Assignment 1A (30 marks) – Lab Week Two – The Digital Counter

Submission Link for Lab Week 2 - Assignment 1A: Multisim file

This assignment can be completed during your Week Two lab period, provided you have completed week one's Multisim installation.

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

Lab Demo: Week 2 or Week 3.

Note: Submit your Multisim File – e.g. Langton_Lab2.ms14 by the deadline. DO NOT PUT YOUR SUBMISSION INTO A COMPRESSED FILE (e.g. Langton_Lab2.zip), as it will not be marked because it does not meet submission standards.

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.

Purpose of Lab – A Tutorial Quick Start with Multisim

This lab exercise leads you through the circuit design flow in Multisim from schematic capture to simulation. You will design and test a circuit that counts the occurrences of a clock signal on a simple digital counter. This lab work constitutes 30% of Assignment One's overall mark. It is advisable to read the entire lab before commencing it and view the on-line video that illustrates the required behaviour of your solution to this lab assignment.

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 lab, you will place and wire the components in the schematic capture shown in Figure 1 below, using the instructions provided in subsequent pages.

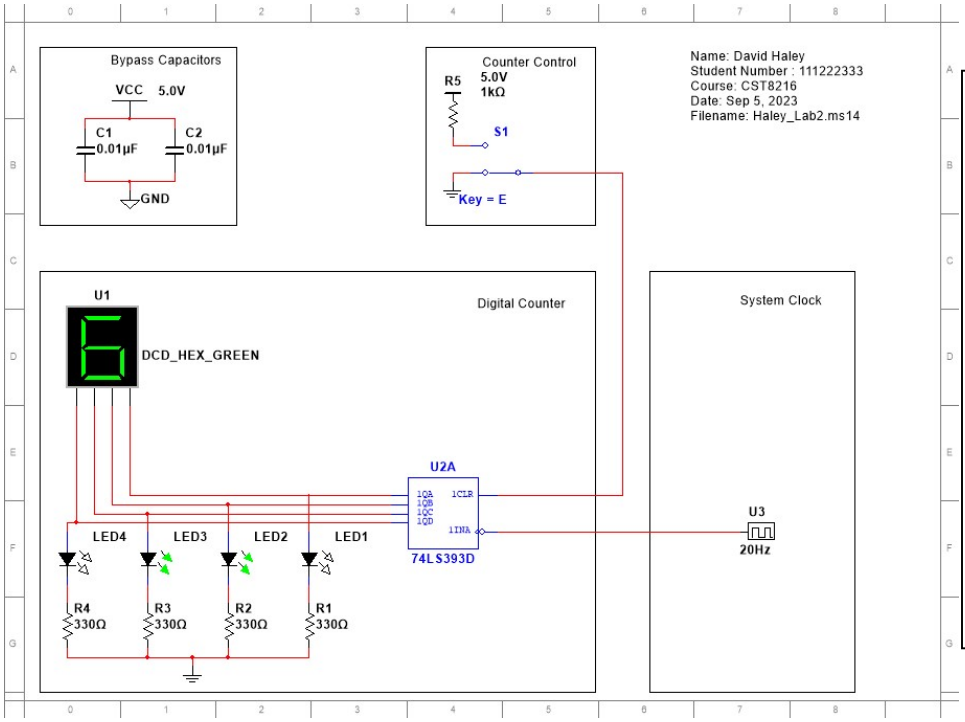


Figure 1. Digital Counter System

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.

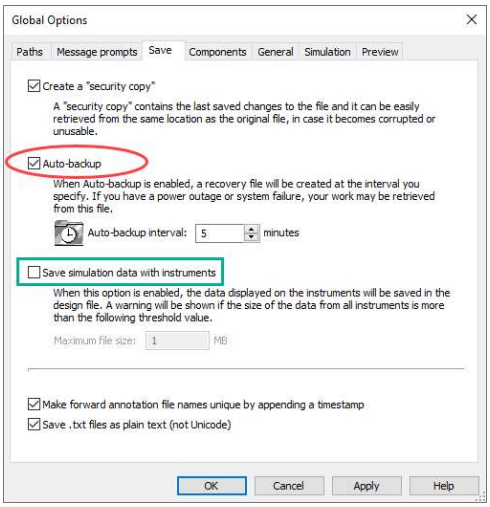
Saving the File

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**.

