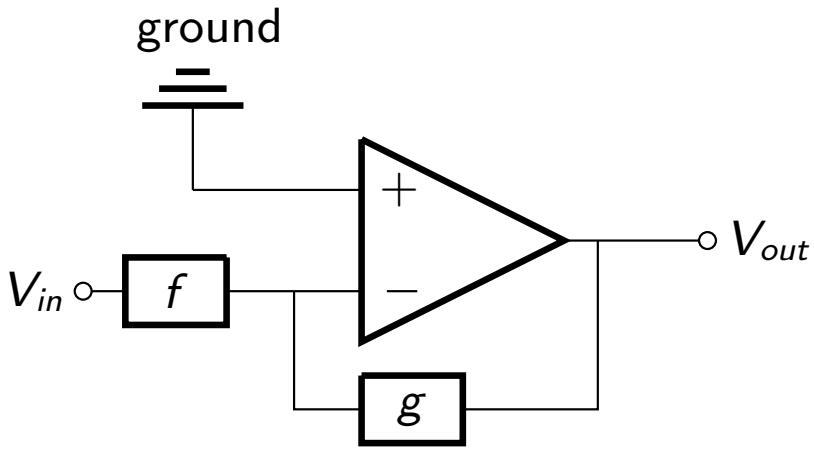
$$V_{out} = -\frac{r}{R} V_{in} \tag{7}$$

Principle of OP-amp operation



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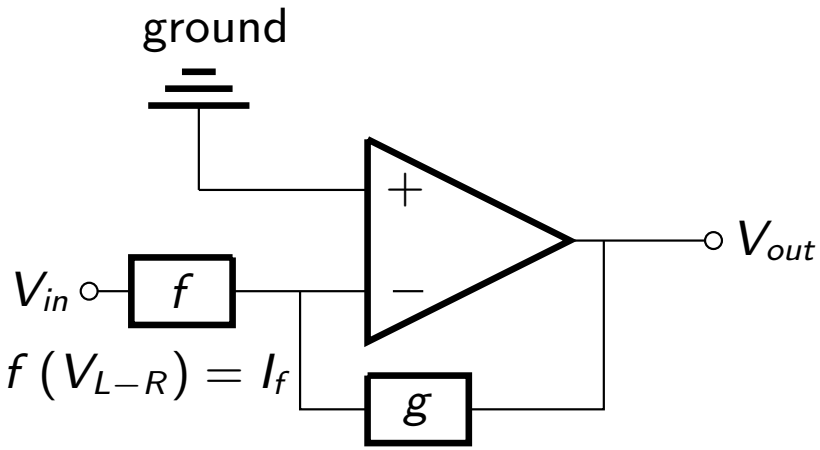

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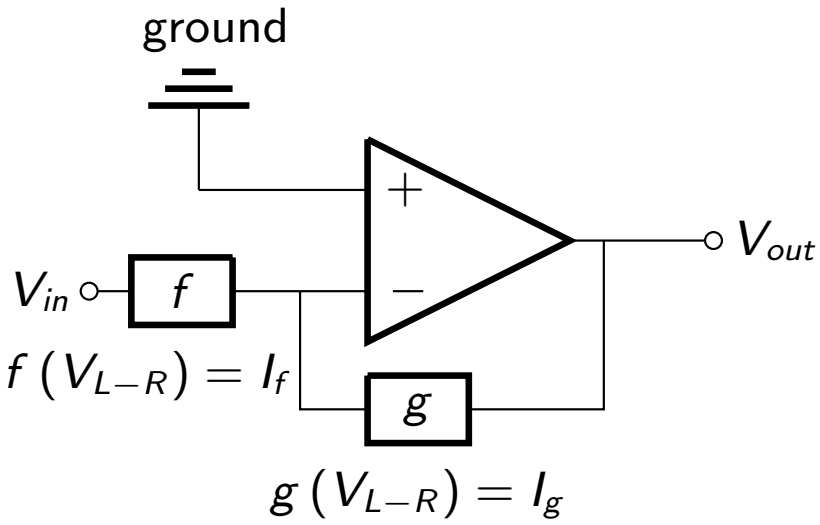

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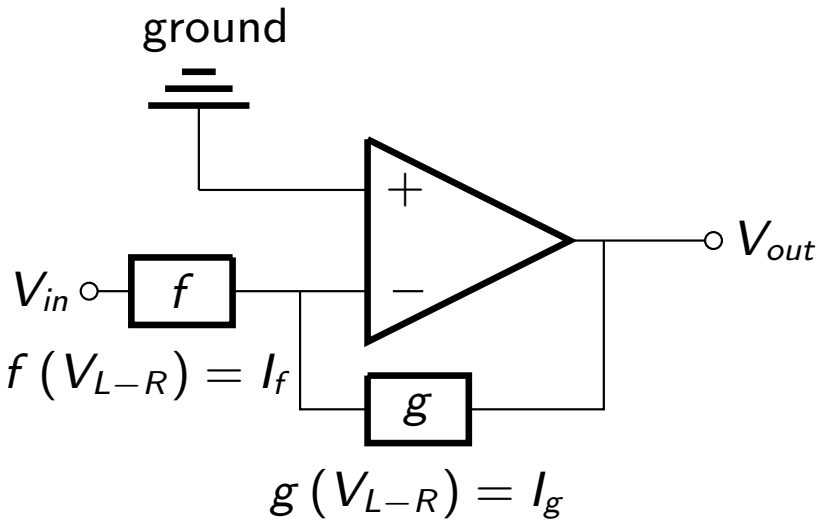

- Negative feedback
  - V_{out} fixed on equilibrium value
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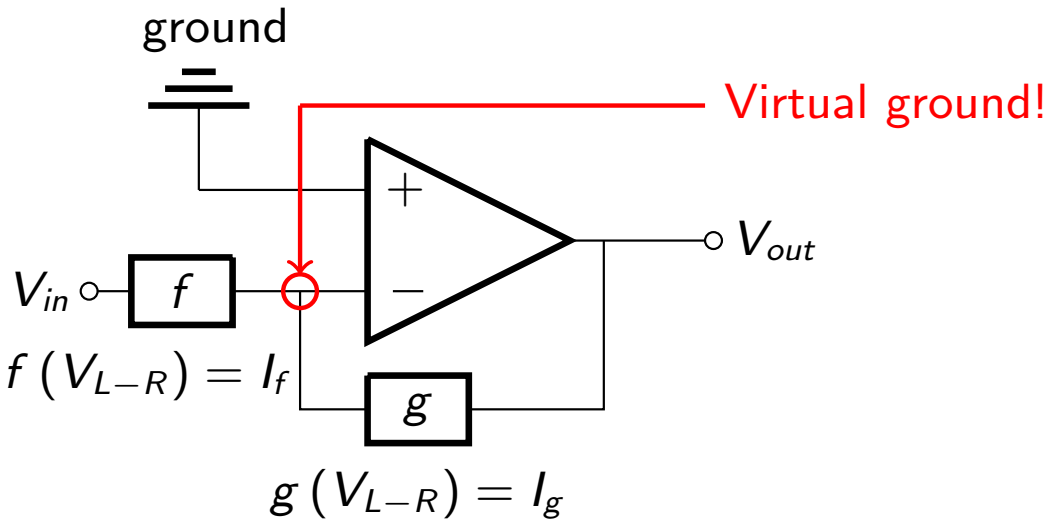

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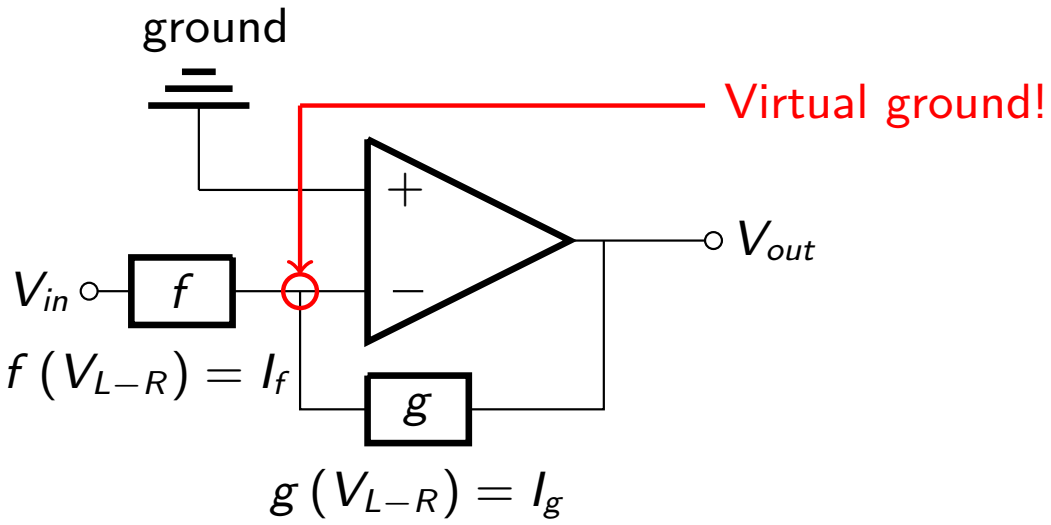

