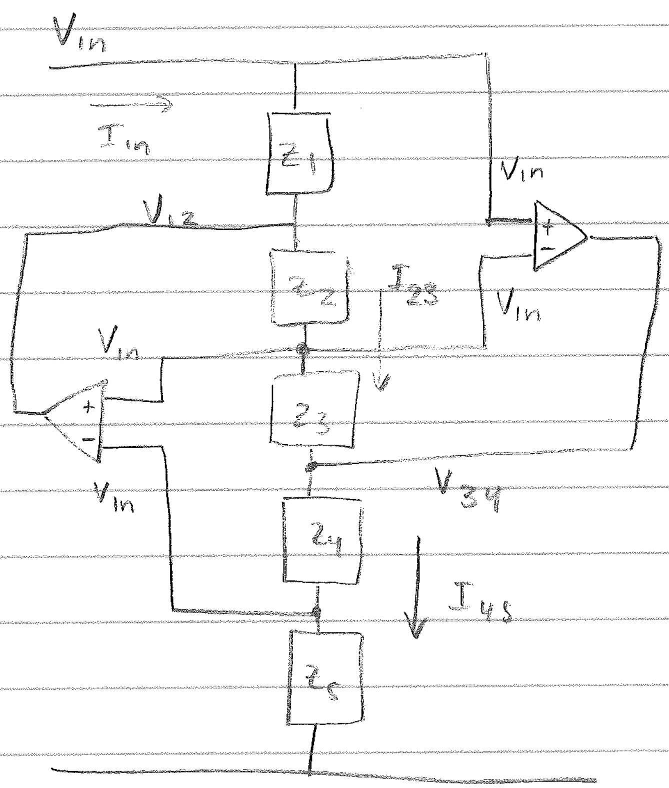
Homework #12 Solution

1) Gyrator circuit



$$I_{45} = \frac{V_{in}}{Z_5} = \frac{V_{34} - V_{in}}{Z_4}$$

$$V_{34} = V_{in}\left(\frac{Z_4}{Z_5} + 1\right)$$

$$I_{23} = \frac{V_{in} - V_{34}}{Z_3}$$

$$= \frac{V_{in}}{Z_3}\left[1 - \frac{Z_4}{Z_5} - 1\right]$$

$$I_{23} = V_{in}\left(\frac{-Z_4}{Z_3 Z_5}\right)$$

$$I_{23} = \frac{V_{12} - V_{in}}{Z_2} \Rightarrow V_{12} = I_{23} Z_2 + V_{in}$$

$$V_{12} = V_{in}\left(\frac{-Z_2 Z_4}{Z_3 Z_5} + 1\right)$$

$$I_{in} = \frac{V_{in} - V_{12}}{Z_1} = \frac{V_{in}}{Z_1}\left(1 - \frac{V_{12}}{V_{in}}\right)$$

$$= \frac{V_{in}}{Z_1}\left[1 + \frac{Z_2 Z_4}{Z_3 Z_5} - 1\right]$$

$$I_{in} = V_{in}\left(\frac{Z_2 Z_4}{Z_1 Z_3 Z_5}\right)$$

$$\Rightarrow \boxed{Z_{in} = \frac{V_{in}}{I_{in}} = \frac{Z_1 Z_3 Z_5}{Z_2 Z_4}}$$

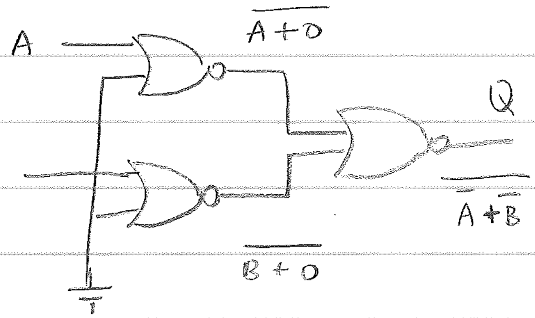
To get a circuit that behaves like an inductor, choose

$$\left[\begin{array}{ll} Z_2 = C_G & (\text{also works if } Z_4 = C_G) \\ \text{all other } Z\text{'s} & Z_1 = Z_3 = Z_4 = Z_5 = R_G \end{array}\right.$$

$$\text{Then } Z_{in} = \frac{R_G^3}{\frac{1}{j\omega C_G} R_G} = j\omega \underbrace{R_G^2 C_G}_{L_{equiv}}$$

Behaves like an inductive impedance $\underline{\underline{Z_{in} = j\omega L_{equiv}}}$

8.1)



$A+0 = A$

$\overline{A+0} = \overline{A}$

Note this is $\overline{\overline{A}+\overline{B}} = \overline{\overline{A}} \cdot \overline{\overline{B}}$

