EE 2720, Fall 03
Solutions of Homework #5.

Problem 1: I first provide a logic circuit showing an AND-OR realization of F. This is shown in figure 1 below:

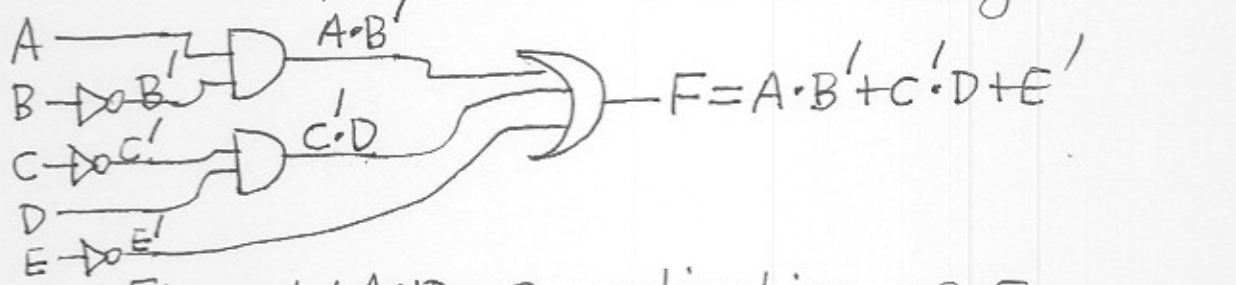

Figure 1: AND-OR realization of F

From the above fig. 1 we get:

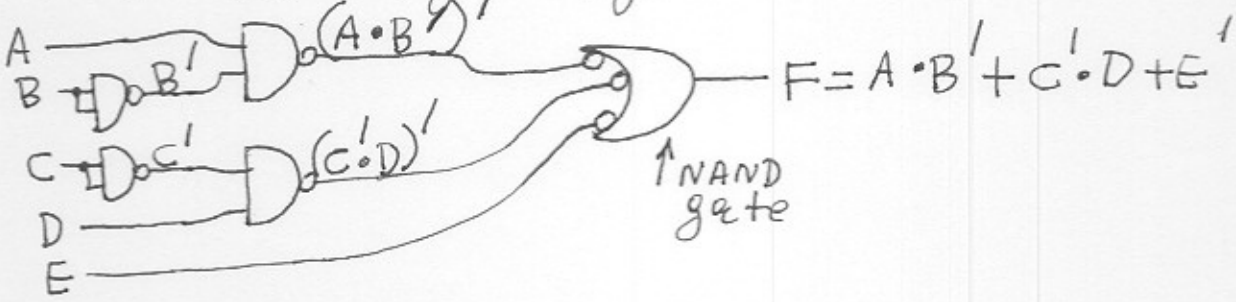

Fig. 2: Realization of F using only NAND gates.

Problem 2: I first provide a logic circuit showing an OR-AND realization of F. This is shown in figure 1 below:

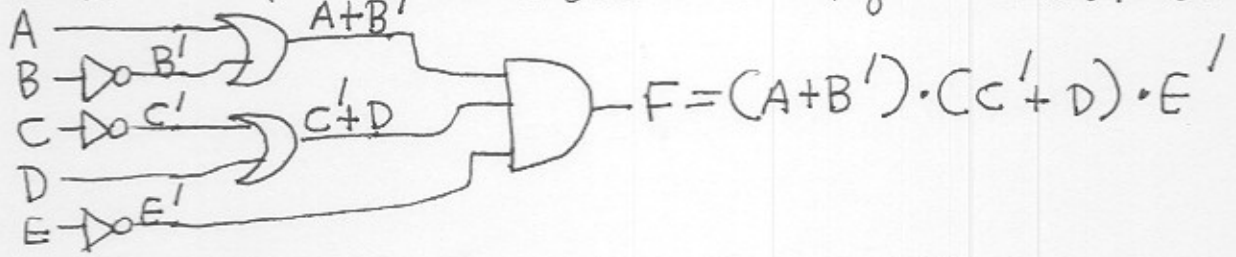

Figure 1: OR-AND realization of F

From the above fig. 1 we get:

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Solutions of HW#5 cont.