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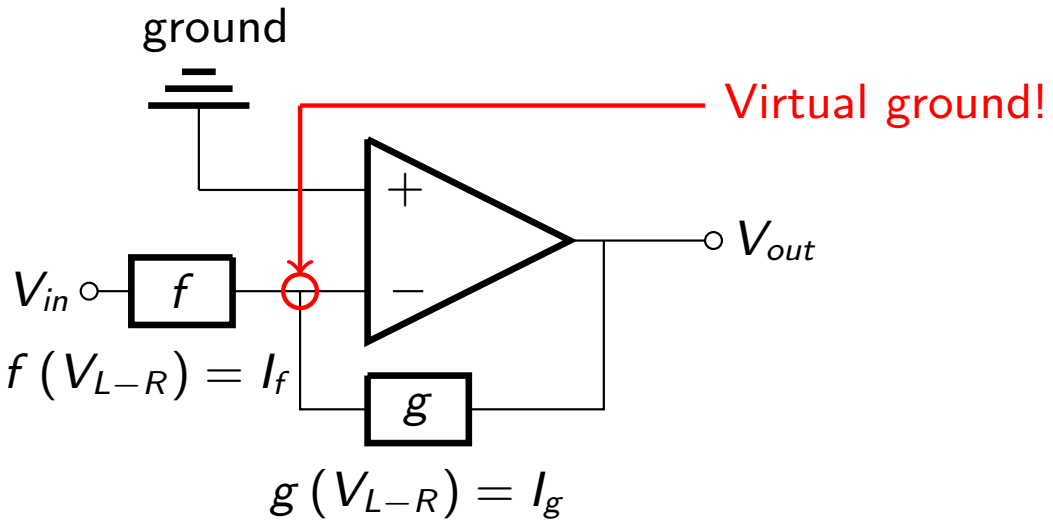

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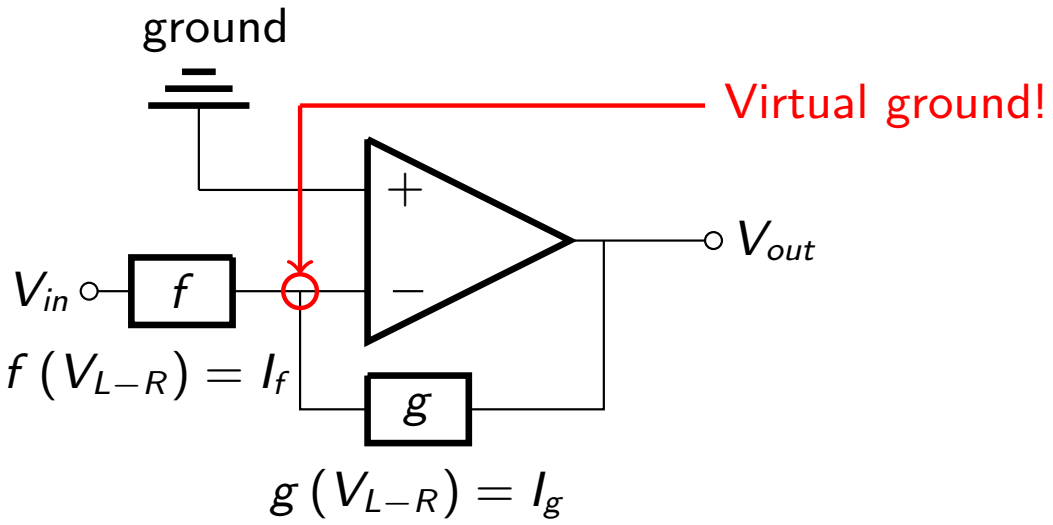

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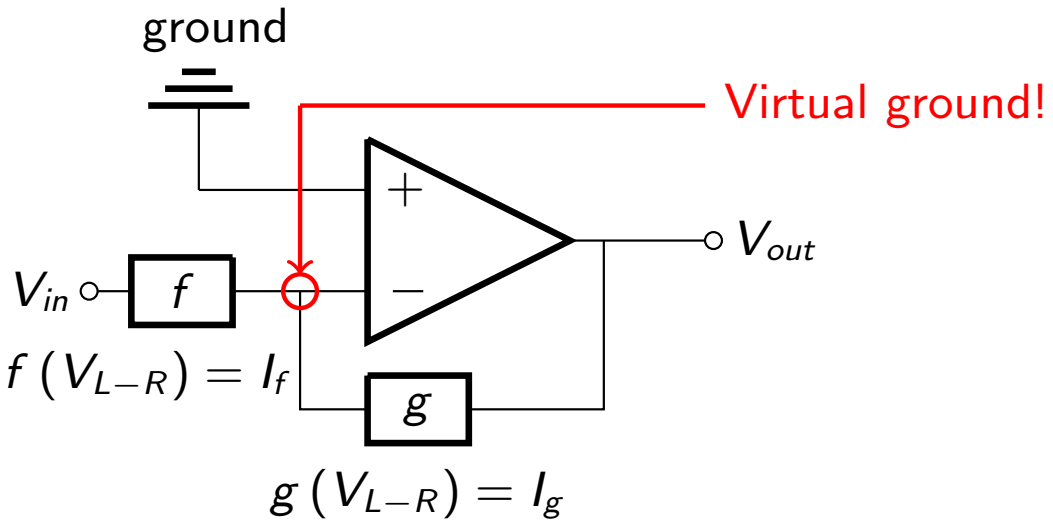

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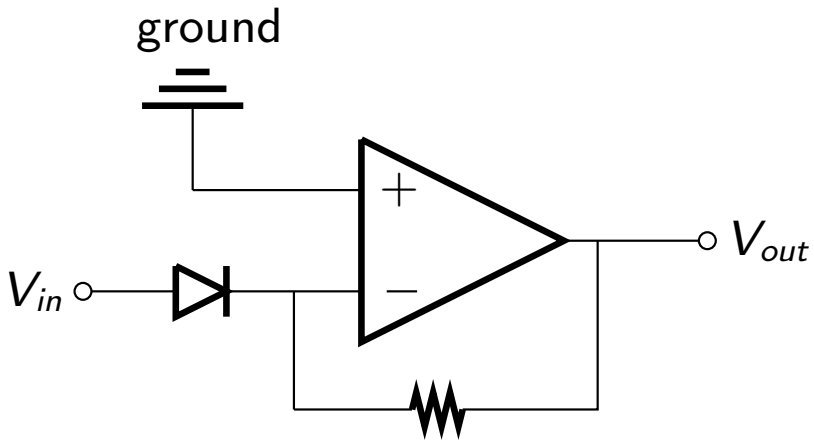
$$V_{out} = -g^{-1}\left[f\left(V_{in}\right)\right] \tag{8}$$

Exponential operator



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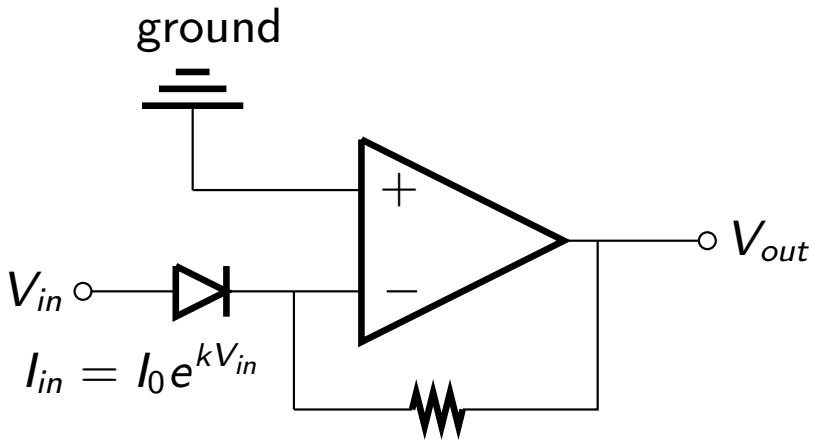

