Franklin W. Olin College of Engineering
Modeling and Control
Engineering of Compartment Systems
Lab 2

The Function Generator

You will be using a GFG-8255A function generator in this lab, shown below:

This device can generate square, triangle, or sine waves up to 10 volts in amplitude from frequencies of 0.5 Hz to 5 MHz. While the generator's controls are analog, the frequency is displayed digitally.

The generator has a number of push-buttons whose function is indicated on their face and a number of knobs whose rotational function is indicated nearby in black. A modified function is available for each knob by pulling the knob out. In this case, the knob's modified function is indicated in orange. An example of a pulled out knob is shown below:

In the case above, the amplitude adjustment knob, by being pulled out, attenuates the amplitude of the signal by an amount determined by its rotation, and also by an additional 20dB (another factor of 10 – you'll learn the nomenclature of dB later).

If desired, yet another 20dB of attenuation can be obtained by pushing the appropriate button, as shown below, so that the green LED above illuminates:

A full manual for the function generator can be found at

http://ece.olin.edu/mc/ecs/fall_08/manual/funcgen/.

The Oscilloscope

The oscilloscope you will be using, the Tektronix TDS3012B, is a very versatile, fairly expensive tool. A photograph of a similar oscilloscope, the 3014B, is shown below:

Further information about the 3012B can be found at:

http://www.tek.com/products/oscilloscopes/tds3000b/index.html

A number of very good primers have been written by Tektronix, as well as specific manuals for this oscilloscope. These can be found at:

http://ece.olin.edu/mc/ecs/fall_08/manual/scope/

You will not learn how to operate the scope completely in one day, or even one month. But in this lab you will get started, and by repeated use and reference to the above web sites, you will learn to use scopes well.

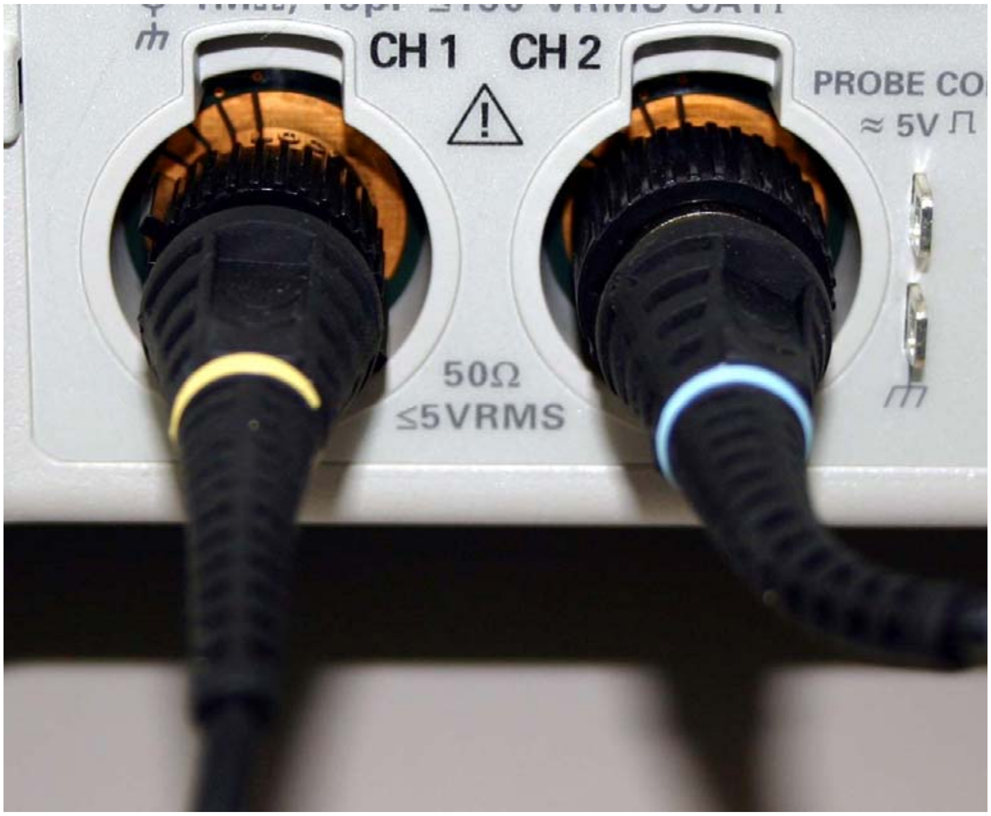
It is important to connect the probes to the scope correctly, and a few hints will help you get started. First, you must realize the each probe has two connections: a probe tip connection and a ground connection.

