Assignment 1A (30 marks) – Lab Week Two – The Digital Counter
Approximately 1.5 to 2 hours to complete

Due Date: By 11:30 P.M. Friday of Week Three using the Submission Link for Lab Week 2 – Assignment 1A: Multisim File

Note: You SHOULD be able to complete this by the end of your week TWO's lab period. Don't forget to submit your Multisim File – e.g. Lab2.ms14 by the deadline. DO NOT PUT YOUR SUBMISSION INTO A COMPRESSED FILE (e.g. Lab2.zip)

The Assessment Rubric accompanies the Submission Link – you should confirm that your submission is functional and completed in accordance with the Rubric – If you have any difficulties with the assignment, ask for assistance.
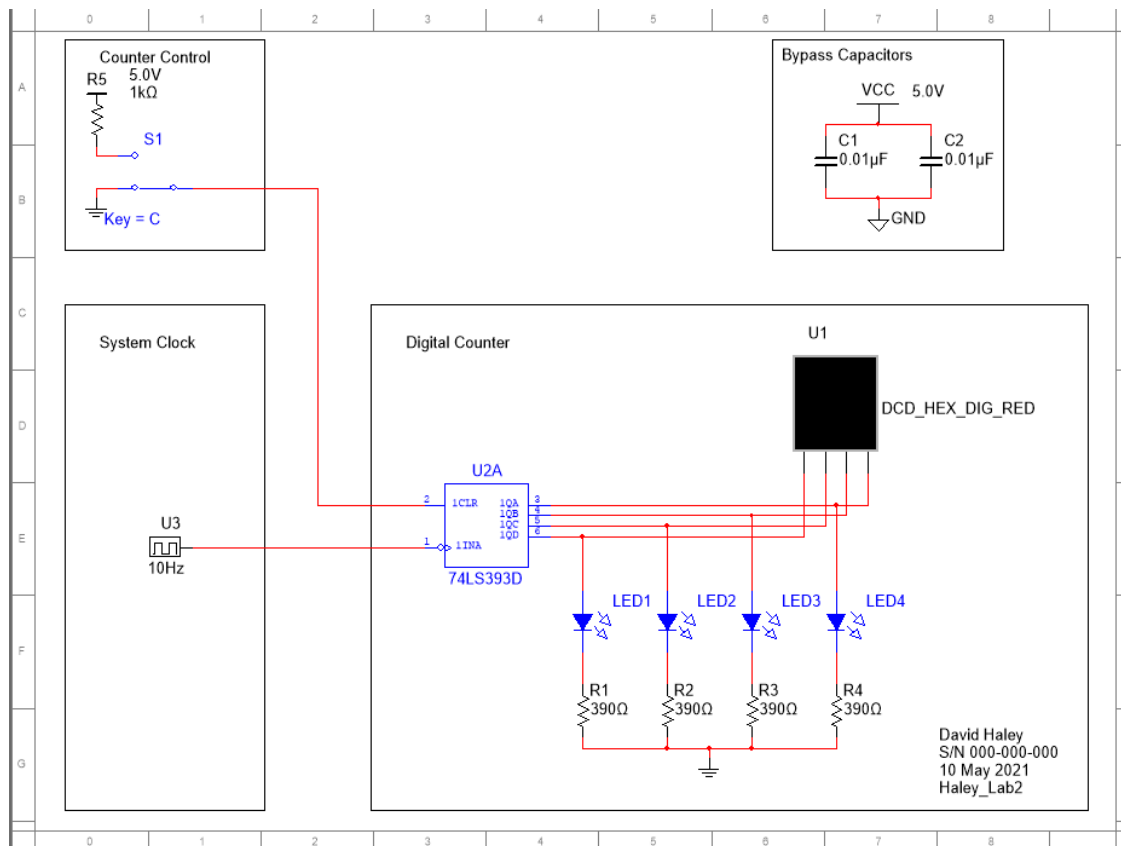

MSM Directory Structure

Create a folder on one of your hard drives or flash drives called CST8216. Then create a subfolder called Lab2.

Schematic Capture

Save your work OFTEN!

In this section, you will place and wire the components in the circuit shown in Figure 1 below.

After you complete this lab assignment, your schematic capture should look VERY close to the one depicted here.

In fact, you will be assessed on the completeness, neatness and placement of all components, including **your** Student Information.

