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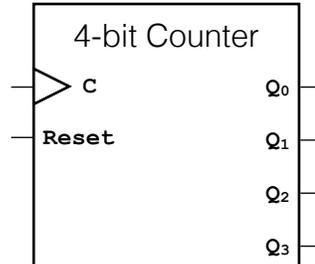
This assignment is due on 7 Dec 2020.

Please remember to write your name and student number.

Please submit a single PDF for each assignment. Handwritten submissions and proprietary formats (e.g. Pages or MS Word) will not be accepted. The Lab portion must be submitted separately.

Assignment 5

1. Given 16-bit operand 00110101 10101100, use a single operation (with or without specific operand) covered in class:
 - A. to clear all odd bit positions to 0?
 - B. to set the leftmost 4 bits to 1?
 - C. to complement the least significant 8 bits?
2. Synchronous binary counter
 - A. Design a counter using a 4-bit synchronous binary counter and an AND gate to design a counter that counts from 0000 through 1100 (you cannot use additional gates nor functional blocks, remember to include the CLK signal source).



- B. Design a 5-bit counter using the above 4-bit synchronous binary counter, an AND gate and a single D flip-flop (remember to include the CLK signal source).
3. A register cell is to be designed for an 8-bit register $R0$ that has the following register transfer functions:

$$\overline{S_1} \cdot \overline{S_0} : R0 \rightarrow R0 \oplus R1$$

$$\overline{S_1} \cdot S_0 : R0 \rightarrow R0 \vee R1$$

$$S_1 \cdot \overline{S_0} : R0 \rightarrow \overline{R0 \oplus R1}$$

$$S_1 \cdot S_0 : R0 \rightarrow R0 \wedge R1$$

Here, \vee denotes bitwise OR operation, while \wedge bitwise AND operation. Design the circuit for a register bit (D flip-flop).
4. Use D flip-flops and gates to design a counter with the following repeated binary sequence: 0, 2, 1, 3, 4, 6, 5, 7.

5. Given two 8-bit registers $R1$ and $R2$, two 8-bit wires with new parallel data inbound for $R1$ and $R2$, and 2-bit mode selector S_1 and S_0 , show the diagram of the hardware that implements the register transfer statement.

$$C_1: R2 \leftarrow R1, R1 \leftarrow R2$$

S_1	S_0	Register Operation
0	0	No change
0	1	Perform C_1
1	0	Load parallel data
1	1	Clear both registers to 0

Lab 4

You must complete the following assignment and submit a PDF of instructions enough to replicate your results, and required documentation. You will also need to upload LogicWork circuit design files as specified, and your own library file. Then upload a single ZIP file to student portal. If you don't have the software, draw the circuit design only and include it in the PDF.

1. Save the library and circuit files we created in class containing the following designs in the final ZIP file:

- (1) Implement 4-bit Ripple Counter in LogicWorks (`circuit1-1.cct`);
- (2) Implement 4-bit Synchronous Counter in LogicWorks (`circuit1-2.cct`);
- (3) Implement 3 digit BCD counter using 4-bit binary counters (`circuit1-3.cct`);
- (4) Provide 10 CLK ticks' timing diagram for (3).

2. Circuit design (`circuit2.cct`).

You are to design a datapath with an 8-bit register array (8 GPRs inside) that can perform certain functions. The datapath takes input $F_{3:0}$ from the control unit for function selection, $Add_{2:0}^1$ and $Add_{2:0}^0$ for register selection, $Ip_{7:0}$ for value input, $Op_{7:0}$ for value output.

$F_{3:0}$	Register Operation
0000	No change
0001	Perform register transferring, assign the value of register at address $Add_{2:0}^0$ to register at $Add_{2:0}^1$.
0010	Clear all registers to 0
0011	Clear a single register to 0, selected by $Add_{2:0}^1$
0100	Load value from $Ip_{7:0}$ into a single register, selected by $Add_{2:0}^1$
0101	Load values from $Ip_{7:0}$ into 2 separate registers at the same time, selected by $Add_{2:0}^1$ and $Add_{2:0}^0$
0110	Output value from a single register to $Op_{7:0}$, selected by $Add_{2:0}^1$
0111	Output inverted value from a single register to $Op_{7:0}$, selected by $Add_{2:0}^1$
1000	Perform addition of 2 registers, selected by $Add_{2:0}^1$ and $Add_{2:0}^0$, store the output to register with address $Add_{2:0}^1$. (Use the adder-subtractor functional block)
1001	Perform subtraction of 2 registers, selected by $Add_{2:0}^1$ and $Add_{2:0}^0$, store the output to register with address $Add_{2:0}^1$. (Use the adder-subtractor functional block)

- A. Write down the sequence for all necessary inputs for computing $24 + 35 - 72$. You will need to load number 54, 35, 72 into the datapath, then perform the necessary calculation, and finally output the results to $Op_{7:0}$. (1pt)
- B. You can use any functional blocks we've discussed in class. The grading criteria for this assignment is as follows:
- 1pt: register array clearing function works properly ($F = 0000,0010,0011$)
 - 1pt: register array transferring function works properly ($F = 0001$)
 - 2pt: register array load/output function works properly ($F = 01XX$)
 - 2pt: register array arithmetic function works properly ($F = 1XXX$)