LATHROP ENGINEERING

Name:

UNIT 8: SYNCHRONOUS COUNTERS

Digital Electronics Unit Due Date: **February 21, 2020**

Welcome to the eighth unit of Digital Electronics! This unit continues the discussion about flip-flops and how they can be used in the creation of counters, but now we get to develop *synchronous counters.* In addition to learning about these new kinds of counters, we'll also discover that there are some IC chips with built-in counter circuits that can be used, and we'll wrap up our work by creating our own 60-second timer using what we know about counters of different kinds. In the end, the expectation is that you learn the following elements of digital logic:

- What a **synchronous counter** is
- How **flip-flops** can be used to create synchronous counters
- How **MSI IC** chips can be used to create counters of different kinds
- How to **design, simulate, and build** your own counters

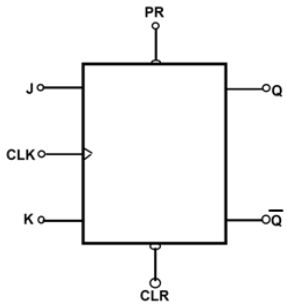
As we move through this unit, you are responsible for making adequate progress through the assignments, and for being done by the Unit Due Date (**February 21, 2020**). You are also responsible for completing each part before moving on to the next. Our unit is broken up into three main parts:

Part 1: **Synchronous Counters** *(20 pts) Approx. 3 days*		
Our unit starts with an introduction to synchronous counters. Here you'll explore how J/K Flip Flops can be used to create counters that control each digit simultaneously. You'll take some detailed notes about how these counters work as well as on the difference between the asynchronous counters from last unit and the synchronous version in this unit. Of course you'll simulate some counters and investigate their functionality!		Notes: Synchronous Counters
		Synch. Counters Assignment
		Working Simulations
		Check-off from Mr. Benshoof

Part 2: **Medium Scale Integration** *(60 pts) Approx. 4 days*		
The second part of our unit introduces two new IC chips: the 74LS163 binary up-counter and the 74LS193 Up/Down-counter. These 'medium-scale integrated' IC chips have combined entire J/K flip-flop synchronous counters into a single 14-pin chip! Here you'll get to explore these two new tools and see how to hook them up in Multisim, for PLDs, and for breadboarding. Of course we have the 74LS163 and 74LS193 chips in the lab, so when you breadboard it you'll be able to use those chips specifically.		Notes: Medium Scale Integration
		74LS163 Up-counter Assignment
		74LS163 Breadboarding
		*74LS**193** Up/Dn Counter Assign.*
		74LS**193** Breadboarding
		Check-off from Mr. Benshoof

Part 3: **60 Second Timer** *(50 pts) Approx. 3 days*		
The final part of our unit is the large "60-second Timer" circuit. Your challenge is to using the ideas of SSI logic (from part 1) and of MSI logic (from part 2) to make a 60-second timer. The timer will combine these different methods to keep track of the one's and ten's place values separately. You'll then make your circuit communicate to two 7-segment displays and get it breadboarded with a CMODS6 chip.		Process Documentation
		Take Unit 8 Quiz
		60-Second Timer Challenge
		Breadboard 60-Second Timer
		Check-off from Mr. Benshoof

(20 pts) Approx. 3 days



A J/K Flip-Flop with inputs on the left and outputs on the right

This unit starts with a new application of the J/K Flip Flop. We certainly remember the J/K Flip Flop from the last unit where we used it to create asynchronous counters. In that unit, we used the inputs (Clock, J, K) in combination with the outputs ($Q, \bar{Q}$) to make a binary counter that went both up and down. The problem with asynchronous counters like those is that we had to wait for the least significant bit to count all the way up before then having to wait for the rising clock edge to trigger the 'carry over'. If our counter had more than 4 bits, this lag time resulting from the ripple of the counter would be problematic. That's where *synchronous counters* come in to play.

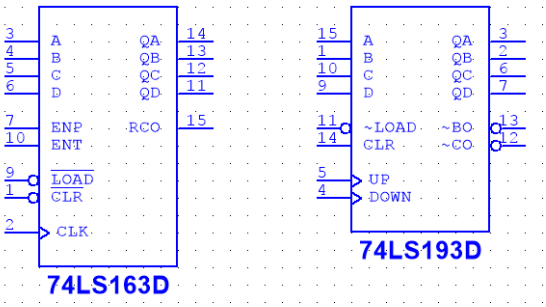
A **synchronous counter** is a counter where all the bits are updated simultaneously. This eliminates the lag time between the increment of the counter and the real-time update of the counter. What we need to do in this first part of the unit is use our J/K Flip Flops to create a synchronous counter.

