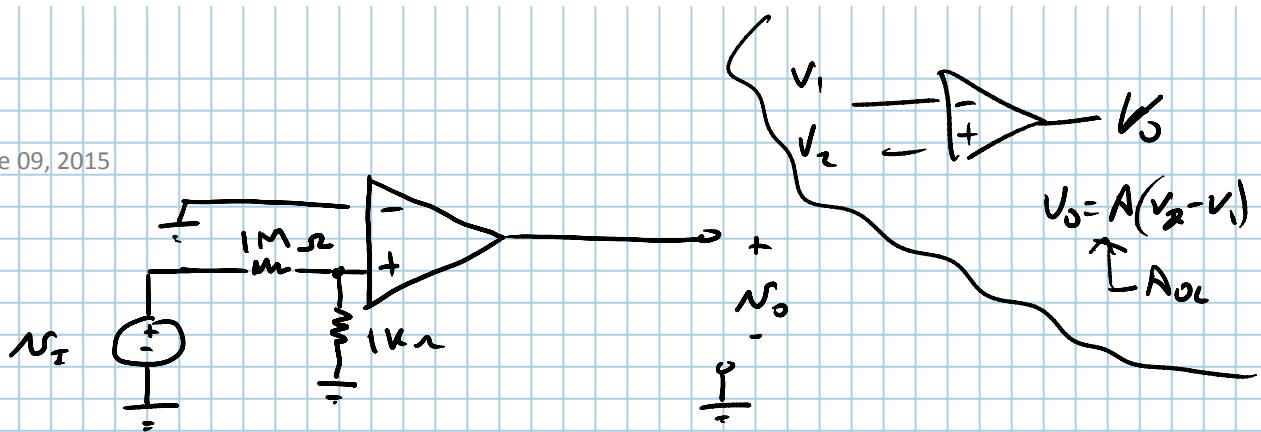


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2.2



$$N_o = A_{OL} (V^+ - V^-) , \quad A_{OL} \neq \infty$$

⋮
⋮

$$V^- = 0V$$

$$V^+ = \left(\frac{1K\Omega}{1K\Omega + 1000K\Omega} \right) N_I$$

$$N_o = A_{OL} \left[\left(\frac{1}{1001} \right) N_I - 0 \right] = \frac{A_{OL}}{1001} N_I = N_o$$

$$N_o = 4V, \quad N_I = 2V, \quad A_{OL} = ?$$

$$\frac{N_o}{N_I} = \frac{4}{2} = \frac{A_{OL}}{1001} \Rightarrow \boxed{A_{OL} = 2002}$$

2.20

DESIGN INV. AMPLIFIER

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$$\bullet A_{CL} = -100 \frac{V}{V}$$

