Computer Engineering 111
Final Exam
May 10, 2000

Name ____

Nine problems, 100 points.

Closed books, closed notes, no calculators. You would be wise to read all problems before beginning, note point values and difficulty of problems, and budget your time accordingly.

Please do not open the test until I tell you to do so.

Good luck!

1. (9 total points)

a) (2 points) convert to hex and binary:

37024 (octal) = (binary) = (hex)

b) (5 points) convert to binary, octal and decimal:

A55.6 (hex) = (binary)

= (octal)

= (decimal)

c) (2 points) convert to octal and hex

100101101011.11100101 (binary) = (octal) = (hex)

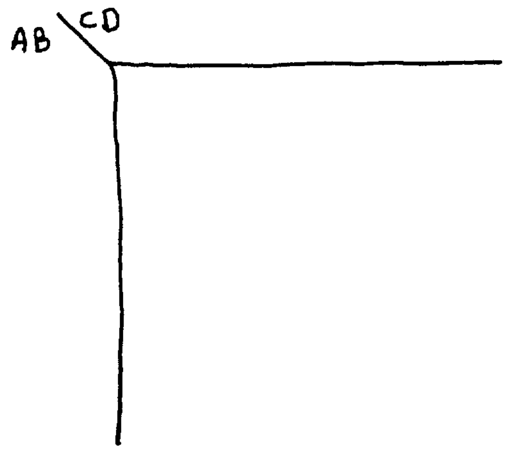
2. (8 points) Your input is an XS3 signal and your output is:

$$F = \begin{cases} 1 & \text{if the input is a valid currency in US dollars, i.e. \$1, \$2, \$5} \\ 0 & \text{otherwise} \end{cases}$$

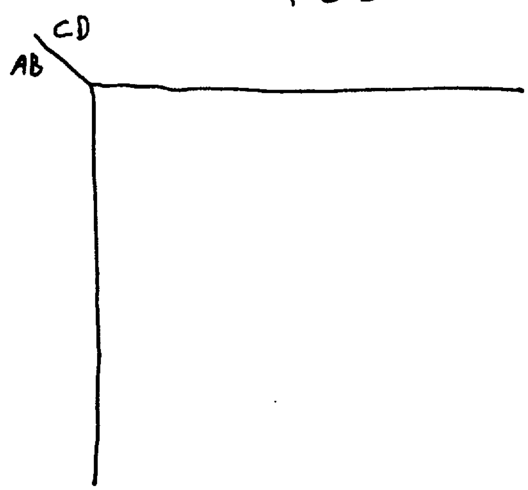
Find a minimal SOP form. Is this unique? Find a minimal POS form. Is this unique? (The first K-map is for the SOP form. The second is for the POS form. Clearly, the entries are the same, but it is much less messy to do the two forms on separate K-maps.)

SOP Form

Decimal	ABCD	F
0	0000	
1	0001	
2	0010	
3	0011	
4	0100	
5	0101	
6	0110	
7	0111	
8	1000	
9	1001	
10	1010	
11	1011	
12	1100	
13	1101	
14	1110	
15	1111	



POS Form



3. (11 total points)
   (1 point) convert 94 and –94 to 8 bit 2's complement representation.

   (1 points) convert 78 and -78 to 8 bit 2's complement representation.

   (1 points) convert 29 and –29 to 8 bit 2's complement representation.

   (2 points) Perform the addition 78 + 29 in 8 bit 2's complement representation.

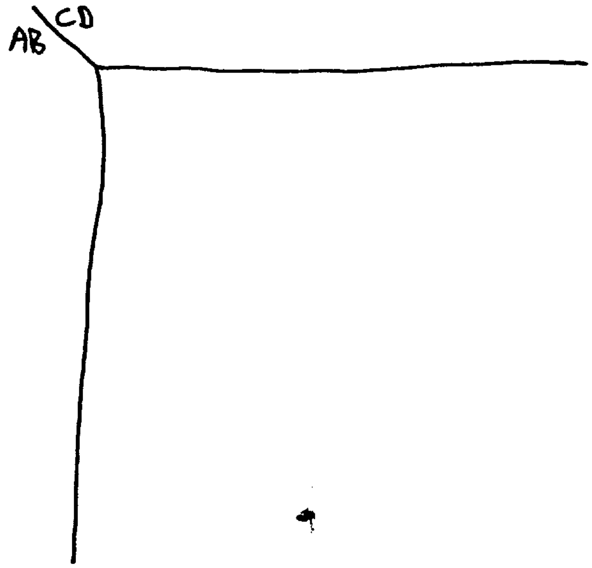
   (2 points) Perform the subtraction 78 - 29 in 8 bit 2's complement representation.

