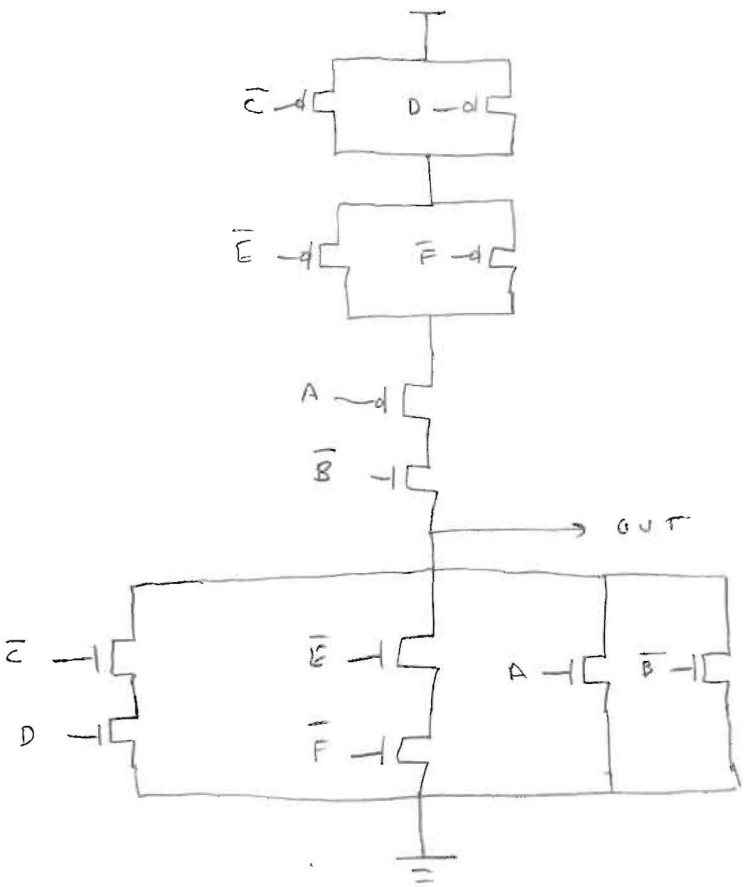
ECE2020 Test 1 Summer 2013 GTL
May 31, 2013 Name: KEY
5 pages, 100 possible points. **Show your work for any possible partial credit.**

Switch level circuits:

1) (15 total point) For the expression below, create a switch level implementation using N and P type switches. Assume both inputs and their complements are available. Your design should contain no shorts or floats. Implement the equations exactly as they are (no simplifying).

$Out_x = (C + \overline{D}) \cdot (E + F) \cdot \overline{A} \cdot B$



Switch-Ready Expressions:

2) (15 points) Transform each of the following Boolean expressions to a form where they are ready for switch level implementation (i.e., there should only be bars over input variables, not over operations). The behavior of the expression should remain unchanged. **Do not implement**, just show the new Boolean equation without any "big bars".

