Name_____

EET 131 Lab #2
Oscilloscope Introduction

Equipment and Components

Tenma Logic probe/pulser
ETS-7000 Digital-Analog Training System
Fluke 45 Digital Multimeter
Tektronix TDS2014 Digital Storage Oscilloscope
Integrated Circuits: 7493

Part 1. Breadboarding Guidelines

Start by reviewing the breadboarding guidelines posted on the course website (also at http://people.sinclair.edu/nickreeder/eet131/breadboardingTips.htm.)

Part 2. Trainer's TTL MODE Terminal

For many digital circuits, you'll need to apply a square wave of a certain frequency as the circuit's input signal. As you know from EET 114, the trainer has a function generator that can produce sine waves, triangle waves, and square waves. When you used this function generator in EET 114, you probably inserted wires into the terminal labeled **OUTPUT**. But for digital circuits, you will not use the function generator's **OUTPUT** terminal. Instead, you'll use the terminal labeled **TTL MODE**.

Later in this lab we'll use the oscilloscope to examine the signal from this TTL MODE terminal. For now, let's see what we can find out using a logic probe.

1. Using a short red wire and a short black wire, connect your logic probe clips to +5 V and Ground on the trainer.

2. Set the function generator's RANGE switch to x1, and set its FREQUENCY knob to 1. With these settings, what frequency have you set the function generator to produce?

   _____

3. Turn on the trainer's power. Touch your logic probe's tip to the trainer's TTL MODE terminal. What do you observe?

   _____

4. Set the function generator's RANGE switch to x10, and set its FREQUENCY knob to 1. With these settings, what frequency have you set the function generator to produce?

   _____

5. Touch your logic probe's tip to the trainer's TTL MODE terminal. What do you observe?

   _____

6. Set the function generator's RANGE switch to x100, and set its FREQUENCY knob to 1. With these settings, what frequency have you set the function generator to produce?

   _____

7. Touch your logic probe's tip to the trainer's TTL MODE terminal. What do you observe?

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Part 3. Setting Up the Oscilloscope

1. Turn the Tektronix TDS2014 oscilloscope on. After a few seconds of warming up, it will display a screen asking you to choose your language. To move past this screen, either press a button or wait a few seconds for this screen to disappear.

2. The Channel 1 trace should be displayed as a flat yellow line on the screen. If it is not displayed, press the **CH1 MENU** button.
    - Notice that pressing this button multiple times will toggle Channel 1 on and off.

3. On the right-hand side of the screen you should see the CH1 menu, which lets you control five settings for Channel 1. For this lab, and for most work with digital circuits, we want these settings as follows:
    - Coupling: **DC**
    - BW Limit: **Off**
    - Volts/Div: **Coarse**
    - Probe: **10X**
    - Invert: **Off**

    Check these settings, and correct them if needed by pushing the menu buttons next to the screen.

4. Check the switch on the probe attached to Channel 1, and make sure that it is set to the same value (**10X**) that you just checked on Channel 1's menu.

5. In the screen's lower left-hand corner, note the value of Channel 1's VOLTS/DIV setting. We want it to be **5.00 V**. Set it to this value by rotating Channel 1's VOLTS/DIV knob.

6. Repeat Step 2 through Step 5 for Channel 2 (which is blue) and Channel 3 (which is purple).

7. Near the bottom center of the screen, note the oscilloscope's SEC/DIV setting. We want it to be **250 µs**. Set it to this value by rotating the SEC/DIV knob.

8. Press the **TRIG MENU** button. On the right-hand side of the screen you should see the trigger menu, which lets you control five trigger settings. For this lab, and for most work with digital circuits, we want these settings as follows:
    - Type: **Edge**
    - Source: **CH1**
    - Slope: **Rising**
    - Mode: **Auto**
    - Coupling: **DC**

    Check these settings, and correct them if needed by pushing the menu buttons next to the screen.

9. Using each channel's vertical position knob, adjust the traces so that the Channel 1 waveform is located near the top of the screen, and the Channel 2 waveform is located near the middle of the screen, and the Channel 3 waveform is located near the bottom of the screen.

10. Connect Channel 1's probe to the oscilloscope's terminal labeled **Probe COMP ~5V @ 1kHz**. This will display a square wave on Channel 1. The display may not be stable. Note the small

yellow arrow near the right edge of the display. This indicates the level of the Channel 1 trigger. Move it up or down by rotating the **TRIGGER LEVEL** knob. Notice that you get a stable display when this arrow is between Channel 1's minimum and maximum limits, but you get an unstable display when you move the arrow outside these limits.

11. Ask me to check your setup before you go any further._____

Part 4. Trainer's TTL MODE Terminal

Let's use the oscilloscope to examine and measure the signal from the trainer's TTL MODE output.

1. Set the function generator's RANGE switch to x1k, and set its FREQUENCY knob to 1. With these settings, what frequency have you set the function generator to produce?

