0. Name (2 pts):

AME 3623: Embedded Real-Time Systems

Midterm Exam

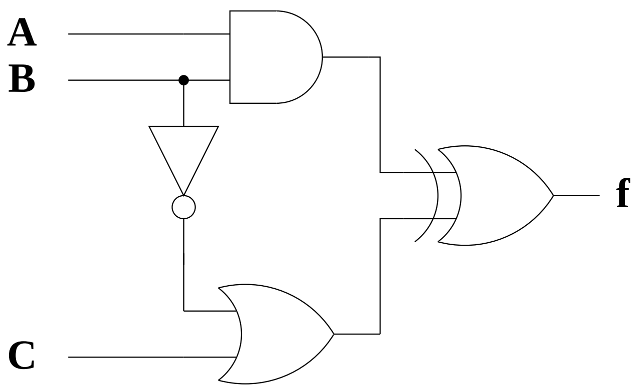
Solution Set

March 15, 2007

Problem	Topic	Max	Grade
0	Name	2	
1	Digital Logic	28	
2	Number Systems	10	
3	Sequential Logic	15	
4	Memory	20	
5	Microcontrollers	27	
Total			

1. **Digital Logic** (28 pts)

Given the following circuit:



(a) (8 pts) Show the corresponding truth table.

A	B	C	f
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

Observations: when AB, $f = \overline{\bar{B} + C}$. *Otherwise,* $f = \bar{B} + C$

Given the following truth table:

A	B	C	f
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	0

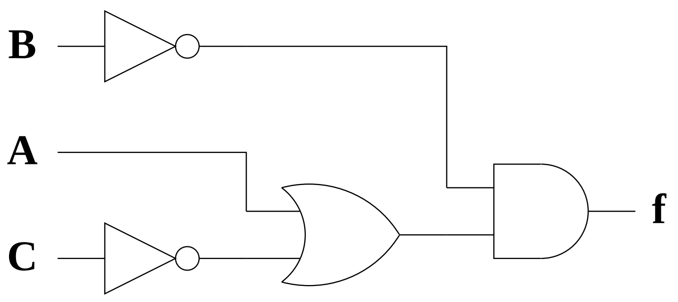
(b) (5 pts) Give the "minterm" form of the corresponding algebraic expression.

$f = \bar{A}\bar{B}\bar{C} + A\bar{B}\bar{C} + A\bar{B}C$

(c) (10 pts) Derive a simplified algebraic description for f. Justify each step (provide the name of the rule that you are using).

$\bar{A}\bar{B}\bar{C} + A\bar{B}\bar{C} + A\bar{B}C$	
$\bar{B}(\bar{A}\bar{C} + A\bar{C} + AC)$	*Distributive and commutative (and associative)*
$\bar{B}(\bar{A}\bar{C} + A\bar{C} + A\bar{C} + AC)$	$X + X = X$
$\bar{B}((\bar{A} + A)\bar{C} + A(\bar{C} + C))$	*Distributive (and associative)*
$\bar{B}((1)\bar{C} + A(1))$	$X + \bar{X} = 1$
$\bar{B}(\bar{C} + A)$	$X * 1 = X$

(d) (5 pts) Draw the corresponding circuit.



2. **Number Systems** (10 pts)

(a) (5 pts) What is the decimal equivalent of $3E$? Show your work.

The decimal equivalent of this is: $16 * 3 + 14 = 62$

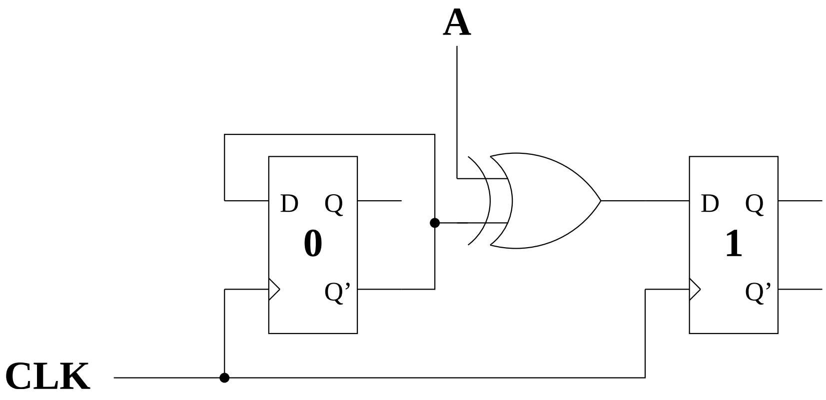
Or: $32 + 16 + 8 + 4 + 2 = 62$

(b) (5 pts) What is the binary equivalent of decimal number 35? Show your work.

