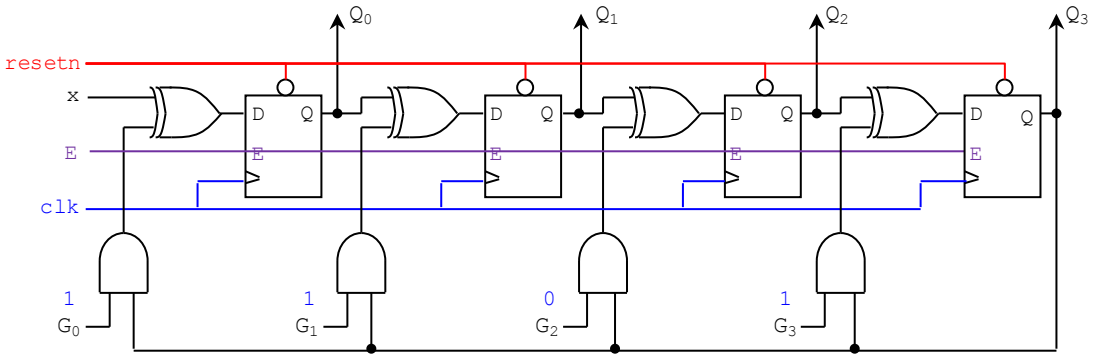
Solutions - Homework 4

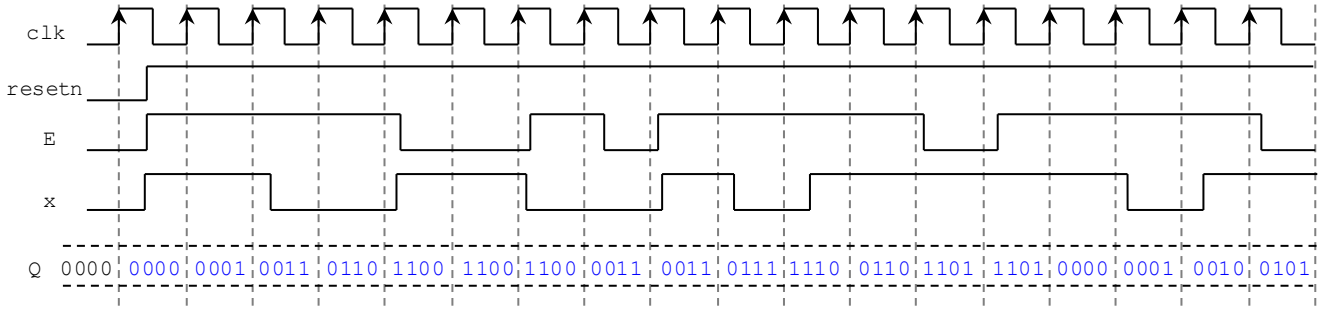
(Due date: November 20th @ 5:30 pm)

Presentation and clarity are very important! Show your procedure!

Problem 1 (14 pts)

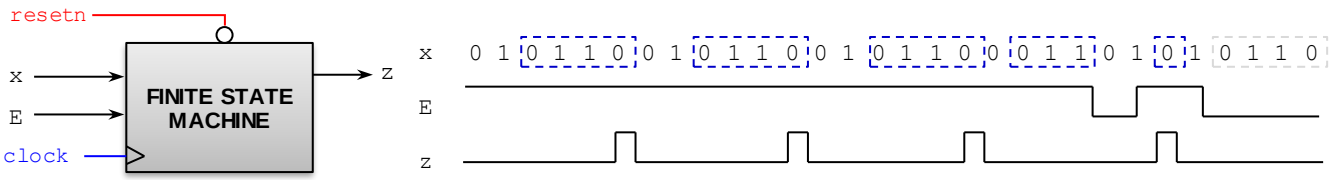
- Complete the timing diagram of the following circuit. $G = G_3G_2G_1G_0 = 1011$, $Q = Q_3Q_2Q_1Q_0$