When using breadboard (NOT IN THIS LAB), the ground connection should be attached to a short wire (perhaps green, for ground). It must be attached to the zero voltage bus bar of the breadboard.

The probe tip has a gold hook on it that can grab another wire (perhaps white, which is traditional for signals). You get the gold hook to come out by pulling back on the cone-shaped probe hood. You may be tempted to remove the probe hood and plug the remaining part of the probe tip into a breadboard. Don't do this – it will likely cause the probe tip wire to get bent and break off. Instead, hook the probe tip to a wire and plug the wire into and desired hole in the breadboard.

The scope probes you will use reduce the amplitude of the voltages they measure by 10 times (10X). Some of the scope probes have connections to the oscilloscope that automatically tell the oscilloscope this attenuation factor, causing the oscilloscope to read-out the correct probe tip voltage. Other probes do not do this, and you have to remember to set the attenuation (use the vertical menu) to 10X manually. In any case, the scope undoes the 10X reduction of the scope probe and indicates the actual voltage on the tip.

Note that there is a yellow ring on the handle of the probe. There is a corresponding ring at the connector to the scope, and, if the connector is to channel 1, this will be the yellow trace on the screen of the scope. The other probe you use should be blue. This is shown in the diagram below:

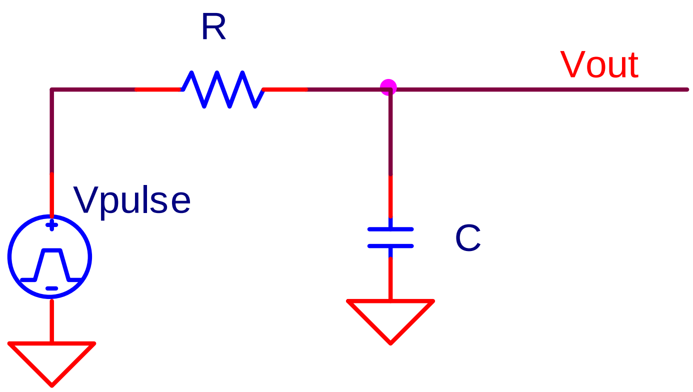


There are a few other hints that will make your measurements easier to make:

- Use the black Autoset button on the right side of the scope to first get it to lock onto your signals.
- To reduce high frequency noise, limit the bandwidth of the scope inputs to 20 MHz . This option is on the vertical menu.
- Be sure to change the horizontal scale to get the best display. Do this with the horizontal scale knob.
- Explore using the measure function to put numerical measurements of waveform properties on the display.
- Explore using the cursor function to measure parts of waveforms manually.
- Once you are ready to record, if the signal is noisy, change the acquire mode to average 16 samples. This will average out noise and give you a really clean display. Keep in mind that averaging responds slowly to changes, and you can get lost in this mode.
- Each scope has a web server inside! We will show you in class how to connect to your oscilloscope's web server and download snapshots of its display to your laptop.

The Actual Experiments

1. Connect up the following circuit, using the alligator clips of the signal generator and the scope. YOU DO NOT HAVE TO USE A BREADBOARD FOR THIS LAB:



Use a 10k (Brown Black Black Red Brown) resistor for R and a 100nF (marked as 100n) capacitor for C. You can hold the wires together with the scope tips and clips on the scope and signal generator.