Figure 1. Digital Counter System

Saving the File

When you first launch Multisim, the program opens a blank file on the workspace called "Design1".

To save the default file with a new name:
Select File/Save to display a standard Windows Save dialog.
Navigate to your CST8216\Lab2 folder and enter **<your last name> + "_Lab2"** as the filename and click on the Save button – i.e. **Langton_Lab2**.

To guard against accidental loss of data, you can set up a timed auto-backup and a "Security Copy" of the file. Use the menu item *Options → Global Options → Save* tab to do so. At the same time, you are selecting ***Auto-backup***, deselect ***Save simulation data with instruments*** as we will not use this feature in this course.

Respond "Yes" to dialogue boxes that indicate that new Template folders will be created.
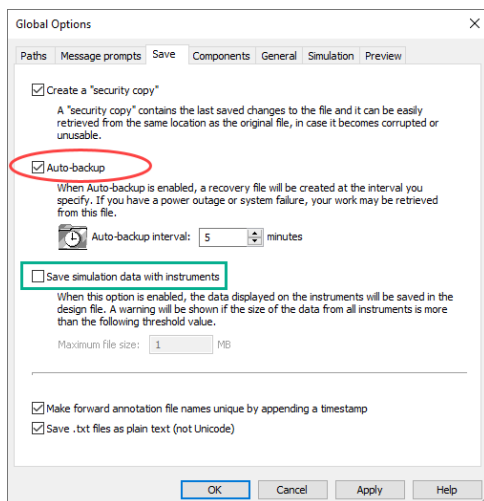
Setting the Correct Sheet Properties

To ensure that your schematic capture will correctly print on 8 ½" x 11" as a full-sized Landscape document, check the Sheet Properties using menu item **Options → Sheet Properties → Workspace→ Sheet Size t**o ensure that the following settings have been selected; otherwise, you may end only being able to print an unreadable, microscopic version of your schematic capture like example below. Now, chose the other indicated options as well.
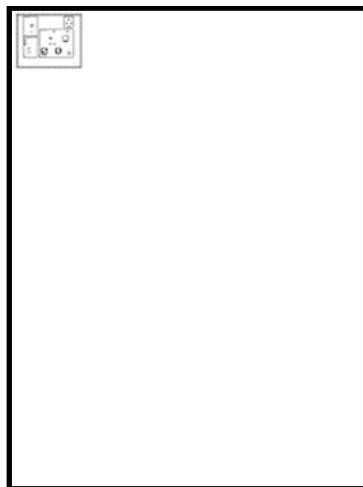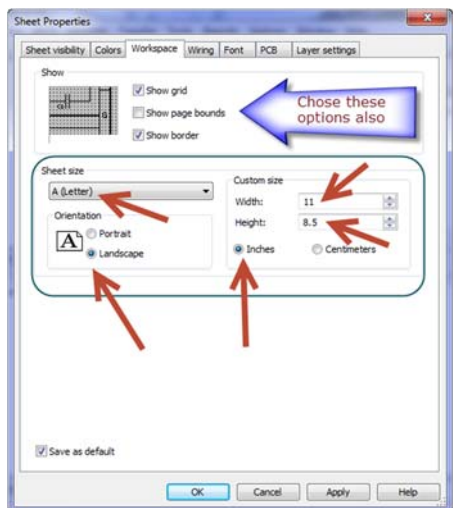
Placing the Components – Digital Counter Section

We will now build our schematic capture by placing the components on the blank schematic capture worksheet.

First, close the Spreadsheet View box at the bottom of the screen and then press F7 to provide maximum viewing area.

