LABORATORY 4

ASSIGNED: 3/21/17

OBJECTIVE: The purpose of this lab is to evaluate the transient and steady-state circuit response of first order and second order circuits.

MINIMUM EQUIPMENT LIST: You will need the following supplies to complete this lab, at a minimum:

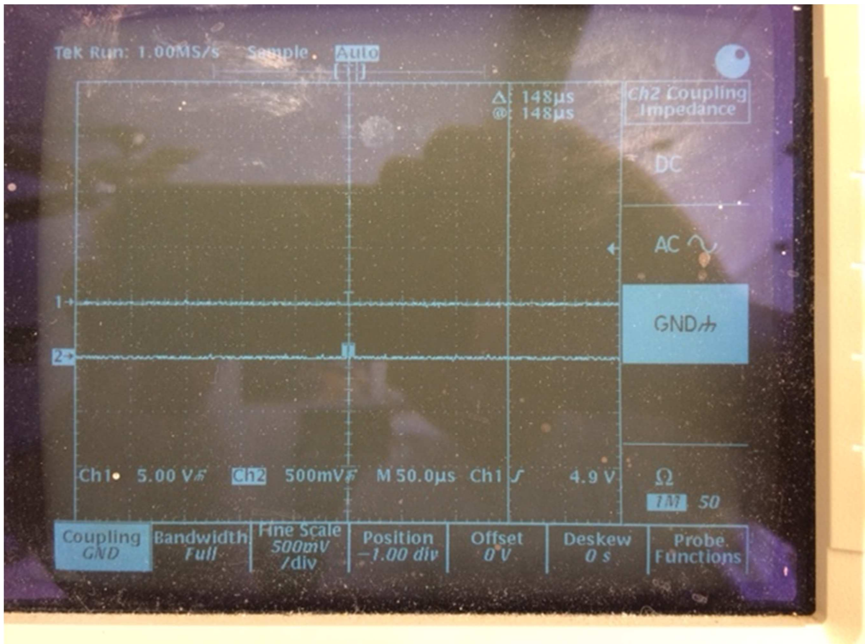
1. Function generator
2. Two-channel oscilloscope
3. BNC cables with clip leads
4. Two oscilloscope probes
5. Breadboard
6. Electronic Components: Capacitors, inductors and resistors

TEST EQUIPMENT CONFIGURATION

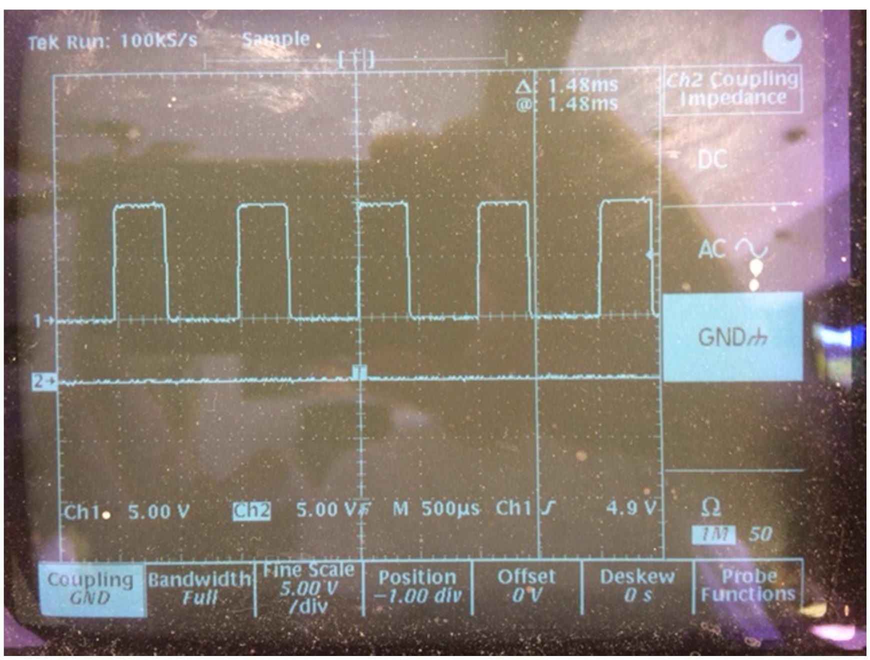
To start your measurements, you will need to configure the function generator to output a pulsed waveform that will sufficiently emulate a switch response. This allows you to provide an electronic signal to your circuit that behaves analogous to a switch that induces a transient response without manually configuring a mechanical switch. This requires the period to be sufficiently long enough that the steady-state response has been achieved before the next period begins.

