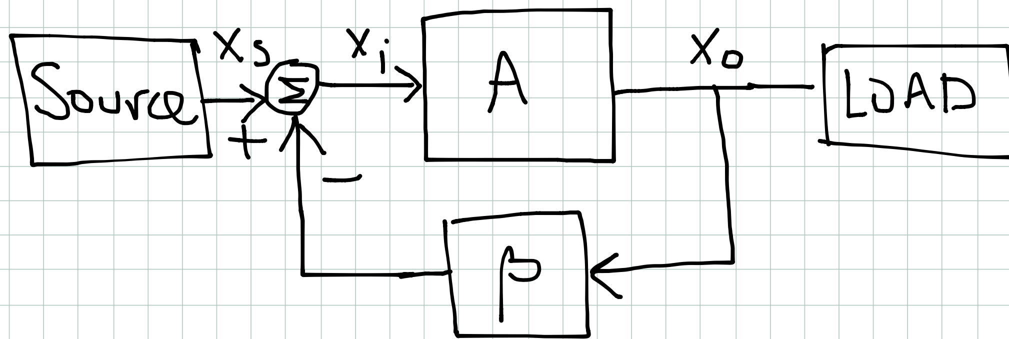
Basic feedback analysis



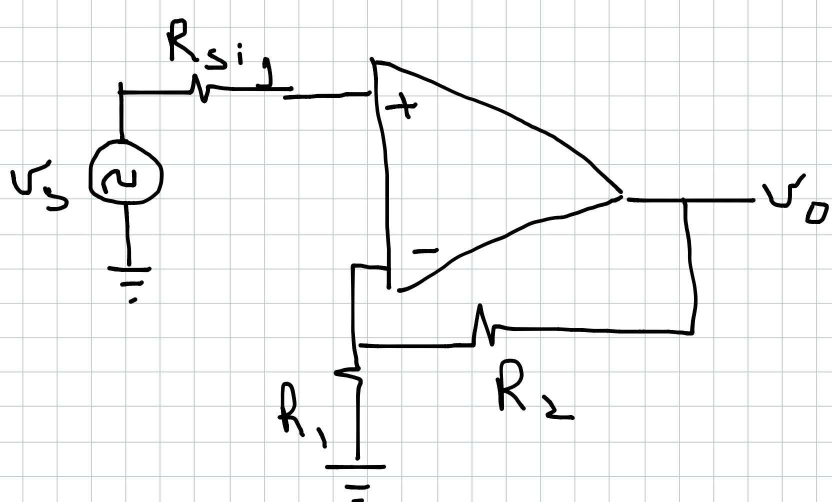
$$x_o = A x_i = A(x_s - \beta x_o)$$

$$A_f = \frac{x_o}{x_s} = \frac{A}{1 + \beta A}$$

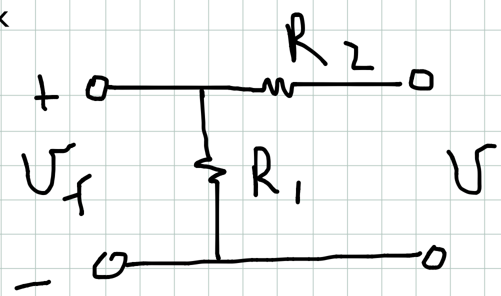
A is non-feedback amplifier gain
Af is feedback amplifier gain

To apply the above equation, the A and β blocks should be ideal.

Feedback analysis of simple non-inverting opamp circuit
Asume opamp with finite gain a but otherwise ideal



feedback network



$$\beta = \frac{v_f}{v_o} = \frac{R_1}{R_1 + R_2}$$

A −> op amp gain a

$$A_f = \frac{a}{1 + \frac{a R_1}{R_1 + R_2}}$$

Example: R2 = 100*R1, a = 10000

Af = 10000/(1 + 10000/101) = 99.99 V/V

Finite opamp gain produces a 1% error on voltage gain.

Example: For above R1 and R2, find value of a required to have 0.1% error

A ideal = 1 + R2/R1 = 101; Af = 101*0.999 = 100.899V/V (for 0.1% error)