1. **Synchronous Counter Notes:** Start by watching the four presentations on synchronous counters. These videos will share the big picture, the nitty-gritty details of how synchronous counters work, a comparison between asynchronous and synchronous counters, and a good example of a functioning counter. Take at least two (2) pages of good notes on the topic, and be sure to include details about how the J/K Flip Flops can be used to make a synchronous counters.
2. **Synchronous Counters Assignment:** Complete the *Synchronous Counters Assignment* by creating the proper simulations in Multisim. Pay particularly close attention to the connections between the inputs/outputs of the J/K Flip Flop to better understand how the system is working. As you continue, keep good notes on new or interesting ideas about these counters.
3. **Working Simulations:** The *Synchronous Counters Assignment* asks you to build your simulated synchronous counter in the standard (not PLD) mode. Complete this circuit and adapt it to count 0-4 as indicated. Have Mr. Benshoof confirm your working counter before moving on to the next part!

Part 1: Tasks	*10-8 points*	*7-5 points*	*4-0 points*
Notes: Synchronous Counters	+ You took 2 full pages of notes on the various *Synchronous Counters* presentations + Your notes include details about using J/K Flip Flops in synchronous counters	- Your notes are missing some of the details about Flip Flops	- Very brief or no notes in your engineering notebook
	5 points	*4-2 points*	*1-0 points*
Synch. Counters Assignment	+ You completed the *Synchronous Counters Assignment* + Your simulations are complete and you've documented interesting ideas in your notebook	- Your assignment is mostly complete	- Your assignment is missing important parts
Working Simulations	+ Your simulations of synchronous counters from the assignment work correctly. + Mr. Benshoof confirmed your working simulation	- Your simulation does not quite work as intended	- Your simulation is missing completely - Mr. Benshoof did not get to see it working

(60 pts) Approx. 4 days

The second part of this unit introduces two new IC chips for us. These new chips are referred as "Medium Scale Integration" because they have relatively complex circuits (4-bit binary synchronous counters using J/K Flip Flops) built into their chip structure. This makes them very compact and useful for creating counters. Part of our job in this part of the unit is to learn what these MIS IC chips are trying to do, and also how to use them in our own simulations and circuits!



In short, the 74LS163 chip will use the ABCD inputs to define the starting points and endpoints of the counting, and the QA, QB, QC, and QD outputs to send a 4-bit binary number out to display. Similarly, the 74LS193 chip uses athe ABCD inputs for the same definitions, the UP/DOWN inputs define the direction of counting, and the Q outputs give a 4-bit binary output for use in your circuit.

1. **Notes:** Start by watching the presentations on medium scale integration and these two chips in particular. There is a combination of general information about MSI chips as well as some very specific information about these two chips in particular.
2. **74LS163 Assignment & Breadboard:** Next, get the *74LS163 Assignment* from Mr. Benshoof and work through it. This assignment will ask you to make some pre-planned circuits as well as to modify those circuits to change the counting range. When you've finished the circuits, make sure everything is properly functioning in Multisim (only) and answer the few reflection questions in your engineering notebook.
3. **74LS193 Assignment & Breadboard:** Finally, get the *74LS193 Assignment* from Mr. Benshoof and work through the circuits it asks you to simulate. Make the requested modifications, make sure your simulation works well, and answer the corresponding reflection questions in your engineering notebook as always!