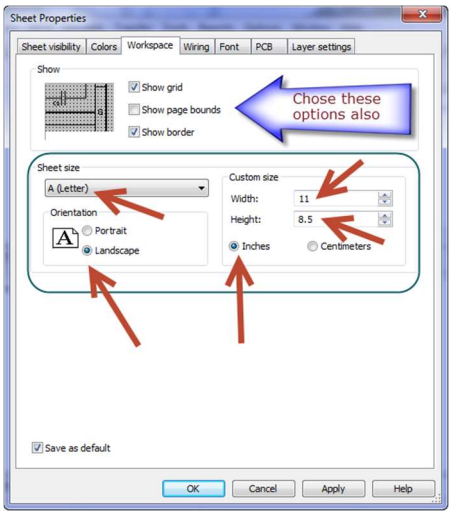
To guard against accidental loss of data, you can set up a timed auto-backup and a "Security Copy" of the file. Use the menu item ***Options → Global Options → Save*** tab to do so. At the same time, you are selecting ***Auto-backup***, deselect ***Save simulation data with instruments*** as we will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

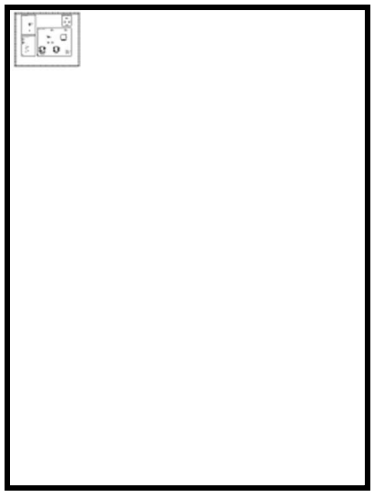
Respond “Yes” to dialogue boxes that indicate that new Template folders will be created.



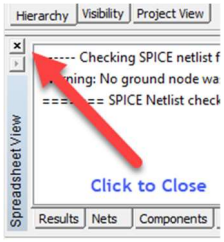
Setting the Correct Sheet Properties

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 Indicators → HEX_DISPLAY → DCD_HEX_GREEN and select the 7 segment display shown in Figure 2 below and click OK.

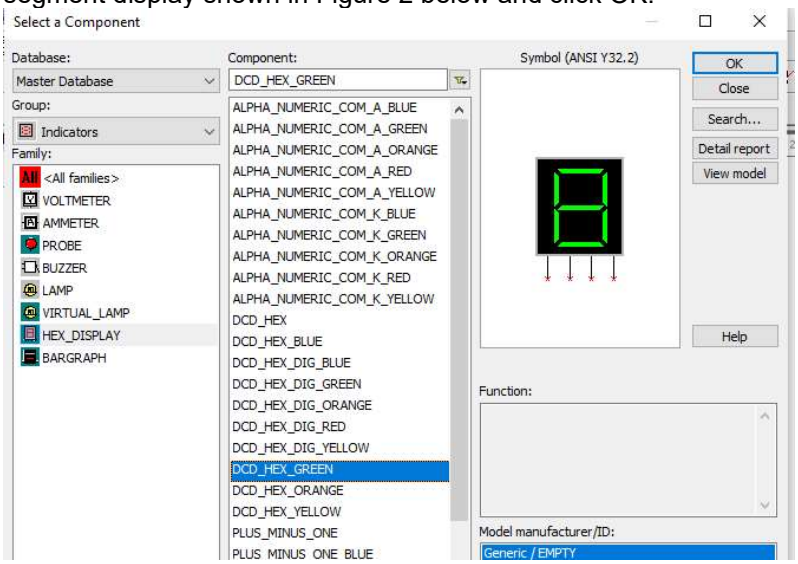
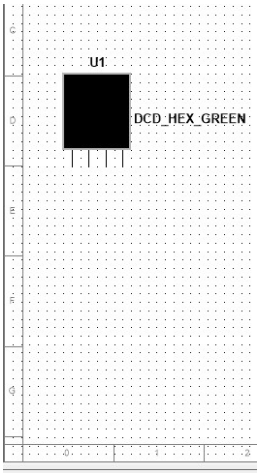
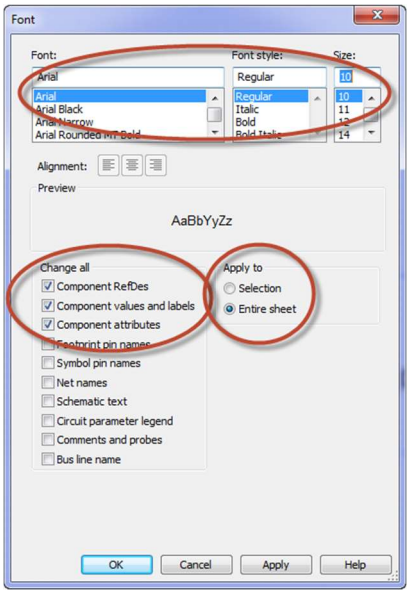