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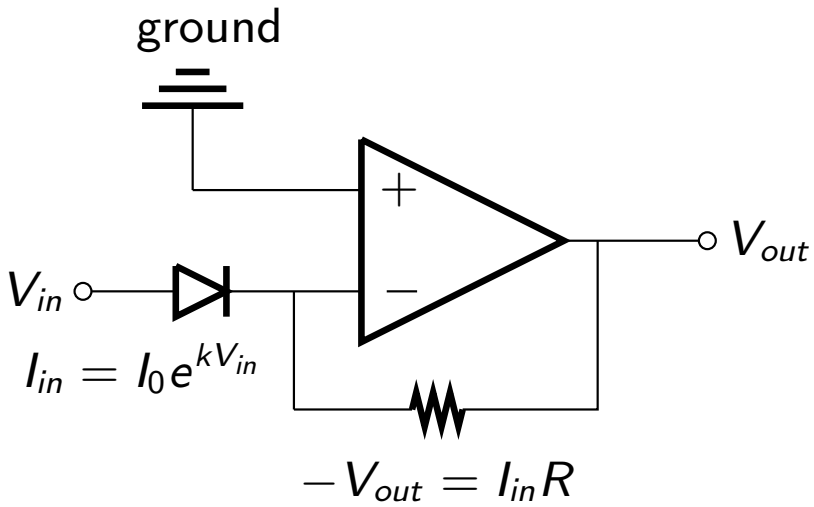

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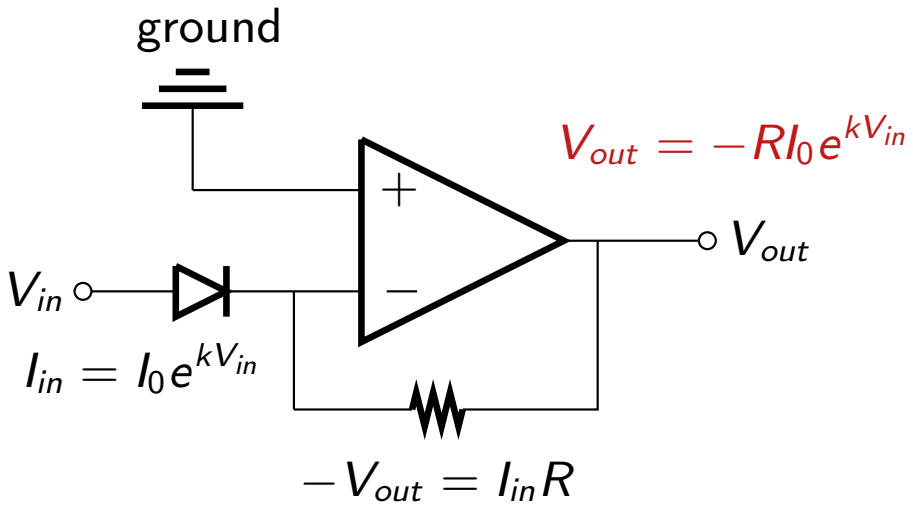

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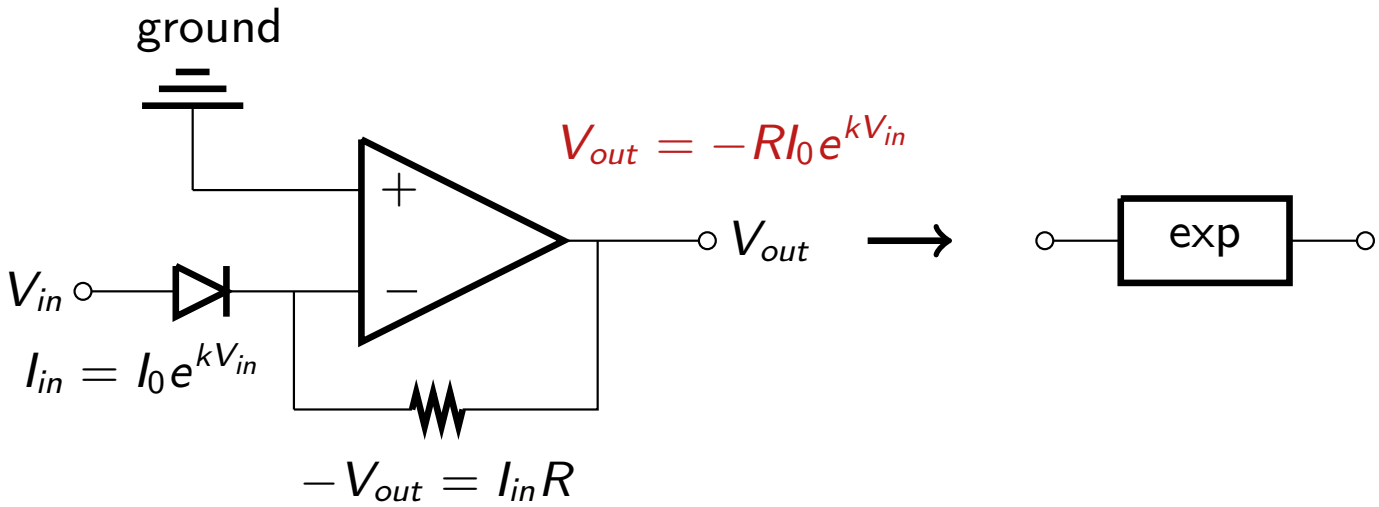
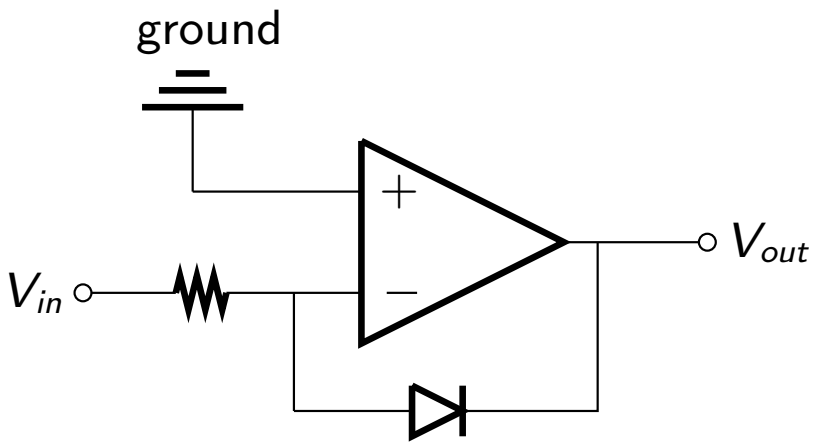


Logarithmic operator



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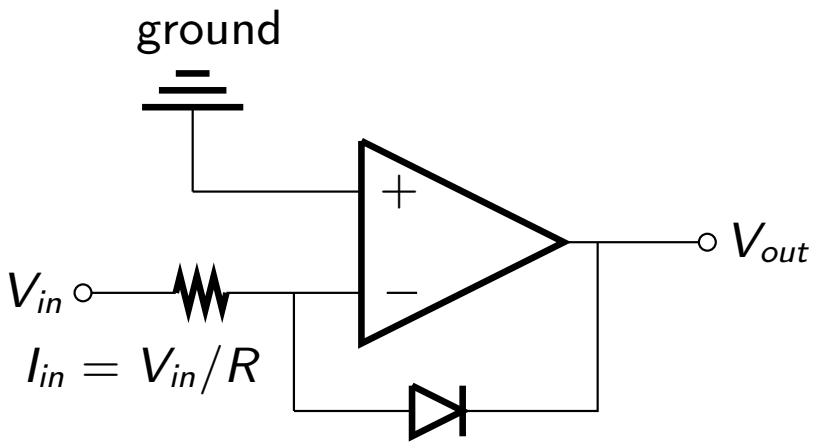