Put the red signal generator tip and the yellow scope probe tip on Vpulse, and Blue scope probe tip on Vout, and all the black clips to ground (they should all be connected together).

Set the Scope to look at both channels 1 and 2 (yellow and blue). Set the signal generator to generate a square wave with a frequency of 100 Hz and a peak-to-peak voltage of 1V (i.e. going from +0.5V to -0.5V). Then adjust the offset of the signal generator (pull out the knob) to+ 0.5 Volts to get the output to go from 0 to +1.0 volt. Use the scope amplitude and average measurement functions to make sure of this value, and measure the amplitudes and averages of both channel 1 and 2.

Press the autoset button on the scope, and if necessary lower the horizontal sweep rate by hand by turning the horizontal knob counter-clockwise to get a good picture.

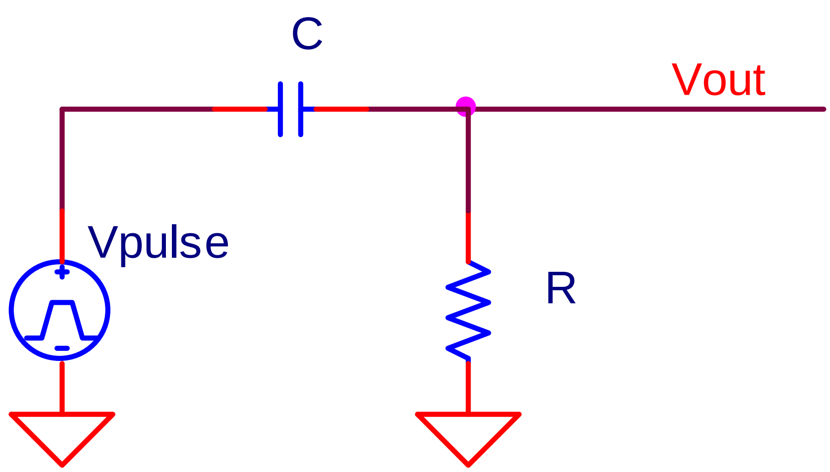
You should get a waveform that makes sense. Capture the waveform over the web to analyze later and include in your lab report. Comment on whether or not the averages of the input and output waveforms differ.

Now switch the signal generate to sine wave mode. Keeping the input amplitude at 1 Volts peak-peak and +0.5 volts offset (you may need to re-adjust the knobs) add a phase measurement between the input (yellow – channel 1) and output (blue – channel 2) on the scope.

Sweep the frequency of the signal generator by hand between 10 Hz and 10 kHz . Observe and record (on paper) the voltage amplitude of the output, and the phase delay between the input and output. Take a few readings for each decade change in frequency.

In your report, create a chart of your hand recorded data (you may wish to use log axes for some parts), and explain what you see.

Now reverse the roles of R and C:



Repeat all of the steps you did above for the first circuit with this new circuit. If there are differences between what you observed for the first circuit and the second one (e.g. waveform, average), explain why you think things are different.

At Home:

Create Simulink simulations for each of your physical experiments and show that the results of the simulation are similar to those you recorded for the physical experiments. For each experiment, EXPLAIN your results, so that we have evidence of your UNDERSTANDING OF CONCEPTS that are going on in these circuits.

Translate your simulink diagrams into differential equations that give the output in terms of the pulse generator input.

Optional (in order of increasing difficulty) – DO NOT WORRY IF YOU CAN'T DO THESE YET:

- If you can, solve the differential equation for the output of each circuit, given a rising step (from 0 to 1 volts) of the input (Hint: assume the input has been 0 forever previously).

- If you can, solve the differential equation for the output of each circuit, given a falling step (from 1 to 0 volts) of the input (Hint: assume the input has been 1 forever previously).

- If you can, solve the differential equation for the output of each circuit for a 1 volt peak to peak sine wave input at a frequency ω (you can make the assumption the input sine wave has an average value of zero).

- If you can, solve the differential equation for the output of each circuit for a 1 volt peak to peak sine wave input at a frequency ω and an offset of +0.5 Volts.