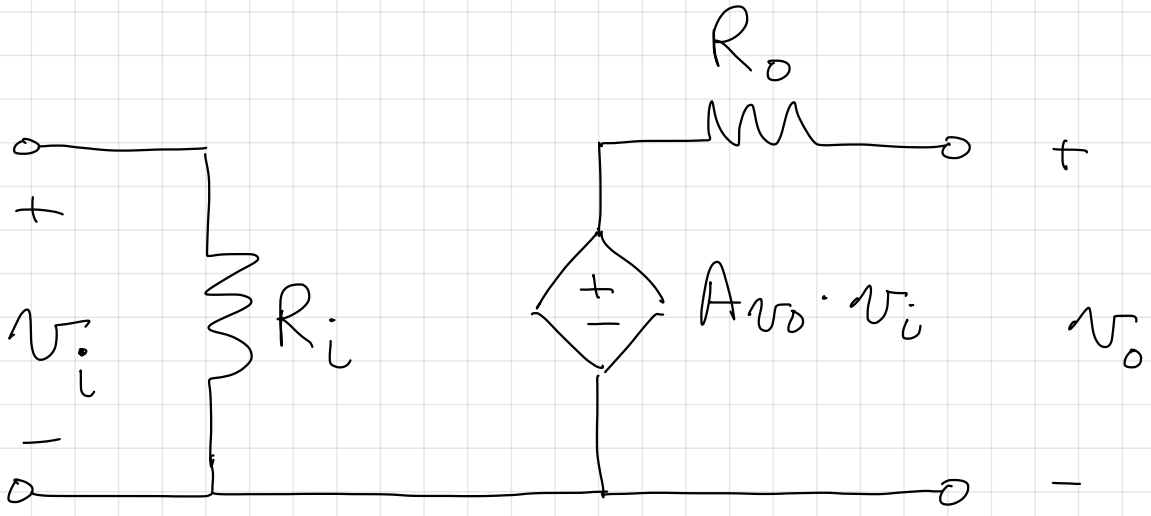
Standard voltage amplifier



$A_{vo} \equiv$ open-loop voltage gain

$R_i \equiv$ input resistance

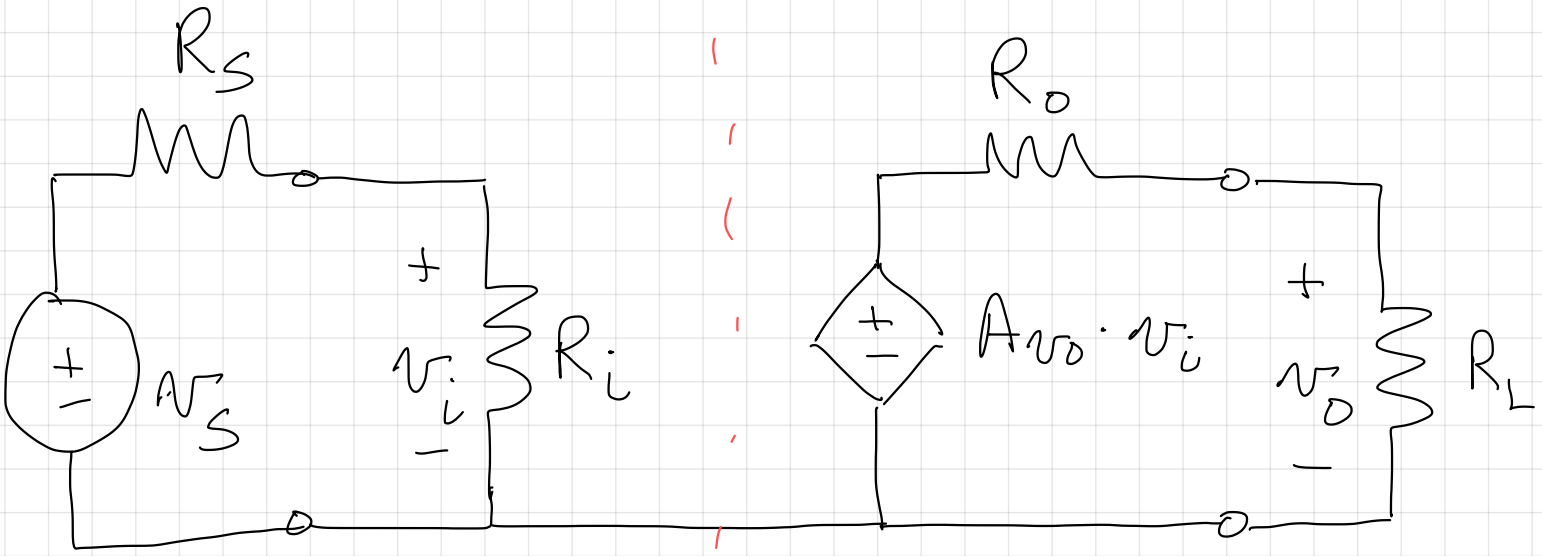
$R_o \equiv$ output resistance

for open loop conditions

$$v_o = A_{vo} \cdot v_i$$

source input : v_s , R_s => series

R_L terminate output



find the closed loop voltage gain : $A_V = \frac{v_o}{v_s}$

left hand side :