$$Outx = \overline{(A + B)}\,(C + D)\,\overline{(E + F)}$$

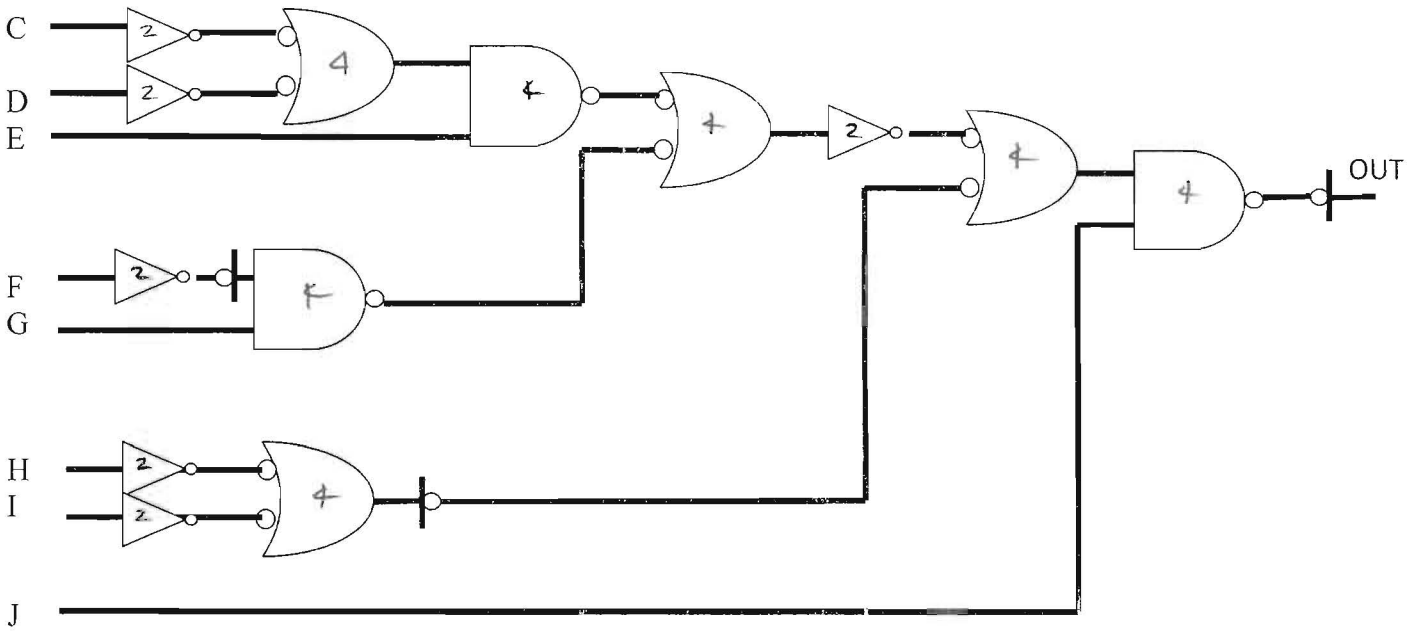
$$\overline{\overline{(A+B)} + \overline{(C+D)} + \overline{(E+F)}}$$

$$(A+B) + \overline{(C+D)} + (E+F)$$

$$(A+B) + \overline{(\bar{C}\cdot\bar{D})} + (E+F)$$

$$(A+B) + \bar{C}\cdot\bar{D} + (E+F)$$

3) Part A (15 points) Write the boolean output expression for the gate design shown below. Also determine the number of switches used in its implementation.



Out $\overline{(((C+D)\cdot E)+\overline{F}\cdot G)+\overline{(H+I)}}\,J = \overline{(C+D)E+\overline{F}G+\overline{H+I}}\,J$

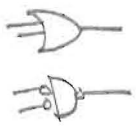
number of switches 40

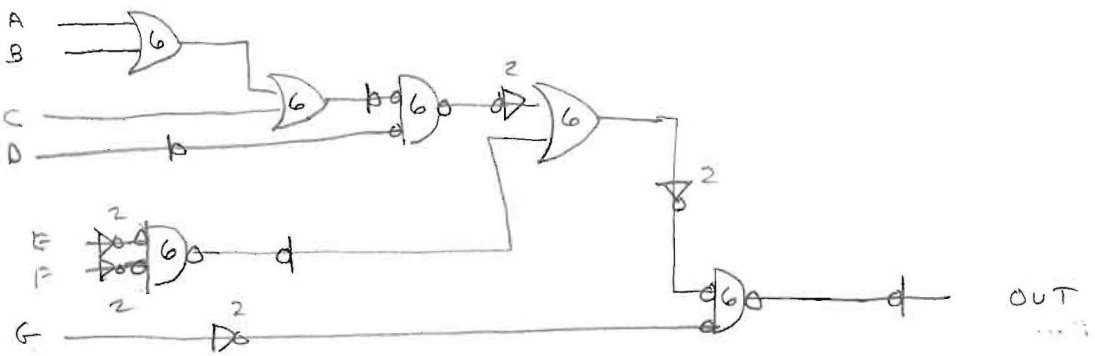
$6 \times 2 + 7 \times 4 = 40$

3) Part B (15 points) Implement the following expression using only two input OR gates and inverters so as to minimize the number of switches required. Then determine the number of switches required. **Use proper mixed logic notation**. Do not modify the expression, do not simplify the expression. Do not assume complements of inputs are available.