   (2 points) Perform the subtraction 94 - 78 in 8 bit 2's complement representation.

   (2 points) Perform the subtraction 78 - 94 in 8 bit 2's complement representation.

4. (7 points) Your input is in natural BCD. F = 1 if ABCD encodes a digit that is part of today's date (05/10/2000), and F = 0 otherwise. Find a minimal NAND-NAND logic for F. Is this solution unique?

Minterm	ABCD	F
0	0000	
1	0001	
2	0010	
3	0011	
4	0100	
5	0101	
6	0110	
7	0111	
8	1000	
9	1001	
10	1010	
11	1011	
12	1100	
13	1101	
14	1110	
15	1111	



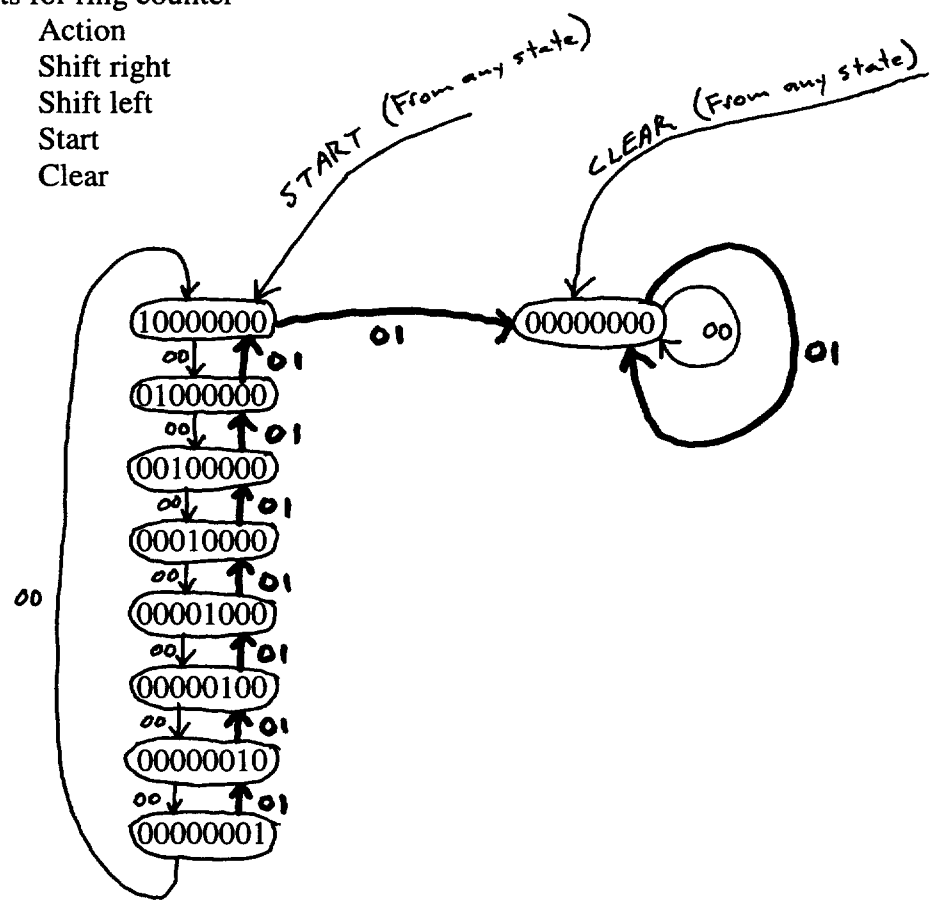
5. (15 points) The 8-bit shift register shown on the next page is able to realize the specified functions from the function table provided. Show how to connect the inputs and any necessary external logic to make it a bidirectional ring counter with an absorbing state. The behavior of the ring counter is completely specified in the Moore diagram provided. Note the two-variable input code that is needed to make the system function will require some (very simple) external logic to function.