From the menu select **Place→Component** to display the **Select a Component** browser, navigate to the DCD_HEX_DIG_RED 7 segment display shown in Figure 2 below and click OK.
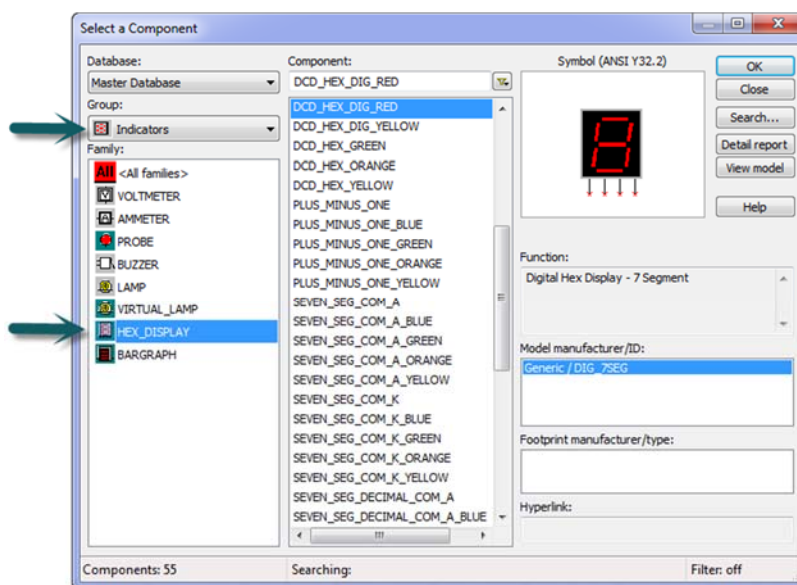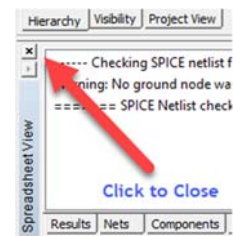

Figure 2. 7-Segment Display

The component appears as a "ghost" on the cursor. Note that this 7-segment display is unique because it decodes and displays values (hence DCD). More on this later in the course!

Moving your cursor, place the component in the position noted on the previous page (and magnified here), then left click to place the component. Since the font size is a bit too large, right-click on the component and then set up the font to Arial, Regular, 10 by clicking on the values so that they appear in the appropriate dialogue box.

At the same time, complete the configuration as per the circled values in the dialogue box.

Click on Apply followed by OK.
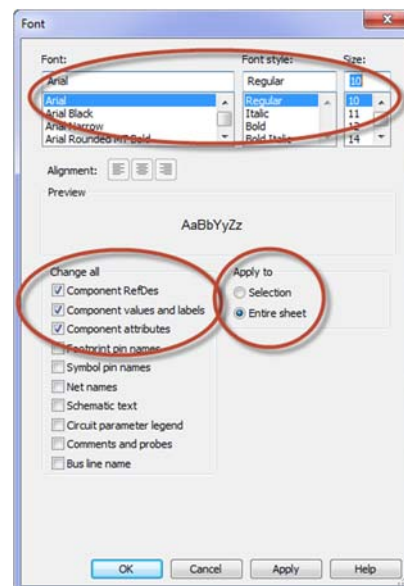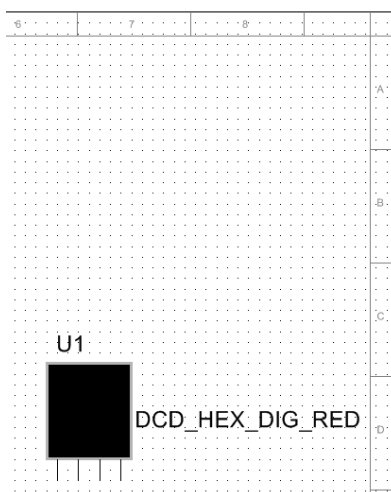
Now, place the remaining components in the Digital Counter area as shown in Figure 3 on the next page, noting that the paragraphs *immediately following* that Figure 4 on the next page contain detailed instructions on how to locate the required components in the component database.
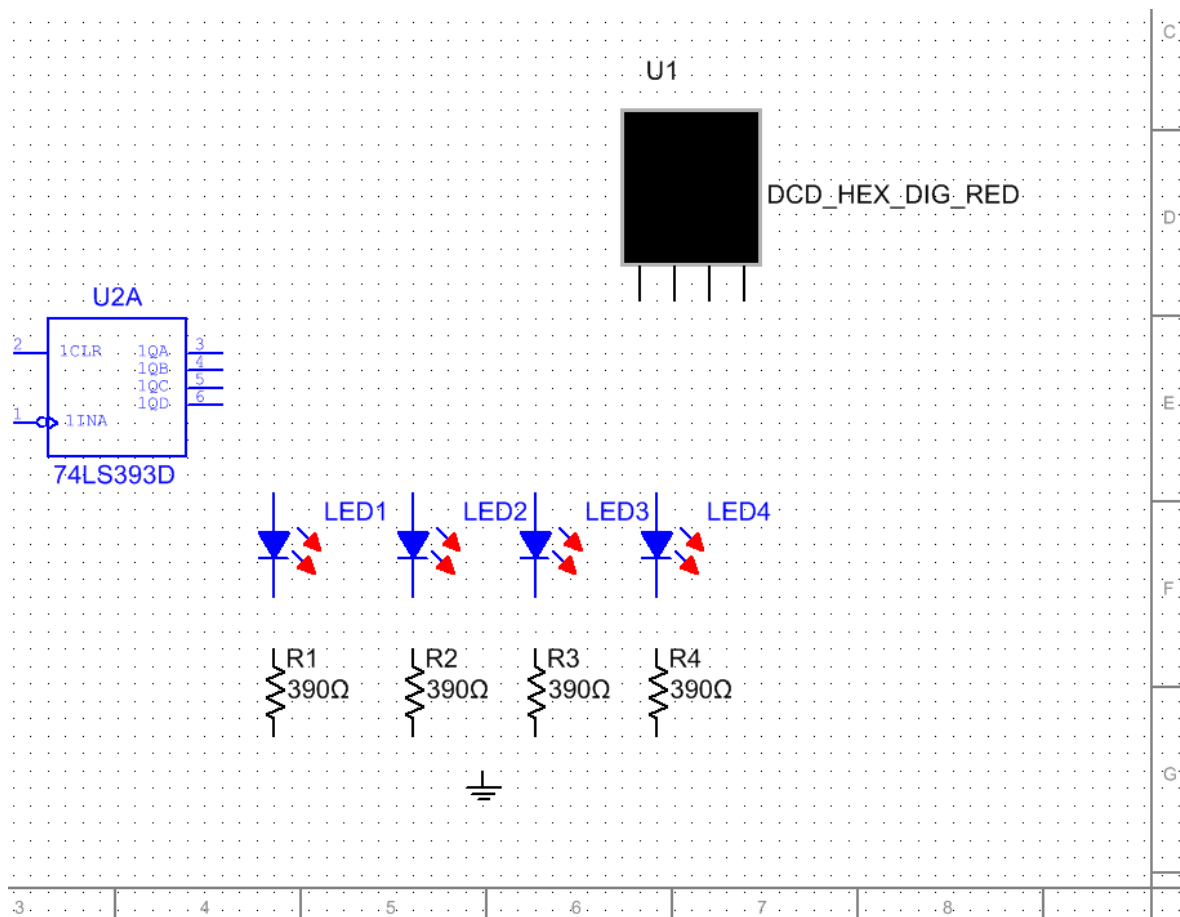

