ENGINEERING SCIENCES 50

QUIZ #1 REVIEW PACKET

FALL 2001
PREPARED BY SILAS WANG

Notes:

- The quiz will be held Tuesday 30 October 2001 from 10 AM to 11:30AM.
- You are allowed one 8½" x 11" sheet of handwritten notes to take into the quiz.
- This packet is not exhaustive. You are responsible for all material covered in class up through flip-flops.

- Number systems (see section handout)
  - know how to convert to and from decimal
  - know how to convert between binary, octal, and hexadecimal
  - <u>complements</u>: know how to find radix and diminished radix complements

Problems:

1. Convert into binary and perform using complements, then convert the answer back into decimal:
   a) $432_{10} - 196_{10}$ b) $41_{10} - 212_{10}$ c) $137_{10} - 154_{10}$
   d) pick any two numbers at random!
2. Convert into binary and then from binary to octal and hexadecimal:
   a) 97_{10} b) 680_{10} c) 371_{10}
   d) pick any random number! you can use Windows Calculator to check your answers.

- Binary codes (see section handout)

straight binary: 0000, 0001, 0010, 0011, ..., 1111

BCD: 0000, 0001, 0010, 0011, ..., 1001

example: 417_{10}

010000010111

excess-3:

0011	0100	0101	0110	0111	1000	1001	1010	1011	1100
0	1	2	3	4	5	6	7	8	9

Gray code: 0000, 0001, 0011, 0010, 0110, 0111, 0101, 0100, 1100, 1101, 1111, 1110, 1010, 1011, 1001, 1000

2-bit code

3-bit code

4-bit code

if you forget the sequence:

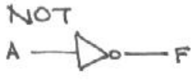
what is the 7th in the sequence? 7 → 0111 → 00111 (add leading zero)

XOR adjacent digits

0100 Gray code

- Gates and truth tables - know them!

NOT



A	F
0	1
1	0

AND

A	B	F
0	0	0
0	1	0
1	0	0
1	1	1

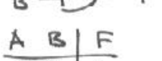
OR

A	B	F
0	0	0
0	1	1
1	0	1
1	1	1

XOR

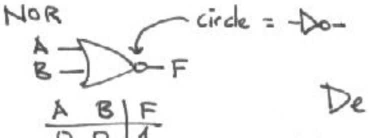
A	B	F
0	0	0
0	1	1
1	0	1
1	1	0

NAND



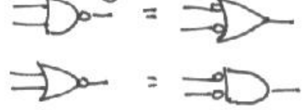
A	B	F
0	0	1
0	1	1
1	0	1
1	1	0

NOR

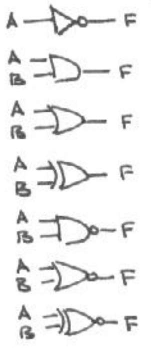


A	B	F
0	0	1
0	1	0
1	0	0
1	1	0

De Morgan's theorem:



Boolean algebra



$F = \bar{A} \equiv A'$

$F = AB \equiv A \cdot B$

$F = A + B$

$F = A \oplus B \equiv A\bar{B} + \bar{A}B$

$F = \overline{AB} = \bar{A} + \bar{B}$ ⟩ De Morgan's theorem

$F = \overline{A+B} = \bar{A}\,\bar{B}$

$F = A \odot B \equiv AB + \bar{A}\bar{B}$

order of operations : NOT → AND → OR

proof by perfect induction: list all possible input combinations in a truth table and show that LHS = RHS for all combinations

Canonical forms (see section handout)

- every term must contain all inputs

e.g., inputs are x, y, z

- $F = \bar{x}yz + x\bar{y}\bar{z} + xyz + \underbrace{x\bar{y}z}_{\text{minterm}}$ sum of products canonical form
- $F = (x+\bar{y}+z)(\bar{x}+\bar{y}+z)\underbrace{(x+y+z)}_{\text{maxterm}}$ product of sums canonical form
- $F = x\bar{y} + \bar{x}yz + y\bar{z}$ sum of products form but not canonical

see table of minterms and maxterms in section handout

$m_i = \bar{M}_i$

notational shorthand :

$\Sigma(0, 2, 5, 7) = m_0 + m_2 + m_5 + m_7$

$\Pi(1, 3, 4, 6) = M_1 M_3 M_4 M_6$

Problems:

1. Simplify algebraically:
    - a) $\bar{x}\bar{y} + x\bar{y} + \bar{x}y$
    - b) $(x+y)(x+\bar{y})$
    - c) $\bar{x}y + x\bar{y} + xy + \bar{x}\bar{y}$
    - d) $\bar{x} + xy + x\bar{z} + x\bar{y}\bar{z}$
    - e) $x\bar{y} + y\bar{z} + \bar{x}\bar{z}$
    - f) $ABC + \bar{A}B + AB\bar{C}$
    - g) $\overline{\bar{x}yz + xz}$
    - h) $\overline{(x+y)}(\bar{x}+\bar{y})$
    - i) $xy + x(wz + w\bar{z})$
    - j) $(B\bar{C} + \bar{A}D)(A\bar{B} + C\bar{D})$

2. Find the complement and simplify:
    - a) $x\bar{y} + \bar{x}y$
    - b) $(A\bar{B} + C)\bar{D} + E$
    - c) $AB(\bar{C}D + C\bar{D}) + \bar{A}\bar{B}(\bar{C}+D)(C+\bar{D})$
    - d) $(x+\bar{y}+z)(\bar{x}+\bar{z})(x+y)$

3. Express using only NOR operations: using NAND only:
    - a) $F = \bar{x}\bar{y} + \bar{x}z + \bar{y}z$
    - b) $F = (y+\bar{z})(x+y)(\bar{y}+z)$

4. Put into canonical form - sum of products: product of sums:
    - a) $F(A, B, C, D) = \bar{B}D + \bar{A}D + B\bar{D}$
    - b) $F(x, y, z) = (xy+z)(xz+y)$

5. Convert to the other canonical form:
    - a) $F(x, y, z) = \Sigma(1, 3, 7)$
    - b) $F(A, B, C, D) = \Pi(0, 1, 2, 3, 4, 6, 12)$

6. Convert to sum of products: product of sums:
    - a) $(AB+C)(B+\bar{C}D)$
    - b) $\bar{x} + x(x+\bar{y})(y+\bar{z})$

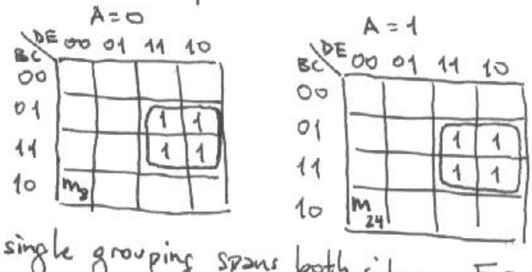
7. Show algebraically that if $xy = 0$, then $x \oplus y = x + y$.

- Analysis of combinational circuits
  - from circuit diagram, derive algebraic expression
  - simplify expression if necessary
  - describe function in words (draw truth table if it helps)
- Synthesis of combinational circuits
  - from word problem, derive truth table
  - draw Karnaugh map
  - obtain simplified algebraic expression
  - draw circuit diagram

Karnaugh maps (see section handout)
- remember to use Gray code
- draw the largest groupings possible

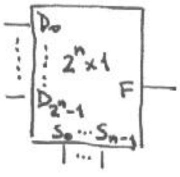
A \ BC	00	01	11	10
0	m_0	m_1	m_3	m_2
1	m_4	m_5	m_7	m_6

- five-variable map:

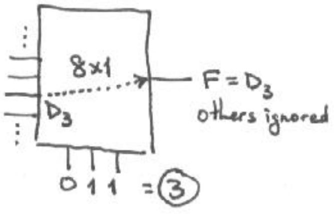


a single grouping spans both sides $F = CD$
e.g., m_8 and m_{16} are adjacent

MUXes

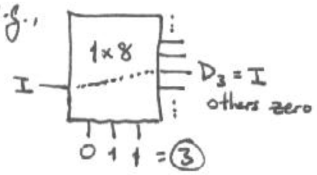


e.g.,

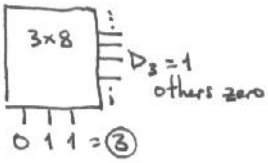


- can be used to implement any function
- recall type 0, 1, 2 implementations

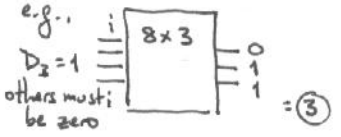
DMUXes
e.g.,



Decoders
e.g.,



Encoders
e.g.,



Problems

1. Simplify using Karnaugh maps:
   a) $F(w,x,y,z) = \Sigma(1,4,5,6,12,14,15)$
   b) $F(A,B,C,D) = \Sigma(0,1,2,4,5,7,11,15)$
   c) $F(w,x,y,z) = \Sigma(2,3,10,11,12,13,14,15)$
   d) $F(A,B,C,D) = \Sigma(0,2,4,5,6,7,8,10,13,15)$
   e) $\bar{w}z + xz + \bar{x}y + w\bar{x}z$
   f) $\bar{B}D + \bar{A}B\bar{C} + A\bar{B}C + AB\bar{C}$
   g) $A\bar{B}C + \bar{B}\bar{C}\bar{D} + BCD + AC\bar{D} + \bar{A}\bar{B}C + \bar{A}B\bar{C}D$
   h) $wxy + yz + x\bar{y}z + \bar{x}y$

