

Name _____

EET 251 Lab #6 Counters

OBJECTIVES:

- 1) Simulate asynchronous counters constructed from flip-flops.
- 2) Simulate, build, and test circuits using a counter chip.
- 3) Display counter outputs on LEDs, on a seven-segment display, and on the oscilloscope.

EQUIPMENT REQUIRED:

- Integrated Circuits: 7447, 7493, Seven-segment display
- 220 Ω Resistor DIP (or seven 220 Ω resistors)
- Digital Circuit Trainer
- Digital Storage Oscilloscope with print capability
- Multisim simulation software

PART A

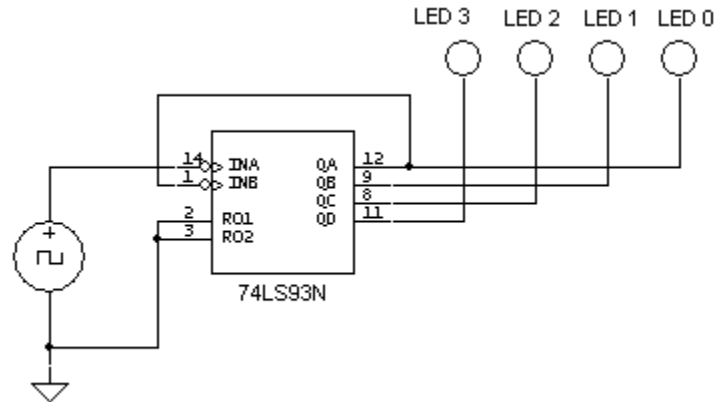
- § Figure 8-5 in the textbook shows a 4-bit asynchronous counter constructed from flip-flops. Using this diagram as a guide, and with the following additional instructions, draw the circuit in Multisim.
 - Use 74LS76 flip-flops.
 - Connect the first flip-flop's clock input to a Clock Voltage Source whose frequency is set to 20 Hz.
 - Connect the four output bits (Q_3 , Q_2 , Q_1 , and Q_0) to four red digital probes, and arrange the probes horizontally so that the most significant bit is on the left and the least significant bit is on the right.
- § Simulate the circuit, and you should see that it counts in binary from 0000_2 to 1111_2 , and then recycles.
- § When your Multisim circuit works correctly, ask me to check it. _____
- § Save the circuit, which you will modify in Part B.

PART B

- § Still in Multisim, modify your circuit to make it a MOD-10 counter. Use Figure 8-6 in the textbook as a guide.
- § Simulate the circuit, and you should see that it counts in binary from 0000_2 to 1001_2 , and then recycles.
- § When your Multisim circuit works correctly, ask me to check it. _____
- § Add an EET 251 title block showing:
 - Your name
 - Today's date
 - The title "MOD-10 Flip-Flop Counter"
- § Get a printout of your circuit and **turn it in with this lab.**

PART C

- § Still in Multisim, let's see how you can make your life much easier by using a counter IC instead of building counters out of flip-flops. The 7493 chip contains four flip-flops internally connected together to form a counter.
- § The diagram below shows how to use a 7493 as a MOD-16 counter, which counts from 0000_2 to 1111_2 and then recycles.



- § Build this circuit in Multisim.
- § Simulate the circuit, and you should see that it counts in binary from 0000_2 to 1111_2 , and then recycles.
- § When your Multisim circuit works correctly, ask me to check it. _____
- § Get a printout of your circuit (with title "MOD-16 7493 Counter" in the title block) and **turn it in with this lab**.

PART D

- § Now build the same MOD-16 counter circuit on the breadboard, using a 7493 chip. Use the TTL MODE terminal for your clock, and use four LEDs to display the output count. Set the clock's frequency low enough so that you can verify correct operation.
- § Notice that in this circuit the two reset pins (pins 2 and 3) are grounded. These reset pins are the key to modifying the counter so that it has a **truncated sequence**, which means it recycles before it counts all the way up to 1111_2 . Using these pins (and without using any additional chips), change your circuit so that it's a MOD-10 counter that counts from 0000_2 to 1001_2 and then recycles.
- § When your breadboarded circuit works correctly, ask me to check it.