Figure 3. Digital Counter Components Layout

Locating the Components

The various components for the Digital Counter can be found by searching in the database as illustrated in the following figures.
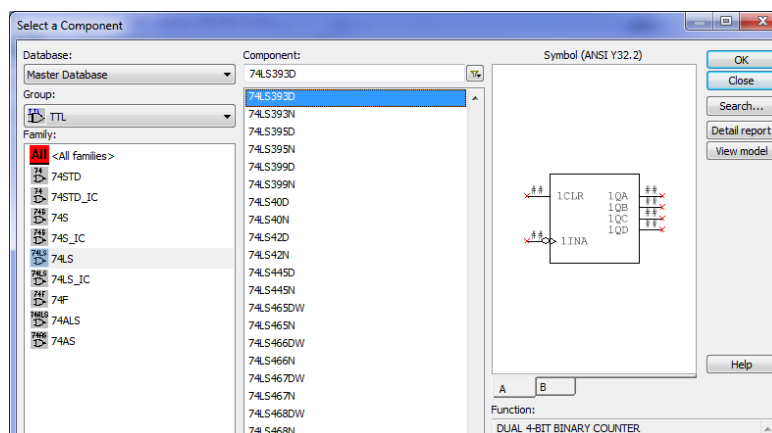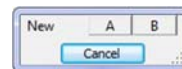

Figure 4. 74LS393D Dual 4-Bit Binary Counter

When you click OK to select the Dual 4-Bit Binary Counter, the following selection box appears. Since we only require one counter, click on **A** and place the counter on the schematic capture.

