

## Lab 5: RC Circuits Time and Frequency Responses

In this lab, we will investigate how to create signals in MATLAB that are then used to control a piece of hardware. Specifically, we will generate square wave and sine wave voltage signals that will be applied across a series RC circuit through a data acquisition device (DAQ). In addition, rather than attempting to measure the voltage across the capacitor with a multi-meter, we will use the DAQ to take the voltage readings for us and send the data right into MATLAB for plotting and analysis.

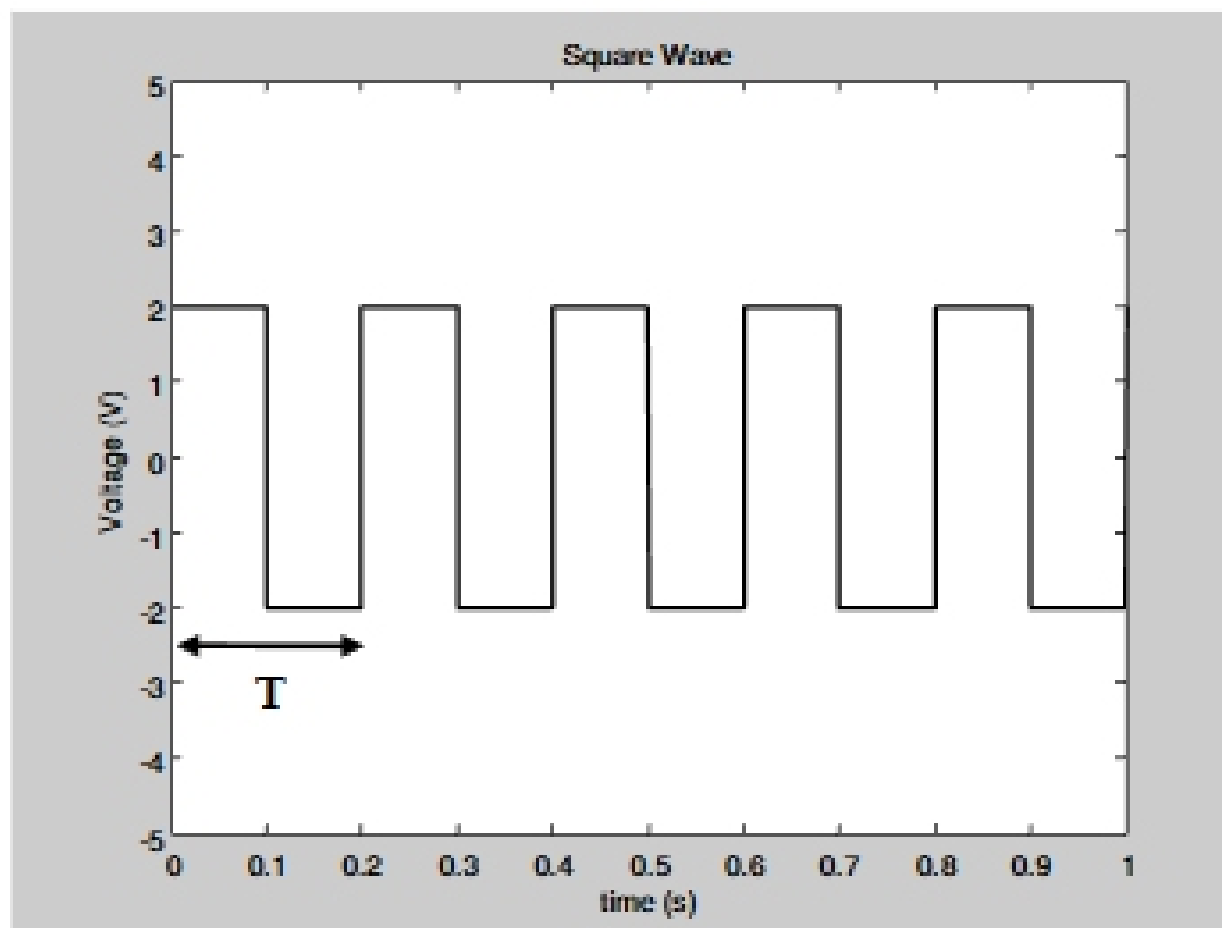
Using computers, microprocessors, or other types of programmable devices to control physical processes is widespread throughout many types of industry. Some applications include controlling a robot in an automotive plant to perform some repetitive manufacturing task, controlling an aircraft through the autopilot, and controlling the speed of an automobile through cruise control. Due to budget and space limitations and safety considerations, we are going to simply control the voltage across a capacitor in a series RC circuit.

### A. Introduction to Lab 5: Presentation by Instructor

Your instructor will introduce the hardware and software that will be used for this lab.

### B. Creating Square Waves in MATLAB

A square wave is a periodic function that oscillates between two amplitudes as shown in the graph below.



The **frequency** of the square wave is the number of cycles completed every second. The frequency of the square wave shown above is 5 Hz since there are 5 complete cycles every second.

The **period** is the time required for one complete cycle of the square wave. The period of the square wave shown above is 0.2 seconds. **Notice that the period is the inverse of the frequency ( $T = 1/f$ ). Same as it is for sinusoidal waves and every single other type of periodic function!**

The **amplitude** of the square wave shown in the diagram is 2 volts.

MATLAB has a function called **square** to generate square waves. It works a whole lot like the sin and cos functions.