Function Table

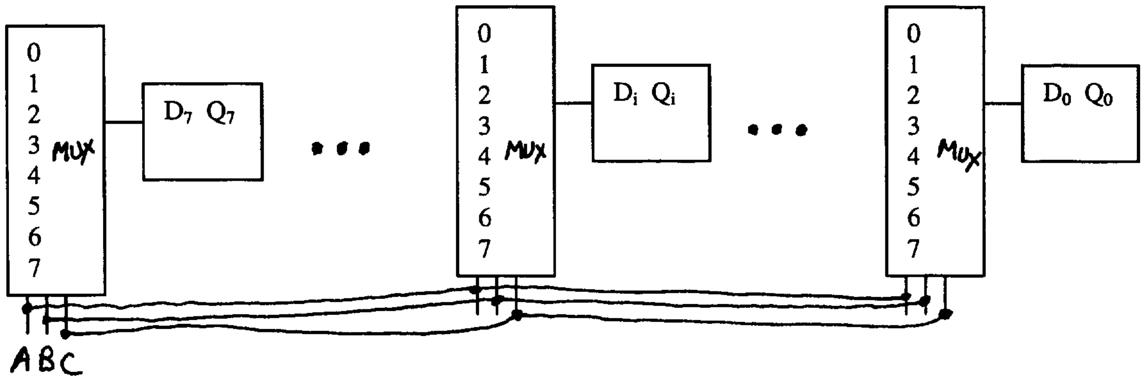
Decimal	ABC	Action
0	000	Shift right
1	001	Hold
2	010	Shift Left
3	011	Shift right twice
4	100	Shift left twice
5	101	Load parallel inputs
6	110	Parallel clear (reset)
7	111	Parallel set

Inputs for ring counter

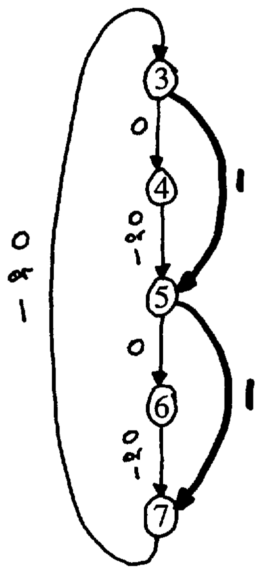
XY	Action
00	Shift right
01	Shift left
10	Start
11	Clear



(Show only necessary connections – not all 8.)



6. (19 points) Implement the Moore diagram below in SOP logic and D flip-flops. The state variables are ABC where A is the most significant bit. The input variable is X. Start your design assuming the unused states are don't cares. Then come back and ensure that these states are tranisent (i.e. you can't get stuck in them.) (Hint: If you ignore the last sentence you will still get most of the problem correct.)



D_A

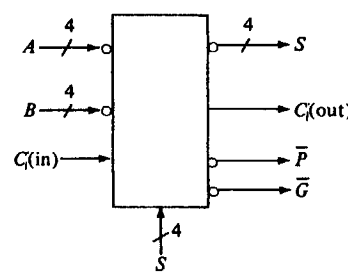
D_B

D_C

ABCX
0000
0001
0010
0011
0100
0101
0110
0111
1000
1001
1010
1011
1100
1101
1110
1111

7. (12 points) You have an 8-bit word, $X_7 \dots X_0$, and you need to generate a ninth bit such that the total 9 bits will have even parity. (Equivalently, you need to check the 8 bits for odd parity.) Do this with just three two-input XOR gates and the 74AS181 ALU, for which the data sheet is on the next two pages. Draw the resulting circuit. (Hint: You will need to break the 4-bit output S line into its four one-bit outputs.)