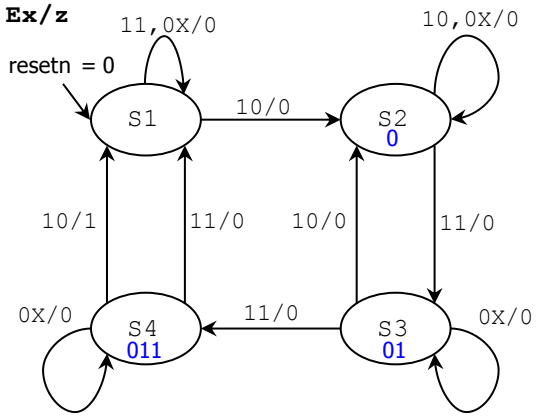
Problem 2 (18 pts)

- Sequence detector: The machine has to generate $z = 1$ when it detects the sequence 0110. Once the sequence is detected, the circuit looks for a new sequence.
- The signal E is an input enable: It validates the input x, i.e., if $E = 1$, x is valid, otherwise x is not valid.



- Draw the State Diagram (any representation), State Table, and the Excitation Table of this circuit with inputs E and x and output z. Is this a Mealy or a Moore machine? Why? (10 pts)
- Provide the excitation equations (simplify your circuit using K-maps or the Quine-McCluskey algorithm) (5 pts)
- Sketch the circuit. (3 pts)

- *State Diagram, State Table, and Excitation Table*:



E	x	PRESENT STATE	NEXT STATE	z
0	0	S1	S1	0
0	0	S2	S2	0
0	0	S3	S3	0
0	0	S4	S4	0
0	1	S1	S1	0
0	1	S2	S2	0
0	1	S3	S3	0
0	1	S4	S4	0
1	0	S1	S2	0
1	0	S2	S2	0
1	0	S3	S2	0
1	0	S4	S1	1
1	1	S1	S1	0
1	1	S2	S3	0
1	1	S3	S4	0
1	1	S4	S1	0

PRESENT STATE			NEXT STATE		
E	x	$Q_1Q_0(t)$	$Q_1Q_0(t+1)$		z
0	0	0 0	0	0	0
0	0	0 1	0	1	0
0	0	1 0	1	0	0
0	0	1 1	1	1	0
0	1	0 0	0	0	0
0	1	0 1	0	1	0
0	1	1 0	1	0	0
0	1	1 1	1	1	0
1	0	0 0	0	1	0
1	0	0 1	0	1	0
1	0	1 0	0	1	0
1	0	1 1	0	0	1
1	1	0 0	0	0	0
1	1	0 1	1	0	0
1	1	1 0	1	1	0
1	1	1 1	0	0	0

State Assignment:
S1: Q=00 S2: Q=01
S3: Q=10 S4: Q=11

This is a Mealy Machine. The output 'z' depends on the input as well as on the present state.

- *Excitation equations, minimization, and circuit implementation*:

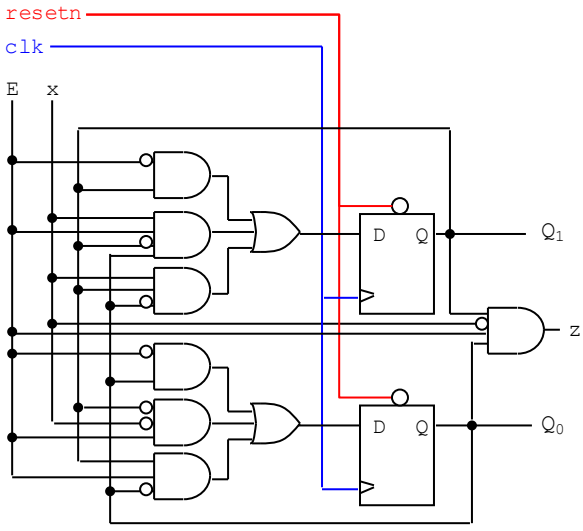
$Q_1(t+1) \leftarrow \bar{E}Q_1(t) + Ex\overline{Q_1(t)}Q_0(t) + xQ_1(t)\overline{Q_0(t)}$
$Q_0(t+1) \leftarrow \bar{E}Q_0(t) + E\bar{x}\overline{Q_1(t)} + EQ_1(t)\overline{Q_0(t)}$
$z = E\bar{x}Q_1(t)Q_0(t)$