1. Suppose I want to generate a square with a period of 0.5 seconds. Calculate the frequency of the square wave.

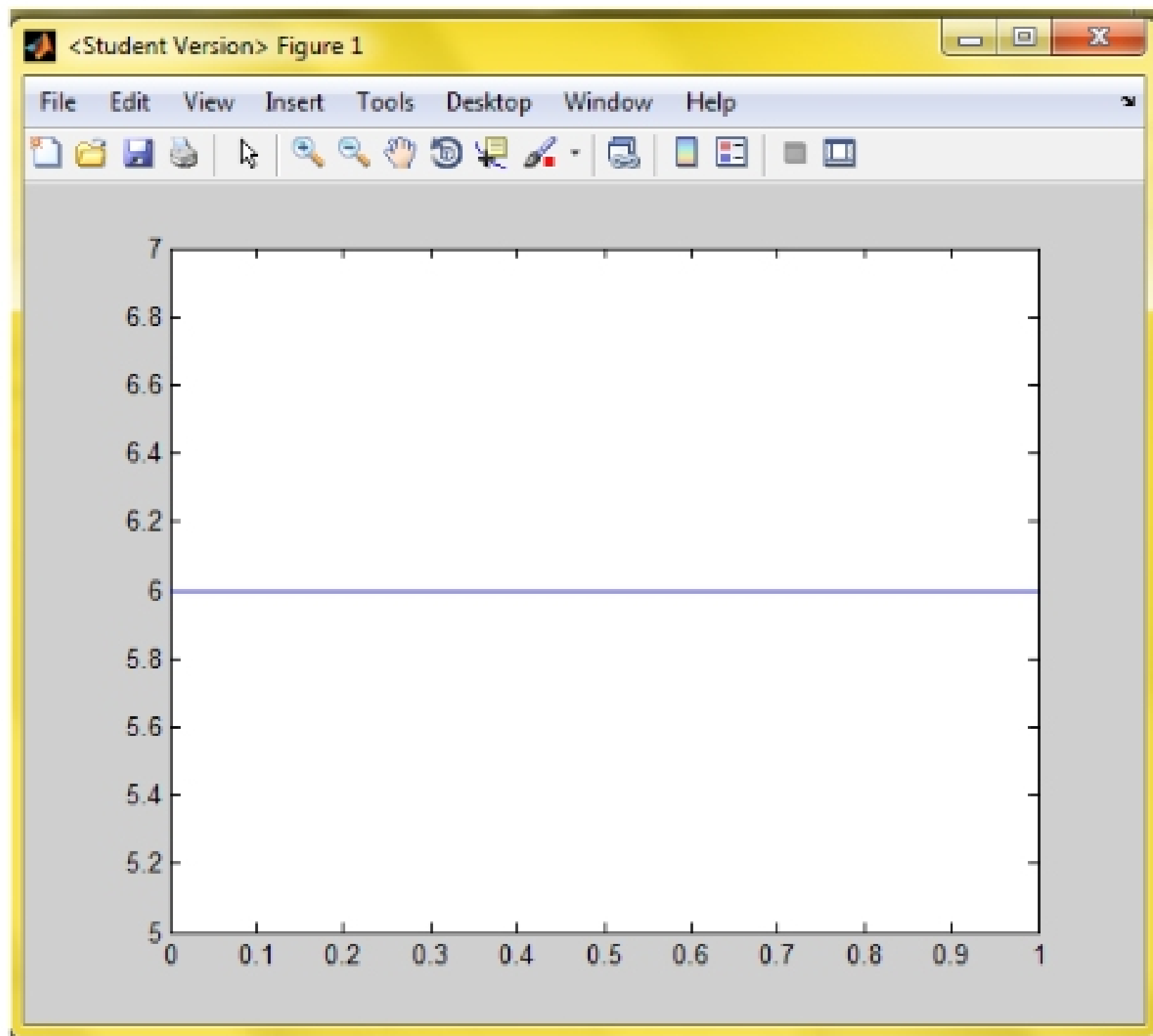
$$\text{frequency} = \underline{\quad 2 \quad} \text{ Hz}$$

2. How much time would be required to plot 3 cycles of this square wave? 0.15
3. In MATLAB, generate a vector, t, of good time values to display 3 cycles of the square wave.
4. Now use the following commands to calculate the y-values corresponding to your time values, t and to plot the square wave (use an amplitude of 6).

```
>> y = 6*square(2*pi*frequency*t); % Insert your value for  
frequency  
>> plot(t,y)
```

5. Copy and paste your plot in the space below.

**MATLAB PLOT:**



### C. Software Check for Digilent DAQ

1. Form teams of 3 students at your recitation tables making sure that at least one team member does not have a MAC because the software does not run on a MAC.
2. Ask your T.A. to give you one of the Digilent Analog Discovery DAQs.
3. Hopefully, at least one of your team members installed the WaveForms software and the MATLAB support package for the Digilent Analog Discovery last week for Engineering Foundations. If not, have one team member (without a MAC computer) go to the Recitation Folder on the Blackboard metasite and follow the instructions for the MATLAB Update under Recitation 5.
4. Software Check #1: Use the USB cable to connect the Analog Discovery DAQ to the computer that has the software installed. Run the Waveforms Software – it should be in a folder called Digilent. **If you get a message that no device was detected, then you failed to install the Waveforms software correctly.** Go back to Blackboard, Step 1 under the Recitation 5: MATLAB Update and run the program: *digilent.waveforms V2.5.4.exe* to