   five-variable maps:
   i) $F(A,B,C,D,E) = \Sigma(0,1,4,5,16,17,21,25,29)$
   j) $F(A,B,C,D,E) = \Sigma(0,2,3,4,5,6,7,11,15,16,18,19,23,27,31)$
   k) $F = \bar{A}\bar{B}C\bar{E} + \bar{A}\bar{B}\bar{C}\bar{D} + \bar{B}\bar{D}\bar{E} + \bar{B}C\bar{D} + CD\bar{E} + BD\bar{E}$

2. Simplify in POS and SOP:

a) $F(w,x,y,z) = \Sigma(0,2,5,6,7,8,10)$

b) $F(A,B,C,D) = \Pi(1,3,5,7,13,15)$

c) $F(x,y,z) = \Sigma(2,3,6,7)$

d) $F(A,B,C,D) = \Pi(0,1,2,3,4,10,11)$

e) $\bar{x}\bar{z}+\bar{y}\bar{z}+y\bar{z}+xy$

f) $\bar{A}\bar{C}+\bar{B}D+\bar{A}CD+ABCD$

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

3. Implement using only NAND gates: only NOR gates:

a) $A\bar{B}+ABD+AB\bar{D}+\bar{A}\bar{C}\bar{D}+\bar{A}B\bar{C}$

b) $BD+BC\bar{D}+A\bar{B}\bar{C}\bar{D}$

c) $w\bar{x}+\bar{y}\bar{z}+\bar{w}y\bar{z}$

d) $F(w,x,y,z) = \Sigma(5,6,9,10)$

4. Implement the following function:

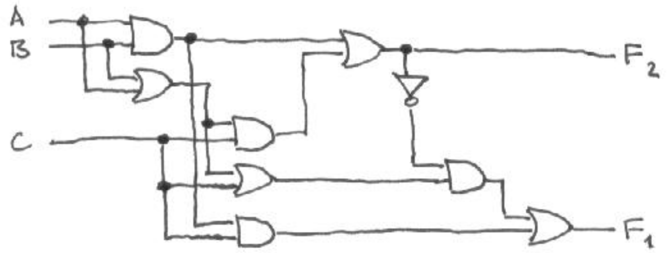
$F(A,B,C,D) = \Sigma(0,1,2,9,11)$

$d(A,B,C,D) = \Sigma(8,10,14,15)$

5. Design a circuit with three inputs and six outputs. The output binary number should be the square of the input number.

6. Design a circuit that detects errors in BCD. The output becomes 1 when the inputs contain any one of the six unused bit combinations in BCD code.

7. What is the truth table?



8. Design a circuit with inputs x, y, z and outputs A, B, C. When the input is 0, 1, 2, or 3, the output is one greater than the input. When the input is 4, 5, 6, 7, the output is one less than the input.

Then try it using the 4-bit adder from the first lab.

9. Implement some of the above using MUXes and decoders.

▶ Sequential logic
- know the types of flip-flops and their excitation / characteristic tables
- know what the following mean:
  gated, master-slave, edge-triggered, direct-inputs, active high, active low

Analysis of state machine
- from circuit diagram, derive excitation equations
- construct state table
- construct state flow diagram
- deduce function of circuit

Synthesis of state machine
- construct state flow diagram from word problem
- assign states and construct state table
- choose flip-flop type and construct excitation equations using Karnaugh maps
- check unused states
- draw circuit diagram

Problems:

1. Draw the circuit diagram:

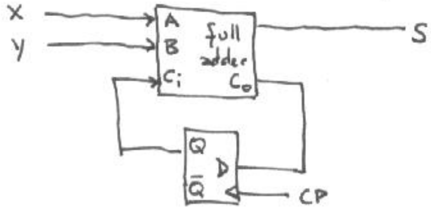
   3 D flip-flops (A, B, C) and one input x

   $D_A = (B\bar{C} + \bar{B}C)x + (BC + \bar{B}\bar{C})\bar{x}$ $\qquad D_B = A \qquad D_C = B$

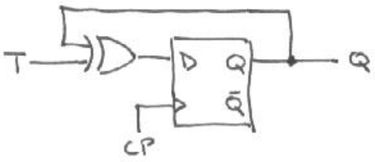
   Draw a sample timing diagram (choose arbitrary values for x)

   Optional: draw a state flow diagram

2. Derive the state table and state flow diagram. What does the circuit do?



3. What does the circuit do?



4. Build a JK flip-flop using only a D flip-flop and some gates.