$Q_1(t+1)$

Q_1Q_0 \ Ex	00	01	11	10
00	0	0	0	0
01	0	0	1	0
11	1	1	0	0
10	1	1	1	0

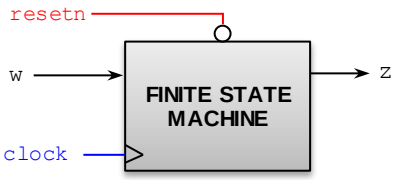
$Q_0(t+1)$

Q_1Q_0 \ Ex	00	01	11	10
00	0	0	0	1
01	1	1	0	1
11	1	1	0	0
10	0	0	1	1



PROBLEM 3 (35 PTS)

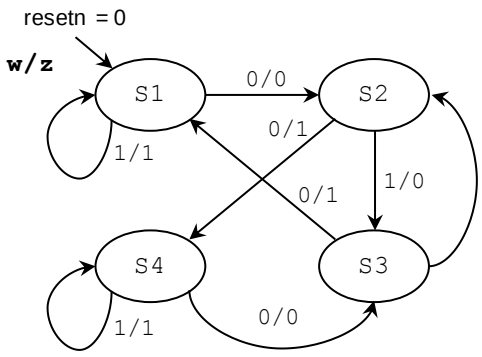
- The following FSM has 4 states, one input w and one output z. (10 pts)
  - ✓ The excitation equations are given by:
    - $Q_1(t+1) \leftarrow Q_0(t)$
    - $Q_0(t+1) \leftarrow \overline{Q_1(t)} \oplus w$
  - ✓ The output equation is given by: $z = Q_1(t) \oplus Q_0(t) \oplus w$

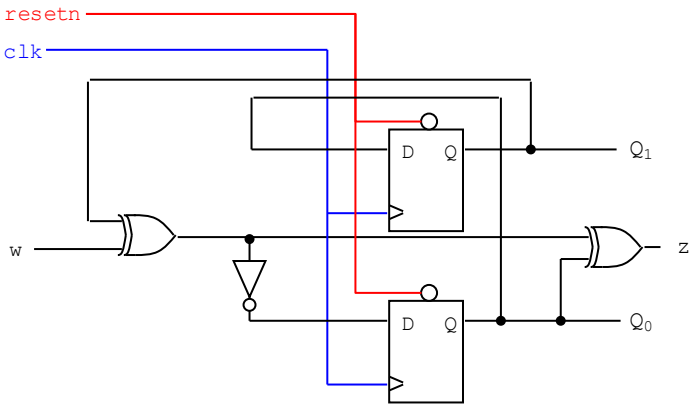


  - ✓ Provide the State Diagram (any representation) and the Excitation Table.
  - ✓ Sketch the Finite State Machine circuit.

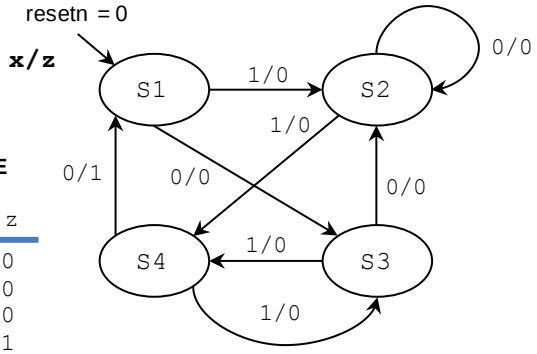
PRESENT STATE			NEXTSTATE		
w	$Q_1Q_0(t)$		$Q_1Q_0(t+1)$		z
0	0	0	0	1	0
0	0	1	1	1	1
0	1	0	0	0	1
0	1	1	1	0	0
1	0	0	0	0	1
1	0	1	1	0	0
1	1	0	0	1	0
1	1	1	1	1	1

w	PRESENT STATE	NEXT STATE	z
0	S1	S2	0
0	S2	S4	1
0	S3	S1	1
0	S4	S3	0
1	S1	S1	1
1	S2	S3	0
1	S3	S2	0
1	S4	S4	1





- Given the following State Machine Diagram. (10 pts)
  - ✓ Is this a Mealy or a Moore machine? Why?
  - ✓ Get the excitation equations and the Boolean equation for z. Use S1 (Q=00), S2 (Q=01), S3 (Q=10), S4 (Q=11) to encode the states.



