COUNTER IMPLEMENTATION AND DIGITAL PROBES

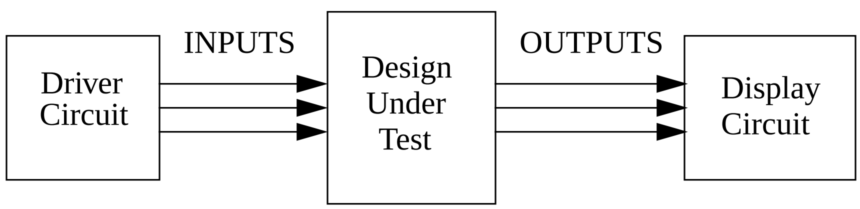
ECE 221 **Fall 2003**

I. OBJECTIVE

The objective of this lab is to build one counter (the modulo 16/10 ripple counter) that you created in Design Project #5 and use the digital probes on the oscilloscope to verify your design is working correctly.

II. INTRODUCTION

Over the past semester you have used the Mentor Graphics software to develop electronic prototypes of various designs. The advantage of using CAD tools such as Mentor is that designers are able to verify their designs before they are actually built. This strategy can save companies both time and money because design errors can be found and corrected before physical implementation. It is important to realize, however, that design does not end with the development of an electronic prototype. The electronic design must be built and tested before it can be truly evaluated. There is no guarantee that an electronic prototype that is verified functionally correct via simulation will work properly when built or will not be difficult to manufacture. In this lab you will build and debug one of the counter designs you have designed electronically. We will use the same test bed as we have done in past labs as shown below:.



For this lab, the *design under test* represents your counter design and is surrounded by a *driver circuit* and a *display circuit*. The driver circuit drives the inputs to the design while the display circuit displays the outputs of the design. The driver circuit used with your counter design will be a set of switches and a square wave from the function generator to create a clock. Instead of using LEDs or seven-segment displays as we have done in previous labs, the display circuit in this lab will be the oscilloscope.

III. PRELAB

In the lab you will implement your minimized design of the ripple counter from the design project. To assist in wiring up your design, you will be introduced to another Mentor tool called *Package* which will automatically place pin numbers on your schematic.

Package is a part of the Printed Circuit Board (PCB) toolset in Mentor. These tools help designers translate a schematic into a set of documents that can be used by manufacturing to build a prototype system. NOTE: The *Package* software does not run correctly when using the x-terminal interface (xterm). Follow the steps below access and automatically generate pin numbers for your design.

1. Go to the directory where your minimized design schematic is located and type in:

   ```
   package ripple (or whatever you named your design)
   ```

   This will start the package software. As the software is starting you will see a large number of warnings scroll in your command window (it might take a minute). Just disregard these. When the **Report - Startup** window appears just close it.

2. The main window shows the parts in your schematic along with the quantity of each part. On the palette, select the **Build** option. When the Build window appear, put the following location in the

Default Component Geometry box.

```
/usr/local/mentor/pkgs/parts_lib/bpl_rls_lib/pcb_geoms
```

These geometries tell the tool how many parts are on each IC and what the pin numbers are for the inputs and outputs. Hit OK to start the build process. Once the build has finished another report window will appear. Scroll down to the bottom of the window and you should see the following statement:

```
No errors found in pins or used mapping files
```

If you don't see that message, try working through this step again and then if it fails again contact the instructor. Close the Report window.

3. Select the **Save->Design All** option under the **File** menu. When the Save window appears, select **Yes** for the **Back Annotate PCB Design Viewpoint** and then hit OK. This will create a viewpoint of your design schematic that has the pin numbers for all of the ICs on it. A *viewpoint* in Mentor is simply a representation of your schematic that has special properties placed on it so it can be used with other Mentor tools. The viewpoint this tool creates is named **pcb_design_vpt** and is found under your **ripple (or your name)** directory. Close the report window that appears and then exit the Package tool by selecting **Session** on the palette followed by **Close Session** on the new palette that appears.

4. To open the viewpoint, first start up Design Architect. When the main Design Architect window appears, select **Set Viewpoint** on the palette. When the Set Viewpoint window appears, type in **ripple (or your name)** as the **Component Name** and if it is not already there, type **pcb_design_vpt** for the **Viewpoint Name**. Hit **OK** and then when the **Open Design Sheet** window appears hit **OK** again. You should see your schematic and when you zoom in on a part, the IC number (U#) and the pin numbers for that IC will be shown in red. Print out the schematic and bring it to lab.

IV. PROCEDURE

1. Using your schematic as a guide wire up your entire circuit. Switches should be used for **MOD10** and **CLR_BAR** inputs. These switches should be connected as you have done in previous labs (with a 10K pull-up resistor). For the clock pulse create a 0-5 volt 1 KHz square wave using the function generator. Attach longer wires to your four outputs so that they can be connected to the oscilloscope via digital probes.

2. Once your circuit is completed you will need to connect the digital signal probes from the oscilloscope to your design as described below.

   2.1) Plug the 16 channel adapter and two flex cables into the slot on the lower right hand corner of the oscilloscope. Each of the flex cables has 8 digital probes leads that can be connected to your design. For this design we will only be using one of the flex cables (up to 8 probes).

   2.2) Attach the clips to the ends of the probes that are labeled 0 through 4. These are attached by inserting the leads into either side of the clip assembly.

   2.3) Clip the digital probe 0 to the clock signal, digital probe 1 to ripple output 0, digital probe 2 to ripple output 1, digital probe 3 to ripple output 2 and digital probe 4 to ripple output 3. Also clip the GND probe to your ground line

3. Once you have connected the digital probes you are now ready to see if your circuit is working correctly. To accomplish this you will need to set up the oscilloscope so that it triggers on a certain event. There are three different trigger types: edge trigger, pattern trigger and advanced trigger. For this lab we will you will use a pattern trigger. Follow the steps given below to set the trigger and verify your circuit is working correctly.

3.1) Select the **Pattern** button. Rotate the **Entry** knob (just left of the **Auto-Scale** button) to scroll through the different digital channels. At channel **D4** select **L** from the items on the screen. Repeat the same process for channels **D3**, **D2**, and **D1**. For channel **D0** instead of **L** select the falling edge symbol from the items on the screen. These settings will trigger data acquisition when then count is at 0000 and the clock is on the falling edge.

3.2) Turn on the digital channels by pressing the **D0-D7** button. You should see a set of output waveforms. Make sure the waveforms fill the entire screen. If they don't toggle the screen item to the largest setting. Use the time knob in the **Horizontal** section to increase your view and verify your design is working correctly for both the binary operation and the modulo-10 operation. If it is not, determine from the waveforms which outputs are incorrect and fix your circuit. If you are not sure how to fix your design try attaching more digital probes to your circuit to isolate the problem (clear input to each flip flop, power and ground lines, etc.).

3.3) Once your waveforms are correct, use the **Quick Print** button to print out waveforms of both the binary operation and Modulo-10 operation. Print copies for both you and your partner.

4. The digital probes can also be used to measure delay in a circuit. Use the cursors to measure the amount of delay that occurs when the output changes from 1111 to 0000 in binary mode. Specifically, measure the delay from the falling clock edge to ripple output 0, from ripple output 0 to ripple output 1, ripple output 1 to ripple output 2 and ripple output 2 to ripple output 3. Then sum all of the delays to get the total propagation delay. When the time scale is zoomed in around the change from 1111 to 0000 your signals might appear jittery. This is due to the continual triggering that is occurring. To remove the jitter, hit the **Single** button in the **Run Control** area. This will run one acquisition of the data from the trigger point.
5. When you are done, clear the trigger patterns for the channels (return them to X). Then place both the clips and adapter/flex cables in their proper pouches and put them on top of the oscilloscope.

V. CONCLUSION

In your lab notebook write a paragraph which summarizes what you did in this experiment and the conclusions you obtained, and then separately answer the following questions.

1. What is the main problem with using ripple counters?
2. What are the advantages of using the digital probes for verifying circuits?
3. Why are the propagation delay times different between the output values?