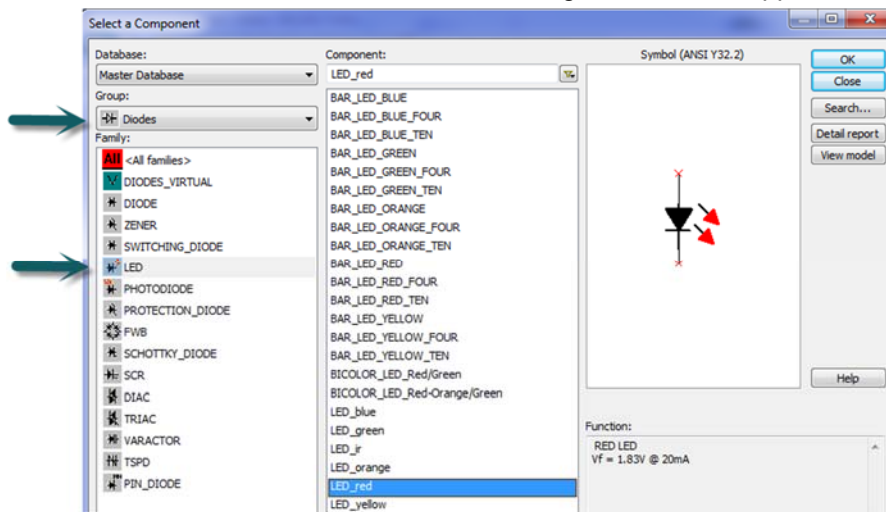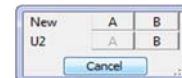Once you have done that, click cancel when the following selection box appears.

Figure 5. Red LED

Hint: After you place the first RED Light Emitting Diode (LED) on the schematic capture, you can "cut and paste" the remaining LEDs using <ctrl><c>, <ctrl><v> keystrokes.
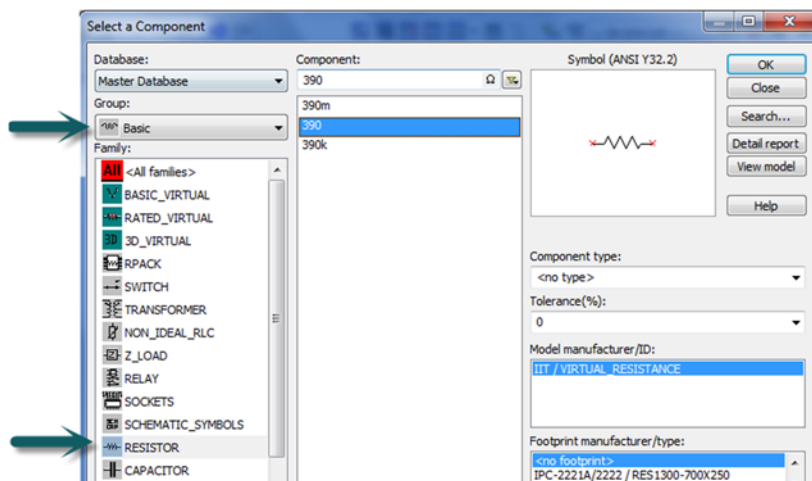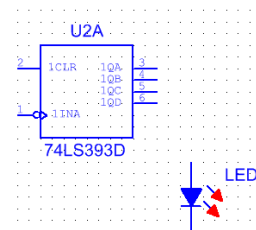

Figure 6. 390 Ω Resistor

As you place the 390Ω (where Ω is the symbol for ohms) resistors, rotate each of them to a vertical orientation using **Ctrl-R** as you move it to the desired location. Note that you can also "cut and paste" the resistors using <ctrl><c>, <ctrl><v> keystrokes.
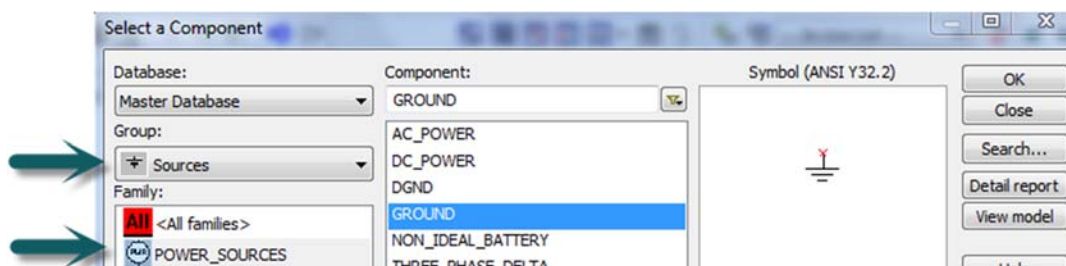