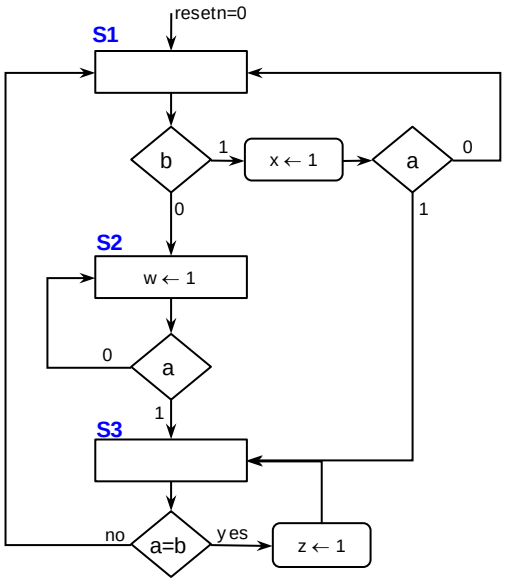
x	PRESENT STATE	NEXT STATE	z
0	S1	S3	0
0	S2	S2	0
0	S3	S2	0
0	S4	S1	1
1	S1	S2	0
1	S2	S4	0
1	S3	S4	0
1	S4	S3	0

	PRESENT STATE		NEXTSTATE		
x	Q_1	Q_0 (t)	Q_1	Q_0 (t+1)	z
0	0	0	1	0	0
0	0	1	0	1	0
0	1	0	0	1	0
0	1	1	0	0	1
1	0	0	0	1	0
1	0	1	1	1	0
1	1	0	1	1	0
1	1	1	1	0	0

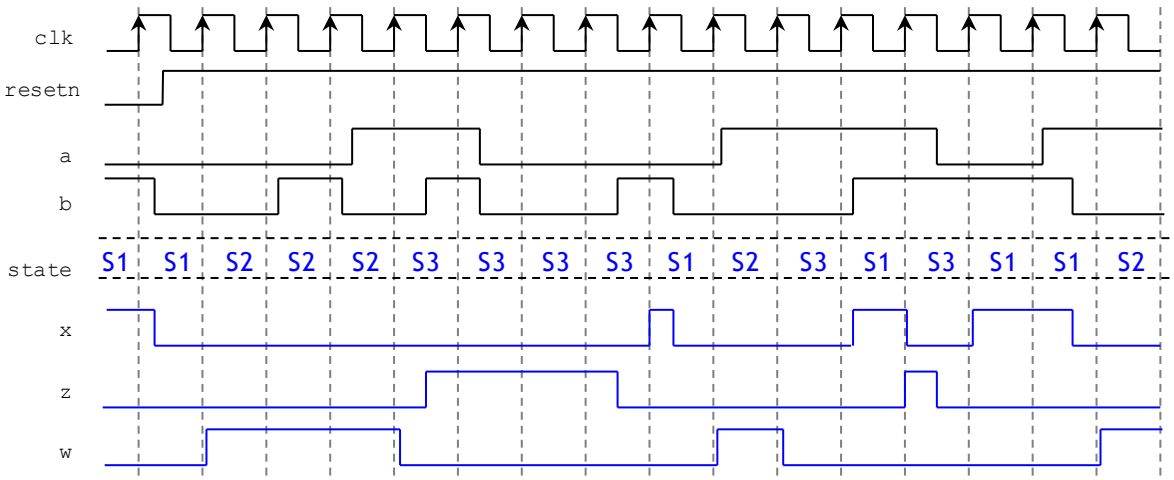
$Q_1(t+1) \leftarrow \overline{x \oplus (Q_1(t) + Q_0(t))}$
$Q_0(t+1) \leftarrow (Q_1(t) \oplus Q_0(t)) + x\overline{Q_0(t)}$
$z = \bar{x} Q_1(t) Q_0(t)$
This is a Mealy Machine. The output 'z' depends on the input as well as on the present state.

