

Université d'Ottawa
Faculté de génie



University of Ottawa
Faculty of Engineering

uOttawa

L'Université canadienne
Canada's university

ITI 1100

**SAMPLE FINAL EXAM
Solutions**

Name:

Student Number:

Good Luck!

Question 1 (8 points)

- a. The solutions to the quadratic equation $x^2 - 10x + 14 = 0$ are $x = 2$ and $x = 6$. What is the base of the numbers? Show your work.

base=8

- b. Show that the dual of the exclusive-OR is equal to its complement.

Q2.24 of the book

$$\begin{aligned} x \text{ xor } y &= x'y + xy' \text{ and } (x \text{ xor } y)' = (x + y')(x' + y) \\ \text{Dual of } x'y + xy' &= (x' + y)(x + y') = (x \text{ xor } y)' \end{aligned}$$

- c. Find the complement of $F = wx + yz$; What is the value of FF' ?

Q2.8 of the book

$$\begin{aligned} F' &= (wx + yz)' = (wx)'(yz)' = (w' + x')(y' + z') \\ FF' &= wx(w' + x')(y' + z') + yz(w' + x')(y' + z') = 0 \\ F + F' &= wx + yz + (wx + yz)' = A + A' = 1 \text{ with } A = wx + yz \end{aligned}$$

Question 2 (8 points)

A majority circuit is a combinational circuit whose output is equal to 1 if the input variables have more 1's than 0's. The output is 0 otherwise.

Design a 3 input majority circuit by finding the circuit's truth table, Boolean equation and a logic diagram.

Q4.6 of the book

$$F = xz + yz + xy$$

Question 3 (11 points)

Design a combinational circuit that generates the 9's complement of a BCD digit by finding the circuit's truth table, Boolean equation and a logic diagram.

Q4.18 of the book

Inputs: ABCD

Outputs: wxyz

$$d(A, b, c, d) = \Sigma(10, 11, 12, 13, 14, 15)$$

$$w = A'B'C'$$

$$x = BC' + B'C = B \text{ xor } C$$

$$y = C$$

$$z = D'$$

Question 4 (5 points)

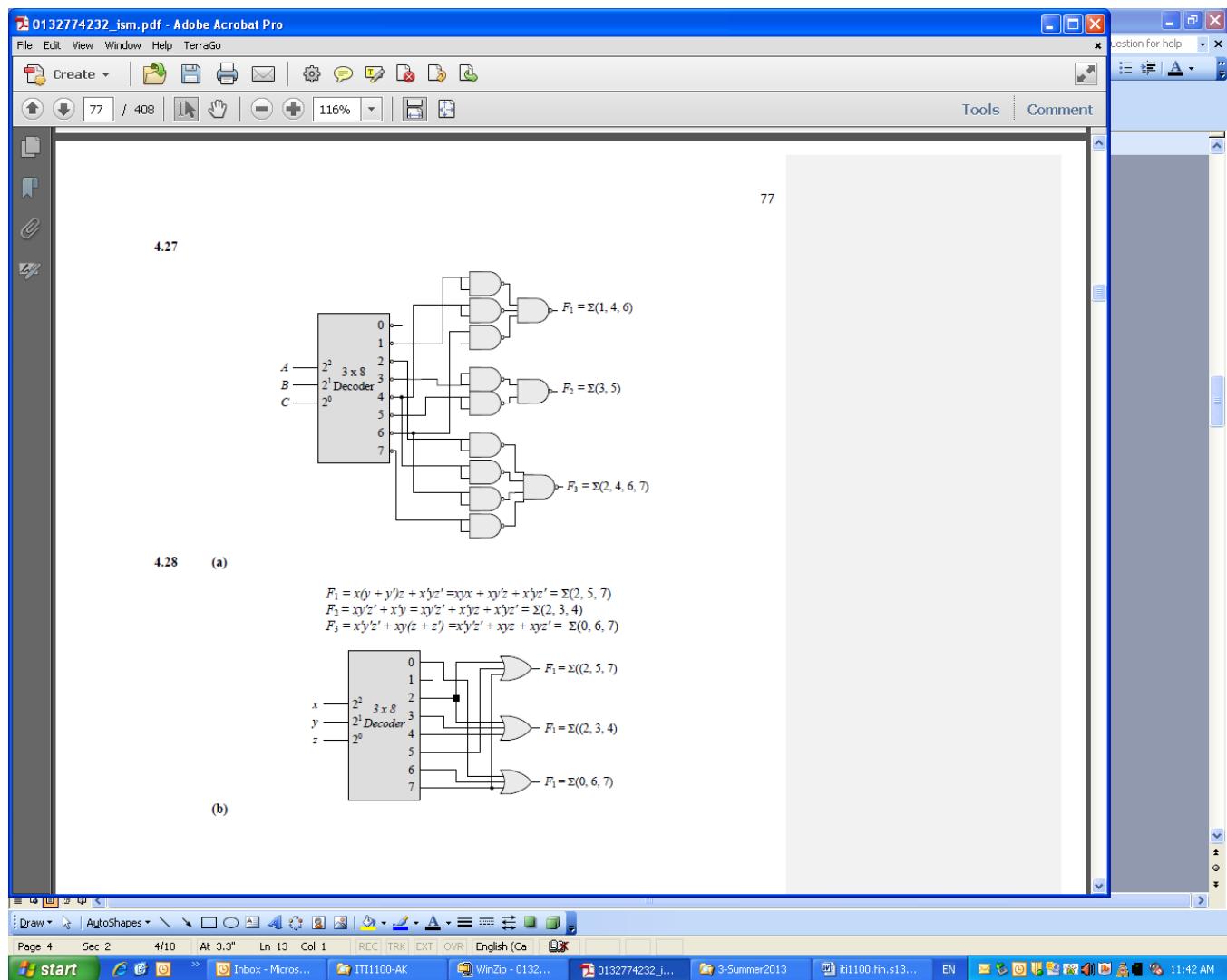
A combinational circuit is specified by the following two Boolean functions:

$$F_1(A, B, C) = \Sigma(1, 4, 6)$$

$$F_2(A, B, C) = \Sigma(3, 5)$$

Implement the circuit with a decoder. Use a block diagram for the decoder and use NAND gates for the gates connected to the decoder outputs.

Q4.27 of the book



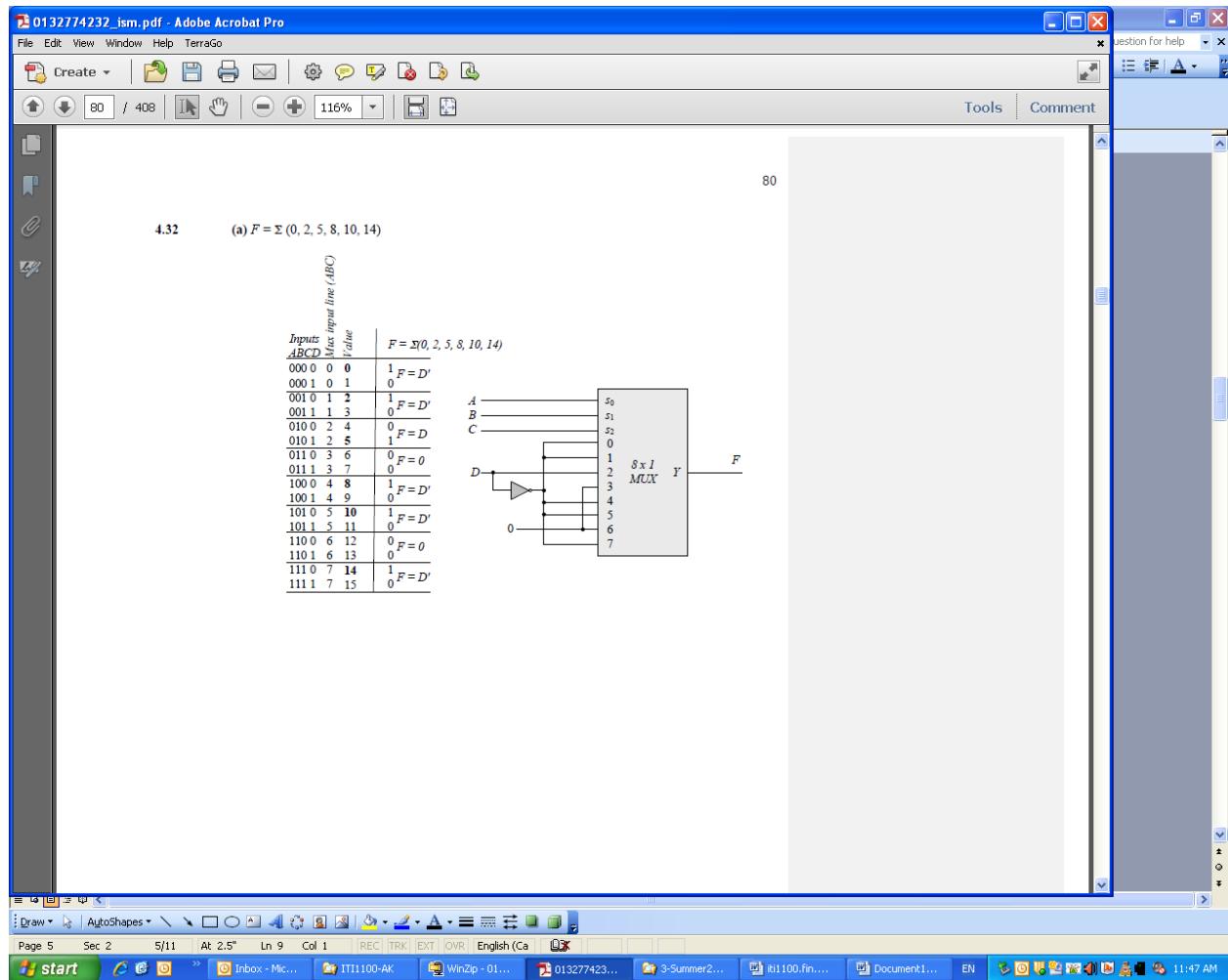
Question 5 (8 points)