Figure 7. GROUND

Once you have placed all the Digital Counter components, draw a rectangle around that section of the system diagram and label it "Digital Counter" as illustrated in Figure 8 below. To draw the rectangle, from the menu use **Place → Graphics → Rectangle**, and to insert the text, use **Place → Text**.
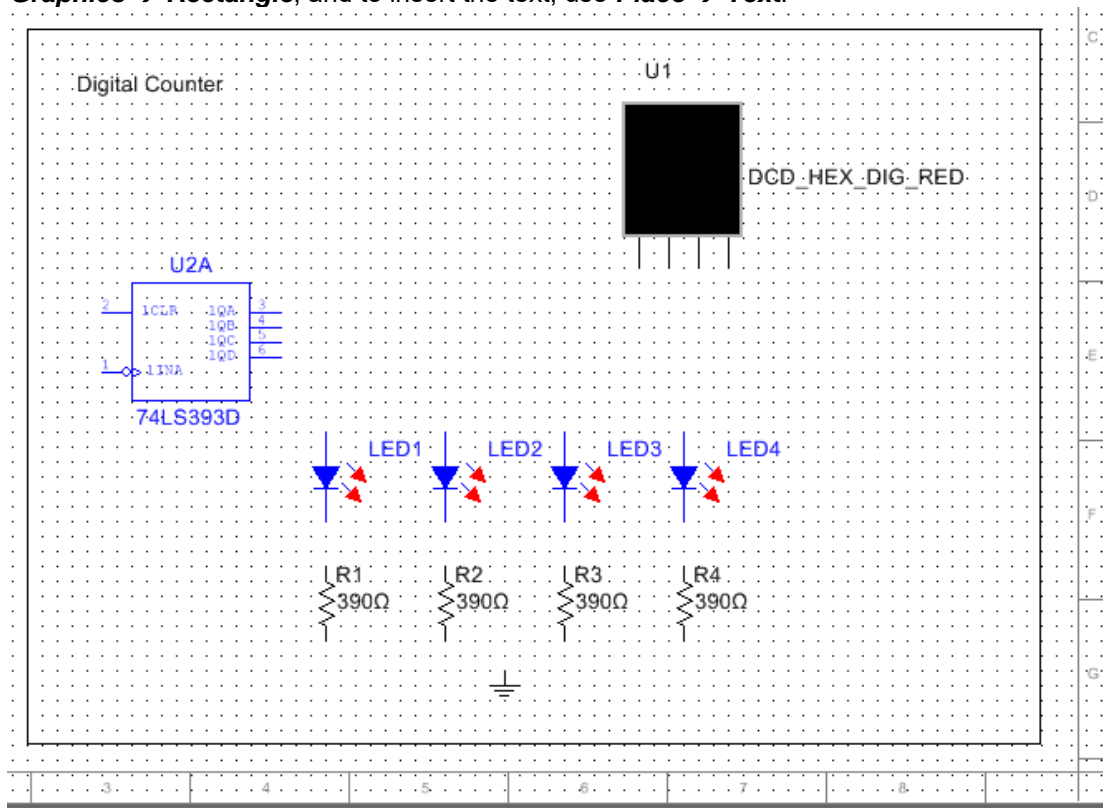

Figure 8. Unwired Digital Counter Components

Placing the Components – Bypass Capacitors Section

Next, we will construct the Bypass Capacitors section in the upper right-hand side of the schematic capture as depicted in Figure 1 on page 1 and Figure 9 to the right. Place its components as shown, then draw a rectangle around the section and label it.

Here are the locations for the components in the Master Database:

The VCC power source ⌐✗ (Click OK to continue when dialogue box appears that refers to the power source connection)

  → Group: Sources, Family: POWER_SOURCES, Component: **VCC**

Figure 9. Bypass Capacitors

The Digital Ground ▽ (Close the Spreadsheet View dialogue box if it reopens after placing the ground on the schematic capture).

  → Group: Sources, Family: POWER_SOURCES, Component: **DGND**

The 0.01µF ─┴─ Capacitors

  → Group: Basic, Family: CAPACITOR, Component: **0.01µF**
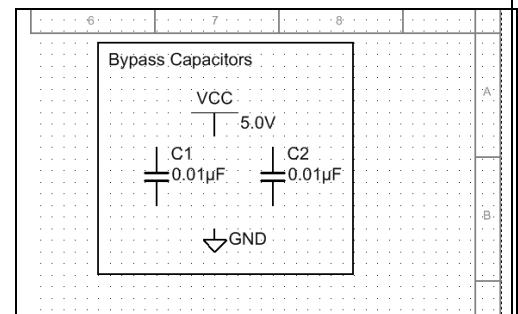Note that "µ" stands for micro, which is the multiplier 10^{-6}.

