Timing Measurements

Introduction

In this lab you will use an oscilloscope to make timing measurements of some digital waveforms.

You will download a CPLD configuration (`.pof`) file from the course web site and use it to configure your CPLD board. The CPLD will then output several different digital waveforms on the board's header pins. You will use the oscilloscope to make various timing measurements.

For this lab you will need:

1. the ELEX 1117 CPLD board, USB Blaster and USB-to-coaxial power connector,

2. three jumper wires with male-to-female pin header connectors, and

3. a USB 'flash' drive ("memory stick").

Procedure

Before the lab, take the on-line course "How to Efficiently Use the Oscilloscope: the TDS 2014" on the course web site.

You may also want to refer to the user manual for the TDS1012B 'scope which is available on the course web site under **Content / Supplementary Material**.

At the start of the lab the instructor will go over the lab rules, give a brief demonstration on how to use the oscilloscope and answer any question you might still have.

Configure CPLD and 'scope

- Download the `.pof` file specified by the lab instructor from the course web site to any convenient location on the lab PC. *Note: different lab sets may use different `.pof` files and obtain different results. Make sure you use the correct `.pof` file or you will get the wrong results.*

- Connect the CPLD board's coaxial power connector to a USB port and push the power button (power LED should go on). Connect the "USB Blaster" to the CPLD and a free USB port. The **POWER** and **ACT** lights should go on.

- Run Quartus, close the startup window and select **Tools / Programmer**.

- Click on **Hardware Setup...**, select **USB-Blaster** from the drop-down box and **Close** the dialog. **USB-Blaster** should appear next to **Hardware Setup...**.

- Click on **Add File...**, navigate to the location of the downloaded `lab1.pof` file and select the `.pof` file name.

- Check the Program/Configure checkbox next to the file name.

- Click **Start**. The progress bar should grow to **100% (Successful)** and the red LED should start to blink approximately once per second. Disconnect the USB Blaster from the CPLD board.

- Connect the two 'scope probes' ground alligator clips to the pin end of one of the jumpers (black, if available) and plug the socket end into the **GND** pin on header P1. This will be the reference ground level for the measurements.

- Clip the two 'scope probes to pin ends of two additional jumpers. You will use these to connect to the pin(s) you want to measure (see below)[1].

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[1]The CPLD clock frequency, is 50 MHz. Digital pulses will have significant frequency components at harmonics of this frequency. Your jumpers should be much shorter than the wavelengths at these frequencies to avoid distorting the signal. At 300 MHz the wavelength in free space is 1 m.
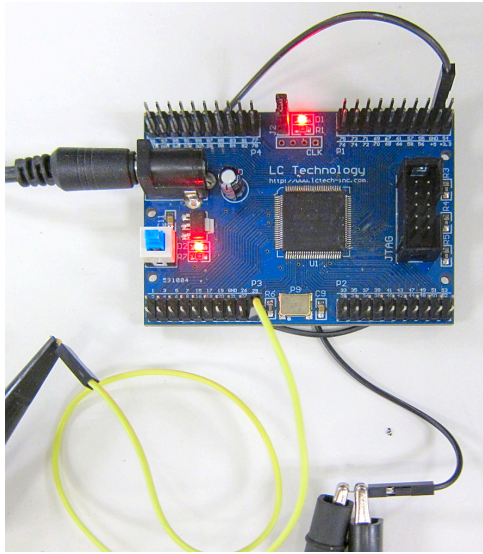
- Turn on the 'scope and plug your USB flash drive into the USB Flash Drive socket on the 'scope:

- Configure the 'scope to save screen images when you push the **PRINT** button by using the menu options: **SAVE/RECALL / Save All / PRINT Button : Saves Image to File**:

You can now make timing measurements on signals that should be present on the CPLD header pins.

Measurement Procedure

1. Configure the oscilloscope to capture a suitable waveform. For digital signals the single-sweep (**SINGLE SEQ**. button) mode is often convenient.

2. Measure the parameter of interest using the following three methods:

(a) the graticule (page 28),

(b) cursors (page 82), and

(c) a measurement function (page 89) if available and applicable.

The measurement procedure is described in the user manual on the pages given above.

Record each of your measurements as shown in Table 1.

3. Save a screen image to your USB flash drive by pressing the **PRINT** button. A clock icon will appear and after a while the name of the file will be displayed at the bottom of the screen:
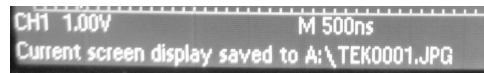
Record the screen capture file name (**TEK***nnnn***.JPG**).

4. After every few measurements show your results (in the table) and screen captures (on the USB drive) to the lab instructor to get credit for completing each measurement.

When recording the measurements from the graticule, write down the time per division, the number of divisions and the calculated time.
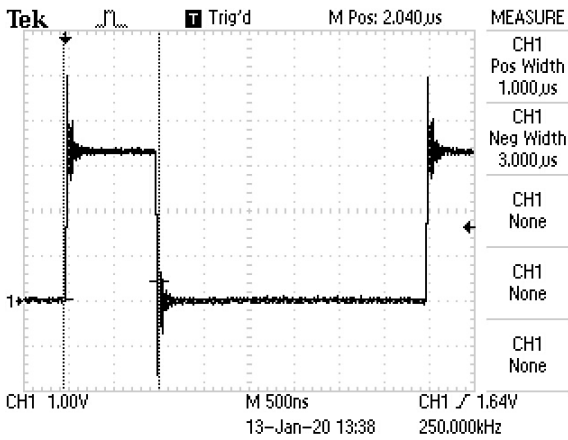
When using the cursors or the measurement function, write the time difference as displayed on the 'scope or the measured value.

Pulse Widths and Duty Cycle

Measure the positive and negative pulse widths of the signal on pin 29 (P3, bottom right). The pulse widths should be measured between the 50% levels.

Compute the duty cycle in percent assuming the signal is active-high. The duty cycle is the fraction of the period duration that the signal is active. It is typically given as a percentage.

For example, your screen capture might look like:

that of the signal, or both. *Hint: Table 3 in Appendix A of the TDS1012B user manual gives the 'scope's rise time as < 3.5 ns and the rise time of the P2220 probe as < 2.2 ns.*

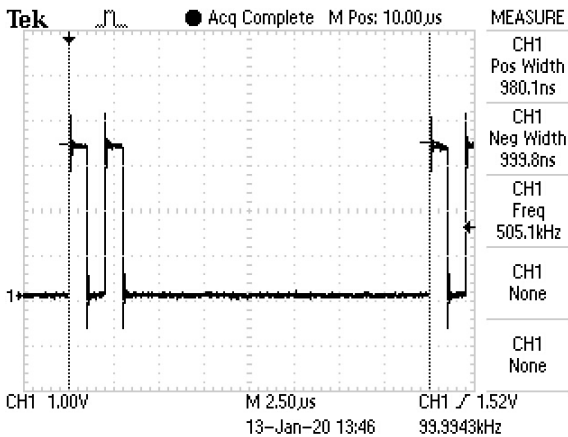For example, the rise time measurement might look like:

Period and Frequency

Measure the period of the signal on pin 2 (P3, bottom left). The frequency of the waveform is the inverse of the period.

Note that this waveform is periodic but has several pulses per period. Adjust the 'scope to show more than one cycle and measure the period. Compute the corresponding frequency. Be ready to explain any differences between your calculations and the 'scope's frequency measurement results.

For example, your screen capture might look like:

Delay

Delays are measured between points on two signals. It is typically measured between points at 50% of the high logic level [2].

You will measure the time it takes for the CPLD to start operating after power is applied.

Connect one jumper to the 3.3 V supply rail pin (P1, bottom right pin). Connect another jumper to connect pin 29 (P3, bottom right). Measure the 3.3V supply with the 'scope's Channel 1 and pin 29 using Channel 2.
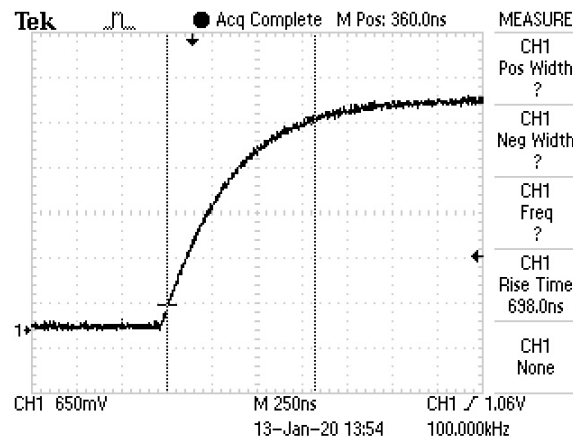
Rise and Fall Time

The rise time is the time for a signal to go from 10% to 90% of its peak value. The fall time is measured from 90% to 10%.

Measure the rise and fall times of the positive pulse appearing on pin 30 (P2, bottom left). To get adequate resolution you will need to measure each edge separately.

Be prepared to explain whether you are measuring the rise and fall times of the 'scope (and probe),

Measure the delay between the rising edge of the power supply and the start of the pulse train on pin 29. This is the time it takes for the CPLD to configure itself after power is applied. You will need to use single-sweep mode and switch the power off and on for each measurement.

The results might look like:

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[2]Or sometimes at the logic thresholds V_{IH} and V_{IL}.

Measurement	Using Graticule (give divisions, time/division, time)	Using Cursors (Δt)	Using 'scope Measurement	Screen Capture File	check
positive pulse width (pin 29)					
negative pulse width (pin 29)					
duty cycle (computed)			—		☐
period (pin 2)					
frequency (computed)			—		☐
rise time (pin 30)					
fall time (pin 30)			—		☐
delay (3.3V to pin 29)					☐

Table 1: Measurements. Give units (e.g. ms or μs).
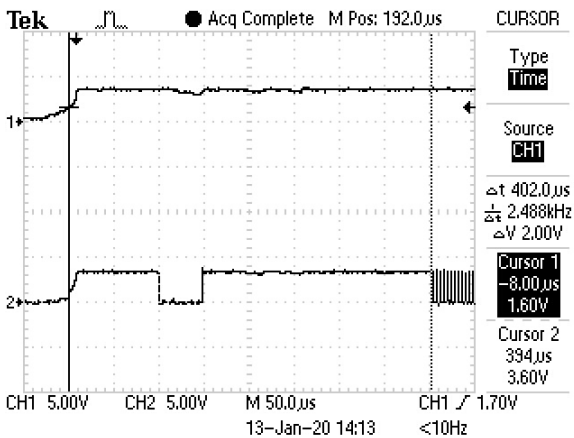
marks if some of the measurements are incomplete.
Take your USB drive when you leave the lab.

Marking

There is no lab prep mark for this lab.

You will receive one mark for each correct measurement (5 marks total). You will receive partial