$$\bullet R_{IN} = 1 k\Omega$$

$$R_{IN} = \frac{N_I}{i_{IN}} = 1 k\Omega = R_1$$

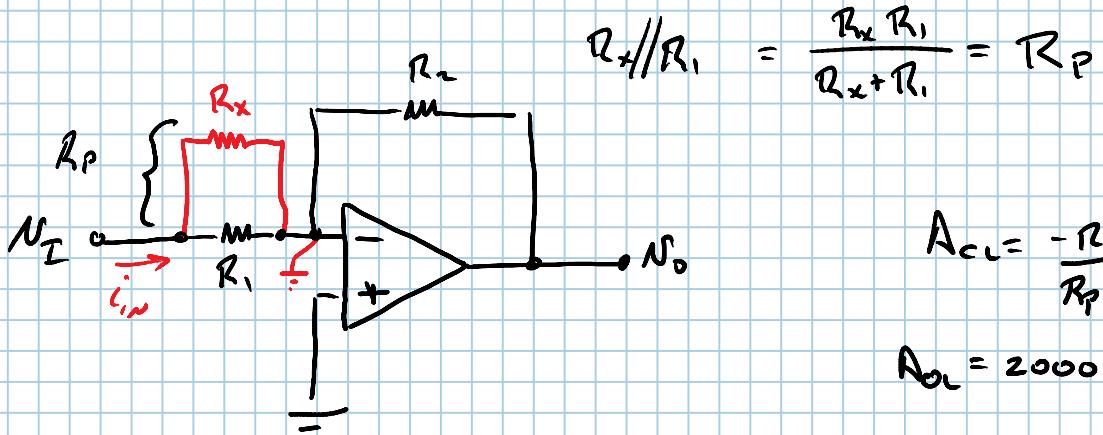
$$(R_1 = 1 k\Omega)$$

$$A_{CL} = -100 = -\frac{R_2}{R_1} = -\frac{R_2}{1 k\Omega} \Rightarrow R_2 = 100 k\Omega$$

$$(b) A_{OL} = 2000$$

$$A_{CL} = \frac{N_O}{N_I} = \frac{-\frac{R_2}{R_1}}{1 + \frac{1 + \frac{R_2}{R_1}}{A_{OL}}} = \frac{-100}{1 + \frac{101}{2000}} = -95.2 = A_{CL}$$

(c)



$$A_{CL} = -\frac{R_2}{R_P} = -100 \frac{V}{V}$$

$$A_{OL} = 2000$$

$$A_{CL} = \frac{-\frac{R_2}{R_P}}{1 + \frac{1 + \frac{R_2}{R_P}}{A_{OL}}} = \frac{-\frac{100}{R_P}}{1 + \frac{1 + \frac{100}{R_P}}{2000}} = -100 = \frac{\left(\frac{2000}{R_P + 100}\right) R_P}{1 + \frac{100}{R_P}} = 1$$

$$\frac{\frac{100}{R_p} \left(\frac{2000}{1 + \frac{100}{R_p}} \right)}{\frac{2000}{1 + \frac{100}{R_p}} + 1} = 100 \Rightarrow \frac{1}{R_p} \left(\frac{2000}{1 + \frac{100}{R_p}} \right) = \frac{2000}{1 + \frac{100}{R_p}} + 1$$

$$\frac{2000}{1 + \frac{100}{R_p}} = R_p \left(\frac{2000}{1 + \frac{100}{R_p}} + 1 \right)$$

$$2000 = R_p \left(2000 + 1 + \frac{100}{R_p} \right) = 2001R_p + 100$$

$$2001R_p = 1900$$

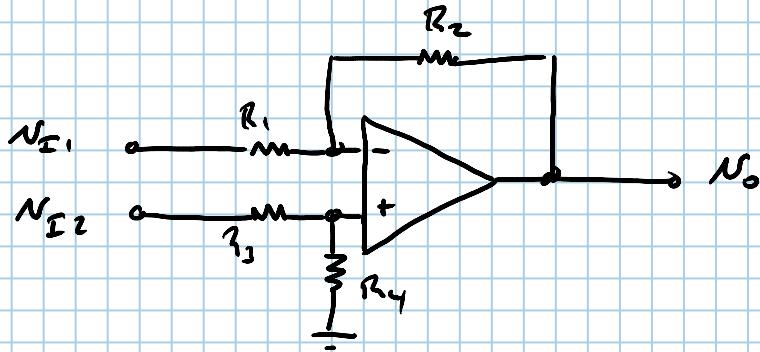
$$\underline{R_p = 0.9495}$$

$$R_p = \frac{1}{\gamma_{R_X} + 1/n_1} \Rightarrow R_X = \frac{1}{\frac{1}{R_p} - \frac{1}{n_1}} = \frac{1}{\frac{1}{0.9495} - \frac{1}{1}}$$

$$\boxed{R_X = 18.8 \text{ k}\Omega}$$

DIFFERENCE AMPLIFIER

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SUPERPOSITION:

$$N_{O1} = \left(-\frac{R_2}{R_1} \right) N_{I1}$$

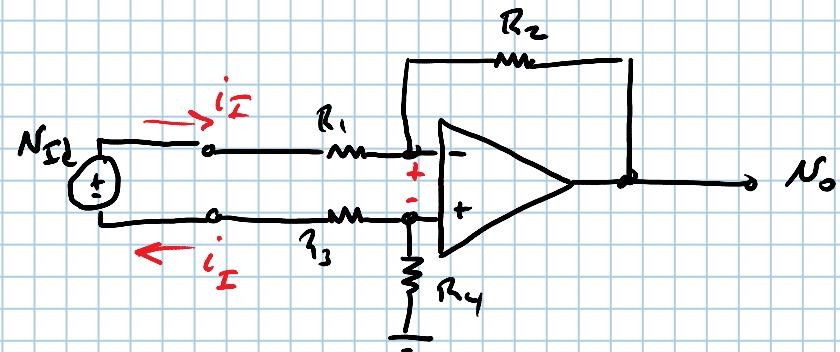
$$N_{O2} = \left(\frac{R_2}{R_3 + R_4} \right) \left(1 + \frac{R_2}{R_1} \right) N_{I2}$$

$$N_{O2} = \left(\frac{1 + \frac{R_2}{R_1}}{1 + \frac{R_3}{R_4}} \right) N_{I2}$$

IF $\frac{R_3}{R_4} = \frac{R_1}{R_2} \Rightarrow N_{O2} = \frac{R_2}{R_1} N_{I2}$

N_{Id}

$$N_o = N_{O1} + N_{O2} = \underbrace{\frac{R_2}{R_1} (N_{I2} - N_{I1})}_{\boxed{\frac{R_2}{R_1} N_{Id} = N_o}}$$