Part 1: Tasks	*12-9 points*	*8-5 points*	*4-0 points*
Notes: Medium Scale Integration	+ You took a full page of notes (or more) on Medium Scale Integration + Your notes include details on the two new chips: 74LS163 and 74LS193	- Your notes are missing important parts - Your notes do not include details on the 74LS163 or the 74LS193	- Your notes are missing totally - Your notes are significantly lacking
74LS163 Assignment	+ You completed the *74LS163 Assignment* on the MSI Up Counter + You included responses to all short reflection questions	- You completed most of the assignment - You answered most of the reflection questions	- You did not do the assignment
74LS163 Breadboard	+ You successfully breadboarded the required 74LS163 circuit	- Your breadboarded circuit did not work as intended	- Your breadboarded circuit is very incomplete
74LS193 Assignment	+ You completed the *74LS193 Assignment* on the MSI Up/Down Counter + You included responses to all short reflection questions	- You completed most of the assignment - You answered most of the reflection questions	- You did not do the assignment
74LS193 Breadboard	+ You successfully breadboarded the required 74LS193 circuit	- Your breadboarded circuit did not work as intended	- Your breadboarded circuit is very incomplete

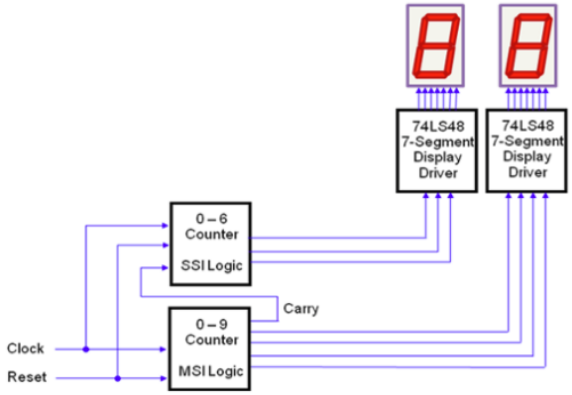
(50 pts) Approx. 3 days

IN this design problem, you have the opportunity to draw together all of the concepts and skills that you have developed with regard to synchronous counter design. You will design, simulate, and create a 60-Second Timer.

THE 60-SECOND TIMER CHALLENGE

The Problem Statement: Design a digital 60-Second Timer that counts from 00 to 59. This design has two control inputs and two output displays. The two inputs are **Clock** and **Reset**. The Clock signal is a 1 Hz square wave that controls the count rate. The **Rest** signal, when it is logic zero, resets and holds the count at zero. When the Reset signal is a logic 1, counting is enabled. When the count reaches sixty seconds, the counting resets at 0.

The circuit overview is given at the right. This shows that you should have two separate parts to your counter. One will follow SSI Logic (Flip Flops) to count 0-6 as the ten's place. The second part will follow MSI logic (74LS163/169) to count 0-9 for the one's place. Note that they are connected by the numerical 'carry'. You will also need your circuit to communicate through a pair of 7-segment displays.



DESIGN SPECIFICATIONS:

- The two output displays are common cathode seven-segment displays that require a multiplexed signal.
- Each display will use a 74LS48 BCD-to-Seven-Segment display driver in Design Mode. (DEC_BCD_7 in PLD Mode)
- The ones-unit display (0–9) is controlled by a synchronous counter designed with a 74LS163 MSI counter IC. (CNTR_4BIN_S in PLD Mode)
- The tens-unit display (0–6) is controlled by a synchronous counter designed with SSI logic gates (J/K).
- Any additional logic may be used as needed to support the counter designs.

SIMULATION & BREADBOARDING:

Create your simulation in either Design Mode or PLD mode – keep in mind that it will need to be made in PLD mode eventually for use on the CMODS6 Chip. Get your design uploaded to the CMODS6 and breadboard your circuit!

Part 3: Tasks	*10-8 points*	*7-4 point*	*3-0 points*
Document Process	+ You kept track of your notes, brainstorms, sketches, and circuit designs in your engineering notebook	- You recorded very few notes of your design process - Notes hard to follow	- You took no notes on your design process
	15-10 points	*9-5 point*	*4-0 points*
60-Second Timer Challenge	+ You completed the 60-Second Timer Challenge as defined on this page	- You attempted but did not complete the 60-Second Timer	- You did not do the 60-Second Timer Challenge
Breadboarding	+ You used the CMODS6 chip to successfully breadboard your circuit + Mr. Benshoof saw your circuit count from 00 to 59 as intended	- Your circuit is not fully breadboarded - Your circuit does not properly count 00 to 59	- You did not breadboard your circuit at all
	10-8 points	*7-4 point*	*3-0 points*
Take Unit 8 Quiz	+ You took the Unit 8 Quiz on the website by the Quiz Due Date + Grade is based on number correct	N/A	(0 pts) You did not take the Unit 8 Quiz