Problem 2 cont:

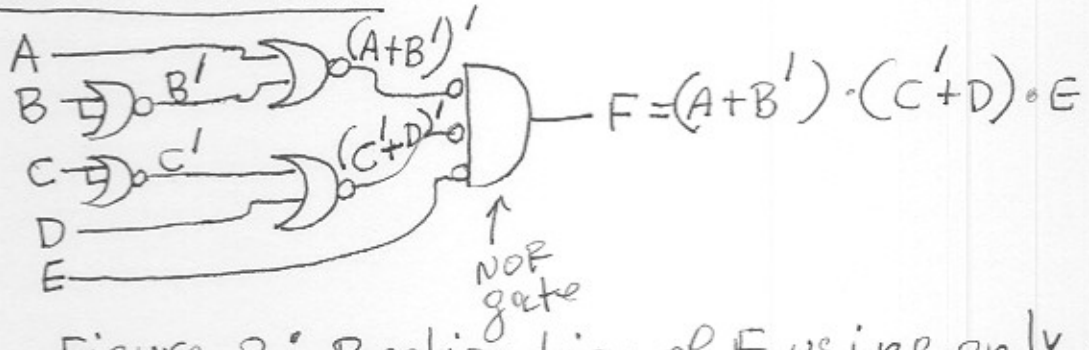

Figure 2: Realization of F using only NOR gates.

Problem 3:

$$F = A\cdot B' + C'\cdot D + E' \quad (1)$$
$$= \left[(A\cdot B' + C'\cdot D + E')'\right]' \quad (1)$$
$$= \left[(A\cdot B')'\cdot(C'\cdot D)'\cdot E\right]' \quad (2)$$
$$= \left[(A'+B)\cdot(C+D')\cdot E\right]' \quad (3)$$
$$= (A'+B)' + (C+D')' + E' \quad (4)$$

The above equations (1), (2), (3), (4) will give us realizations #1, 2, 3, 4 respectively shown in figures 1, 2, 3, 4 respectively.

(a)

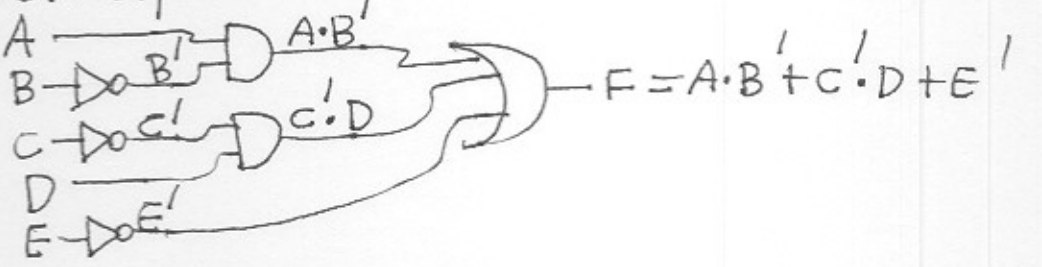

Figure 1: AND-OR circuit realization of F.

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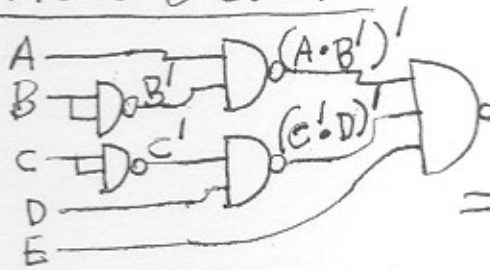
Solutions of HW#5 cont.

Problem 3 cont:

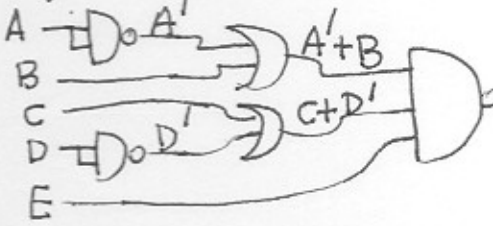
(b).



$$[(A\cdot B')'\cdot(C'\cdot D)'\cdot E]' = A\cdot B' + C'\cdot D + E' = F$$

Figure 2: Realization of F using only NAND gates.

