AC Circuits Laboratory   Lab # 2

The Oscilloscope and Transient Analysis

Lab Objectives

1. To work individually using simulation software to plot data obtained by simulation.
2. To demonstrate basic skills in the use of the oscilloscope to measure circuit parameters.

Pre-Laboratory Preparation

Prior to your scheduled laboratory meeting time the following items need to be completed:

Research

1. Carefully read the textbook sections and review your course notes on "**Transients in Capacitive Networks**," both the charge and discharge phases.

Circuit Analysis

1. Determine the equation for and plot using Excel, the voltage across C_1 in the circuit of Figure 1 for the following two cases (R_m represents the scope probe impedance):
   a. **Charging**: S_1 closed and S_2 open, assume C_1 is initially uncharged ($V_{C1}(0)$= 0V)
      i. Place your Thevenin equivalent circuit, the equation for $V_{C1}(t)$ and your plot all on the top half of a single sheet of paper (only your equation should be handwritten).
      ii. Make sure your plot has a clear title, axis labels and appropriate scaling.
   b. **Discharging**: S_2 closed and S_1 open, assume C_1 has completely charged to E_{TH} through R_1 just prior to t=0 for this phase.
      i. Place your Thevenin equivalent circuit, the equation for $V_{C1}(t)$ and your plot all on the bottom half of the single sheet of paper used in step a (above).
      ii. Make sure your plot has a clear title, axis labels and appropriate scaling.
2. Using Multisim, simulate the same two cases (from steps 1.a and 1.b above). For the charging case place an initial condition on C_1 of 0V and for the discharging case, use an initial condition of E_{TH} (from your calculations). You will find the initial condition setting for C_1 under the "Initial conditions" SPICE parameter located on the "Value" tab of C_1. **Note: Since you are looking at the charging and discharging cases individually, feel free to replace S1 and S2 with either a wire (for a closed switch) or an open-circuit (for an open switch).**
   a. For both cases use the "Transient analysis" simulation to view and print the voltage across C_1 as a function of time. Simulate long enough to reach steady state but for a short enough period of time to be able to view the transient portion of the waveform in at least half of the plot window. You will need to change the "Initial Conditions" analysis parameter from "Automatically determine initial conditions" to "User-defined" in order to activate the user-defined initial condition you specified for C_1.
   b. Use the cursor tool to determine tau_{charge} and $tau_{discharge}$. **Hint** – See the charge and discharge characteristic curves in your text and note the voltage levels at t=tau for each curve.
   c. For each case, save the schematic and plot on a single sheet of paper (paste into WORD for example)

Pre-Lab Quiz Preparation

1. The online prelab quiz questions will be based on your calculations and simulation results.

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AC Circuits Lab Procedure: Work with your lab partners and make sure you know your assigned roles

PART 1 – C_1 Charging Phase

1. Build the circuit shown in Figure 1 using:
   a. A lab power supply for E_1
   b. An Omron B3F-1022 for S_1 and S_2 (Digikey SW403-ND) (use an ohmmeter to verify the switch is correctly connected.)
   c. Measure your actual component values and write these on your schematic. When using the LCR meter to measure C_1, use the 120Hz setting and write this frequency next to the measured value of C_1.
2. Connect CH1 from your bench oscilloscope across C_1. Leave the probe across C_1 as it affects the circuit and has been included in your prelab calculations and simulations. Adding a couple of extra wires as "test points" can make the measurement of the voltage across C_1 easier.
   NOTE: The probe switch must be in the "10X" position.
3. Verify that the scope is also set to 10x. Press the illuminated Channel # button, then select the "Probe" menu option. If not selected, selected the 10:1 ratio option.
4. Verify (and ensure) that the initial voltage across C_1 is zero (or close to it).
5. Set-up the oscilloscope time-base to capture the entire charging cycle including the transient phase and just reaching steady state. Use the automated measurement function to show the minimum and maximum voltages on the oscilloscope screen.
6. Press and hold S_1 long enough to charge C_1. Think about how long should be long enough; refer to your prelab calculations.
   a. Watch the voltage increase slowly across the capacitor (the channel 1 line moves vertically on the scope – remember, the voltage is on the y-axis).
7. Wait for the voltage across C_1 to reach its maximum value and then release S_1. The capacitor will start to slowly discharge through the scope probe (R_m = 10M).
   a. **Capture the charging waveform** using the oscilloscope RUN/STOP button and paste it into a Word document using the top half of the page only. Title the plot appropriately.
8. Press S_2 and watch the voltage across C_1 drop instantly (at this timescale). Most people can use a scope this way; but you will capture this transition in Part 2.

PART 2 – C_1 Discharging Phase

To set up the scope to "trigger" and display one event, our discharge event, do the following:

1. Set an appropriate time-base to capture the discharge phase (see your prelab work).
2. Press the HORIZONTAL section's "Single Seq" (single sequence) button.
   a. We would like to view a signal that is decreasing - the voltage across C_1 falls after S_2 is pressed.
3. Press the TRIGGER section's "Trigger" button, from the menu, choose:
   "Type" and select "Edge"
   "Source": 1
   "Slope": falling edge (down arrow)
   "Mode": Normal
4. Within the TRIGGER section, adjust the trigger level to 1 volt (10V @1 x) as indicated in the upper right hand of the display.
   a. This is the "trigger level" which defines the voltage the scope will trigger on and then take a snap-shot of the voltage waveform.
5. Recharge C_1 completely.
6. Press S_2 to discharge C_1.
7. Press the HORIZONTAL section's "Single" (single sequence) button - get it ready to take another snapshot. In single acquisition mode you need to press this each time you want to capture an event.
8. Recharge C_1 completely.

