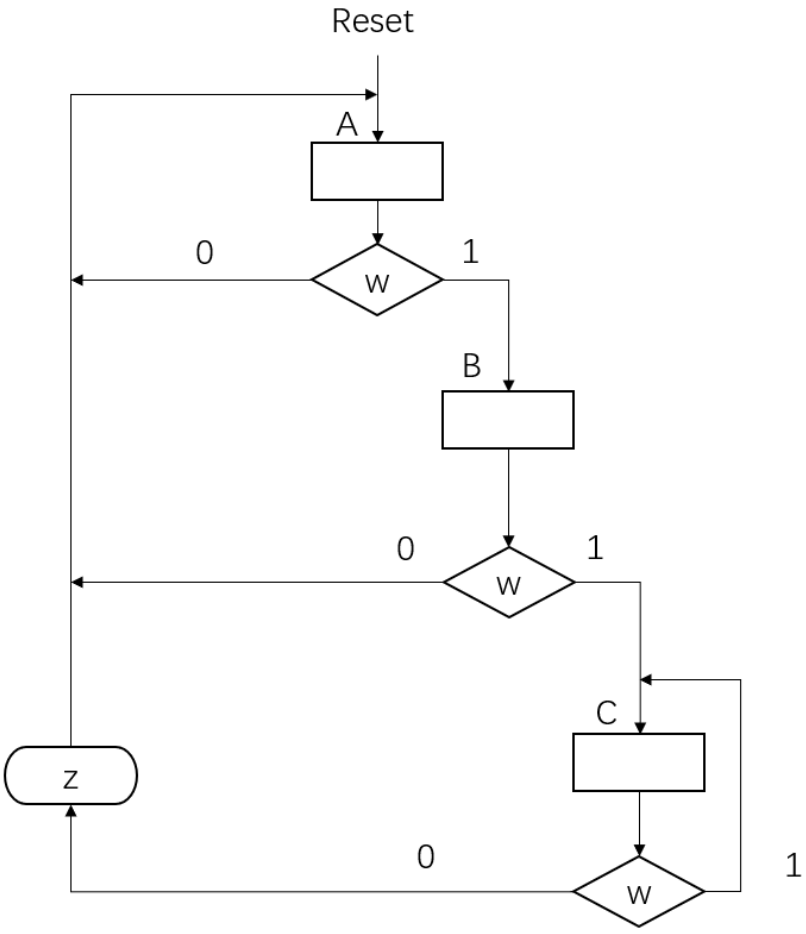
CprE 281 HW13
ELECTRICAL AND COMPUTER ENGINEERING
IOWA STATE UNIVERSITY

ASM charts, Register machines and i281 CPU Architecture
Finish by Dec. 4, 2023

P1. (15 points): Given the algorithmic state machine (ASM) chart shown below:

A. Draw the state diagram that represents this finite state machine. Is this a Mealy machine or Moore machine? Why?
B. Derive output expressions and next state expressions.
C. Draw the circuit using DFFs, AND gates, OR gates, and NOT gates.