Note: The VCC power source ⌐✗ , and the Digital Ground ▽ symbols MUST be placed on EVERY Multisim schematic capture that contains **Digital components** (such as counters); otherwise, your design may not correctly function!
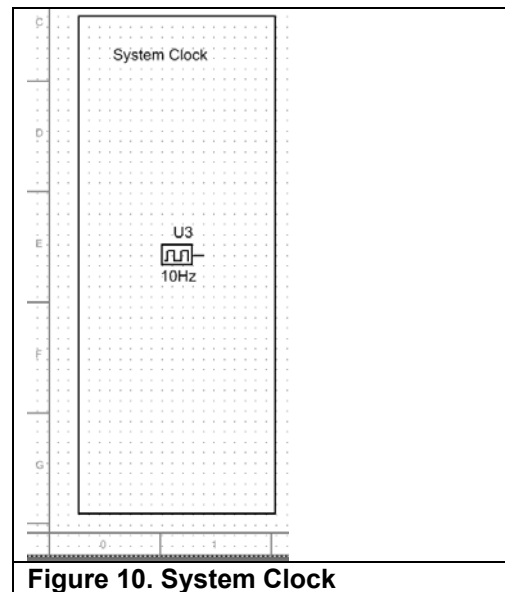
Placing the Components – System Clock Section

Next, we will construct the System Clock section in the lower left-hand side of the schematic capture as depicted in Figure 1 on page 1 and Figure 10 to the right. To do so, create a new area on the schematic capture, place its component as shown, then place a rectangle around the section and label it.

Here is the location for the component in the Master Database:

U3
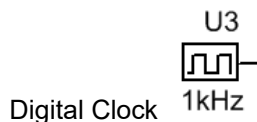
Digital Clock   1kHz

➔ Group: Sources, Family: DIGITAL_SOURCES, Component: **DIGITAL_CLOCK**

Note: Change the frequency of the DIGITAL_CLOCK to 10 Hz by double-clicking on it and changing the frequency from **1k** to **10.** If you successfully changed the frequency, your schematic capture should reflect the one in Figure 10.
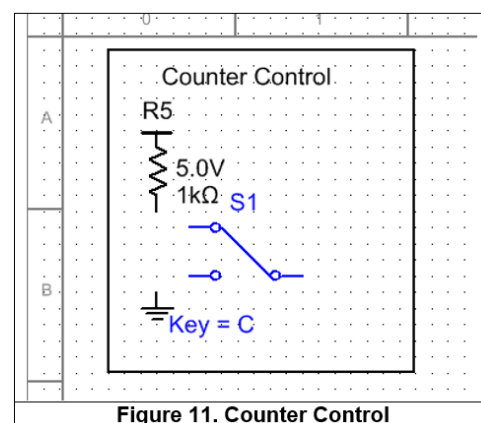

Figure 10. System Clock

Placing the Components – Counter Control Section

Next, we will construct the Counter Control section in the upper left-hand side of the schematic capture as depicted in Figure 1 on page 1 and Figure 11 to the right. To do so, create a new area on the schematic capture, place its component as shown, then place a rectangle around the section and label it.

Here are the locations for the components in the Master Database:

R5

The VCC power source/pull up resistor   5.0V
1kΩ

Figure 11. Counter Control
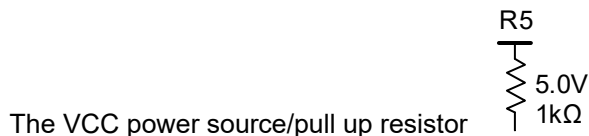
➔ Group: Basic, Family: RATED_VIRTUAL, Component: **PULLUP_RATED**

S1

Key = Space

The Single Pole Double Throw (SPDT) switch

➔ Group: Basic, Family: Switch, Component: **SPDT**

After placement, right-click on the SPDT switch and select Flip Horizontal to obtain the correct orientation of the switch. Since switch S1 is used to Enable/Clear the counter, we must change default name to a more meaningful one; in this case *Key = C* (C for Clear) by double-clicking on S1's *Key = Space* and changing the "Key for toggle" value to "C."