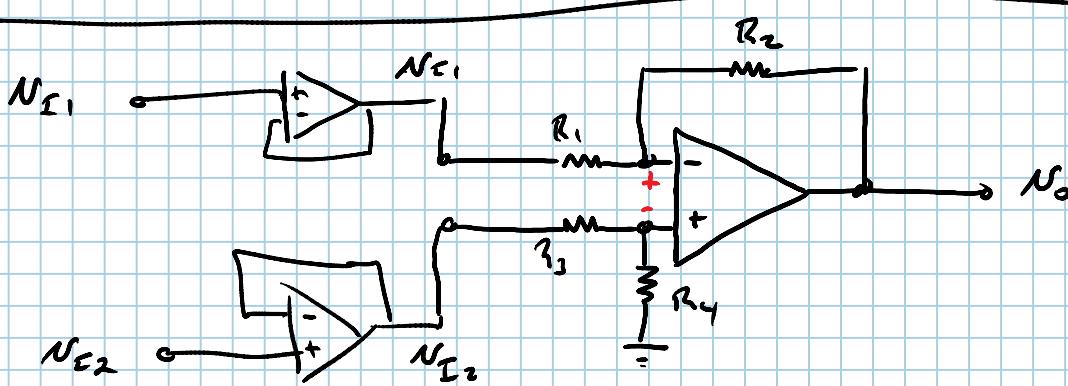


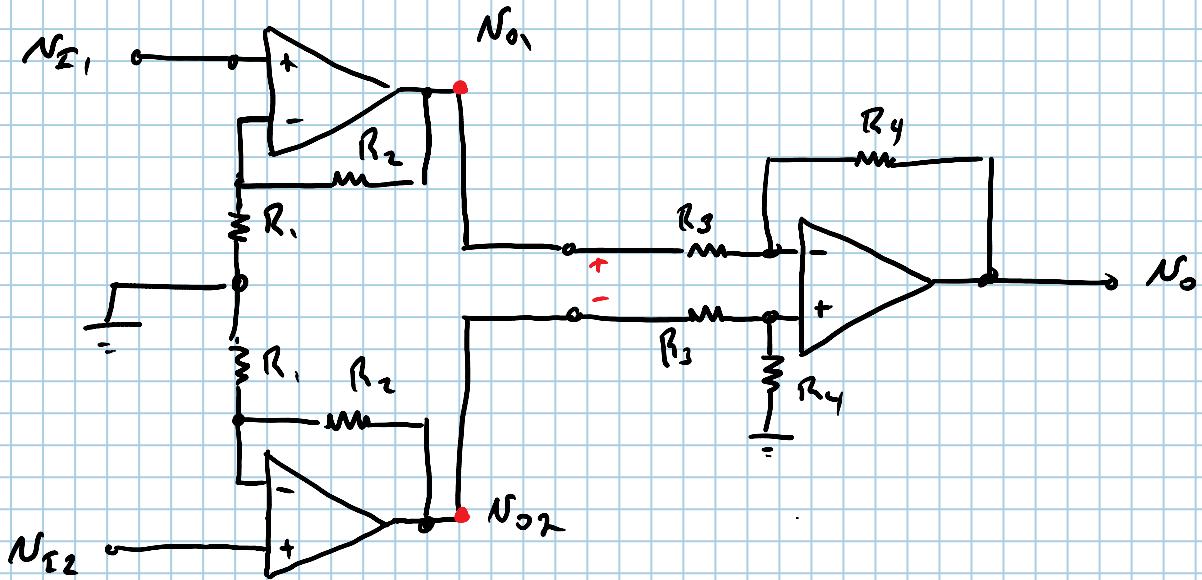
$$i_I R_1 + 0 + i_I R_3 = N_{Id}$$

$$i_I (R_1 + R_3) = N_{Id}$$

$$i_I = \frac{N_{Id}}{R_1 + R_3}$$

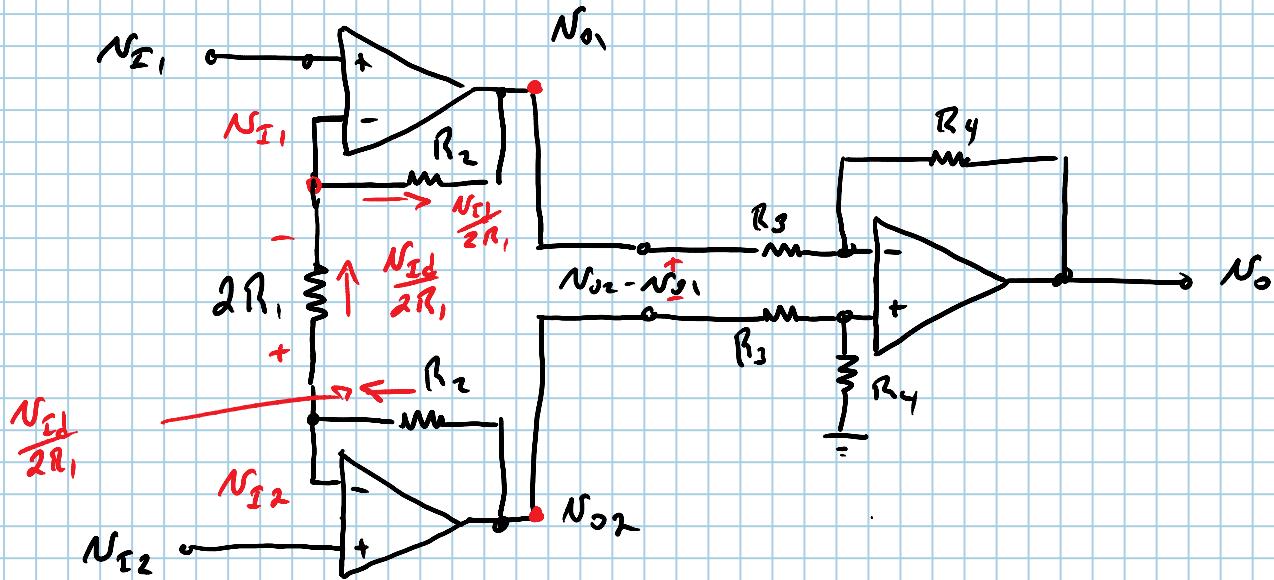
IF $R_1 = R_3 \Rightarrow i_I = \frac{N_{Id}}{2R_1} = \frac{N_{Id}}{R_{in}} \quad R_{in} = 2R_1$





$$N_{O1} = \left(1 + \frac{R_2}{R_1}\right) N_{I1}, \quad N_{O2} = \left(1 + \frac{R_2}{R_1}\right) N_{I2}$$

