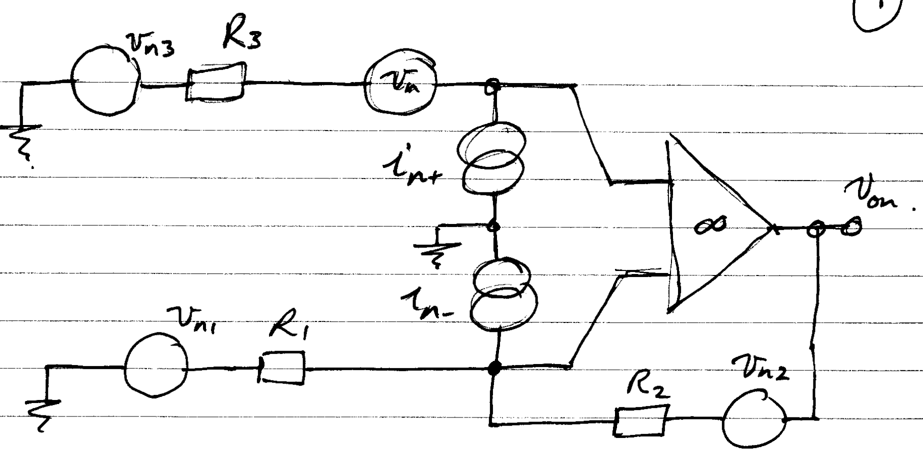
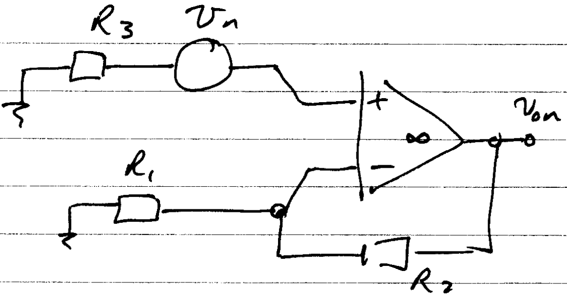
Derivation of op-amp circuit noise performance



1. v_{on} due to v_n .....

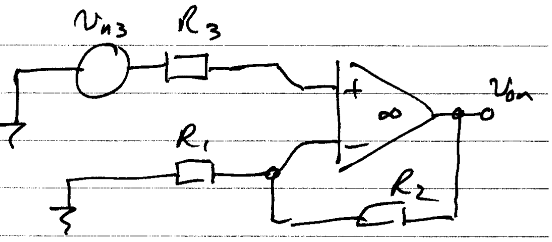


$v^+ = v_n$.

v^+ is operated on by the non-inverting amplifier gain (R_3 has no effect).

$$v_{on}\Big|_{v_n} = v_n \frac{R_1 + R_2}{R_1}.$$

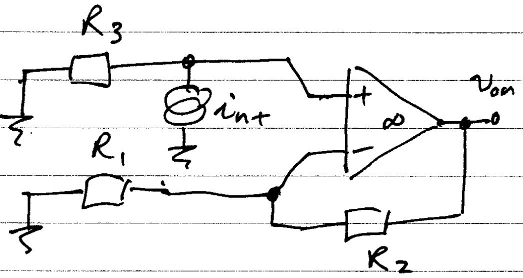
2. v_{on} due to v_{n3} .....



v_{n3} is in the same position in the cct as v_n to is treated in the same way.

$$v_{on}\Big|_{v_{n3}} = v_{n3} \frac{R_1 + R_2}{R_1}$$

3. v_{on} due to i_{n+} ....

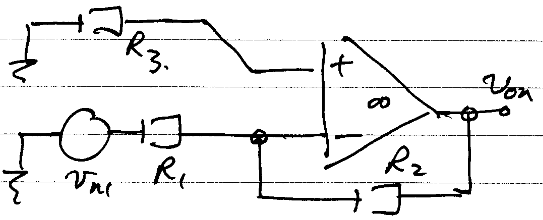


i_{n+} cause a voltage $i_{n+}R_3$ across R_3 which again is operated on as for v_n.

$$v_{on}\Big|_{i_{n+}} = i_{n+}R_3 \cdot \frac{R_1 + R_2}{R_1}.$$

(4) v_{on} due to R_1 ....