   _____

2. Disconnect Channel 1's probe from the "Probe COMP ~5V @ 1kHz" terminal and use a short piece of red wire to connect the probe to the trainer's TTL MODE terminal. Also use a short black wire to connect the oscilloscope probe's ground clip to the trainer's Ground. You should see a square wave displayed on the oscilloscope's screen.

3. While watching the oscilloscope screen, rotate the function generator's FREQUENCY knob, and then set it back to 1. What do you observe?

   _____

4. While watching the oscilloscope screen, turn the function generator's RANGE switch to x10k, and then to x100, and then back to x1k. What do you observe?

   _____

5. As you know, the trainer's function generator also has a **FUNCTION** switch that lets you choose between sine, triangle, or square waves. While watching the oscilloscope screen, turn the switch to its three different settings. What do you observe?

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6. The trainer's function generator also has an **AMPLITUDE** knob that lets you set the amplitude of the waveform being produced. While watching the oscilloscope screen, rotate the knob through its entire range. What do you observe?

   _____

7. To make sure that the frequency is accurately set to 1 kHz, use the Fluke 45 multimeter to measure the frequency of the output from the trainer's TTL MODE terminal. Adjust the frequency until it is 1 kHz.

8. Press the oscilloscope's **CURSOR** button to turn on the on-screen cursors.

9. Push the **Type** option button and select **Time**.

10. Push the **Source** option button and select CH1.

11. Turn the **CURSOR 1** and **CURSOR 2** knobs to place Cursor 1 on the rising edge of a pulse on Channel 1, and place Cursor 2 on the falling edge of that same pulse. The time displayed under **Delta** in the Cursor Menu is the pulse width. Record this pulse width here. (Round all measurement values and calculation results to three significant digits.)

    Pulse width = _____

12. Use the cursors to measure the period of the Channel 1 waveform, and record it here.

    Period = _____

13. Using the previous two values, compute the frequency and duty cycle of the Channel 1 waveform, and record them here.

    Frequency = _____ Duty cycle = _____

14. Press the oscilloscope's **MEASURE** button to see the Measure Menu.

15. Press the top option button; the Measure 1 Menu appears.

16. Press the **Source** option button and select **CH1**.

17. Then press the **Type** option button and select **Pos Width.** The **Value** readout will display Channel 1's pulse width, which should match the pulse width you measured above.

18. Press the **Back** option button.

19. Press the second option button from the top; the Measure 2 Menu appears.

20. Press the **Source** option button and select **CH1**. Then press the **Type** option button and select **Period.** The **Value** readout will display Channel 1's period, which should match the period you measured above.

21. Press the **Back** option button.

22. Press the third option button from the top; the Measure 3 Menu appears.

23. Press the **Source** option button and select **CH1**. Then press the **Type** option button and select **Freq.** The **Value** readout will display Channel 1's frequency, which should match the frequency you computed above.

24. Press the **Back** option button, and you should see Channel 1's pulse width, period, and frequency displayed.

25. Ask me to check your measurements before you go any further._____

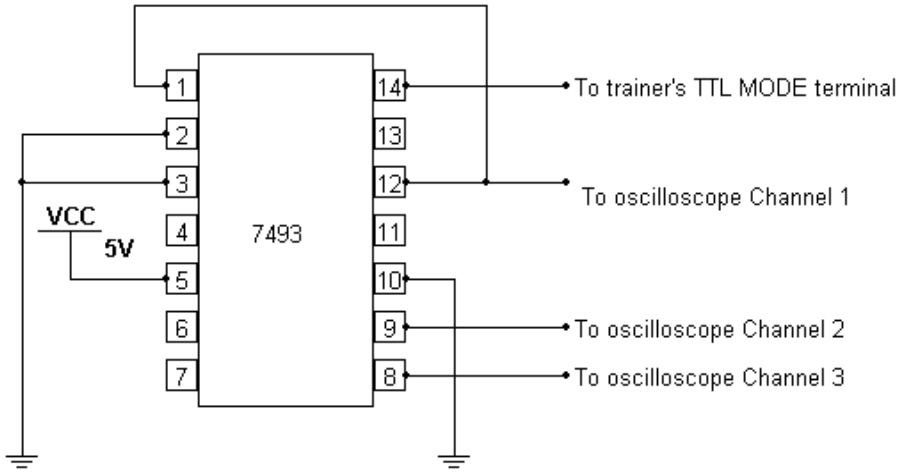
Part 5. Building a Counter Circuit

1. Disconnect Channel 1's probe from the trainer's TTL MODE terminal (but leave the ground clip connected).

2. Change the oscilloscope's SEC/DIV settings from 250 µs to **50 ms**.

3. Use the Fluke 45 multimeter to measure the frequency of the output from the trainer's TTL MODE terminal. Adjust the frequency until it is 50 Hz.

4. **With the trainer's power turned off**, build the circuit shown below, using a 7493 chip. Note the following:
    - In this diagram, when two wires cross each other, they're not connected unless there is a junction (a dot) at the intersection. For example, the wire connecting pin 12 to pin 1 is not connected to the wire from pin 14. And the wires from pins 8 and 9 are not connected to the wire from pin 10.
    - Connect pin 5 to your power bus.
    - Connect pins 2, 3, and 10 to your ground bus.



5. Turn the trainer's power on. With the oscilloscope's probes connected to the 7493's pins as shown in the diagram above, you should see three waveforms on the oscilloscope's display, but these waveforms will probably not be stable.

6. To stabilize the display, set the oscilloscope's trigger to Channel 3 and adjust the trigger level. **Whenever you display several signals of different frequencies, you should trigger off the lowest-frequency signal**, which in this case is the signal on Channel 3.

7. Ask me to check your circuit before you go any further.

Circuit works correctly? _____ DIP inserted correctly? _____
Using power bus? _____ Wire colors? _____ Wire lengths? _____
Wire ends trimmed? _____ DIP accessible? _____

8. Press the oscilloscope's **CURSOR** button to turn on the on-screen cursors, and then use the cursors to measure the **pulse widths** and **periods** of the waveforms on Channels 1, 2, and 3. From these values compute the **frequencies** and **duty cycles**. Record your values in the table below, rounded to three significant digits.

	Pulse width (Measured)	Period (Measured)	Frequency (Computed)	Duty Cycle (Computed)
Channel 1				
Channel 2				
Channel 3				

9. Using the oscilloscope's **MEASURE** button, display the **frequencies** of the waveforms on all three channels at the same time.

10. Ask me to check your measurements before you go any further._____

11. Without changing your circuit, increase the function generator's frequency to 20 kHz and set the oscilloscope's SEC/DIV setting to 100 μs. Use the oscilloscope's **cursors** to make the same measurements that you made above, and record your data in the table below, rounded to three significant digits.

	Pulse width (Measured)	Period (Measured)	Frequency (Computed)	Duty Cycle (Computed)
Channel 1				
Channel 2				
Channel 3				

12. Using the **MEASURE** button, display the **pulse widths** of all three channels at the same time. These pulse widths should be close to the values you recorded in your table.

13. Ask me to check your measurements._____

14. You're finished with this circuit and can take it apart.

Part 6. Logic Pulser

The Tenma logic probe also contains a logic pulser that you can set to produce either a square wave or a series of pulses. As described in Section 3-8 of the textbook, this feature can be useful for troubleshooting circuits by letting you "inject" pulses or a square wave. Let's look at how it works.

1. Make sure that the logic probe's power and ground clips are still connected to the trainer's power and ground. Then turn on the trainer's power supply.

2. Notice that the logic probe has a switch that can be set to either 0.5 PPS (pulses per second) or 400 PPS. Set this switch to 400 PPS.

3. If the probe produces a waveform with 400 pulses per second, what is the waveform's frequency? What is its period?

   Frequency = _____

   Period = _____

4. Connect the oscilloscope's Channel 1 probe to the logic probe's metal terminal labeled **SQ**. Press the oscilloscope's **AUTO SET** button to have the oscilloscope automatically figure out which settings are best for displaying this waveform. You should see a square waveform.

5. Move the oscilloscope probe from the probe's metal SQ terminal to its metal PULSE terminal. Press the oscilloscope's **AUTO SET** button. You should a series of spiky pulses.

6. Press the oscilloscope's PRINT button to make a printout of the oscilloscope's display. Write your name on this printout and staple it to this lab when you turn it in.

Review Questions

1. Based on your observations in Part 2, what conclusion can you draw regarding the usefulness of the logic probe for digital circuits whose logic levels are changing, rather than constant?

2. Based on your observations in Part 4, what can you conclude about the effect that the function generator's four controls have on the waveform produced at the TTL MODE terminal?

3. What colors are the traces for the following channels?

   Channel 1 trace _____ Channel 2 trace _____ Channel 3 trace _____

4. In most cases, what are the best settings for each of the following channel parameters?

   Coupling _____ BW Limit _____ Volts/Div _____

   Probe _____ Invert _____

5. In most cases, what are the best settings for each of the following trigger parameters?

   Type _____ Source _____ Slope _____

   Mode _____ Coupling_____

I recommend that you write down these standard channel settings and trigger settings in a handy place for future reference, and that you **check these settings whenever you use the oscilloscope.** Setting these parameters to other values can give confusing results and lead to incorrect measurements.

For further study

On the course website (also at http://people.sinclair.edu/nickreeder/eet131/oscopeManual.htm), I have instructions on downloading this oscilloscope's user manual from the Tektronix website. The manual is easy to read and contains some good exercises to teach you how to use the scope's many features. I recommend that you download the manual and spend some time working through these exercises.