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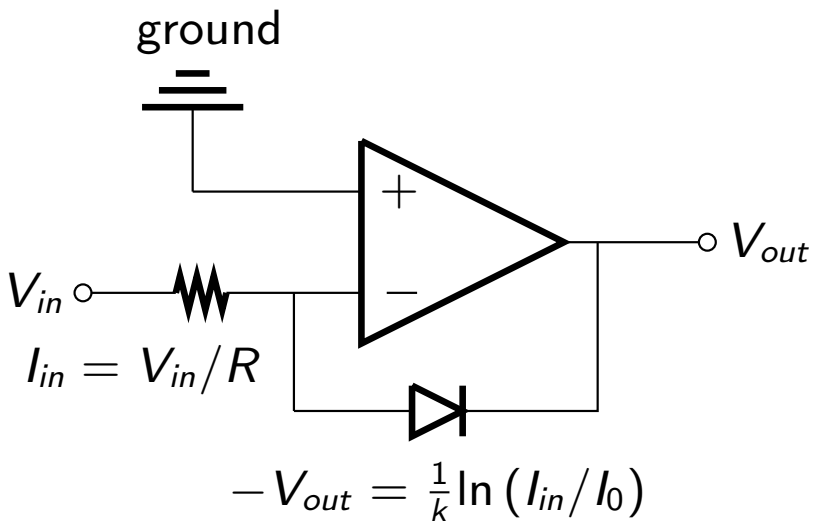

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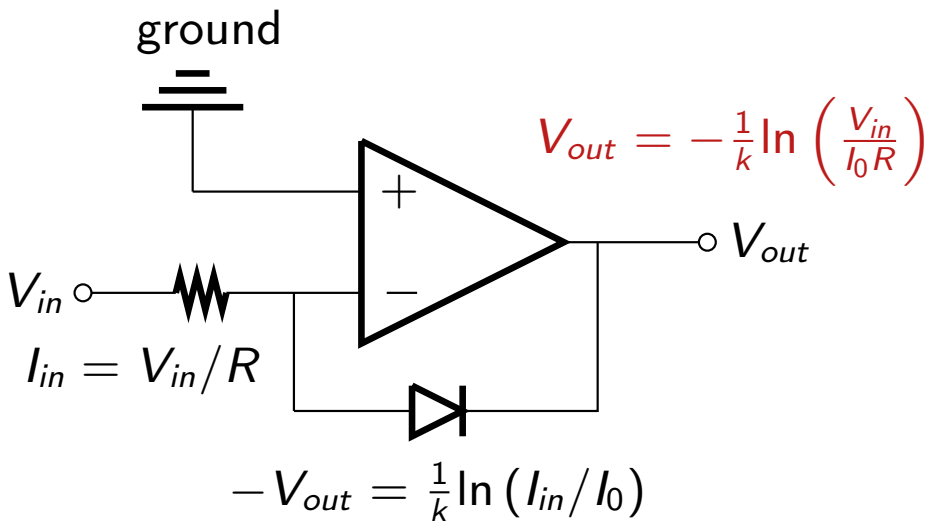

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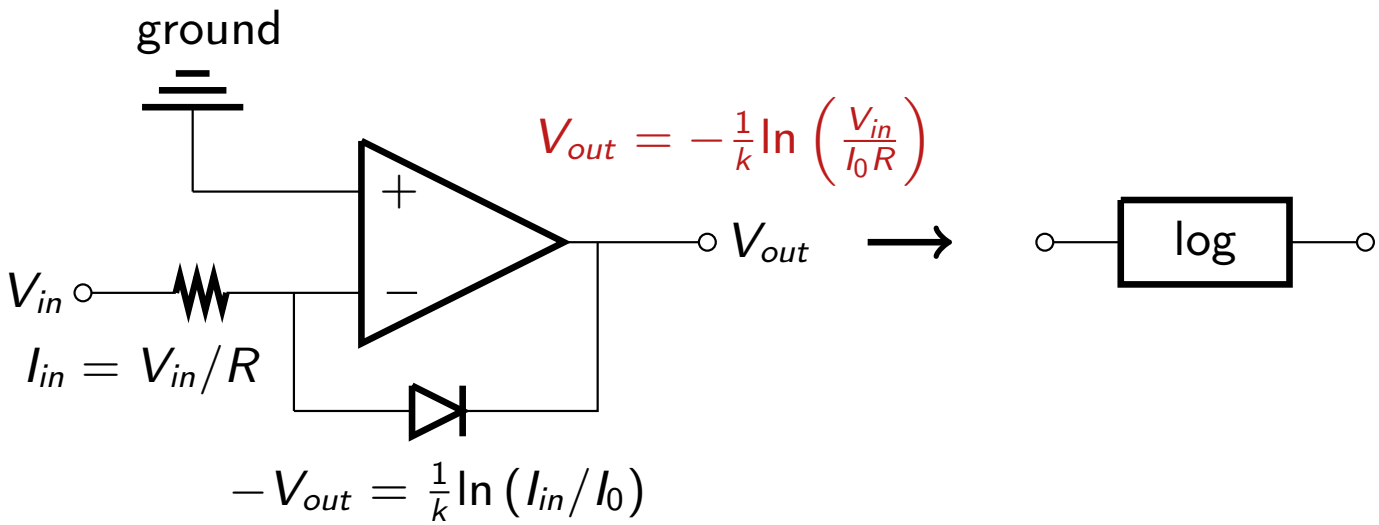
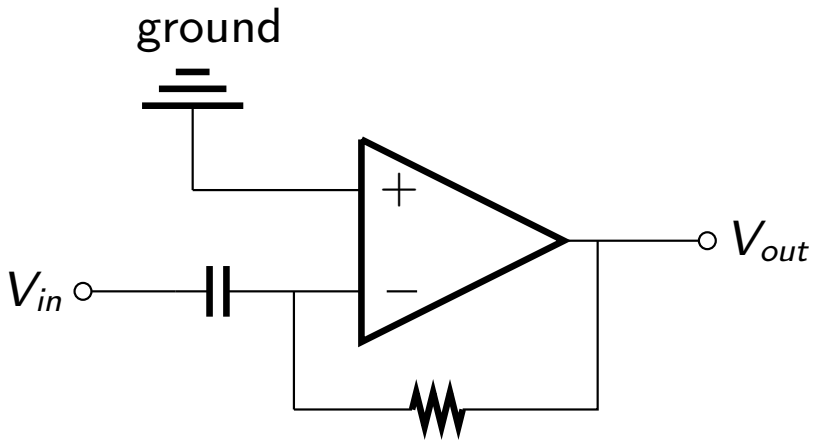


Differential operator



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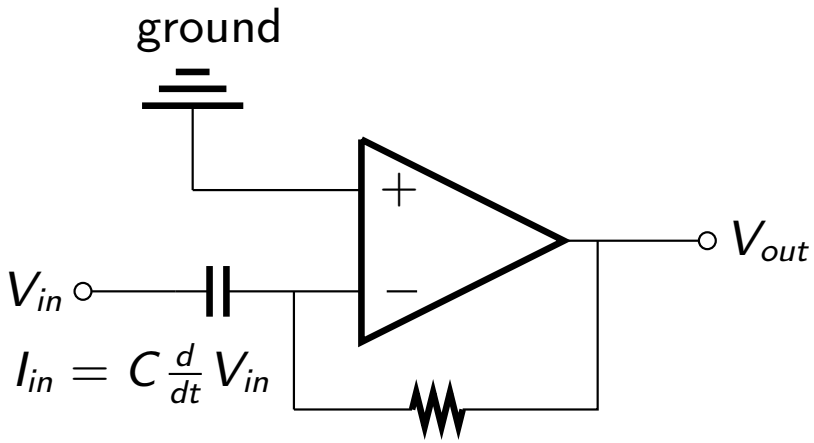

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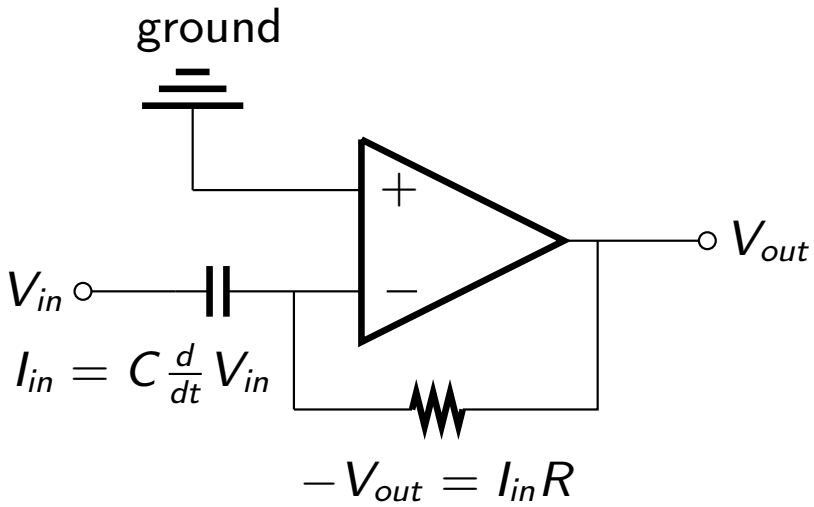