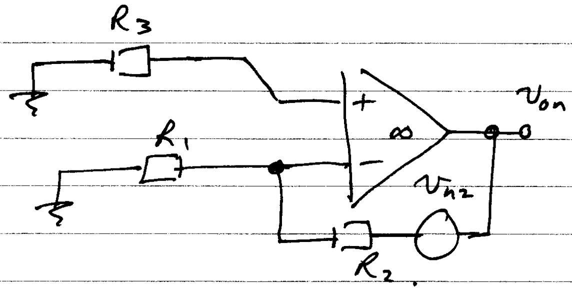
The amplifier looks like an inverting amplifier as far as R_1 is concerned.



$$v_{on}\Big|_{R_1} = -v_{n1}\frac{R_2}{R_1}$$

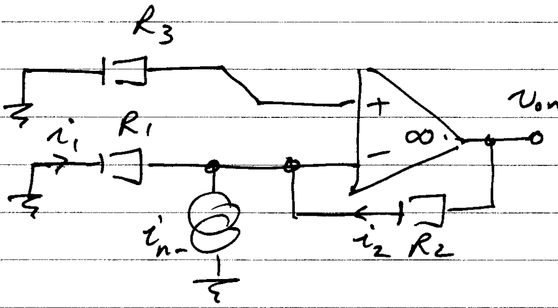
(5) v_{on} due to R_2 ....

$$v_{on}\Big|_{R_2} = v_{n2}$$



(6) v_{on} due to i_{n-} ....

i_1 must be zero because v^- is zero so there is no voltage across R_1 so $i_2 = i_{n-}$ and a voltage $i_{n-}R_2$ will be developed across R_2.



Since $v^- = 0$, $\quad v_{on}\Big|_{i_{n-}} = i_{n-}R_2$

<u>So</u>

$$\overline{v_{on}^2} = \overline{v_n^2}\left(\frac{R_1+R_2}{R_1}\right)^2 + \overline{v_{n3}^2}\left(\frac{R_1+R_2}{R_1}\right)^2 + \overline{i_{n+}^2}\,R_3^2\left(\frac{R_1+R_2}{R_1}\right)^2$$

$$+ \overline{v_{n1}^2}\,\frac{R_2^2}{R_1^2} + \overline{v_{n2}^2} + \overline{i_{n-}^2}\,R_2^2$$

(3)

$$= \left(\frac{R_1+R_2}{R_1}\right)^2 \left[\overline{v_n^2} + \overline{v_{n3}^2} + \overline{i_{n+}^2} R_3^2 + \frac{R_2^2}{R_1^2} \frac{R_1^2}{(R_1+R_2)^2} \overline{v_{n1}^2} + \frac{R_1^2}{(R_1+R_2)^2} \overline{v_{n2}^2} + \overline{i_{n-}^2} \frac{R_2^2 R_1^2}{(R_1+R_2)^2} \right]$$

$$= G^2 \left[\overline{i_{n+}^2} R_3^2 + \overline{i_{n-}^2} \left(\frac{R_1 R_2}{R_1+R_2}\right)^2 + \overline{v_n^2} + \overline{v_{n3}^2} + \overline{v_{n1}^2} \frac{R_2^2}{(R_1+R_2)^2} + \overline{v_{n2}^2} \frac{R_1^2}{(R_1+R_2)^2} \right]$$

$$= G^2 \left[\overline{i_{n+}^2} R_3^2 + \overline{i_{n-}^2} \left(\frac{R_1 R_2}{R_1+R_2}\right)^2 + \overline{v_n^2} + \overline{v_{n3}^2} + \frac{4kTR_1R_2^2}{(R_1+R_2)^2} + \frac{4kTR_2R_1^2}{(R_1+R_2)^2} \right]$$

$$= G^2 \left[\overline{i_{n+}^2} R_3^2 + \overline{i_{n-}^2} \left(\frac{R_1 R_2}{R_1+R_2}\right)^2 + \overline{v_n^2} + \overline{v_{n3}^2} + \overline{v_{nf}^2} \right]$$

where $\overline{v_{nf}^2} = \dfrac{4kTR_1R_2(R_1+R_2)}{(R_1+R_2)^2} = \dfrac{4kTR_1R_2}{R_1+R_2}$

= noise expected from $R_1 \| R_2$ where R_1 & R_2 are the feedback resistors.