Circuit works? _____ DIP inserted correctly? _____

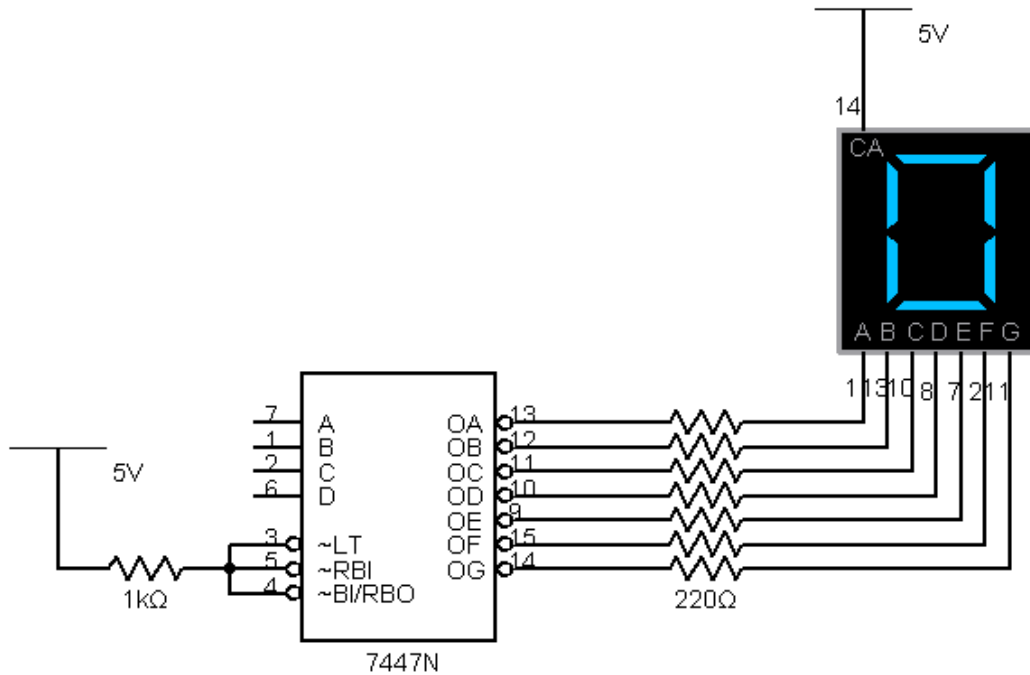
Using power bus? _____ Wire colors? _____

Wire lengths? _____ Wire ends trimmed? _____

DIP accessible? _____ *******DO NOT TAKE YOUR CIRCUIT APART.*******

PART E

- § **Do not take your circuit apart.** In the following steps you'll add to it.
- § Disconnect your counter's four output bits from the LEDs.
- § **Leaving your counter in place,** build the circuit shown below. Here we have a 7447 connected to a seven-segment display through seven 220 Ω resistors. Pin numbers are given on the diagram. (But use a data sheet to find power and ground pins for the 7447.)
- § After you've built this circuit, connect your counter's four output bits to the 7447's four input pins (labeled A, B, C, D in the diagram, with A being the least significant bit).



- § When you apply power, the display should count up in decimal from 0 to 9, and then recycle. (It might start at some number other than 0. That's okay.)
- § When your breadboarded circuit works correctly, ask me to check it.

Circuit works? _____ DIPs inserted correctly? _____

Using power bus? _____ Wire colors? _____

Wire lengths? _____ Wire ends trimmed? _____

DIPs accessible? _____

*******DO NOT TAKE YOUR CIRCUIT APART.*******

PART F

- § Now let's display the counter's output on the oscilloscope. Connect your counter's four output bits to the oscilloscope's four channels, in the following order:
 - Output bit Q_0 to oscilloscope Channel 1.
 - Output bit Q_1 to oscilloscope Channel 2.
 - Output bit Q_2 to oscilloscope Channel 3.
 - Output bit Q_3 to oscilloscope Channel 4.
- § Increase the clock frequency to 10 kHz. Use the frequency counter to get the frequency as close to 10 kHz as you can.
- § Arrange the four traces in order on the oscilloscope screen, with Channel 1 at the top of the screen and Channel 4 at the bottom. Make sure that at least one cycle of each waveform is displayed.
- § Also be sure to set your trigger appropriately to get a stable display without using the **STOP** button.
- § Use the oscilloscope's **MEASURE** button to simultaneously display the frequencies of all four waveforms, in numerical order with Channel 1's frequency displayed first and Channel 4's displayed last.
- § When you're satisfied with your display, ask me to check it. _____
- § Get a printout of the oscilloscope screen (including the four frequency measurements), and turn it in with this lab. Label it as **MOD-10 Counter**.

- § Finally, change the counter back to a MOD-16 counter. Leave the clock frequency at 10 kHz, and make sure that the oscilloscope is still displaying the frequencies of the four channels.
- § When you're satisfied with your display, ask me to check it. _____
- § Get a printout of the oscilloscope screen (including the four frequency measurements), and turn it in with this lab. Label it as **MOD-16 Counter**.

EET POST-LAB CHECKOUT

To be completed before leaving each lab session. Turn in the completed checklist with your lab report.

NAME _____ DATE _____ BENCH # _____

COURSE # _____ LAB # _____

Complete the following tasks and leave your workbench clean, safe, and neat before leaving the lab for the day.

Check	Lab Closeout Activity
	All equipment turned OFF.
	All lab power supply voltage and current controls set to minimum, including those on the trainer.
	DMM red test leads connected to voltage/resistance ports.
	All test leads loosely coiled and stowed. No dangling or tangled leads!
	Faulty or defective equipment reported to instructor.
	All components/jumpers removed from breadboard and stored properly in drawers, etc., not left on shelves in parts cabinet.
	Floor around your bench clear of dropped parts.
	Tools returned to storage box or drawer.
	Tool box properly closed and stowed on bench or in drawer.
	Instruments moved to back of bench or shelf, leaving clear workspace at the front of the bench.
	Borrowed parts and equipment returned.
	Personal items removed from bench: calculators, books, pens, papers, etc.
	Flash drive removed from computer.
	Trash placed in wastebasket.

Thank you!