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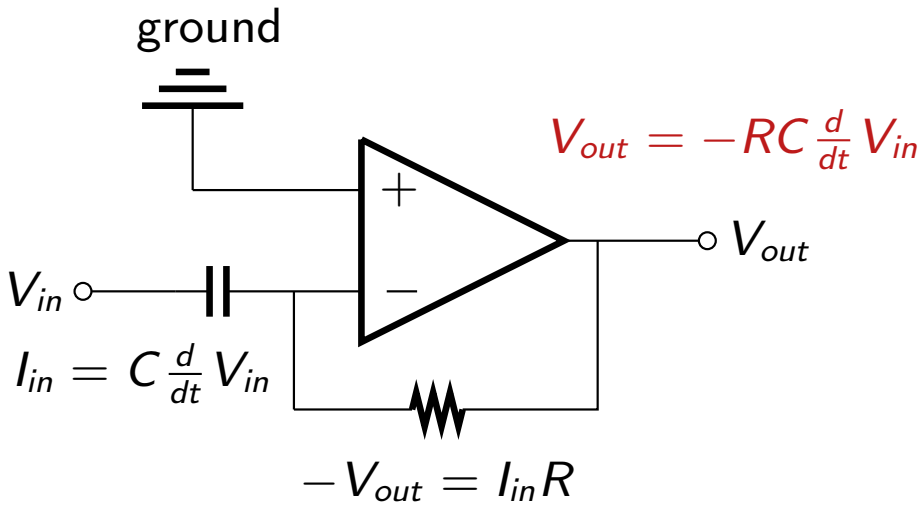

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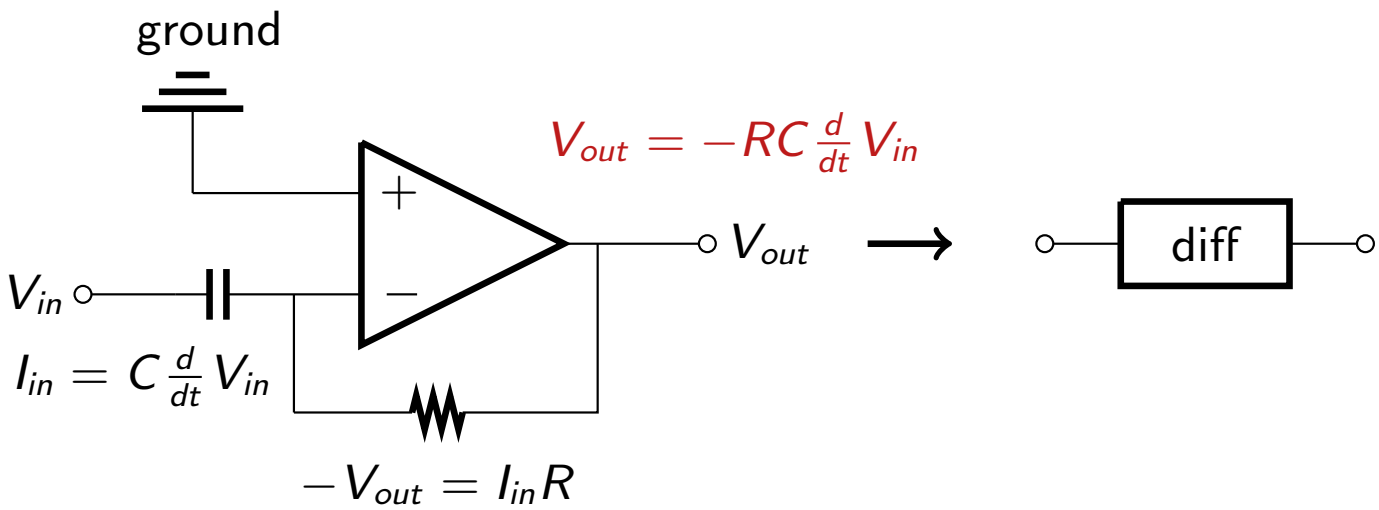

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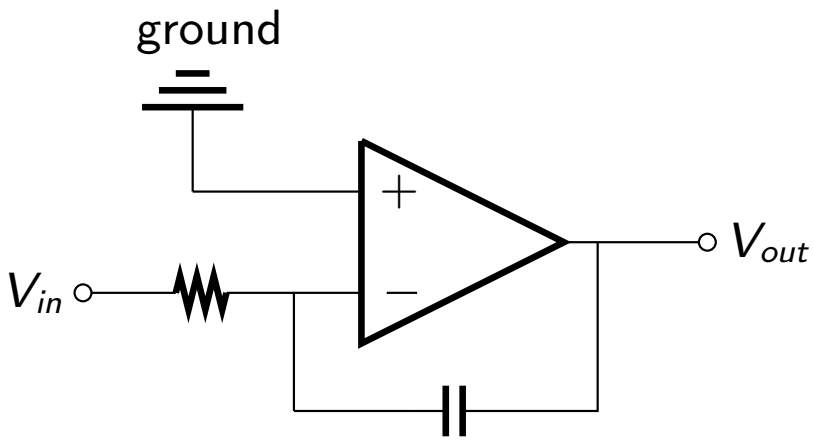

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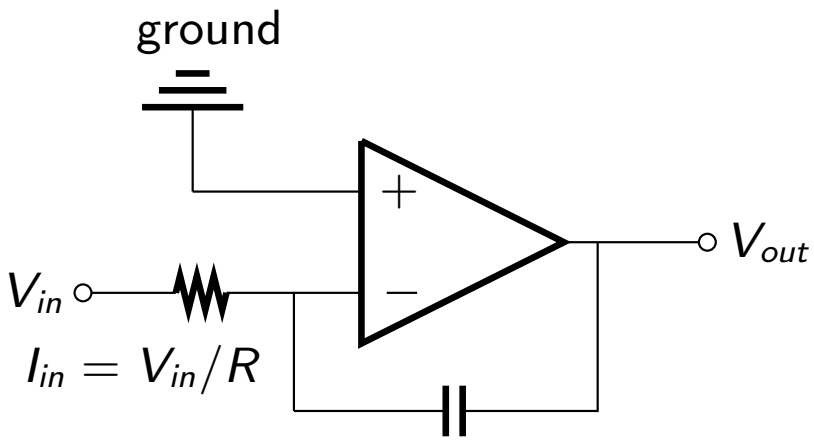

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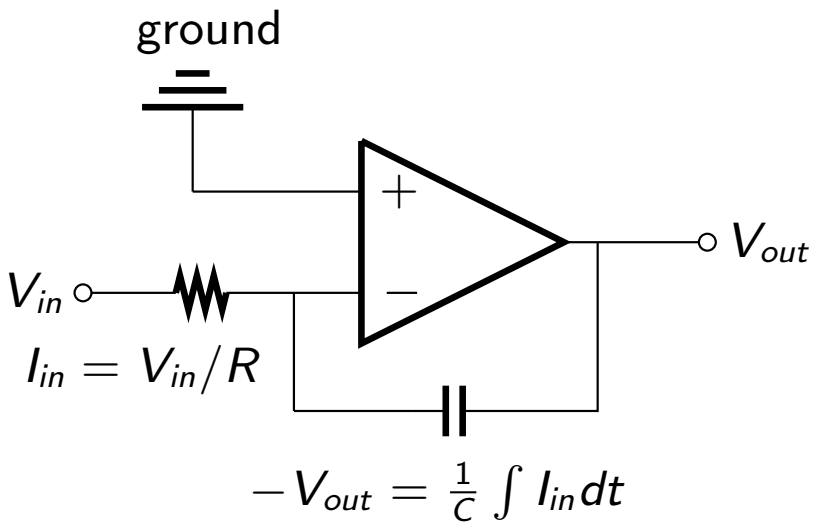

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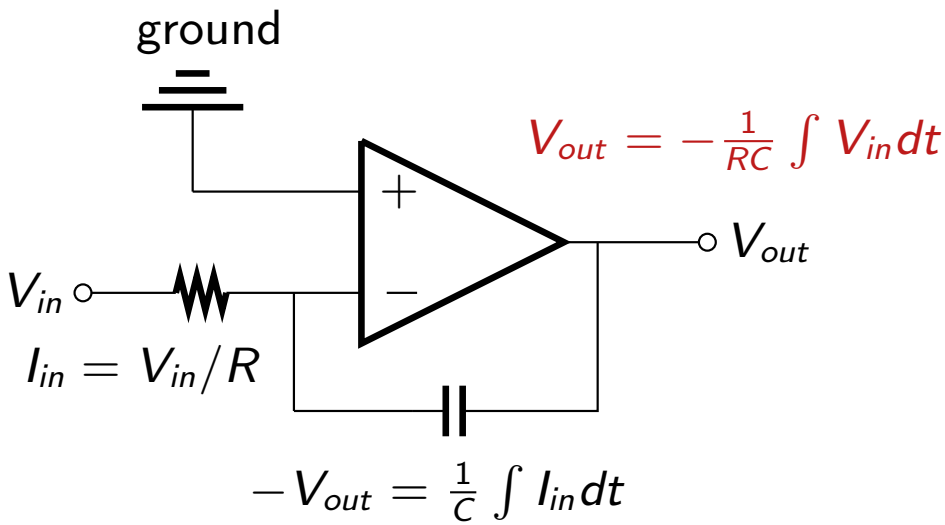

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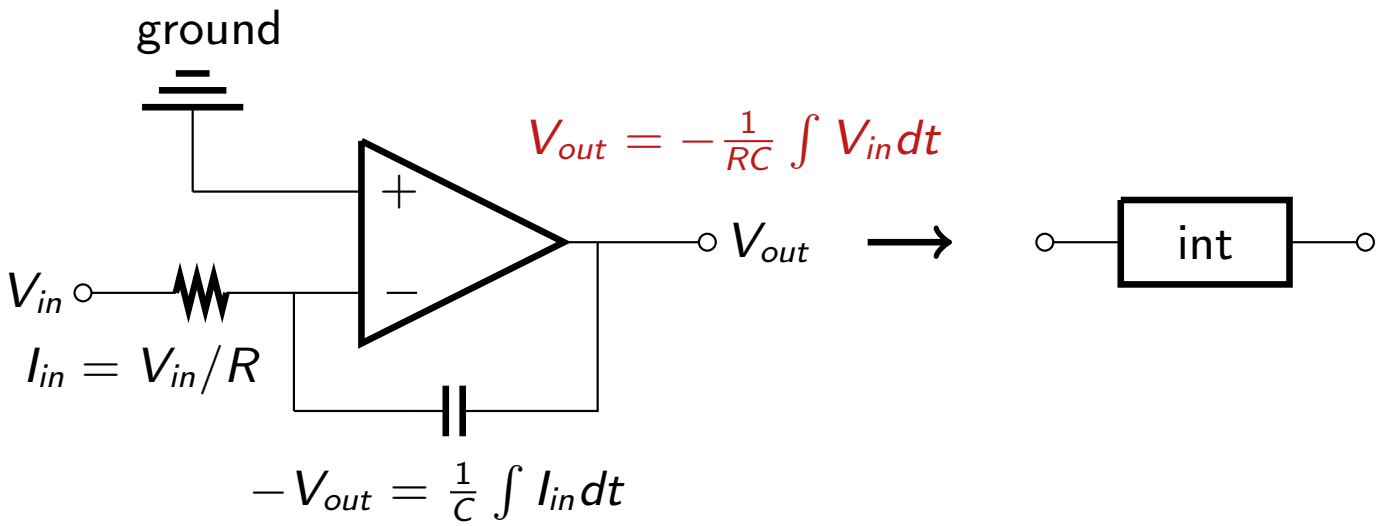

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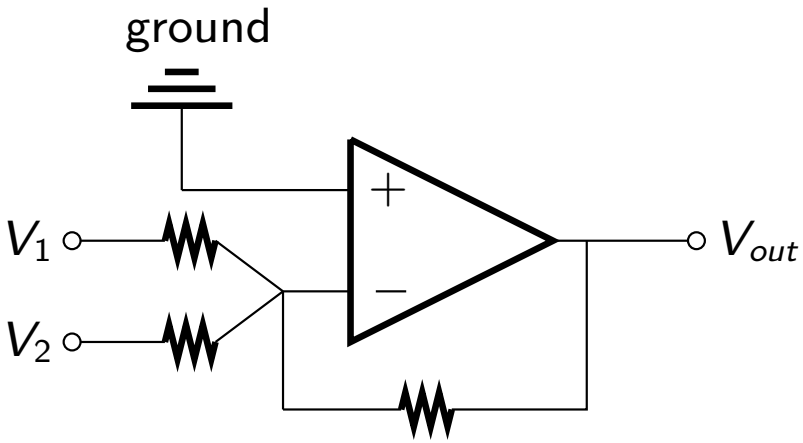

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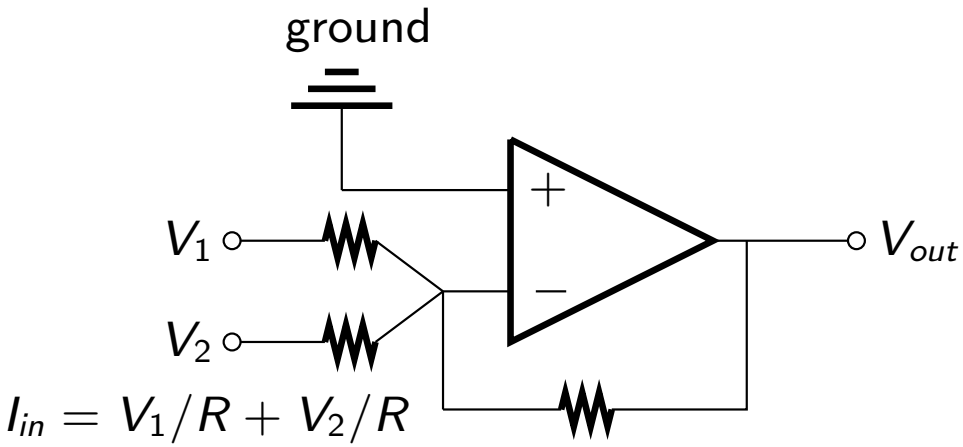
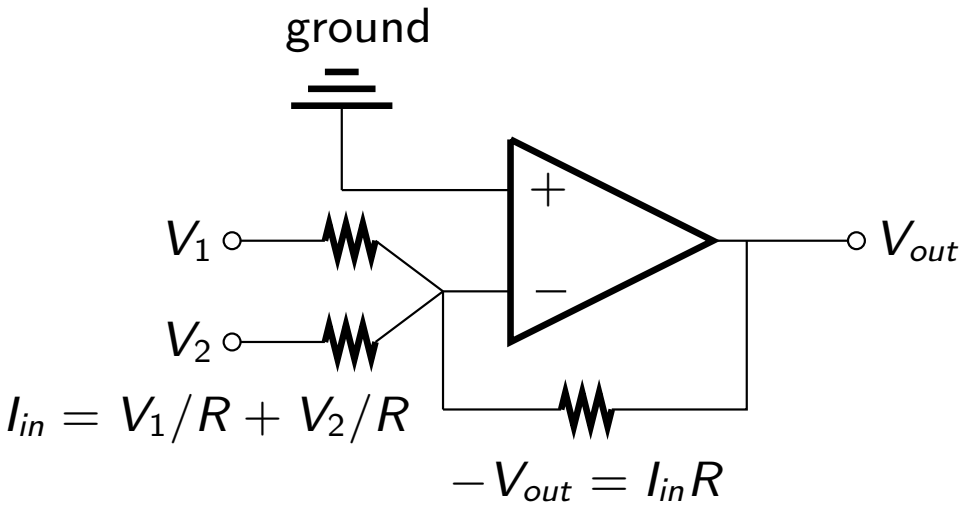
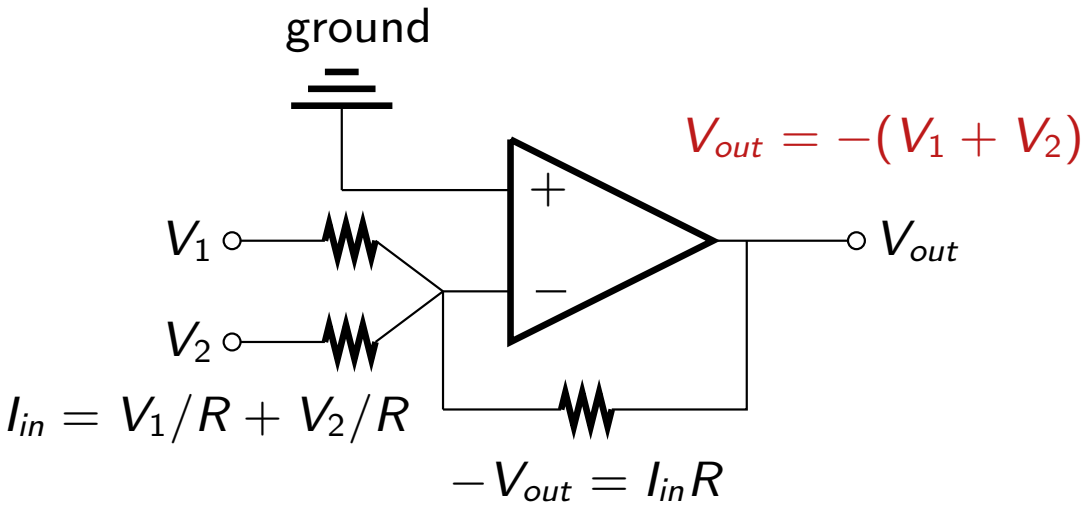


$I_{in} = V_1/R + V_2/R$

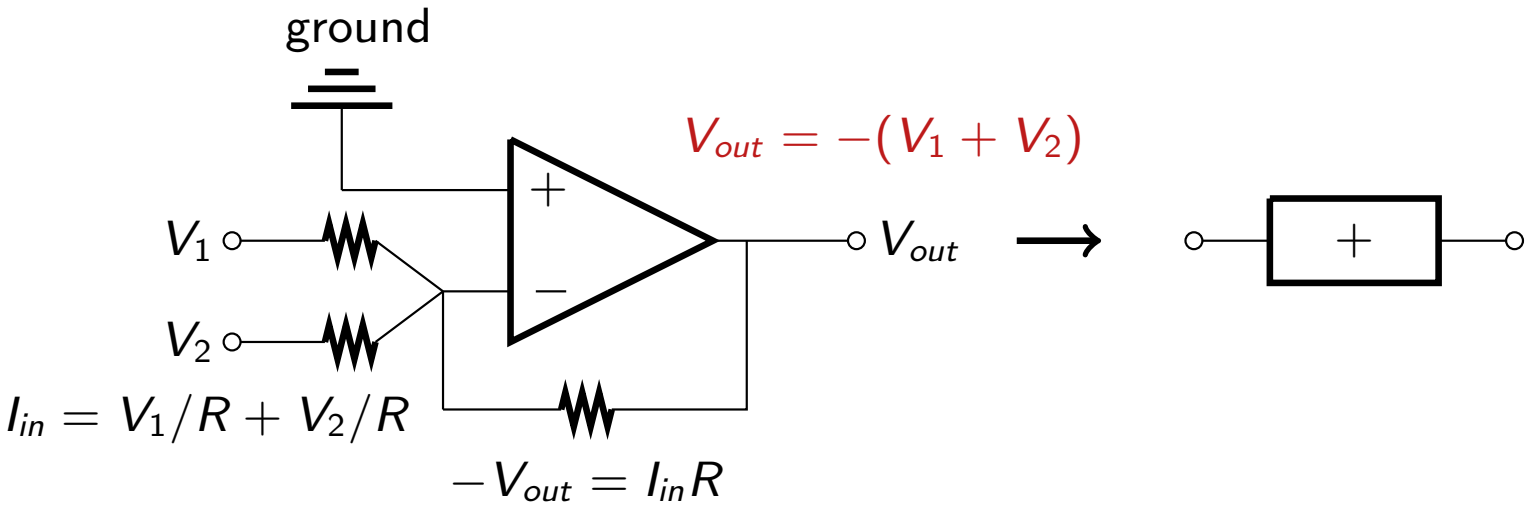
Addition operator



Addition operator

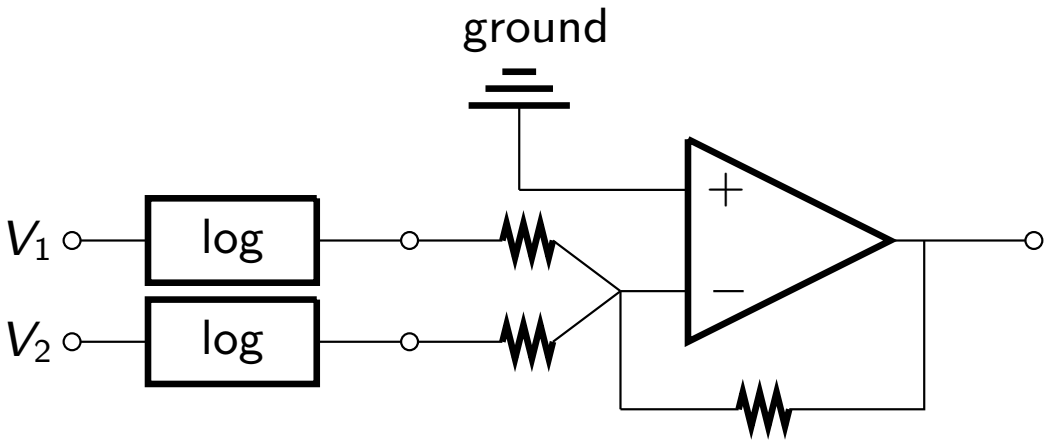


Addition operator

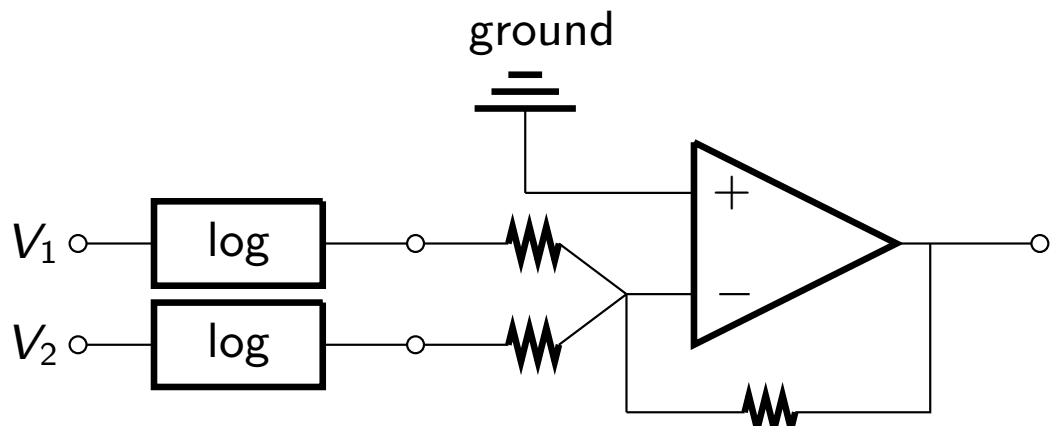


Multiplication operator

Multiplication operator

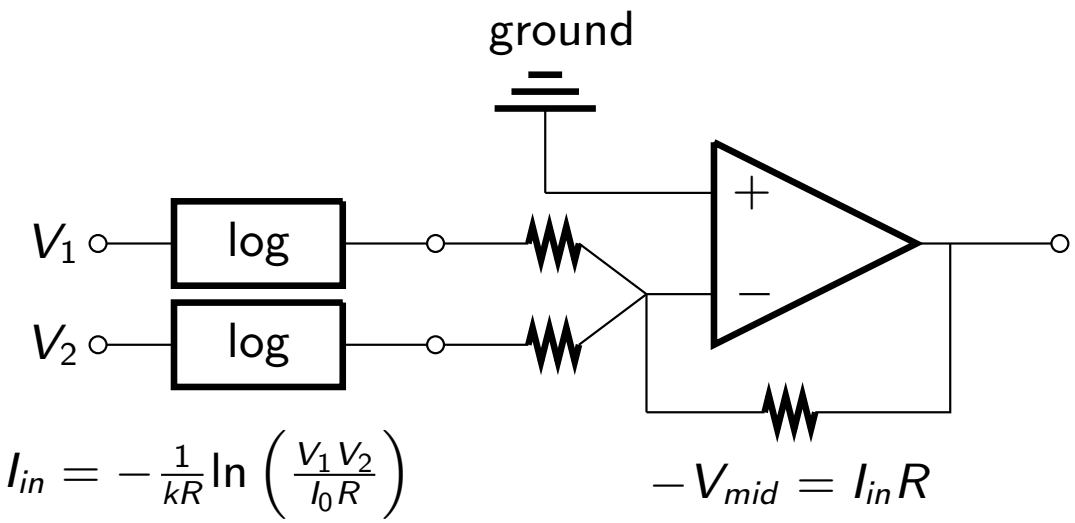


Multiplication operator

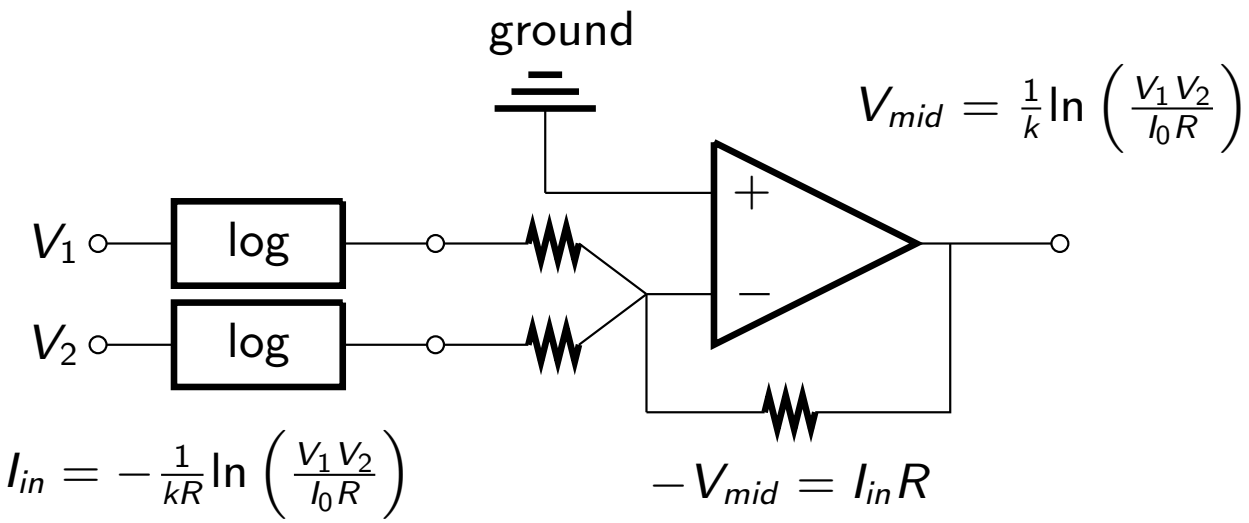


$$I_{in} = -\frac{1}{kR} \ln\left(\frac{V_1 V_2}{I_0 R}\right)$$

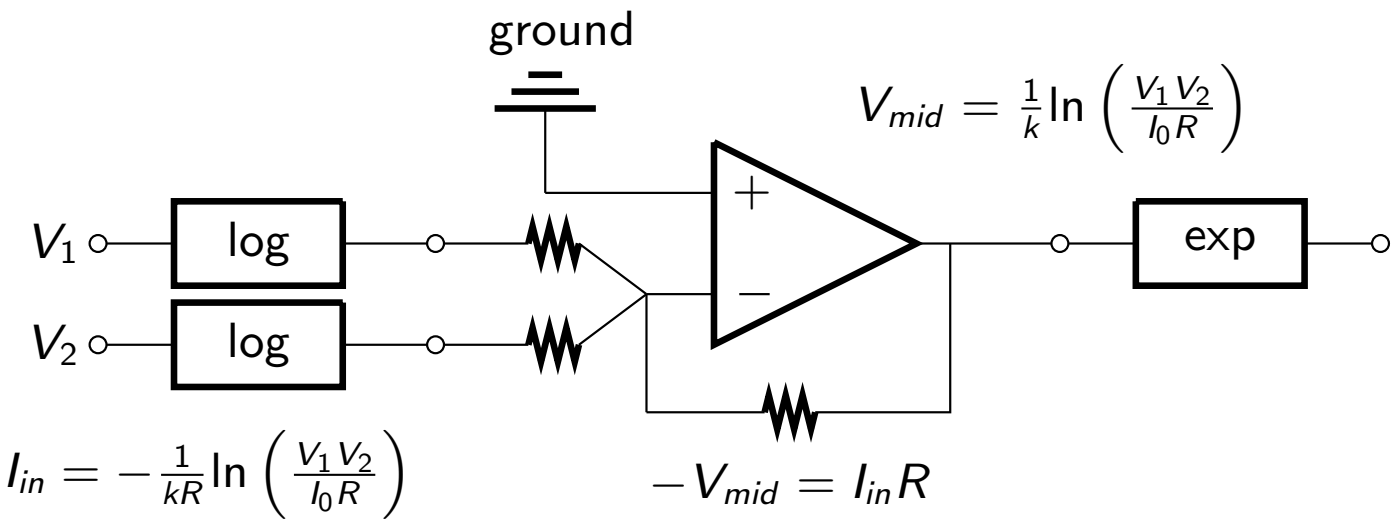
Multiplication operator



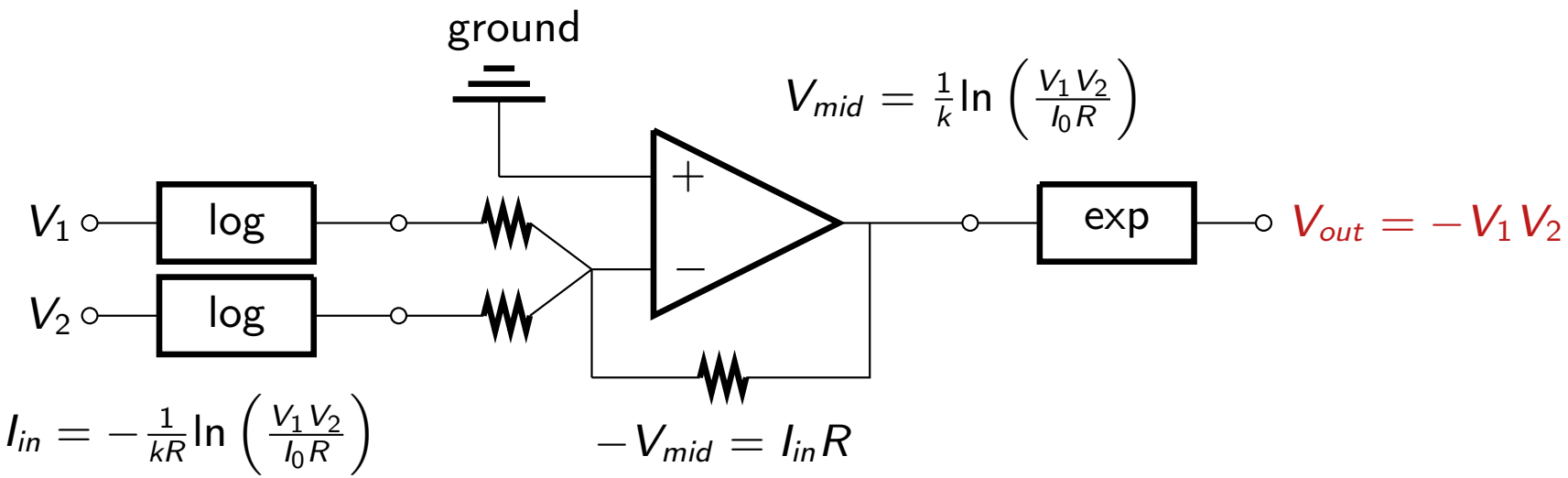
Multiplication operator



Multiplication operator



Multiplication operator



From Amplifier to Information Revolution

As amplifiers have developed from vacuum tube $\rightarrow$ transistor $\rightarrow$ integrated circuit embedded amplifier, combined with switching logic circuit, became modern processor which enable the Information Revolution

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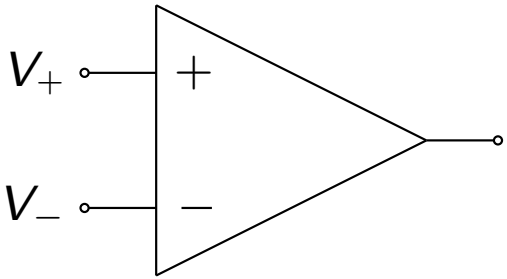

Thank You!