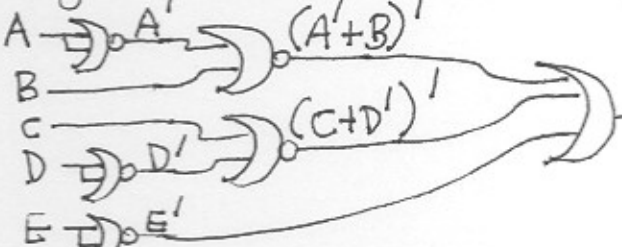
(c).



$$[(A'+B)\cdot(C+D')\cdot E]' = (A'+B)' + (C+D')' + E' = A\cdot B' + C'\cdot D + E' = F$$

Figure 3: Realization of F using only OR and NAND gates

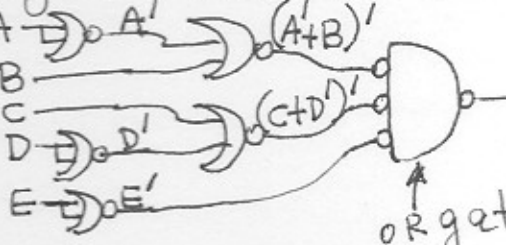
(d)



$$(A'+B)' + (C+D')' + E' = A\cdot B' + C'\cdot D + E' = F$$

Figure 4: Realization of F using only NOR and OR gates.

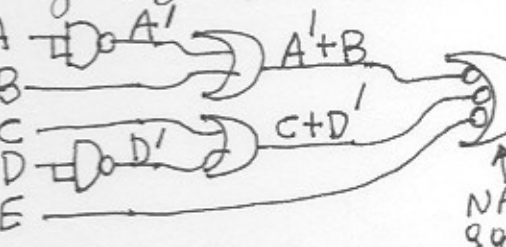
(e).



$$[(A'+B)\cdot(C+D')\cdot E]' = (A'+B)' + (C+D')' + E' = A\cdot B' + C'\cdot D + E' = F$$

Figure 5: Another realization of F using only NOR and OR gates.

(f).



$$(A'+B)' + (C+D')' + E' = A\cdot B' + C'\cdot D + E' = F$$

Figure 6: Another realization of F using only OR and NAND gates.

Problem 4:

$$F=(A+B')\cdot(C+C'+D)\cdot E' \quad (1)$$
$$=\left[\left[(A+B')\cdot(C'+D)\cdot E'\right]'\right]' \quad (2)$$
$$=\left[(A+B')'+(C'+D)'+E\right]' \quad (3)$$
$$=(A'\cdot B+C\cdot D'+E)' \quad (4)$$

Equations (1), (2), (3), (4) above will give us realizations #1, 2, 3, 4 respectively, shown in figures 1, 2, 3, 4 respectively.

(a)

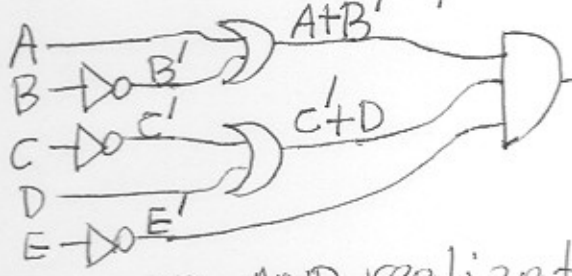


Figure 1: OR-AND realization of F.

(b)

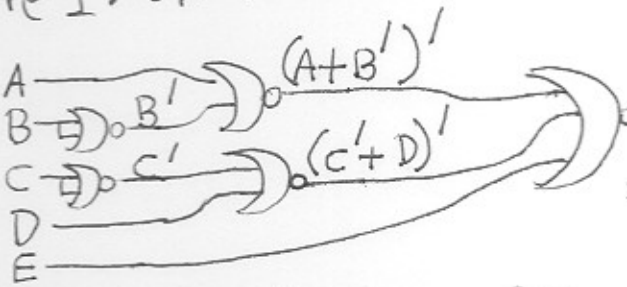


Figure 2: Realization of F using only NOR gates.

(c)

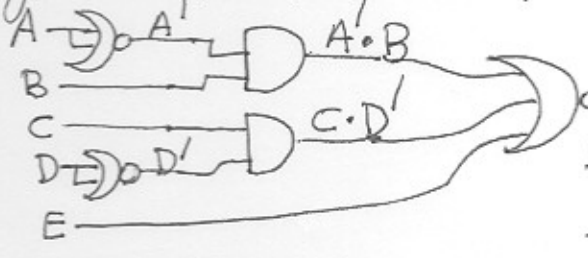
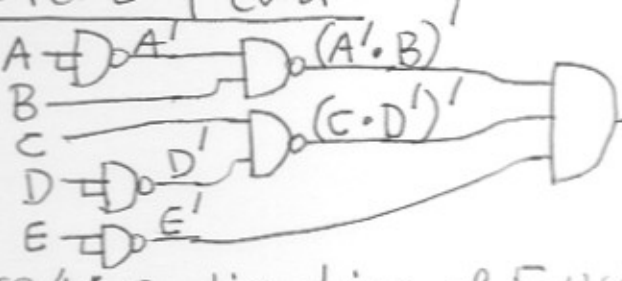


Figure 3: Realization of F using only AND and NOR gates.