value	**binary**	i	2^i
35	*0000000*		
		5	*32*
3	*0100000*		
		1	*2*
1	*0100010*		
		0	*1*
0	*0100011*		

3. **Sequential Logic** (15 pts)

Given the following circuit:



(a) (5 pts) What are the possible states (list all of them)? (by *state* we are referring to the stored information only)

All combinations of the individual bit values (there are 4 in total):

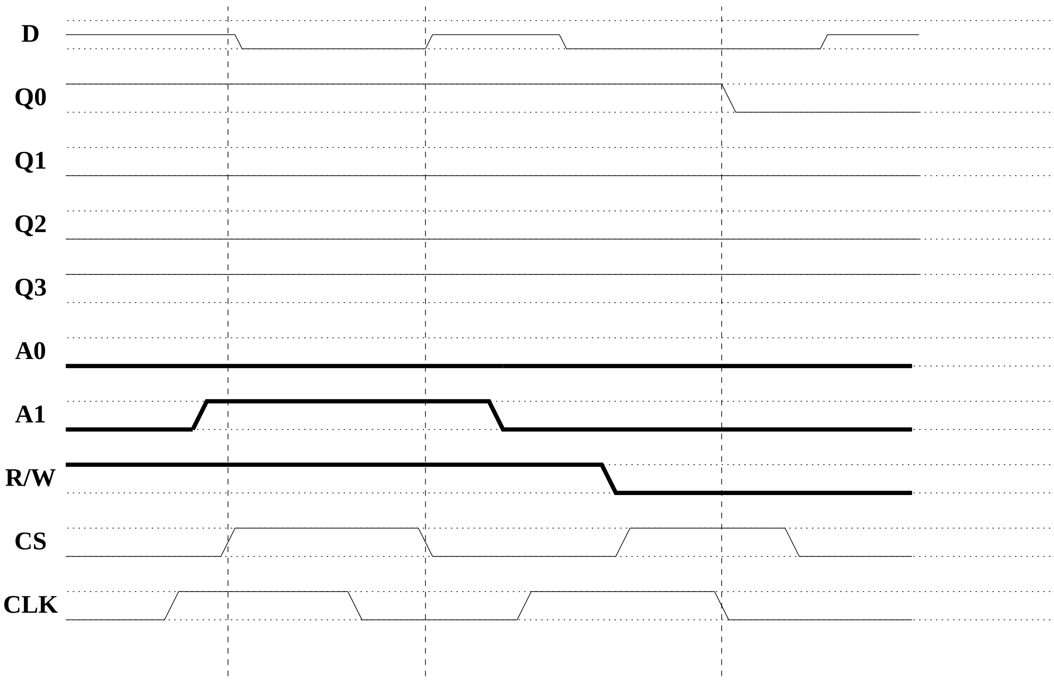
$Q1, Q0 = 00, 01, 10, 11$

(b) (10 pts) Assume an initial state of $Q1 = 0$ and $Q0 = 1$, and that $A = 1$. What is the sequence of states over 5 clock cycles?

$Q1, Q0 = 01$ *(initial)*, 10, 01, 10, 01, 10

4. **Memory** (20 pts)

(a) (10 pts) For the timing diagram below, fill in the missing control signals. Specifically, we wish to read from $Q2$, and then write a 0 to $Q0$.



Note: we were pretty liberal about grading the timing diagram. In addition to having the signals be in the correct states (at certain times), we looked for having the signals be set up in time for the read or write operation. Specifically, the address and R/W lines needed to be configured before the chip select line went high.

(b) (5 pts) Briefly explain the function of the chip select signal (in general, not for part a).

A bus typically has many devices connected to it, but usually at most one device is reading from the bus while one is writing to the bus. The chip select signal tells a particular device that it is active, and his hence allowed to perform either a read or write operation from/to the bus.

