Pre-Lab 10

Carefully read the entirety of Lab 10, then answer the following questions. Attach a separate sheet of paper, if necessary, to show all work and calculations.

1. Carefully read Circuit 1.

   (a) Fill out the following transition table to convert a JK flip-flop to a T flip-flop.

T	Q	Q+	J	K
0	0			
0	1			
1	0			
1	1			

   (b) Derive an expression for J.

   (c) Derive an expression for K.

2. Carefully read Circuit 2.

   (a) Fill out the following transition table to convert a D flip-flop to a T flip-flop.

T	Q	Q+	D
0	0		
0	1		
1	0		
1	1		

   (b) Derive an expression for D.

3. Carefully read Circuit 3.

   (a) Derive an equation for the input to flip-flop A (you will treat it like a D flip-flop) to obtain the stated functionality.

   (b) Derive an equation for the input to flip-flop B (you will treat it like a D flip-flop) to obtain the stated functionality.

   (c) Derive an equation for the input to flip-flop C (you will treat it like a D flip-flop) to obtain the stated functionality.

   (d) Derive an equation for the input to the clock signal to obtain the stated functionality.

4. Carefully read Circuit 4.

   (a) Decide which type of flip-flop you would like to use (D or JK).

   (b) Decide if you would like your counter to count up or count down.

   (c) Fill out the following transition table for your counter. (The right-most column can be used for flip-flop values, as needed.) Treat all unused states as don't cares.

A	B	C	D	A+	B+	C+	D+	
0	0	0	0					
0	0	0	1					
0	0	1	0					
0	0	1	1					
0	1	0	0					
0	1	0	1					
0	1	1	0					
0	1	1	1					
1	0	0	0					
1	0	0	1					
1	0	1	0					
1	0	1	1					
1	1	0	0					
1	1	0	1					
1	1	1	0					
1	1	1	1					

(d) Derive a minimum equation for either D_A or J_A and K_A.

(e) Derive a minimum equation for either D_B or J_B and K_B.

(f) Derive a minimum equation for either D_C or J_C and K_C.

(g) Derive a minimum equation for either D_D or J_D and K_D.

Lab 10: Registers and Counters

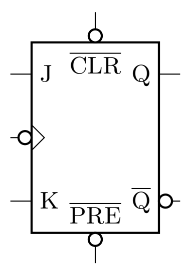
This lab will introduce two important sequential circuits: registers and synchronous counters. Registers are used to store and shift multiple bits of data. The synchronous counter built in this lab is a decade counter, which counts from 0–9 or 9–0 over and over again.

For lab resources and information, go to the following URL or scan the QR code. doctor-pasquale.com/digital-systems-lab-10

10.1 Flip-Flops

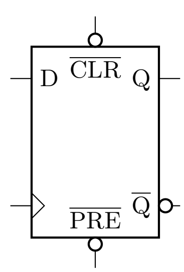
A flip-flop is a synchronous (edge-triggered) building block for sequential circuits. Each flip-flop can do two or more of the following: hold ($Q^+ = Q$), reset ($Q^+ = 0$), set ($Q^+ = 1$), toggle ($Q^+ = Q'$). The two flip-flop chips available in lab are the 7474 (dual D flip-flop) and 74112 (dual JK flip-flop). There is a third common type of flip-flop, known as a T flip-flop, that we do not have. However, it is possible to convert flip-flops from one form to another. These first two circuits will allow you to determine how to convert between flip-flop forms, using both the JK and D flip-flops as a T flip-flop.

Circuit 1: In the pre-lab, you determined how to wire up a JK flip-flop to act as a T flip-flop. Use a clock frequency of approximately 1 Hz, wire up the circuit and display the output on a 7-segment display. Annotate the diagram below. Demonstrate its functionality to your instructor to receive a stamp.



Instructor Stamp: ______

Circuit 2: In the pre-lab, you determined how to wire up a D flip-flop to act as a T flip-flop. Use a clock frequency of approximately 1 Hz, wire up the circuit and display the output on a 7-segment display. Annotate the diagram below. Demonstrate its functionality to your instructor to receive a stamp.



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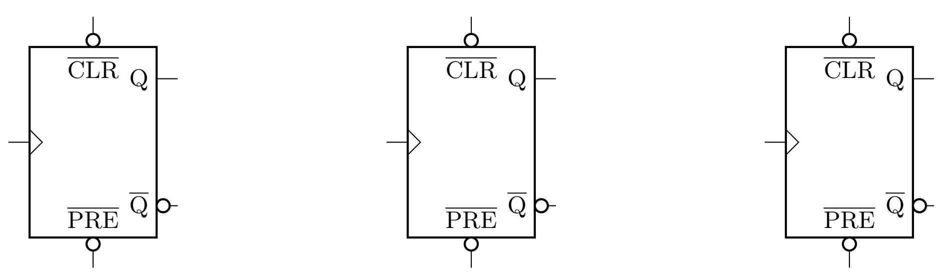
10.2 Registers

Registers are digital logic devices that store and shift binary data. They are comprised of flip-flops. The storage capacity of a register denotes how many ones and zeros can be stored at any given time. Shifting refers to the movement of bits from one flip-flop to another.