Implement the following Boolean function with a multiplexer.

$$F(A,B,C) = \sum(2,4,6)$$

Q4.32 of the book

Similar to this one



Question 6 (11 points)

A PN flip-flop has four operations: clear to 0, no change, complement, and set to 1, when the inputs P and N are 00, 01, 10, and 11, respectively.

Q5.4 of the book

5.3 $Q'(t+1) = (JQ' + K'Q)' = (J' + Q)(K + Q') = J'Q' + KQ$

5.4

	P	N	Q(t+1)
0 0	0	0	0
0 1	0	Q(t)	Q(t)
1 0	Q(t)	Q(t)	1
1 1	1		

	P	N	Q(t)	Q(t+1)
0 0	0	0	0	0
0 1	0	0	1	0
1 0	0	1	0	0
1 1	1	0	1	1

5.5

The truth table describes a combinational circuit.
The state table describes a sequential circuit.
The characteristic table describes the operation of a flip-flop.
The excitation table gives the values of flip-flop inputs for a given state transition.
The four equations correspond to the algebraic expression of the four tables.

(e) $\begin{array}{c|cc|cc} & Q(t) & Q(t+1) & | & P & N \\ \hline 0 & 0 & 0 & | & 0 & x \\ 0 & 1 & 1 & | & 1 & x \\ 1 & 0 & x & 0 & x & 0 \\ 1 & 1 & x & 1 & x & 1 \end{array}$