In the following experiments, you will need to correlate two channels simultaneously to evaluate the circuit behavior. This will require configuring the oscilloscope "scope" by:

1. Turning on "CH1" and "CH2" on.
2. Configure the "ZERO" reference line for both traces, which can be accomplished by selecting the "GND" coupling in the vertical menu for both channels. You can adjust the position of the ground potential by adjusting the "vertical position" knob up or down. It is useful to position the traces on one of the ten gridlines.
3. Once the scope is configured, enable measurements by changing the coupling back to "DC" for both traces.



Next, you will want to configure the function generator to produce a 1kHz square wave. You can do this by selecting the appropriate buttons to emulate this waveform type. Connect a BNC cable to the output of the 50-ohm port and connect the other clip leads from the other end of the BNC cable to the scope "CH1" probe.



Verify the signal period is the same as you configured the function generator to produce. Note that scopes are designed to measure time-domain voltages. Thus, the horizontal axis denotes time and the vertical axis denotes voltage amplitude. Each grid "division" is time timespan you set on the scope, configured by adjusting the "horizontal scale". In the figure above, the scope was configured for a 500uS scale, which means the entire screen shows 5mS of time and each division corresponds to 500uS.

With a scope, it is necessary to ensure that the "trigger" is set properly to capture the signal you are trying to measure. This is set by adjusting the "main trigger level" control knob. On the plot above, you will notice the arrow on the right side detailing the trigger threshold. This arrow should be centered around the middle of the signal amplitude you are tring to measure. You will also need to make sure that the scope is triggering on the correct channel. This is configured by selecting the "trigger menu" button and setting it to "CH1".

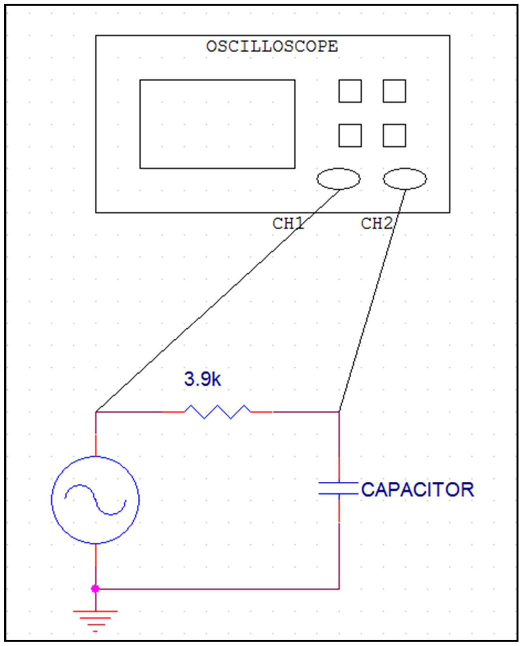
Likewise, the vertical axis is also divided up in 10 segments, where each grid "division" is the amplitude you set on the scope by adjusting the vertical scale. However, depending on the scope probe you are using, the measurement may be a direct 1:1 scale or a 1:10 scale (ie: the probe measurement is 1/10 of the actual amplitude). You can determine this by reading the label on the probe.

In the figure above, the scope was configured for a 5V scale with the ground reference line "1-cursor on the left side" set at mid-screen. This means that the scope will capture voltages ranging between +/- 20V and "2-cursor on the left side" will capture voltages ranging between +25 / -15V (because the ground reference is shifted down 5V.

Adjust the function generator "amplitude" and "offset" knobs until you achieve "10V" amplitude with the negative-going part of the waveform starting at "0V". For the function generators provided in class, you may need to pull the "offset" knob outward to provide for this offset correction.