$$N_O = \frac{R_4}{R_3} \left(1 + \frac{R_2}{R_1}\right) (N_{I2} - N_{I1}) = \boxed{\frac{R_4}{R_3} \left(1 + \frac{R_2}{R_1}\right) N_{Id} = N_O}$$



$$\frac{N_{I1} - N_{o1}}{R_2} = \frac{N_{Id}}{2R_1}$$

$$\frac{N_{o2} - N_{I2}}{R_2} = \frac{N_{Id}}{2R_1} \Rightarrow N_{o2} = \frac{R_2}{2R_1} N_{Id} + N_{I2}$$

$$N_{o1} = N_{I1} - \frac{R_2}{2R_1} N_{Id}$$

$$\begin{aligned} N_{o2} - N_{o1} &= \frac{R_2}{2R_1} N_{Id} + N_{I2} - \left(N_{I1} - \frac{R_2}{2R_1} N_{Id} \right) \\ &= 2 \frac{R_2}{2R_1} N_{Id} + \underbrace{N_{I2} - N_{I1}}_{N_{I2}} \end{aligned}$$

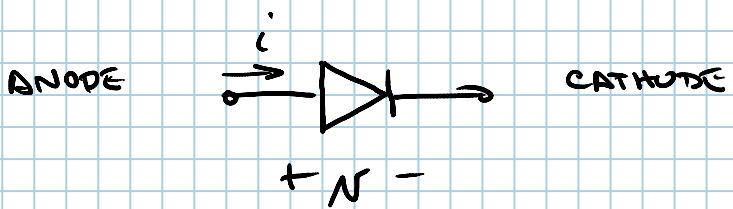
$$N_{o2} - N_{o1} = \left(\frac{R_2}{R_1} + 1 \right) N_{Id}$$

$$N_o = \left(1 + \frac{R_4}{R_3} \right) N_{Id} \frac{R_4}{R_3}$$

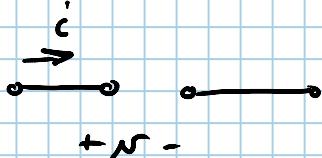
$$N_o = \frac{R_4}{R_3} \left(1 + \frac{R_2}{R_1} \right) (N_{I2} - N_{I1})$$

The Ideal Diode

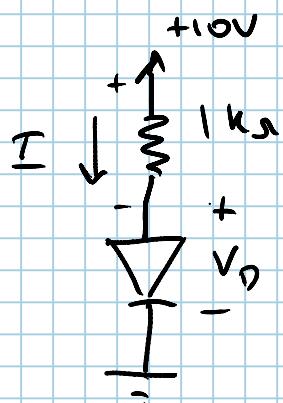
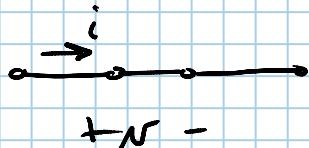
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$N < 0 \Rightarrow$ OPEN CIRCUIT, $i = 0$



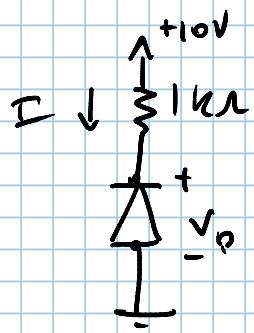
$N > 0 \Rightarrow$ CLOSED CIRCUIT, $i > 0$, $N = 0$



ASSUME DIODE TO BE "FORWARD-BIASED"
(CONDUCTING CURRENT)