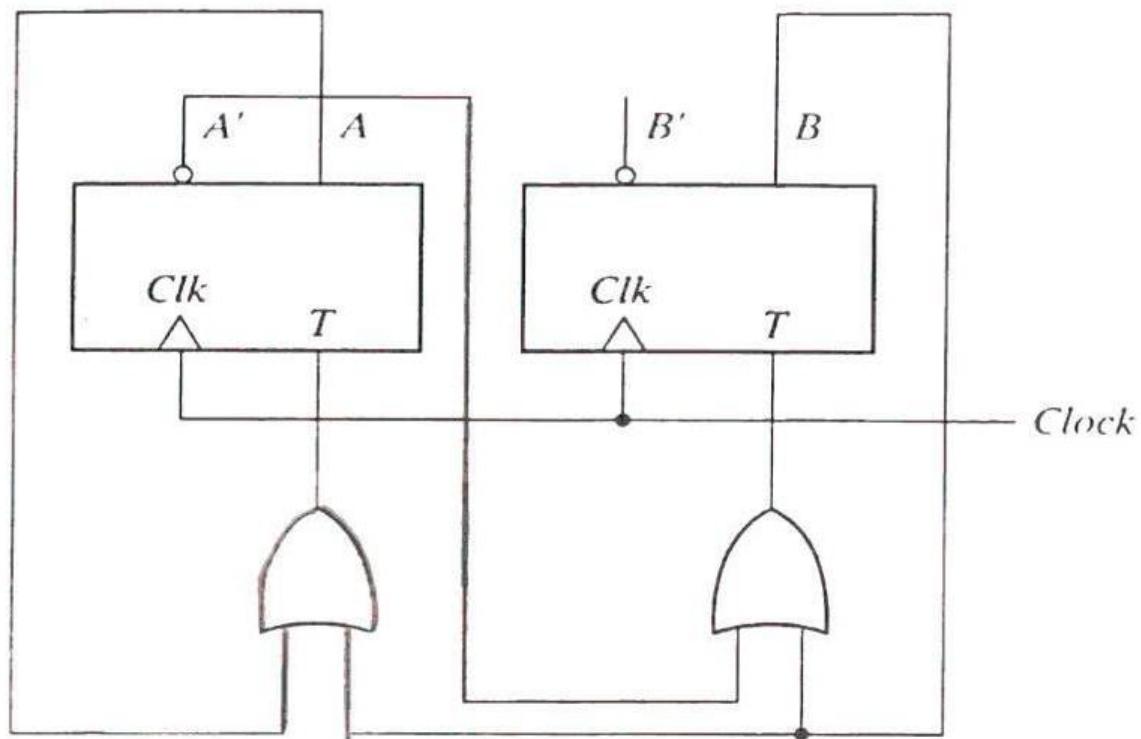
(d) Connect P and N together.

- a. Tabulate the characteristic table.

- b. Derive the characteristic equation.
- c. Tabulate the excitation table or the transition table.

Question 7 (8 points)

Derive the state table, state equations and the state diagram of the following sequential circuit:

Q5.8 of the book

0132774232_ism.pdf - Adobe Acrobat Pro

File Edit View Window Help TerraGo

Tools Comment

119 / 408 116% Tools Comment

119

5.8 A counter with a repeated sequence of 00, 01, 10.

	Present state	Next state	FF Inputs
A	B	A	B
0	0	0	0
0	1	1	0
1	0	0	0
1	1	0	0

$$\begin{aligned} T_A &= A + B \\ T_B &= A' + B \end{aligned}$$

Repeated sequence:
00 → 01 → 10 →

5.9

	$J_A = x$	$K_A = B$	$J_B = x$	$K_B = A'$
$A(t+1)$	$= J_A A' + K_A' A = xA' + B'A$			
$B(t+1)$		$= J_B B' + K_B' B = xB' + AB$		
x	A	B	$xA' + B'A$	$xB' + AB$
0	0	0	0	0
0	0	1	0	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	1
1	0	1	1	0
1	1	0	1	1
1	1	1	0	1

Question 8 (10 points)

For the following state table:

Present State	Next State		Output	
	$x = 0$	$x = 1$	$x = 0$	$x = 1$
a	e	d	0	0
b	d	c	0	1
c	a	e	1	0
d	a	b	1	0
e	d	c	0	1

Q5.12 and 5.13 of the book

0132774232_ism.pdf - Adobe Acrobat Pro

File Edit View Window Help TerraGo

Create | File | Print | Mail | Tools | Comment

121 / 408 | 116% |



(c) input state next st output

input	state	next st	output
0	0	0	0
1	0	1	0
0	1	0	0
1	1	1	1

State machine: D-flop with direct input of the input to the original machine:
output logic: $y = (\text{input}) \&\& (\text{state} == b)$

5.12 Present state Next state Output

Present state	0	1	0	1
a	f	b	0	1
b	d	a	0	0
d	g	a	1	0
f	f	b	1	1
g	g	d	0	1

Digital Design With An Introduction to the Verilog HDL – Solution Manual. M. Mano. M.D. Ciletti. Copyright 2012.
All rights reserved.