$= A \cdot B$

by de Morgan

Assume a logic system such that ground → 0

A	B	$\overline{A}$	$\overline{B}$	Q
0	0	1	1	0
0	1	1	0	0
1	0	0	1	0
1	1	0	0	1

↑ same as A + B

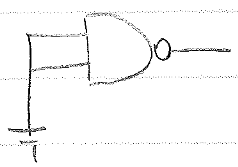
8.2) Use only NAND gates (simplify with Boolean algebra)

a) $(AB)+(\bar{A}B)+(A\bar{B})+(\bar{A}\bar{B})$

$= \underbrace{(A+\bar{A})}_{1}B + \underbrace{(A+\bar{A})}_{1}\bar{B}$

$= B+\bar{B}$

$= 1$, i.e. always true



will do the trick

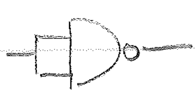
$\overline{0+0} = 1$

b) $[(A\cdot B)+C]\cdot[(A\cdot B)+D] = (AB)(AB)+C(AB)+ABD+CD$

$= \underbrace{AB+C(AB)}_{AB}+D(AB)+CD$

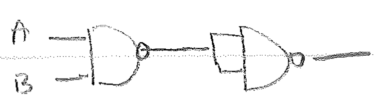
$= \underbrace{AB+D(AB)}_{AB}+CD$

$= AB+CD$

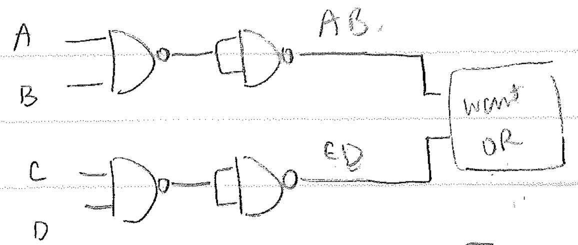


is an inverter : both inputs 0 ⇒ NAND gives 1
both inputs 1 ⇒ NAND gives 0

so



is AND

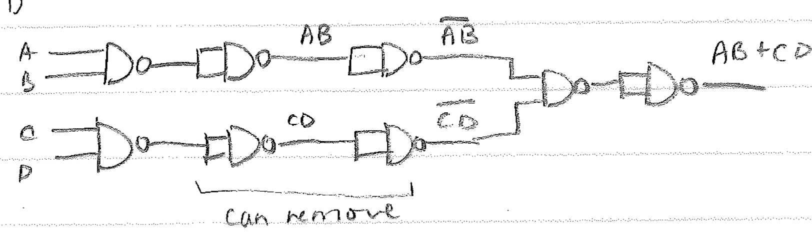


De Morgan

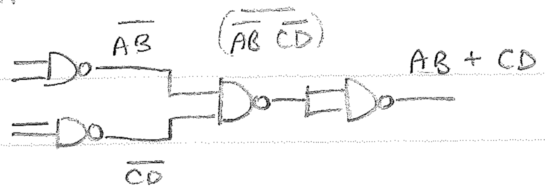
$AB+CD = \overline{\overline{AB}\cdot\overline{CD}}$

so can make OR with inverters & AND

We get

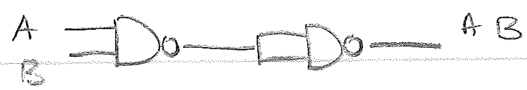


Simplified:

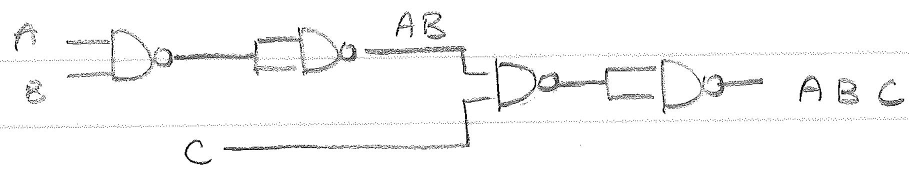


c) $\left[(\bar{A}B)(AB)\right] + (AB) = (\overbrace{\bar{A}B + 1}^{1})\,AB$

$= AB$, just AND

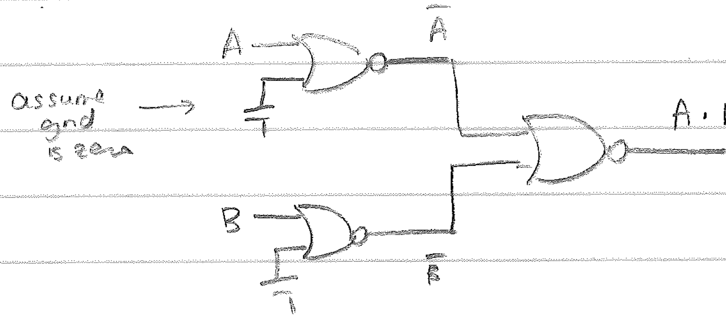


d) $(\underbrace{1+B}_{1})\cdot(ABC) = ABC$

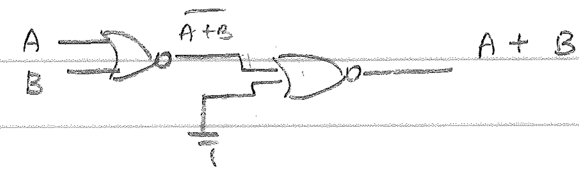


8,3) Using only NOR : $\overline{A+B}$ use Boolean rules

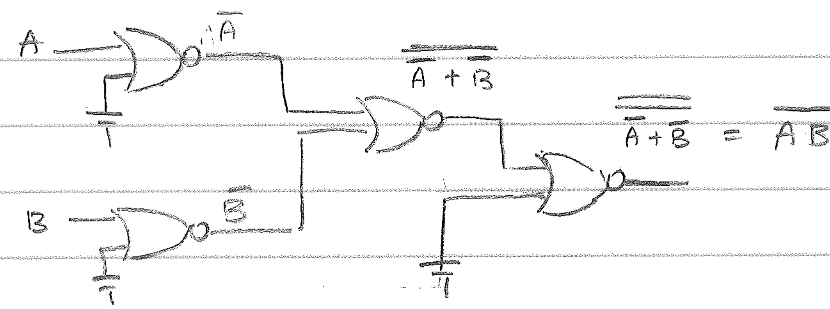
AND : $A \cdot B = \overline{\overline{A} + \overline{B}} = \overline{\overline{A+0} + \overline{B+0}}$



OR $A + B = \overline{\overline{A+B}} = \overline{(\overline{A+B}) + 0}$

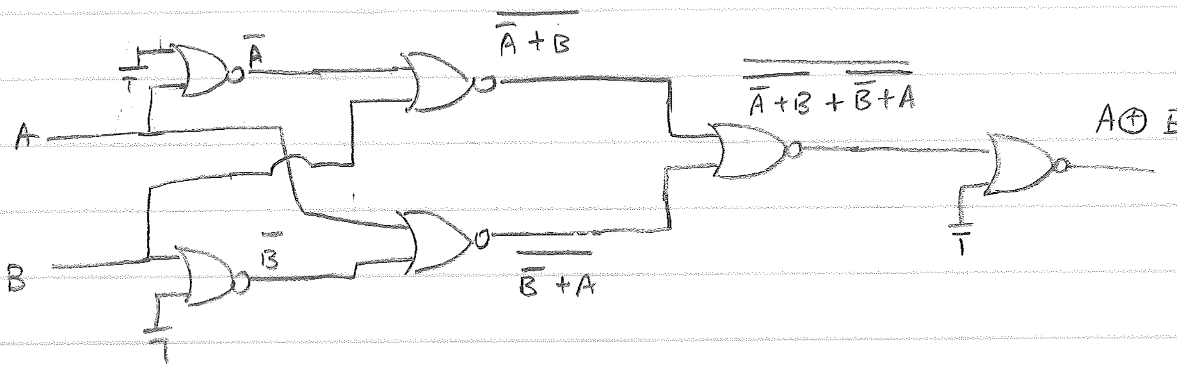


NAND $\overline{A \cdot B} = \overline{A} + \overline{B} = \overline{\overline{\overline{A} + \overline{B}}} = \overline{\left(\overline{\overline{A+0} + \overline{B+0}}\right) + 0}$

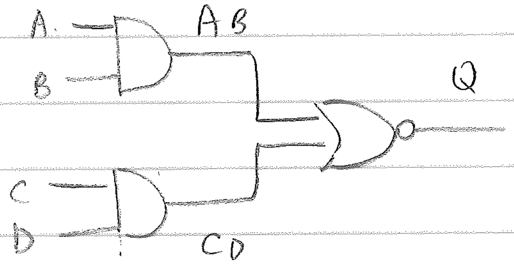


XOR

$$A \oplus B = A\bar{B} + \bar{A}B$$
$$= \overline{\bar{A}+B} + \overline{A+\bar{B}}$$
$$= \overline{\overline{\overline{\bar{A}+B} + \overline{A+\bar{B}}}}$$



8.4)



AND-OR-INVERT gate

(16 possible input combinations)

A	B	C	D	AB	CD	Q
0	0	0	0	0	0	1
0	0	0	1	0	0	1
0	0	1	0	0	0	1
0	0	1	1	0	1	0
0	1	0	0	0	0	1
0	1	0	1	0	0	1
0	1	1	0	0	0	1
0	1	1	1	0	1	0
1	0	0	0	0	0	1
1	0	0	1	0	0	1
1	0	1	0	0	0	1
1	0	1	1	0	1	0
1	1	0	0	1	0	0
1	1	0	1	1	0	0
1	1	1	0	1	0	0
1	1	1	1	1	1	0