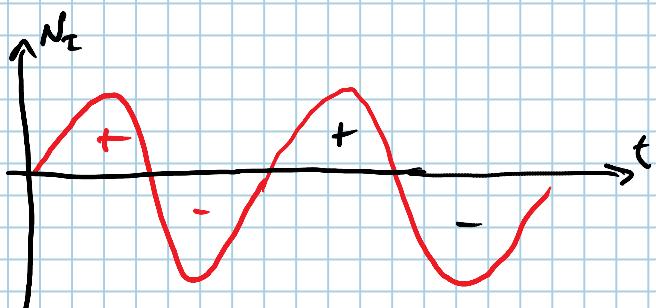
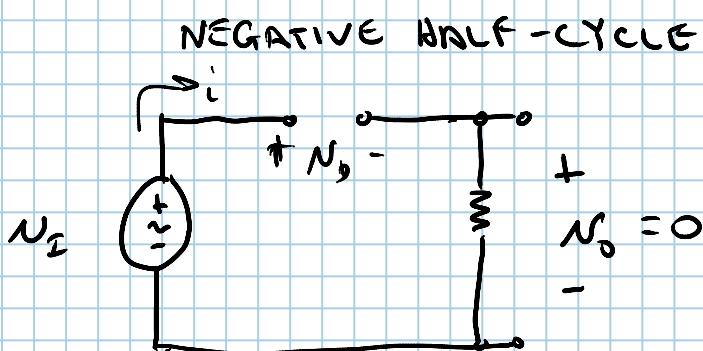
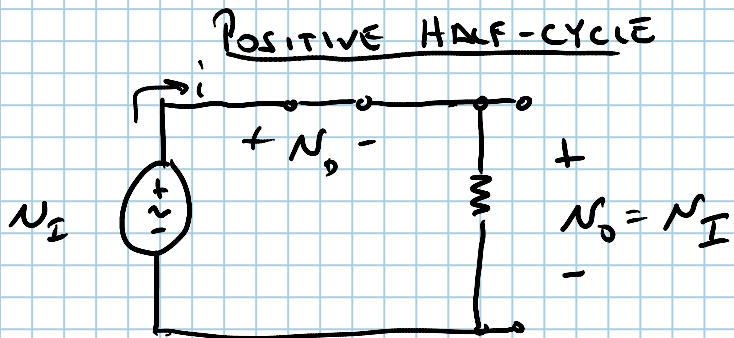
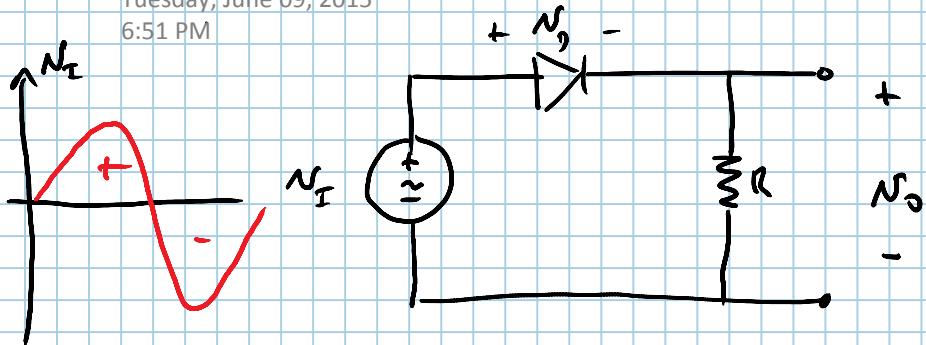
$$I = \frac{10 - 0}{1k\Omega} = \underline{\underline{10 \text{ mA}}}$$

$$V_D = \emptyset V$$

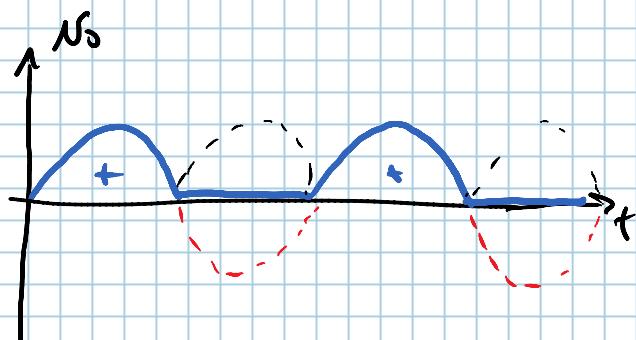


$$I = \emptyset \text{ mA}$$

$$V_D = 10V$$



AC SIGNAL



DC SIGNAL

HALF-WAVE RECTIFIER