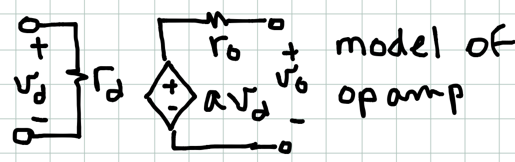
Af = 100.899 => 100.899(1 + a/101) = a

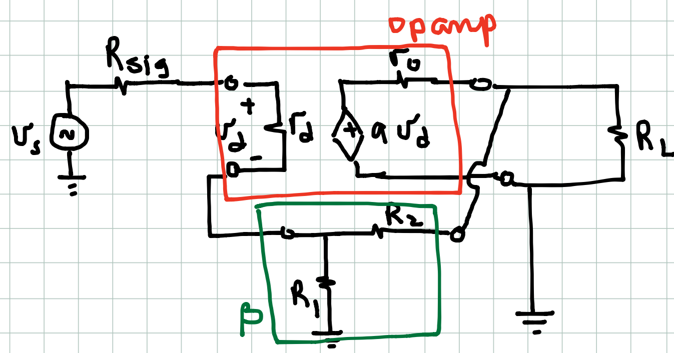
100.899 + 100.899*a/101 = a

100.899 = a (1- 100.899/101)

a = 100899   <- value required to have 0.1% error in gain

Non-inverting amplifier with finite a, rd and ro





Feedback method: Integrate

1) non-ideal features of feedback network into amplifier
2) non-ideal characteristics of load into amplifier
3) non-ideal characteristics of source into amplifier
4) find non-feedback amplifier gain A
5) apply feedback gain formula

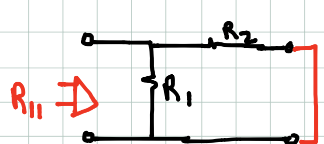
$$Af = A/(1 + \beta A)$$

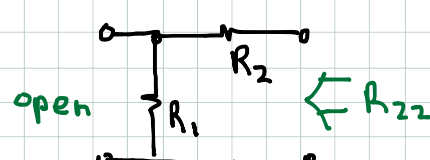
For a voltage amplifier:

1) ideal source is voltage source without thevenin resistor
2) ideal load is open circuit
3) feedback network resistances must be transfered to amp

Example: Let ro = 100 , rd=10k, a = 10000, Rsig = 1k, R1 = 100, R2 = 10000, RL = 10k

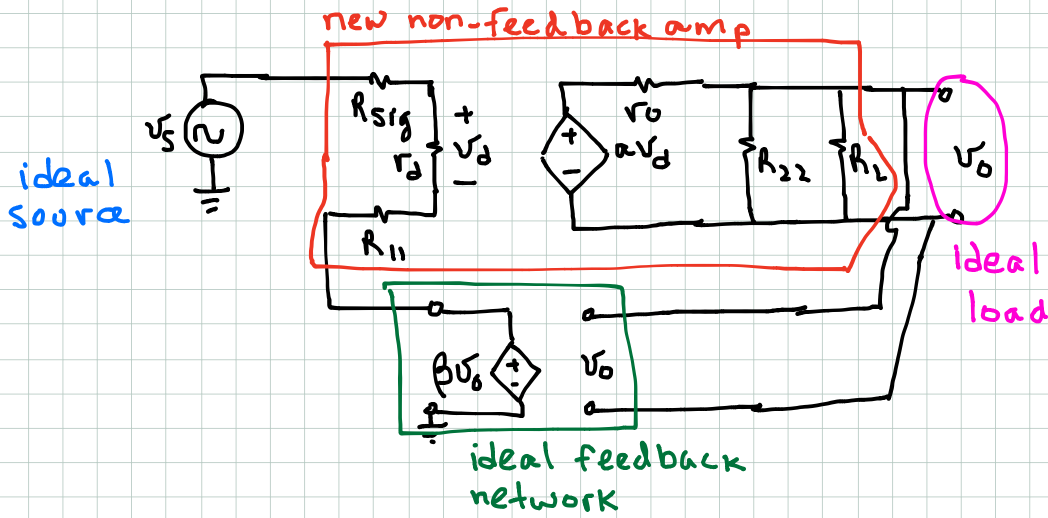
Find R11 and R22 for feedback network





R11 = R1 || R2 = 100 || 10000 = 99

R22 = 100 + 10,000 = 10,101



$$v_o = \frac{R_{22} || R_L}{r_o + R_{22} || R_L} a v_d$$

$$v_d = \frac{r_d}{r_d + R_{11} + R_{sig}} v_s$$

$$A = \frac{v_o}{v_s} = \frac{R_{22} || R_L}{r_o + R_{22} || R_L} \, a \, \frac{r_d}{r_d + R_{11} + R_{sig}}$$

$$R_{22} || R_L = 10101 || 10k \simeq 5k$$

$$A = \frac{5k}{5k + 100} 10000 \frac{10k}{10k + 99 + 1k} = 8833 \, V/V$$

$$A_f = \frac{8833}{1 + 8833/101} = \boxed{99.85 \frac{V}{V}}$$

Advantage of feedback method: calculate feedback amplifier gain (closed-loop) from analysis of non-feedback amplifier (open-loop).

Direct calculation (analyzing circuit without applying the feedback method) is practical for only the simplest cases.