- Provide the state diagram (in ASM form) and complete the timing diagram of the FSM whose VHDL description is listed below. (15 pts)

```
library ieee;
use ieee.std_logic_1164.all;

entity circ is
   port ( clk, resetn: in std_logic;
          a, b: in std_logic;
          x,w,z: out std_logic);
end circ;
```

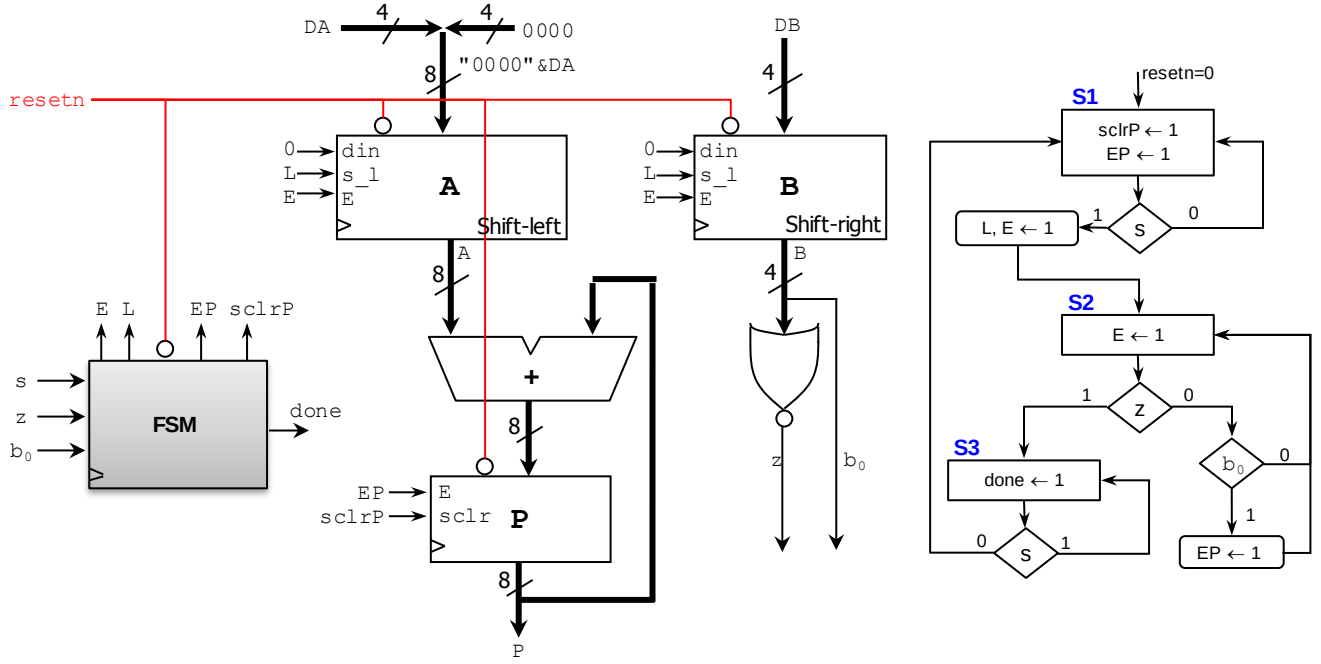


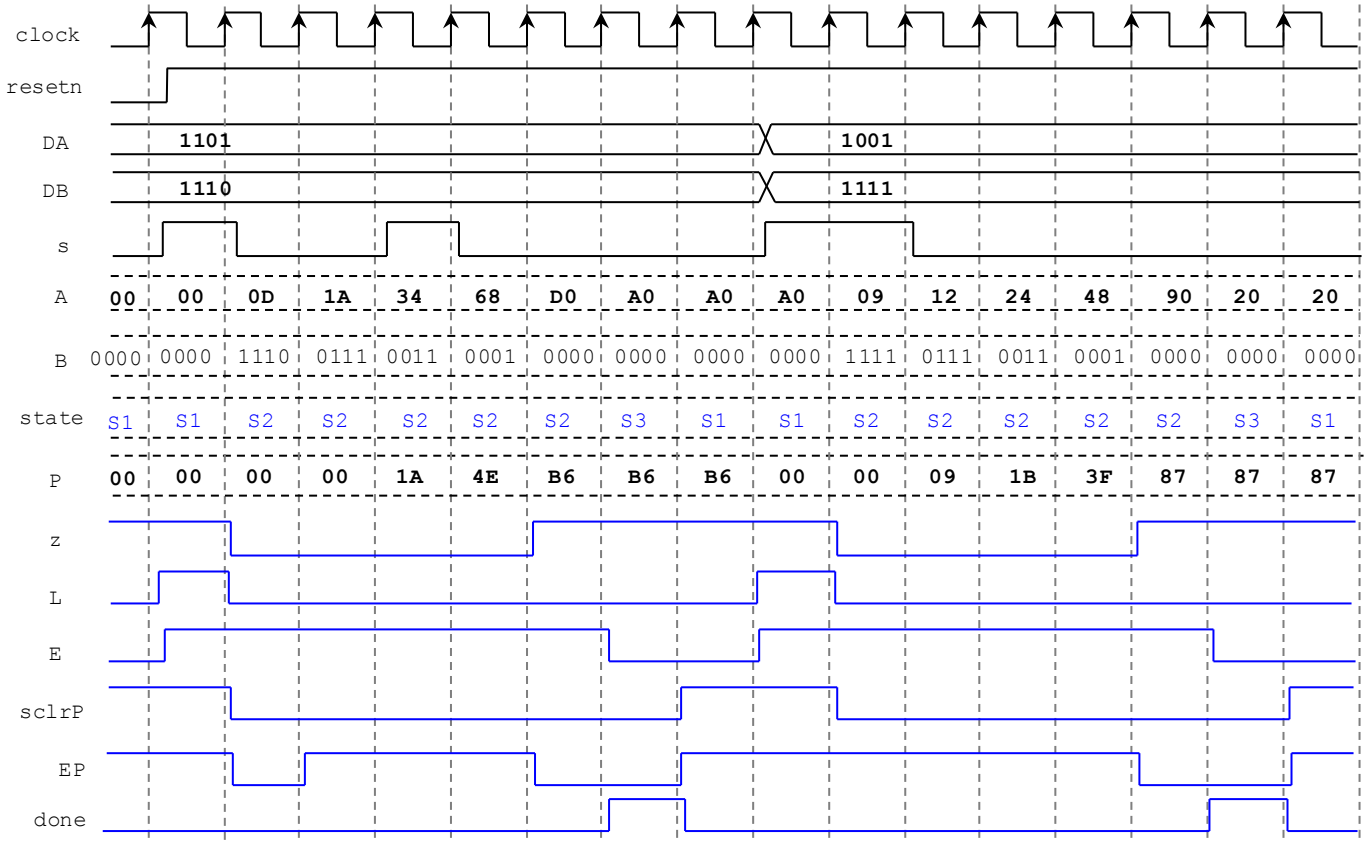

```
architecture behavioral of circ is
   type state is (S1, S2, S3);
   signal y: state;
begin
  Transitions: process (resetn, clk, a, b)
  begin
     if resetn = '0' then y <= S1;
     elsif (clk'event and clk = '1') then
        case y is
          when S1 =>
            if b = '1' then
              if a = '1' then y <= S3; else y <= S1; end if;
            else
              y <= S2;
            end if;

          when S2 =>
            if a = '1' then y <= S3; else y <= S2; end if;

          when S3 =>
            if a = b then y <= S3; else y <= S1; end if;
        end case;
     end if;
  end process;

  Outputs: process (y, a, b)
  begin
      x <= '0'; w <= '0'; z <= '0';
      case y is
         when S1 => if b = '1' then x <= '1'; end if;
         when S2 => w <= '1';
         when S3 => if a = b then z <= '1'; end if;
      end case;
  end process;
end behavioral;
```



PROBLEM 4 (18 PTS)

- Complete the following timing diagram (A and P are specified as hexadecimals) of the following Iterative unsigned multiplier. The circuit includes an FSM (in ASM form) and a datapath circuit.
  Register (for P): *sclr*: synchronous clear. Here, if $sclr = E = 1$, the register contents are initialized to 0.
  Parallel access shift registers (for A and B): If $E = 1$: $s\_l = 1 \rightarrow$ Load, $s\_l = 0 \rightarrow$ Shift





PROBLEM 5 (15 PTS)

- Attach a printout of your Project Status Report (no more than two pages, single-spaced, 2 columns). This report should contain the current status of the project, including a block diagram of your system. You **MUST** use the provided template (`Final Project – Report Template.docx`).