6

Out= $\overline{((\overline{A+B+C})\cdot \overline{D}+\overline{EF})\cdot G}$





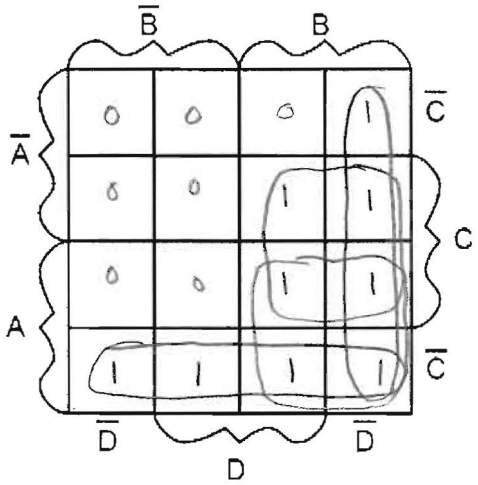
Number of switches 46

$6 \times 6 + 5 \cdot 2 = 36 + 10 = 46$

Karnaugh Maps:

4) (15 points) For the following expression, derive a simplified ***sum of products*** expression using a Karnaugh Map. Circle and list **ALL** the prime implicants, indicating which are essential.

$A\cdot\overline{C} + A\cdot B\cdot\overline{C} + B\cdot\overline{D} + B\cdot C\cdot D$



prime implicants	essential? yes	no
$A\cdot\overline{C}$	☒	☐
$B\cdot\overline{D}$	☐	☒
$B\cdot C$	☒	☐
$A\cdot B$	☐	☒
	☐	☐
	☐	☐
	☐	☐
	☐	☐

Simplified sum of products $A\cdot\overline{C} + B\cdot C + B\cdot\overline{D}$

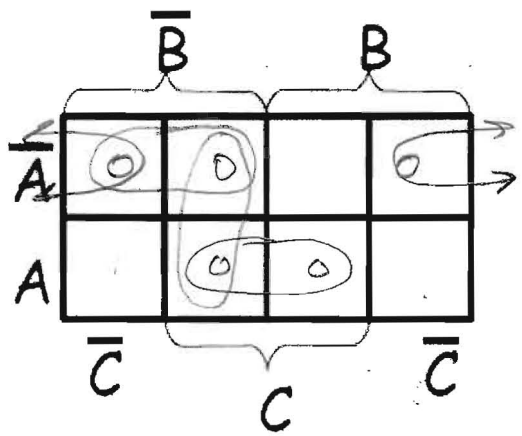
5) (10 points) Determine the canonical product of sums (using maxterms) expressions for the truth table below:

A	B	C	OUT	
0	0	0	1	
0	0	1	1	
0	1	0	1	
0	1	1	1	
1	0	0	0	$\bar{A}+B+C$
1	0	1	0	$\bar{A}+B+\bar{C}$
1	1	0	0	$\bar{A}+\bar{B}+C$
1	1	1	0	$\bar{A}+\bar{B}+\bar{C}$

POS (maxterms) = $(\bar{A}+B+C)(\bar{A}+B+\bar{C})(\bar{A}+\bar{B}+C)(\bar{A}+\bar{B}+\bar{C})$

6) (15 points) For the following expression, derive a simplified ***product of sums*** expression using a Karnaugh Map. Circle and list **ALL** the prime implicants, indicating which are essential.

out = (A+B+C) (A+$\bar{B}$+C) (A+B+$\bar{C}$) ($\bar{A}$ + $\bar{B}$ + $\bar{C}$) ($\bar{A}$ + B+ $\bar{C}$)



prime implicants	essential? yes	no
$\bar{A}+\bar{C}$	☒	☐
$A+C$	☒	☐
$B+\bar{C}$	☐	☒
$A+B$	☐	☒
	☐	☐

Simplified product of sums = $(\bar{A}+\bar{C})(A+C)(B+\bar{C})$

$(\bar{A}+\bar{C})(A+C)(A+B)$