Figure 2. 7 - Segment Display

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! Note that the colour “green” may/may not show when placing the DCD_HEX_GREEN component; however, it will when the circuit is completed and run.

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.

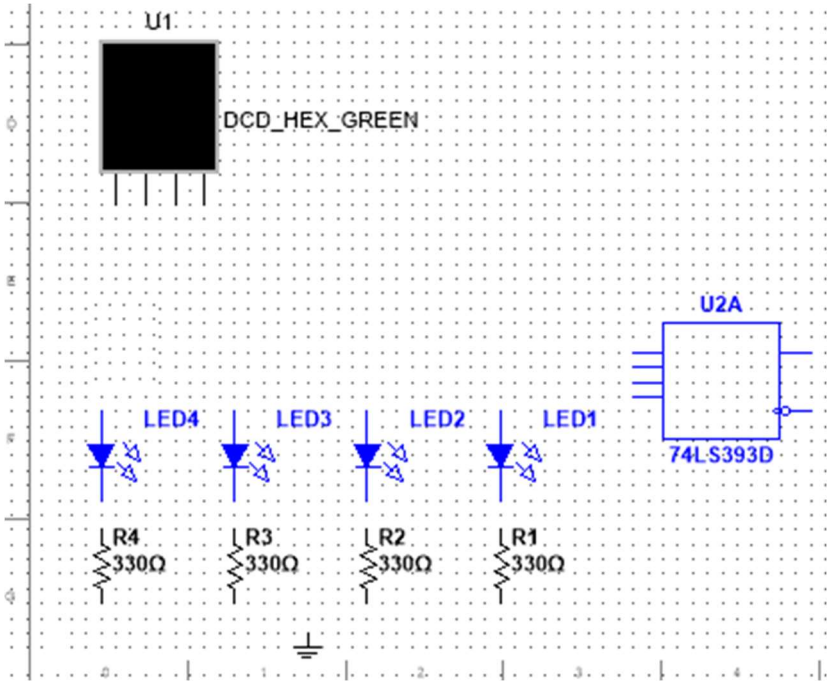


Figure 3. Digital Counter Components Layout

Locating the Components

The various components for the Digital Counter can be found by searching in the database as illustrated in the following figures (Navigate to TTL → 74LS → 74LS393D)

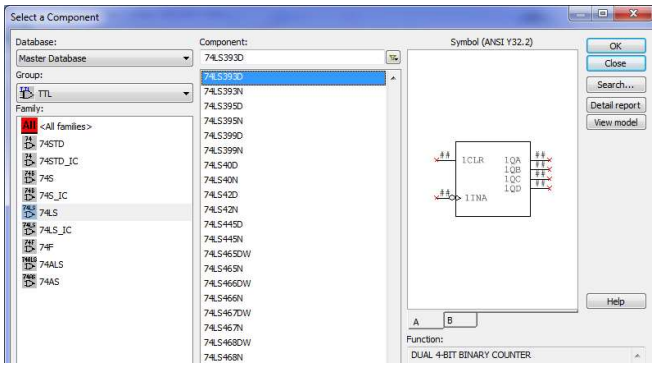
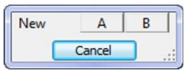
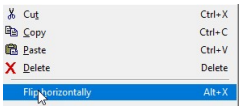


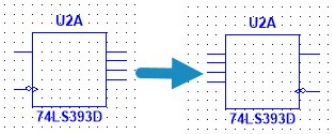
Figure 4. 74LS393D Dual 4-Bit Binary Counter



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 and then click on **Cancel**,

Now, flip the component horizontally by right-clicking on it, so that it appears as shown on the previous page and below.





Once you have done that, you are ready to place the Light Emitting Diodes (LEDs) as illustrated in the following figures. (Navigate to Diodes → LED → LED green)

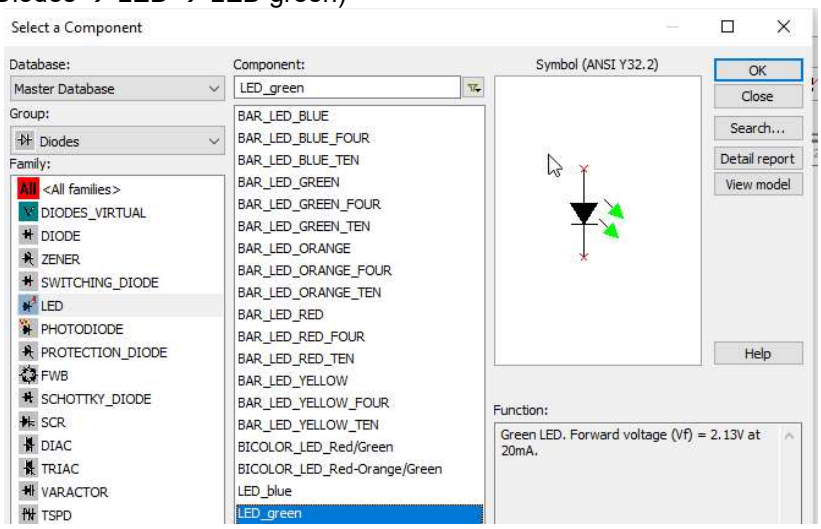
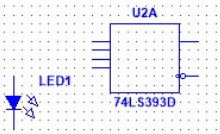


Figure 5. Green LED



Hint: After you place the first GREEN LED on the schematic capture, you can "cut and paste" the remaining LEDs using <ctrl><c>, <ctrl><v> keystrokes. Note that the colour “green” may/may not show when placing the LED; however, it will when the circuit is completed and run.

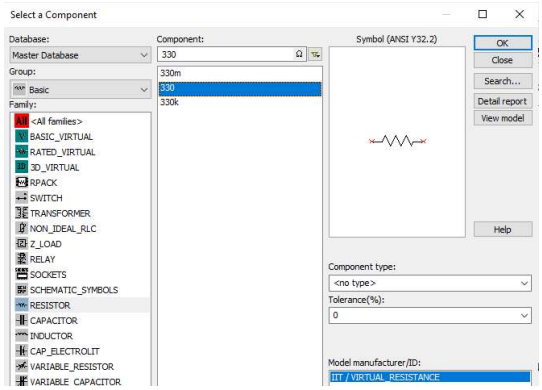
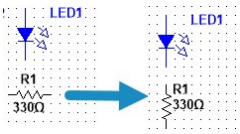


Figure 6. 330 Ω Resistor

Now, navigate Basic → Resistor →330. As you place the 330Ω resistors (where Ω is the symbol for ohms), rotate each of them to a vertical orientation using **Ctrl-R**, then move the rotated resistors to their desired locations. Note that you can also "cut and paste" the resistors using <ctrl><c>, <ctrl><v> keystrokes.



Now, navigate Sources → POWER_SUPPLIES → GROUND and place the GROUND at the correct position.

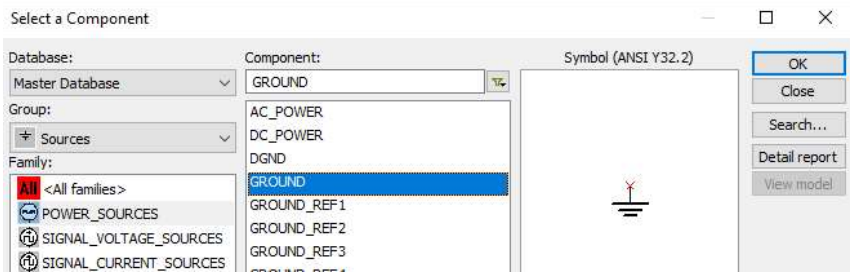


Figure 7. GROUND

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***.

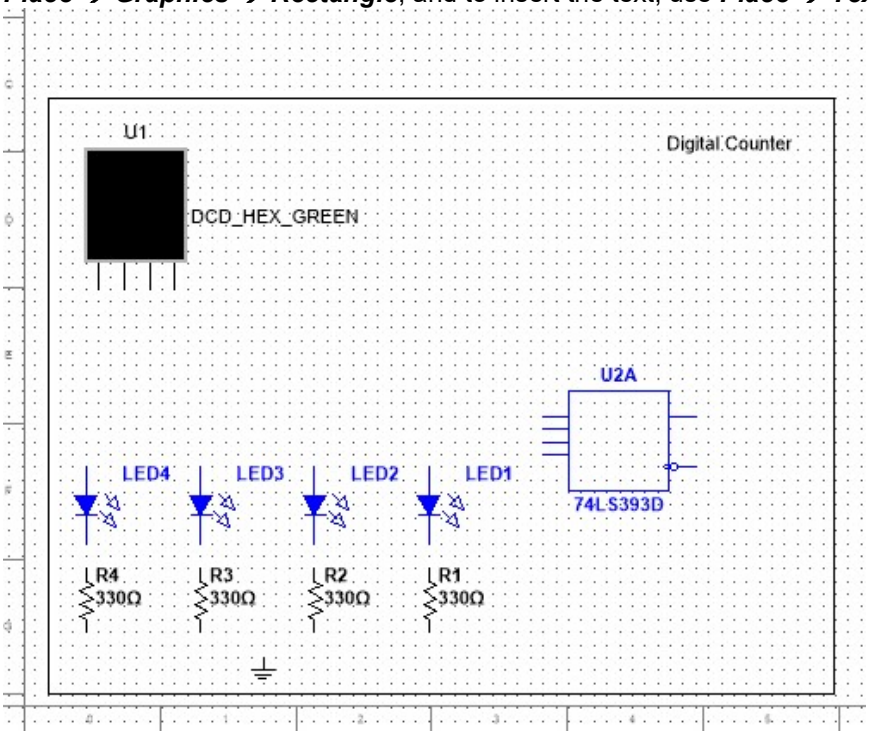


Figure 8. Unwired Digital Counter Components

Placing the Components – Bypass Capacitors Section

Next, we will construct the Bypass Capacitors section in the upper left-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.

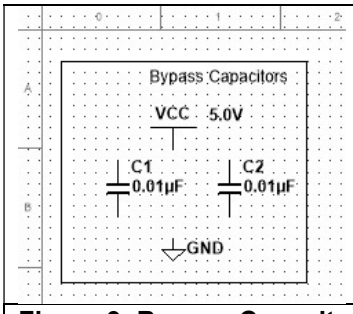


Figure 9. Bypass Capacitors

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**

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}.
Hint: In the Component Window, type "0.01" (without the quotes) → 0.01µ will appear

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 right-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.

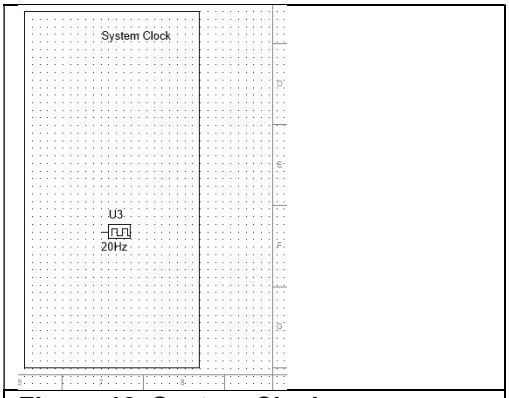
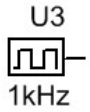


Figure 10. System Clock

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

Digital Clock 

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

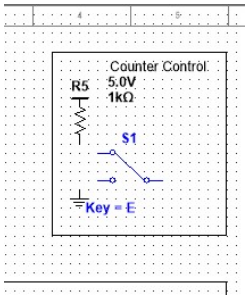
Change the frequency of the DIGITAL_CLOCK to 20 Hz by double-clicking on it and changing the frequency from **1k** to **20.** If you successfully changed the frequency, your schematic capture should reflect the one in Figure 10.

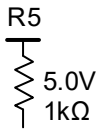
Now, flip the component horizontally by right-clicking on it, as you previously did for the 74LS393D component, so that it appears as shown in Figure 10.

Placing the Components – Counter Control Section

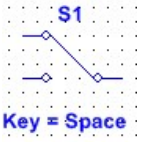
Next, we will construct the Counter Control section in the upper right-hand side of the schematic capture as depicted in Figure 1 on page 1 and Figure 11 to the right. To do so, create a new area on the schematic capture, place its component as shown, then place a rectangle around the section and label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

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



The VCC power source/pull up resistor 

➔ Group: Basic, Family: RATED_VIRTUAL, Component: **PULLUP_RATED**

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 = E*** (E for Enable) by double-clicking on S1's ***Key = Space*** and changing the "Key for toggle" value to "E."

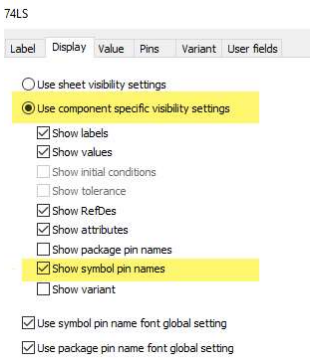
The Ground 

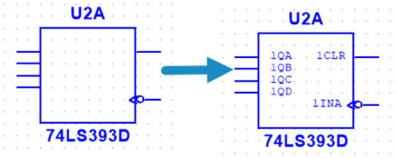
➔ Group: Sources, Component: **GROUND**

Displaying the Pin Names on Components

As illustrated in Figures 3 and 8, the 74LS393D Component does not have any associated names on its input/output lines. As such, we must make those visible prior to wiring the Digital Counter.

To do so, right-click on the 74LS393D component and make the highlighted changes in the Display tab. After clicking on OK, you would see the following results.





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.

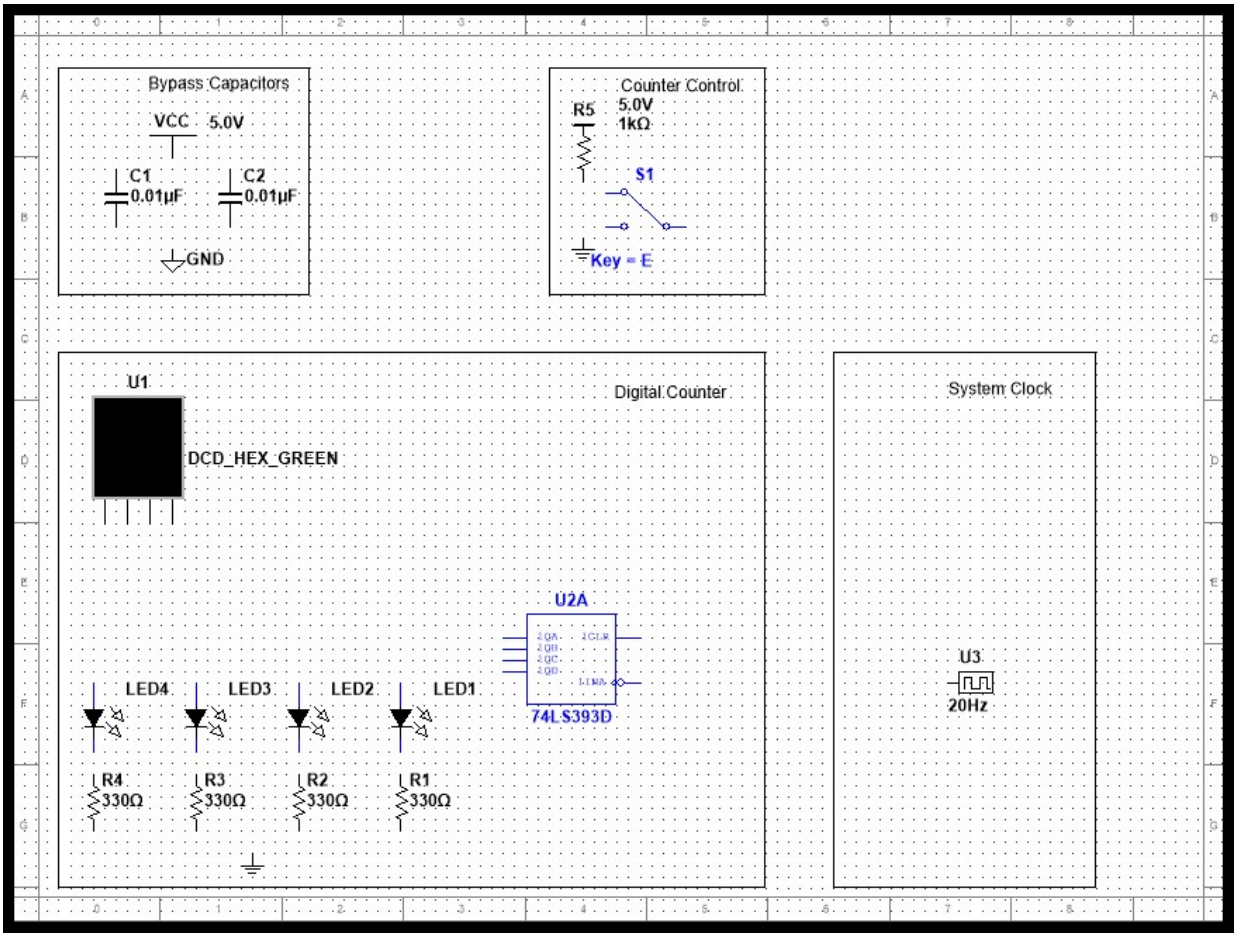


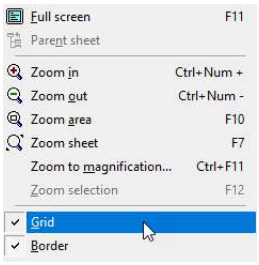
Figure 12. Unwired Digital Counter System

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:

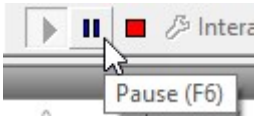
- Click on a pin on a component to start the connection and move the mouse. A wire appears, attached to your cursor.
- Click on the destination pin to finish the connection. Multisim automatically and intelligently places the wire.
- You can manually control the flow of the wire by clicking on points 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>, holding that key, then pressing on <J>.
- Finish wiring the circuit, and then insert your Student Information: Name, Student Number, Course, Date, and File Name in the upper 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 submitting printing your solution to hide the schematic capture placement dots. You do that from the View menu.



Simulation of the Digital Counter System

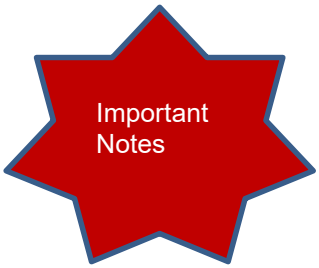
In this section, you will simulate the design.

After ensuring that you have changed the frequency of the DIGITAL_CLOCK to **20 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. 

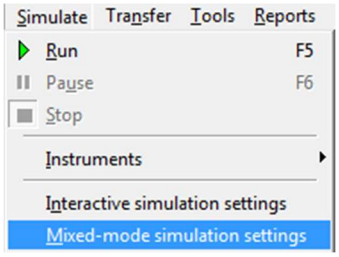
Determine by investigation what functionality Switch1 (S1), controlled by the "E" key, has on this design and what how the values displayed on the LEDs correlate with the values displayed on the HEX Display.

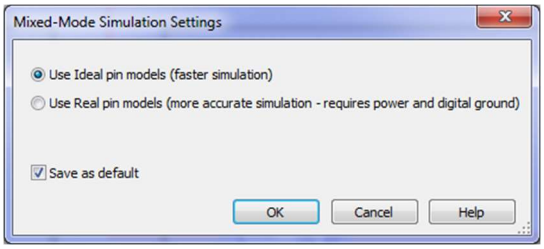


LEDs Not Displaying the Binary Count

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).

If the simulation does not run at all or is very erratic, you may have to make a setting change in Multisim; stop the simulation and then make the following **Simulate** configuration change in Multisim:





Warning Message
If you get the following warning message when you run an Interactive Simulation, you can **ignore the message**:

"Probes do not plot to the Graphed for interactive simulation. Connect an oscilloscope or run a transient simulation to see Grapher data."

Simulation Error Message
If you get the following error message when you run an Interactive Simulation in Multisim, **answer No**.
"A simulation error has occurred. Would you like to run the Convergence Assistant to attempt to resolve this problem automatically?"
Then, check your circuit to ensure that you have used both types of grounds in it (for the Digital Counter Lab) and that no wires have been mistakenly cross-connected with each other, shorting out an input or output to/from one of the circuit components such as the Counter chip or Hex Display.