by voltage division : $v_i = v_s \left(\frac{R_i}{R_s + R_i} \right)$

$$\frac{v_i}{v_s} = \frac{R_i}{R_s + R_i}$$

right hand side : by voltage division

$$v_o = A_{vo} v_i \left(\frac{R_L}{R_L + R_o} \right)$$

$$\frac{v_o}{v_i} = A_{vo} \left(\frac{R_L}{R_L + R_o} \right)$$

$$\frac{v_o}{v_s} = \frac{v_o}{v_i} \cdot \frac{v_i}{v_s} = \frac{v_o}{v_s}$$

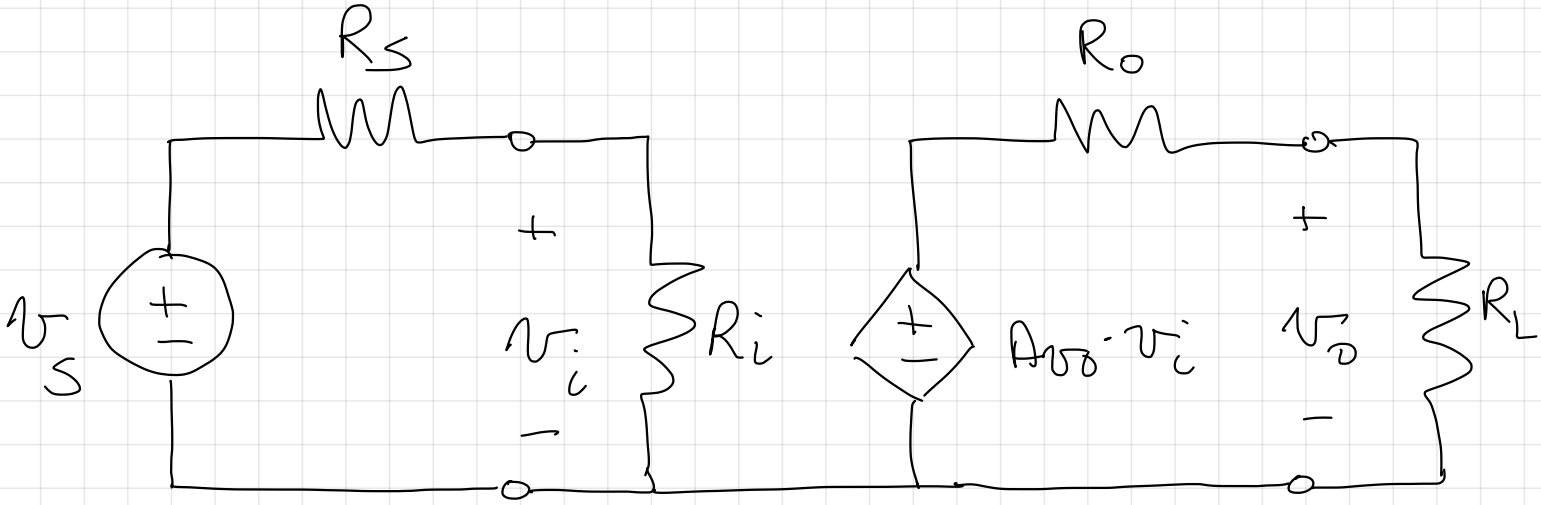
$$\frac{v_o}{v_s} = A_{vo} \left(\frac{R_L}{R_L + R_o} \right) \cdot \left(\frac{R_i}{R_s + R_i} \right)$$

A_{vo} => large

R_o => small, ideally zero.

R_i => large, ideally infinity

Example



$A_{vo} = 200\ V/V$ $\quad R_L = 10\Omega$

$R_S = 1M\Omega$

$$\frac{v_o}{v_s} = A_{vo}\left(\frac{R_L}{R_o+R_L}\right)\left(\frac{R_i}{R_i+R_s}\right)$$

case 1: large output resistance $R_o = 1k\Omega$
smaller input resistance $R_i = 100k\Omega$

$$\frac{v_o}{v_s} = (200)\left(\frac{10}{1000+10}\right)\left(\frac{100\times10^3}{100\times10^3+1\times10^6}\right)$$

$$= (200)(.0099)(0.0909)$$

$$\frac{v_o}{v_s} = 0.18\ \frac{V}{V}$$

Case 2: $R_i = 1\,M\Omega$

$R_o = 100\,\Omega$

$$\frac{v_o}{v_s} = (200)\left(\frac{10}{10+100}\right)\left(\frac{1\times10^6}{1\times10^6+1\times10^6}\right)$$

$$= 200\left(\frac{1}{11}\right)\left(\frac{1}{2}\right)$$

$$\boxed{\frac{v_o}{v_s} = 9.\overline{09}\ V/V}$$

$$\frac{v_o}{v_s} = A_{vo}\left(\frac{R_L}{R_o+R_L}\right)\left(\frac{R_i}{R_i+R_s}\right)$$

One amplifier alone can't always do the job needed so we can cascade amplifiers togethers.