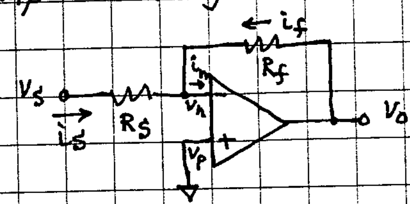
ex:

Which op-amp config, (inverting or noninverting), has highest input resistance. Use that config to design amp with V-gain of 1000.

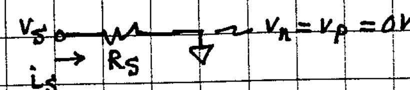
Inverting:



1) $v_n = v_p = 0V$

input resistance $R_{in} \equiv \dfrac{v_s}{i_s}$

equiv circuit



clearly $\dfrac{v_s}{i_s} = R_s$ since $i_s = \dfrac{v_s - 0V}{R_s} = \dfrac{v_s}{R_s}$

gain $\equiv \dfrac{v_o}{v_s}$ $i_n = 0$ so $i_f = -i_s$

- Feedback current flows in series resistor R_s.

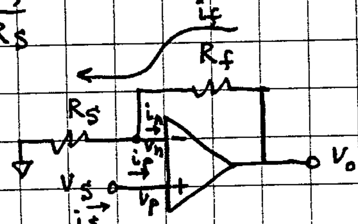
$v_o = i_f R_f$ since $v_n = 0$ $(v_o = v_n + i_f R_f)$

$= -i_s R_f$ since $i_n = 0$

$= -\dfrac{v_s}{R_s} R_f$ from above

gain $\equiv \dfrac{v_o}{v_s} = -\dfrac{R_f}{R_s}$

Non-inverting:



input resistance $\equiv \dfrac{v_s}{i_s} = \dfrac{v_s}{i_p} = \dfrac{v_s}{0} = \infty$

This has the higher input resistance.

gain $= \dfrac{v_o}{v_s}$ Use ideal op-amp rules to find gain.

1) $v_n = v_p$ and $v_p = v_s \Rightarrow v_n = v_s$

ex: (cont) 2) $i_n = i_p = 0A \Rightarrow i_f$ flows thru R_f and R_S

$$i_f = \frac{v_n - 0V}{R_S} = \frac{v_p - 0V}{R_S} = \frac{v_S - 0}{R_S} = \frac{v_S}{R_S}$$

$$v_o = v_n + i_f R_f = v_n + \frac{v_S}{R_S} R_f = v_p + \frac{v_S}{R_S} R_f = v_S + \frac{v_S}{R_S} R_f$$

$$\therefore v_o = v_S \left(1 + \frac{R_f}{R_S}\right)$$

$$\text{gain} \equiv \frac{v_o}{v_S} = 1 + \frac{R_f}{R_S}$$

We want gain = 1000. Use $\frac{R_f}{R_S} = 999$.

Engineering considerations:

1) R's we use are 10% so we just use $\frac{R_f}{R_S} = 1000$.

2) Current i_f comes from v_o terminal of op-amp. Op-amp such as LF353 that we use in lab is rated for max output current of 10 mA.

This means we must choose R_S and R_f such that $i_f \le 10$ mA. $i_s = \frac{v_n}{R_S} = \frac{v_S}{R_S}$ and $i_f = \frac{v_o - v_n}{R_f} = \frac{v_o - v_S}{R_f}$.

Given our gain is 1000 and v_o cannot exceed op-amp pwr supply voltages, we conclude that $|v_o| \le 12V$, (if pwr supply V's are $V_{cc} = 12V$ $-V_{cc} = -12V$).

Then $|v_S| \le \frac{12V}{1000} = 12mV$.

So we need $\frac{12mV}{R_S} \le 10$ mA or $R_S \ge \frac{12\,mV}{10mA} = 1.2\,\Omega$

Just to be safe we can use $R_S + R_f \ge 12\,k\Omega$ so that if $v_o = 12V$ and $v_n \ne v_p$, (because v_S is too large and we no longer have linearity), we still have $i_f \le 10mA$. $\therefore$ Use $R_S = 13\,\Omega$ $R_f = 13\,k\Omega$.

Note: $R_f < 10M$ also recommended so feedback not too weak. Double these for safety margin.