Circuit 3: Using either three D flip-flops or three JK flip-flops, create a 3-bit parallel in / parallel out shift register. Each output (Q_A, Q_B, and Q_C) will have its own individual LED. The design will include two pushbuttons as inputs. If one of the pushbuttons is pressed, the register will LOAD inputs from a DIP-switch directly to each flip-flop. If the other pushbutton is pressed, the register will SHIFT from Q_A toward Q_C. If neither pushbutton is pressed, the register will HOLD (not do anything).

- **Flip-Flop A** – The input to this flip-flop will be equal to A if the load pushbutton is pressed. The input will be 0 if the shift pushbutton is pressed. If neither pushbutton is pressed, the clock signal will be inhibited.
- **Flip-Flop B** – The input to this flip-flop will be equal to B if the load pushbutton is pressed. The input will be equal to the output of Q_A if the shift pushbutton is pressed. If neither pushbutton is pressed, the clock signal will be inhibited.
- **Flip-Flop C** – The input to this flip-flop will be equal to C if the load pushbutton is pressed. The input will be equal to the output of Q_B if the shift pushbutton is pressed. If neither pushbutton is pressed, the clock signal will be inhibited.

Draw a circuit diagram below using the flip-flops shown. Label the inputs so it is clear if you are using a D or JK flip-flop. Demonstrate its functionality to your instructor to receive a stamp.



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10.3 Counters

Synchronous counters are simply devices that are synched to an external clock so that all flip-flops change simultaneously. When this happens, the output cycles through values (for example, a decade counters counts 0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 –9 and then loops back through again).

Circuit 4: In the pre-lab, you made design decisions regarding a decade counter. Now it's time to build it! Use your selected flip-flop type to create a decade counter. The output should display on a single 7-segment display. A block diagram of the circuit is shown in figure 10.1.

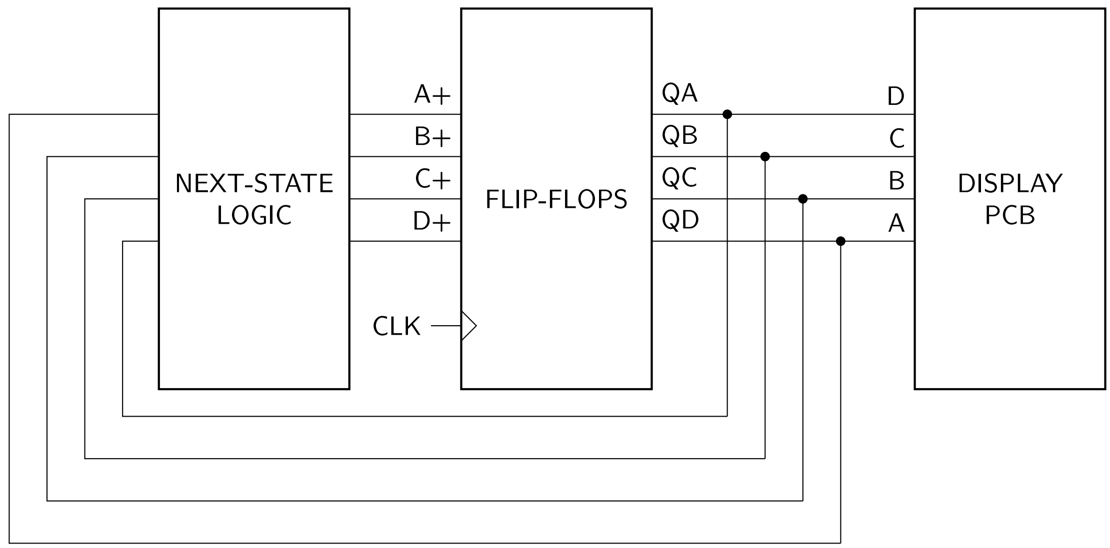
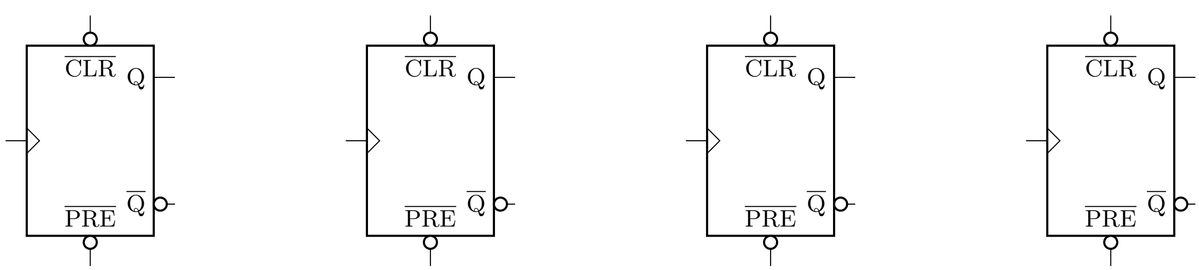


Figure 10.1: Block diagram of the synchronous counter circuit.

Draw a circuit diagram of your completed circuit. Label the inputs so it is clear if you are using a D or JK flip-flop. Demonstrate the functionality of your counter to your instructor to receive a stamp.



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