9. Using what you learned earlier, adjust the vertical and horizontal settings until the display shows the discharge of the capacitor while filling the majority of the screen.
10. Repeat steps 8 and 9 if necessary in order to **capture an informative plot**. Paste your results into the same WORD document you created during Part 1, Step 7 but use the bottom half of the page. **Don't forget to title your waveform.**
11. Print your Word document and have your instructor review it and issue a sign-off for both sections of lab.

PART 3 – Data Analysis

1. Using the charging and discharging oscilloscope plots, estimate tau_{charge} and $tau_{discharge}$ and compare your experimental results to your prelab calculations and simulation results in an Excel data table. Place your measurements and annotations directly on your printed plots to show exactly how you arrived at your time constant values (done neatly by hand is ok).
   a. Show percent-error calculations, using your calculated values as a basis.
   b. Describe any significant discrepancies

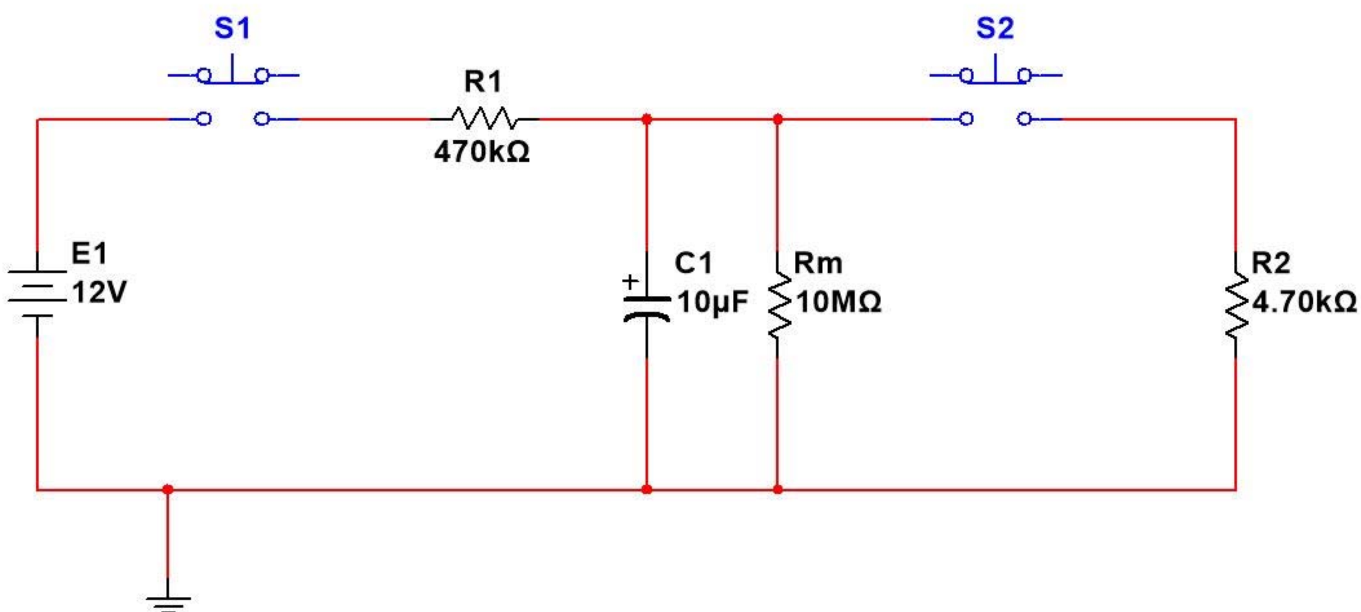

Figure 1 - RC Charge and Discharge Circuit

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Make sure your lab work has been signed off on the following page. Work not bearing a signoff from an instructor or TA will not be accepted for grade.

Post Lab Requirements:

After lab, **<u>during a time specified by your instructor</u>**, take the Post Lab Quiz on myCourses. You may use your prelab work, lab data and answers to the lab questions as reference material.

Turn in your completed documentation at the beginning of next week's lab <u>before</u> you take that week's prelab quiz, (remember, it's late 10 minutes after lab starts). Your submission package will be graded and returned with comments. <u>Submit the following 3 pages in order</u> (and nothing else) at the start of lab NEXT week:

1. The following cover sheet (completely filled in by all of your team members), one per team.
2. Your lab data on one page (both scope prints with time constant calculations and annotations), one per team.
3. Your percent error calculations in Excel and explanations from Part 3 of the lab on one page. Don't forget to include at least one sample calculation, one per team.

Submit NO ADDITIONAL PAPER or INFORMATION other than that requested. Extraneous Information such as the lab handout, prelab work, etc. will result in reduced credit for this assignment.

If you have any questions about the lab submission, please ask your instructor for clarification.

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Team Name and Lab Section:..

Team Members Present (printed)

First Name, Last Name	Role This Lab	RIT Program

TEAM LABORATORY RESULTS GRADE

(all work done neatly, legible and properly organized, all signoffs in place, calculations and signoffs in place, no missing information and no extraneous information)

Instructor Signature, Charge Phase ________	/10
Charge Phase Screen Capture (w/calcs and annotations)	/15
Instructor Signature, Discharge Phase ________	/10
Discharge Phase Screen Capture (w/calcs and annotations)	/15
Excel Data Table with % Error calcs and sample	/10
Final Team Grade	**/60**

Instructor Comments