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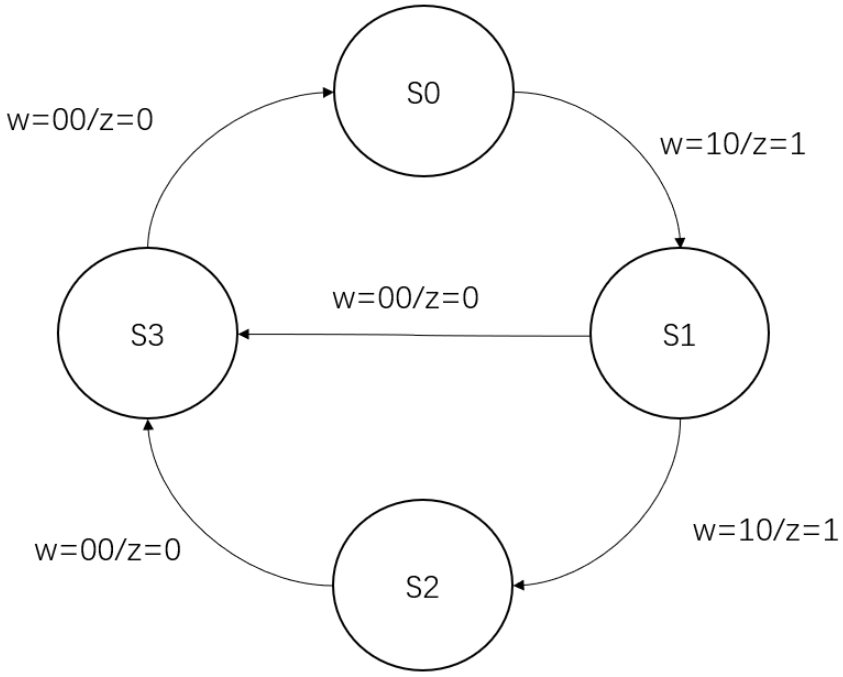
P2. (15 points): Given the state diagram for an FSM below:

A. Let w = w1 w0 to be the two-bit input. Draw the state table.
B. Derive output expressions and next state expressions.
C. Draw the circuit using DFFs, AND gates, OR gates, and NOT gates.



P3. (10 points): Draw the algorithmic state machine (ASM) chart for the graph in P2.

P4. (10 points) Consider a register machine with three registers R0, R1, and R2. Let the initial values be: R0 = 0, R1 = x, and R2 = y. The values x and y are two random integers (positive or zero). Write out the instructions (in the table format shown in P5) for the register machine such that it will add x and y and store the sum in R0. Write a short comment for each line/block of your program.

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P5. (15 points) Consider the following register machine program:

Step	Instruction	Register	Go to step	[Branch to step]
1	Deb	1	2	7
2	Deb	2	3	5
3	Inc	0	4	
4	Inc	3	2	
5	Deb	3	6	1
6	Inc	2	5	
7	End			

(Note: register R0 is shortened to 0, register R1 is shortened to 1, etc.)

A. Let R0 = 0, R1 = 3, R2 = 2, and R3 = 0: What will be the values stored in R0, R1, R2, and R3 after the machine finishes running this program?

B. Let R0 = 0, R1 = 0, R2 = 100, and R3 = 0: What will be the values stored in R0, R1, R2, and R3 after the machine finishes running?

C. Let R0 = 0, R1 = x, R2 = y, and R3 = 0 where x and y are two random integers (positive or zero). Write the values of R0, R1, R2, and R3 in terms of x, y, and any necessary constant numbers.

P6. (15 points) Decoding a CPU instruction.

A. Draw the circuit diagram for the OpCode decoder of the i281 CPU using decoders of various sizes. Label all inputs, outputs, and pins.
B. Explain how the output BRG is computed.
C. Give concrete bit values for a 16-bit instruction that guarantees that BRG will be set to 1. Is there another bit pattern that also sets BRG to 1?

P7. (10 points) Write an assembly program (in i281assembly language) that stores the numbers 2, 5, and 3 into registers A, B, and C, respectively. Then, computes their sum and stores the result in register D. The values of A, B, C should remain 2, 5, and 3.

Hint: Use the i281 simulator, which works in a web browser (for best results use Firefox).
https://www.ece.iastate.edu/~alexs/classes/i281/index.html

Click on the "Load" button to try some of the stored examples. You may find the ones in the Arithmetic section particularly useful. Click the green button labeled "Go to CPU" and then "Step" multiple times to trace the execution of the program. You can also try the "Load New File" button to upload your own assembly file (in plain text format) into the simulator. This link may help too (it contains a Java compiler for the i281):
https://www.ece.iastate.edu/~alexs/classes/2023_Fall_281/i281_CPU/i281_CPU_Software.zip

P8. (10 points) Convert your assembly program from P7 into i281 machine code.