Draw | AutoShapes | Page 10 Sec 2 10/14 At 4.8° Ln 21 Col 1 REC TRK EXT OVR French (Can)

start | Inbox - Micros... WinZip - 0132... 0132774232_... 3-Summer2013 K1100.fin.s13... Document1 - M... EN 11:59 AM

5.13 (a) State: $a f b c e d g h g g h a$

Input: 0 1 1 1 0 0 1 0 0 1 1

Output: 0 1 0 0 0 1 1 1 0 1 0

(b) State: $a f b a b d g d g g d a$

Input: 0 1 1 1 0 0 1 0 0 1 1

Output: 0 1 0 0 0 1 1 1 0 1 0

a. Draw the corresponding state diagram.

b. Tabulate the reduced table.

c. Draw the state diagram corresponding to the reduced state table.

d. Starting from state a, and the input sequence 0111000, determine the output sequence for the above reduced state table.

Question 9 (12 points)

- a. The contents of a four-bit register is initially 0110. The register is shifted six times to the right with the serial input being 1011100. What is the content of the register after each shift.

Q6.4 of the book

6.4 0110 => 0011, 0001, 1000, 1100, 1110, 0111, 1011

- b. List the sequence of states produced with 3 and 4 flip-flops in a Johnson counter. The initial value of the register is 000 and 0000 respectively.

Q6.30 of the book

0132774232_ism.pdf - Adobe Acrobat Pro

File Edit View Window Help TerraGo

Tools Comment

182 / 408

6.30

The 5-bit Johnson counter has the following state sequence:

$ABCDE$ decoded output: $A'E'$ AB' BC' CD' DE'	$\rightarrow 00000 \rightarrow 10000 \rightarrow 11000 \rightarrow 11100 \rightarrow 11110 \rightarrow$ $\rightarrow 11111 \rightarrow 01111 \rightarrow 00111 \rightarrow 00011 \rightarrow 00001 \rightarrow$	$A'E'$ AB' BC' CD' DE'
---	--	--

6.31

```

module Reg_4_bit_beh (output reg A3, A2, A1, A0, input I3, I2, I1, I0, Clock, Clear);
  always @ (posedge Clock, negedge Clear)
    if (Clear == 0) {A3, A2, A1, A0} <= 4'b0;
    else {A3, A2, A1, A0} <= {I3, I2, I1, I0};
endmodule

module Reg_4_bit_Str (output A3, A2, A1, A0, input I3, I2, I1, I0, Clock, Clear);
  DFF M3DFF (A3, I3, Clock, Clear);
  DFF M2DFF (A2, I2, Clock, Clear);
  DFF M1DFF (A1, I1, Clock, Clear);
  DFF M0DFF (A0, I0, Clock, Clear);
endmodule

module DFF(output reg Q, input D, clk, clear);
  always @ (posedge clk, posedge clear)
    if (clear == 0) Q <= 0; else Q <= D;
endmodule

module L_Reg_4_bit ();
  wire A3_beh, A2_beh, A1_beh, A0_beh;
  wire A3_str, A2_str, A1_str, A0_str;
  reg I3, I2, I1, I0, Clock, Clear;

```

c. A Johnson counter with n flip-flops produces a sequence of many states?

d. What is the characteristic equation for the complement output of a JK flip-flop?

Q5.3 of the book

$$5.3 \quad Q'(t+1) = (JQ' + K'Q)' = (J' + Q)(K + Q') = J'Q' + KQ$$

Question 10 (8 points)

Using D flip-flops,

Q6.28 of the book

6.28

Present state ABC	Next state ABC
000	001
001	010
010	100
011	xxx
100	110
101	xxx
110	000
111	xxx

$A \swarrow BC$

$D_A = A \oplus B$

$D_B = AB' + C$

$D_C = A'B'C'$

Self-correcting

- a. Design a synchronous counter with the following repeated binary sequence 0, 1, 2, 4, 6.

- b. Draw the logic diagram of the counter.

Question 11 (11 points)

Design a 3-bit ring counter using T Flip-flops. The initial value of the register is 100. Draw the logic diagram of the counter.

Q6.x of the book