Solutions of HW #5 cont.

Problem 4 cont.

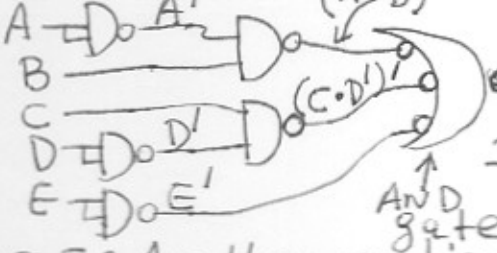
(d).



$$(A'\cdot B)'\cdot(C\cdot D')'\cdot E' = (A+B')\cdot(C'+D)\cdot E' = F.$$

Figure 4: Realization of F using only NAND and AND gates.

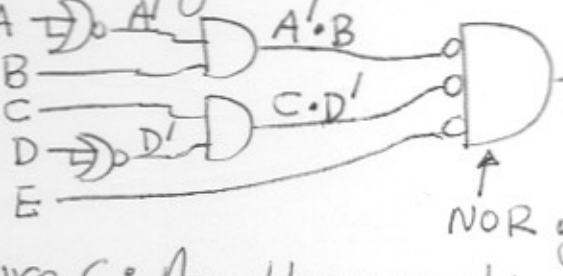
(e).



$$(A'\cdot B + C\cdot D' + E)' = (A'\cdot B)'\cdot(C\cdot D')'\cdot E' = (A+B')\cdot(C'+D)\cdot E' = F.$$

Figure 5: Another realization of F using only NAND and AND gates.

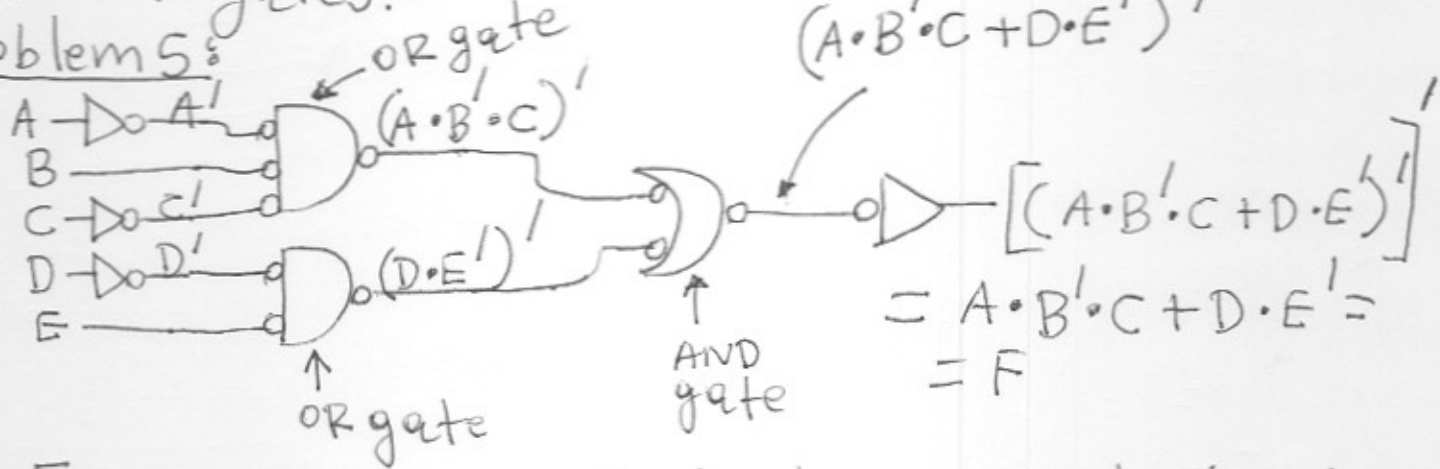
(f).



$$(A'\cdot B)'\cdot(C\cdot D)'\cdot E' = (A+B')\cdot(C'+D)\cdot E' = F$$

Figure 6: Another realization of F using only AND and NOR gates.