The Ground

➔ Group: Sources, Component: **GROUND**

The Unwired Digital Counter System

Your unwired Digital Counter System should now look like the schematic capture in Figure 12 below. If it does, then you are ready to wire the circuit. If not, ensure all components, names, rectangular blocks, etc. are correctly placed/aligned before continuing.
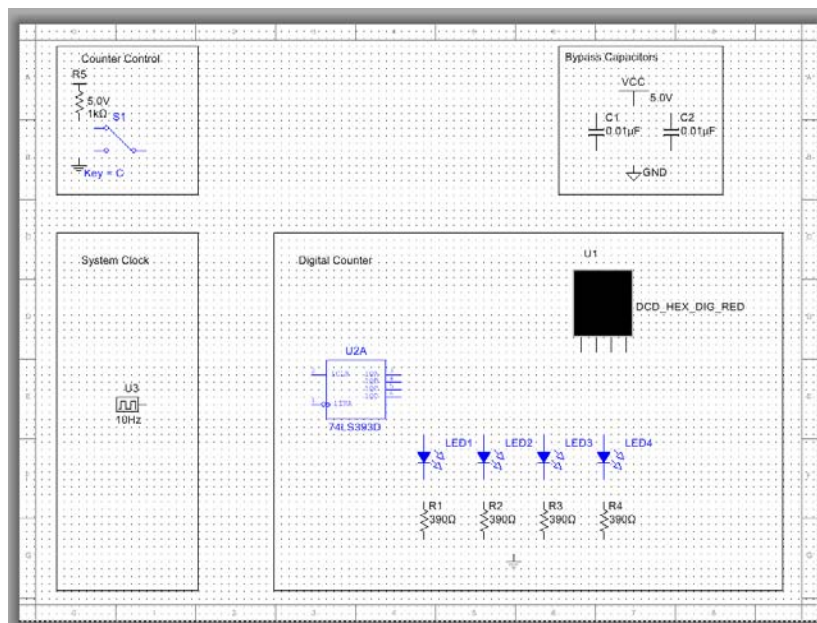

Figure 12. Unwired Digital Counter System

Wiring the Digital Counter System

Multisim is modeless; there is no need to toggle between wiring and part placement modes. As soon as your cursor is over a pin, Multisim knows you want to wire and the pointer changes to a crosshair.

To wire the circuit:

- Click on a pin on a component to start the connection and move the mouse. A wire appears, attached to your cursor.
- Click on the destination pin to finish the connection. Multisim automatically and intelligently places the wire.
- You can manually control the flow of the wire by clicking on points as you move the mouse. Each click "fixes" the wire to that point.
- If you find that you cannot wire components to a particular point in the circuit (e.g. the ground associated with the resistors, you can force a Junction Point by pressing on CTRL J.
- Finish wiring the circuit, and then insert your Student Information: Name, Student Number, Date, and File Name in the lower right-hand corner of the drawing as illustrated on page 1 of this document, substituting your own particulars.
- You should also turn off the "Grid" before printing your solution to hide the schematic capture placement dots. You do that from the View menu.
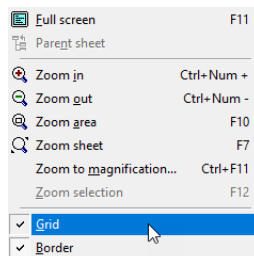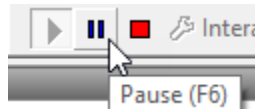
Simulation of the Digital Counter System

In this section, you will simulate the design.

After ensuring that you have changed the frequency of the DIGITAL_CLOCK to **10 Hz**, "run" the simulated design by
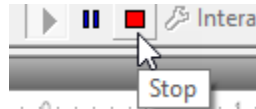clicking on the Green Arrow ▶ on the menu bar, or by pressing the **F5** key on your keyboard.

You can also Pause the simulation

and Stop the simulation.

Determine by investigation what functionality Switch1 (S1), controlled by the "C" key, has on this design, and what how the values displayed on the LEDs correlate with the values displayed on the HEX Display.

Important Note

If the LEDs do not work, it is likely that either you do not have the ground correctly connected to the bottom of each of the LEDs or that you must make a Settings change in Multisim (or both).

To make the setting change in Multisim, stop the simulation and then make the following **Simulate** configuration change in Multisim: