ME220 Lab #3: Experiments with a Phototransistor.

Due : 4/30/08, before 5:00 pm.

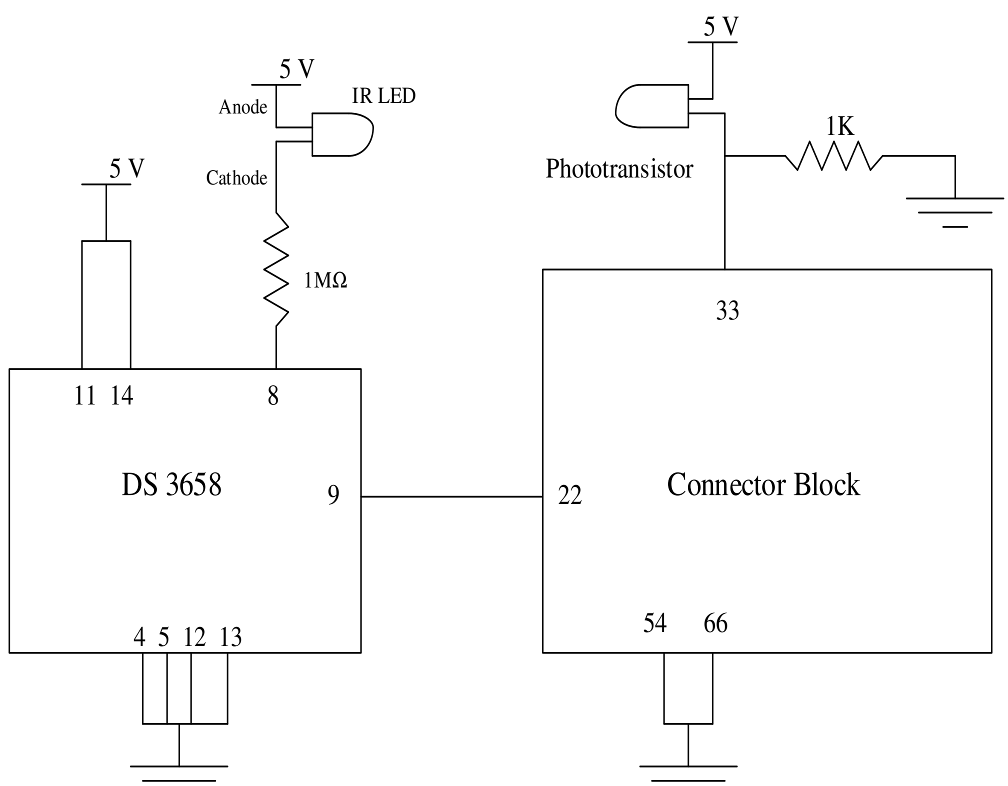
Acknowledgement
Zachary Nelson of National Instruments orchestrated a donation of the LabView Software and the National Instruments Data Acquisition hardware that we'll be using in the lab this quarter. Zach will visit sometimes during the quarter, so please be nice to him!

Goals of this Lab :

Part 1 – Build Some Hardware and Software

We're going to use essentially the same set-up as Lab 2, but instead of looking at weak signals buried in noise, we're now going to look at higher frequency signals.

The figure below shows the circuit diagram from Lab 2 with one modification: the 1 MΩ resistor connected to the LED should be replaced with a 10 kΩ resistor. Remember that the anode of the LED is the long lead and the cathode is the short lead. The collector of the phototransistor is the short lead and it gets connected to power.



Open a new VI from Labview.

Create a signal source (right click, select Input, Simulate Signal). Set it for a square wave at 1000 Hz, amplitude 2 and offset 2. Set the Number of samples to 1000 and the Samples per second to 100,000 Hz. Place the VI in a while loop (right click, Execute Control, While Loop, and then drag loop around signal source).

Create an analog output (right click, select functions, output, DAQmx Assistant). Select Analog Output, Voltage, "ao0", and finish. Set the output range for 0-10V. Select "generate continuously" and check the box for "use timing from waveform data." Click the "OK" button. Draw a wire from the output of the "simulate square" to the input of the DAQ assistant.

Create a signal input (right click, select Input, DAQ Assist). Select Analog Input, Voltage, "ai1", and finish. Set the range to –5V and +5V. Set the Task Timing to "Acquire N Samples" and set Samples to Read to 1000 and Rate to 100,000 Hz. Press OK.

Create a Spectral Measurement function (right click, Analysis, Spectral). The measurement option should be set to "Magnitude RMS" and change Result to Linear (instead of dB). Press Ok. Draw a wire from the output of the DAQ Assistant (input DAQ assistant not output DAQ assistant) to the input of Spectral Measurements.

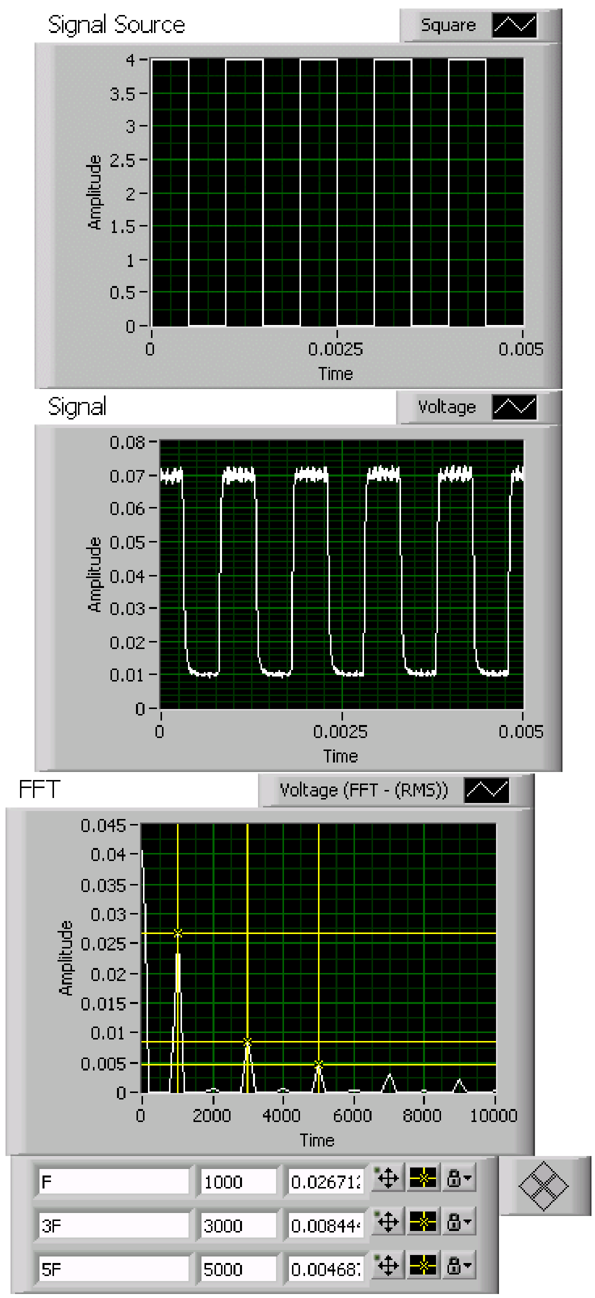
Now we are going to create three graph indicators (right click on the front panel, Graph Inds, Graph). Connect the first graph to the output of Simulate Signal. Connect the second graph to the output of the DAQ Assistant (input). The third graph should be connected to the output of Spectral Measurements.

You are going to be measuring the amplitude of the FFT at specific frequencies. To make this easier, we are going to set up cursors on the FFT graph. Right click on the graph and select Visible Items. Check Cursor Legend. The Cursor Legend will appear to the right of the graph. You can move the legend to a convenient location. Right click on the graph again and select Properties. Click on the Cursors Tab. Press Add three times. Change the name of the first cursor to F, the second cursor to 3F, and the third cursor to 5F (select the desired Cursor in the pull down box and then type the name in the Name box). In the box that says "Allow Dragging" change "Free Dragging" to "Snap to Point." Do this for all three cursors.

You are now ready to run your VI. It may help to zoom in your graphs. Right click on the graph, select "X Scale", and then uncheck "AutoScale X." Do this for all three graphs. Select the Edit Text icon on the tool panel. On the first two plots, click on the x-axis limit and change it to 0.005. Change the x-axis scale on the FFT plot to 10,000. Finally, in the cursor legend click on the first row, second column. Change the value to 1000 (this is the frequency of the input signal). You should see a cursor snap to the peak at 1000 Hz and the value in the third column should change to the amplitude at that peak.

Change the value in the second row second column to 3000 (3*f) and change the value in the third row second column to 5000 (5*f).

Your output should look something like this:



Record the amplitude of the peak at f, 3f, and 5f. Calculate the amplitude ratios for 3f/1f and 5f/1f. What should the ratios of 3f/1f and 5f/1f be for an ideal square wave?

Record the peak amplitudes at f, 3f, and 5f, as well as the ratios, for a range of frequencies between 300 Hz and 10 kHz. You may need to adjust your sampling rate and number of samples as you change frequencies. Plot the ratios as a function of frequency.

Part 2 – Determination of the Time Constant
Set your circuit to produce a signal at 500Hz.
The photosensor itself has some small capacitance that can affect our measurements. It would be nice if we knew what this capacitance is, so let's measure it. To do this, we need to find the time constant of the signal. The time constant is the amount of time it takes for a signal edge to rise to 63% of its final value. 63% comes from the exponential rise equations that approximate a rising signal. To make this measurement we must use the cursors function on the oscilliscope. The cursors button one of the buttons on the top row. Push that button and experiment with the settings, see if you can find out how to use them. Ask if you're having trouble. Note: adjusting the types of cursors is done with the position knobs for channel 1 and 2.
To make the measurement you should setup your sensor signal so that its lower voltage level is even with the horizontal crosshairs on the scope. Zoom in on the signal (both time and voltage) until a rising edge of the signal is easy to see. Using the cursors, find the voltage which is 63% of the final voltage level. Now, using the time cursors, find the time between the beginning of the rising edge, and the point at which the rising edge reaches this 63% voltage level. This time difference is your time constant measurement.

Part 3 –
Now set your frequency to 1000 Hz. Change the resistor used for the photosensor to 2k. Repeat the time constant measurement. Now take a few more measurements at 1000Hz with resistor values of 5k, 10k, 50k and 100k (you may have to use series or parellel resistances to get these values). Finally, plot time constant as a function of resistance. Estimate the capacitor value knowing that $\tau = RC$. Based on the data points you took, how accurate are your measurements? What is the greatest difference between the capacitor values calculated from your time constant measurements? What could be affecting your accuracy?