Problem 5:



$$= A\cdot B'\cdot C + D\cdot E' = F$$

Figure 2: The equivalent OR-AND logic circuit for F.

Problem 6:

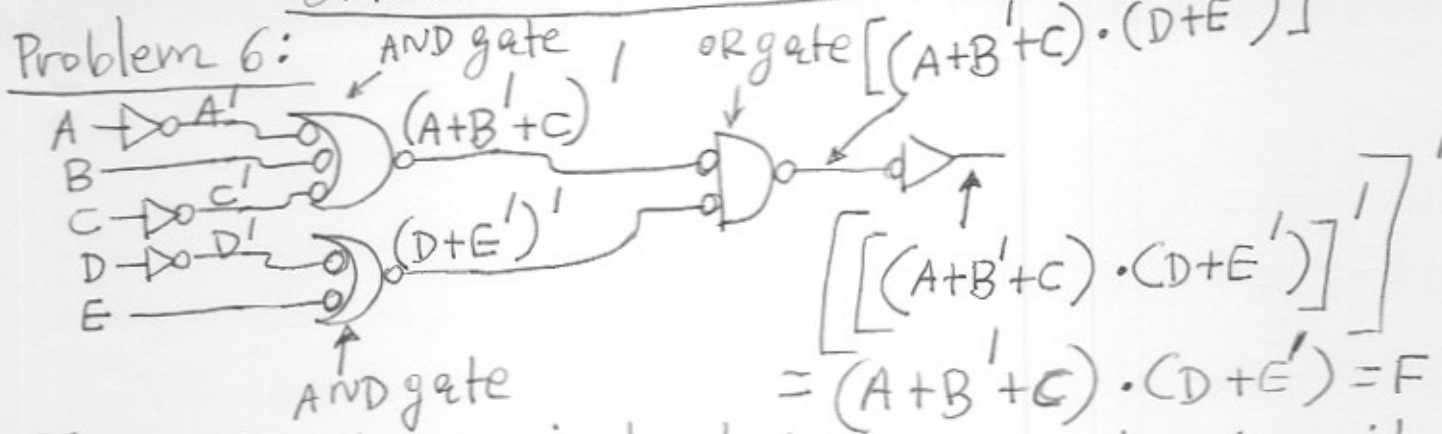


Figure 2: The equivalent AND-OR logic circuit for F.

Problem 7:

(a). Proof of (5) or proof of $X \oplus 0 = X$
- Case $X=0$: $0 \oplus 0 = 0$
- Case $X=1$: $1 \oplus 0 = 1$

(b) Proof of (6) or proof of $X \oplus 1 = X'$
- Case $X=0$: $0 \oplus 1 = 1$
- Case $X=1$: $1 \oplus 1 = 0$

(c) Proof of (7) or proof of $X \oplus X = 0$
- Case $X=0$: $0 \oplus 0 = 0$
- Case $X=1$: $1 \oplus 1 = 0$

(d) Proof of (8) or proof of $X \oplus X' = 1$
- Case $X=0$: $0 \oplus 1 = 1$
- Case $X=1$: $1 \oplus 0 = 1$

Note: The above equations (5), (6), (7), (8) can also be proved by using equation (1) on top of page 5 of handout #11.

(e). Proof of (11) or proof of

$$X \cdot (Y \oplus Z) = X \cdot Y \oplus X \cdot Z$$

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Solutions of HW#5 cont.

Problem 7 cont.

The right side of (11) is:

$$X\cdot Y \oplus X\cdot Z = X\cdot Y\cdot (X\cdot Z)' + (X\cdot Y)'\cdot XZ = X\cdot Y\cdot (X'+Z') +$$
$$+ (X'+Y')\cdot X\cdot Z = \cancel{X\cdot Y\cdot X'}^{0} + X\cdot Y\cdot Z' + \cancel{Y'\cdot X\cdot Z}^{0} + Y'\cdot X\cdot Z$$
$$= X\cdot Y\cdot Z' + X\cdot Y'\cdot Z = X\cdot (Y\cdot Z' + Y'\cdot Z) = X\cdot (Y \oplus Z).$$

But we have now reached the left side of (11) so the proof is completed.

Note: In the above proof, I used eq. (1) on top of page 5 of handout #11 twice.