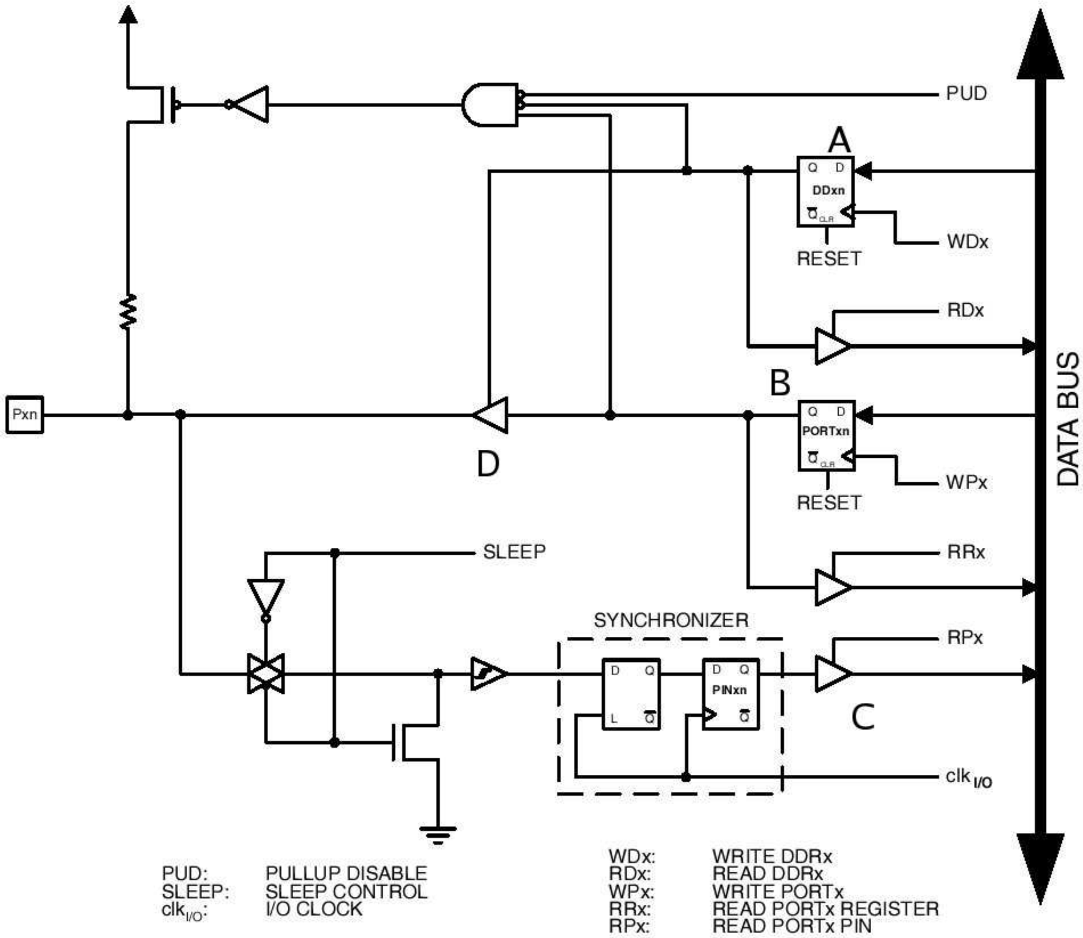
(c) (5 pts) Briefly explain the difference between the types of memory that we call RAM and ROM.

RAM = Random Access Memory

ROM = Read Only Memory

RAM can be changed at any time, but its contents are erased when power is turned off. ROM can only be changed under very specific conditions, but maintains its contents when power is turned off.

5. **Microcontrollers** (27 pts)



(a) (5 pts) Identify component "D". Explain in brief the function of this type of component.

Component D is a tristate buffer. When the select line is high, it drives the output with the same value as the input. However, when the select line is low, it does not drive the output. This device allows multiple devices to selectively drive a line at different times.

Assume an initial state of:
$DDRB = 0x34$
$PORTB = 0xA5$

(b) (5 pts) What effect does the following code have on $DDRB$ and on the above circuit (in terms of components A, B, C, and D)?

```
DDRB = DDRB | 0x40;
```

This line of code ensures that bit 6 of DDRB is turned on (component A), but leaves the other bits of DDRB unchanged. In turn, this turns on the select line of component D, which will then copy the output of component B to the pin.

(c) (5 pts) What effect does the following code have on the state of this circuit (in terms of components A, B, C, and D)?

```
PORTB = PORTB & ~0x40;
```

This line of code ensures that bit 6 of PORTB is turned off (component B). However, in this case, this bit was previously 0. So, there is no change to the hardware state.

(d) (5 pts) What is the function of a general purpose register? (be brief)
A general purpose register is used to temporarily store the result of a computation or the value of a memory location.

(e) (7 pts) List two properties of all buses (be brief).

- *A bus may have an arbitrary number of devices connected to it.*
- *At any one time, at most one device may write to a bus.*