Figure 4–11
A 4-bit universal arithmetic logic unit (74AS181) (Part b reprinted by permission of Texas Instruments)



(a) Symbol

(continued)

SELECTION				ACTIVE-LOW DATA		
				M = H	M = L; ARITHMETIC OPERATIONS	
S3	S2	S1	S0	LOGIC FUNCTIONS	Cn = L (no carry)	Cn = H (with carry)
L	L	L	L	F = $\overline{A}$	F = A MINUS 1	F = A
L	L	L	H	F = $\overline{AB}$	F = AB MINUS 1	F = AB
L	L	H	L	F = $\overline{A} + B$	F = $A\overline{B}$ MINUS 1	F = $A\overline{B}$
L	L	H	H	F = 1	F = MINUS 1 (2's COMP)	F = ZERO
L	H	L	L	F = $\overline{A + B}$	F = A PLUS $(A + \overline{B})$	F = A PLUS $(A + \overline{B})$ PLUS 1
L	H	L	H	F = $\overline{B}$	F = AB PLUS $(A + \overline{B})$	F = AB PLUS $(A + \overline{B})$ PLUS 1
L	H	H	L	F = $\overline{A \oplus B}$	F = A MINUS B MINUS 1	F = A MINUS B
L	H	H	H	F = $A + \overline{B}$	F = $A + \overline{B}$	F = $(A + \overline{B})$ PLUS 1
H	L	L	L	F = $\overline{A}B$	F = A PLUS (A + B)	F = A PLUS (A + B) PLUS 1
H	L	L	H	F = $A \oplus B$	F = A PLUS B	F = A PLUS B PLUS 1
H	L	H	L	F = B	F = $A\overline{B}$ PLUS (A + B)	F = $A\overline{B}$ PLUS (A + B) PLUS 1
H	L	H	H	F = A + B	F = (A + B)	F = (A + B) PLUS 1
H	H	L	L	F = 0	F = A	F = A PLUS A PLUS 1
H	H	L	H	F = $A\overline{B}$	F = AB PLUS A	F = AB PLUS A PLUS 1
H	H	H	L	F = AB	F = $A\overline{B}$ PLUS A	F = $A\overline{B}$ PLUS A PLUS 1
H	H	H	H	F = A	F = A	F = A PLUS

SELECTION				ACTIVE-HIGH DATA		
				M = H	M = L; ARITHMETIC OPERATIONS	
S3	S2	S1	S0	LOGIC FUNCTIONS	$\overline{C_n}$ = H (no carry)	$\overline{C_n}$ = L (with carry)
L	L	L	L	F = $\overline{A}$	F = A	F = A PLUS 1
L	L	L	H	F = $\overline{A + B}$	F = A + B	F = (A + B) PLUS 1
L	L	H	L	F = $\overline{A}B$	F = $A + \overline{B}$	F = $(A + \overline{B})$ PLUS 1
L	L	H	H	F = 0	F = MINUS 1 (2's COMPL)	F = ZERO
L	H	L	L	F = $\overline{AB}$	F = A PLUS $A\overline{B}$	F = A PLUS $A\overline{B}$ PLUS 1
L	H	L	H	F = $\overline{B}$	F = (A + B) PLUS $A\overline{B}$	F = (A + B) PLUS $A\overline{B}$ PLUS 1
L	H	H	L	F = $A \oplus B$	F = A MINUS B MINUS 1	F = A MINUS B
L	H	H	H	F = $A\overline{B}$	F = $A\overline{B}$ MINUS 1	F = $A\overline{B}$
H	L	L	L	F = $\overline{A} + B$	F = A PLUS AB	F = A PLUS AB PLUS 1
H	L	L	H	F = $\overline{A \oplus B}$	F = A PLUS B	F = A PLUS B PLUS 1
H	L	H	L	F = B	F = $(A + \overline{B})$ PLUS AB	F = $(A + \overline{B})$ PLUS AB PLUS 1
H	L	H	H	F = AB	F = AB MINUS 1	F = AB
H	H	L	L	F = 1	F = A	F = A PLUS A PLUS 1
H	H	L	H	F = $A + \overline{B}$	F = (A + B) PLUS A	F = (A + B) PLUS A PLUS 1
H	H	H	L	F = A + B	F = $(A + \overline{B})$ PLUS A	F = $(A + \overline{B})$ PLUS A PLUS 1
H	H	H	H	F = A	F = A MINUS 1	F = A

Figure 4-11 Continued

8. (10 points) Put the following into SOP form:

$$F = \overline{\overline{\overline{AB}\;\overline{C\overline{D}}} \cdot \overline{\overline{E}F + G\overline{H}}}$$

$$G = A \oplus B \oplus C \oplus D$$

9. (9 points) Assume the system below always starts in state A = 0, B = 0. Analyze the system's behavior, produce the Moore diagram, and state in words what the system is doing.