RC TRANSIENT CIRCUIT

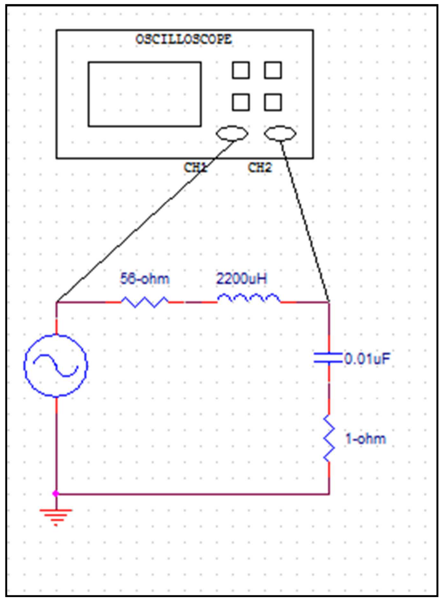
Configure the first-order "RC" circuit shown using a 3.9k resistor and the ceramic capacitor provided in the lab and answer the corresponding questions:



1. Determine the time constant of your circuit and add a screen-shot of the oscilloscope measurements to your lab report.
2. Based on the time constant from your measurements, determine the capacitor value (capacitance).
3. Conduct an internet search to verify what the capacitance should be given the markings on the component and calculate the percent difference between your measured value and the marked value. If your error is greater than 5%, explain the large deviation from expectation.
4. Given the measured capacitance value, solve for the differential equation that determines the capacitor voltage and plot it using MATLAB or EXCEL. Does your plot represent your measured plots? Explain significant deviations if present.

RLC TRANSIENT CIRCUIT

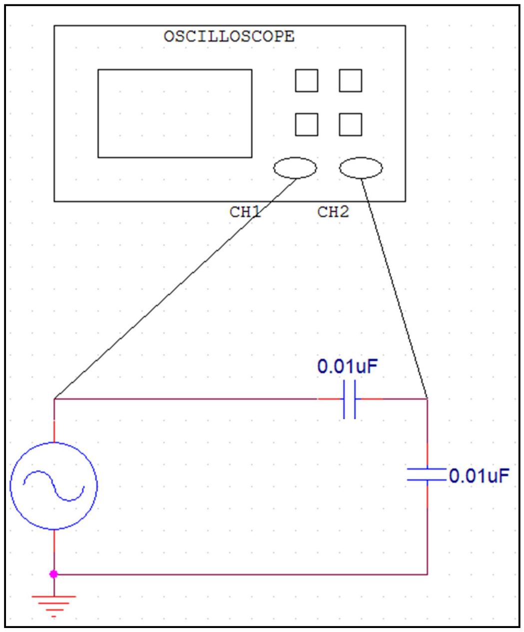
Configure the second-order "RLC" circuit shown and answer the corresponding questions:



1. Determine the time constant and natural frequency of your circuit and add a screen-shot of the oscilloscope measurements to your lab report.
2. Describe the dampening characteristics of your circuit.
3. Simultaneously plot the capacitor voltage and current. Current measurements can be made by moving "CH2" probe across the 1-ohm resistor (because V = I by ohms law) and moving "CH1" to the capacitor. You will need to change the vertical scale of "CH2" to plot the currents. What is the phase shift between the current and voltage waveforms?
4. Solve for the differential equation that determines the capacitor voltage and plot it using MATLAB or EXCEL. Does your plot represent your measured plots? Explain significant deviations if present.
5. With the same capacitor and inductor, replace the 56-ohm resistor such that it will provide a critically damped circuit response. Annotate the resistance value selected and add a screen-shot of the oscilloscope measurements to your lab report.

AC VOLTAGE DIVIDER

Configure the AC voltage divider as shown, change the function generator response to provide a sinusoidal waveform with the same amplitude and offset used in previous questions within this lab and answer the corresponding questions:



1. Determine the voltage amplitude and DC-offset at "CH2". Be sure and add a screen-shot of the oscilloscope traces to your lab report.
2. Using phasor analysis techniques, determine the expected amplitude of the signal at "CH2" and describe sources of differences between the measured and calculated results.