Lab #2 – Time Constants

The purposes of this lab are

- to familiarize yourself with the oscilloscope and signal generator
- to gain a feel for the behavior of RC and LR circuits and their time responses
- to appreciate that capacitors and inductors are not 'ideal'.

Equipment at each station:	Centrally available:
digital oscilloscope	wire and wire cutters/stripper
2 multimeters	red and black banana plug cables
2 power supplies	alligator clips
signal generator	assorted resistors
breadboard with power connections	assorted capacitors
potentiometer	10mH inductors

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1. Oscilloscope Review

- Turn on the digital oscilloscope and setup in DC-coupled mode to measure steady-state (DC) voltages. Review how to make calibrated DC voltage measurements on either channel (1 or 2). Measure the unknown DC voltage that the instructor puts around the room.
- The real utility of an oscilloscope lies in its ability to look at AC (changing with time) voltages. After a brief review of the oscilloscope by the instructor, measure the amplitude and frequency of the unknown sinusoidal voltage with zero DC offset that the instructor puts around the room. Note that voltage amplitude can be expressed as pp (peak-to-peak), amplitude, and rms (root-mean-square) values. The digital scope has explicit measuring capabilities for AC voltages and periods as well as for DC voltages. Use the three different methods to measure the AC signal provided.
- Measure the same AC signal with the digital voltmeter. Do these measurements agree?
- Measure the AC signal with a DC offset that the instructor puts around the room. A large DC offset shows the difficulty of measuring small AC signals and the usefulness of AC coupling. Try the AC coupling feature.
- Measure the signal of unknown amplitude, frequency, and DC offset that the instructor puts around the room.
- Attach a length of wire to the scope input and attempt to detect the frequency and amplitude of WDCR. (Hint: 1340 on your AM dial).

2. Triggering

- Display the triangle wave with no offset that the instructor puts around the room. After a brief review of triggering by the instructor try triggering on 1, 2, ext, and line and observe how each works or fails to work.
- What use is triggering off the line? With a length of cable connected to the scope trigger off line and see 60 Hz.
- Using the triangle wave from the instructor, trigger your scope on channel 1 and gradually increase the trigger level. Note how the scope cannot trigger above the highest level of the signal or below the lowest. It is useful to display the trigger level on the scope for this exercise.
- Experiment with adjusting the +/- slope trigger choice while examining the triangle wave and note what happens.

3. Function Generator

- All of the signals that the instructor has generated can be generated using your own function generators.
- Make a sine wave with your function generator and measure it on channel 2 of your scope, leaving the instructors signal on channel 1. Varying the frequency, amplitude, and offset of your signal, explore trying to measure the two signals by triggering off either channel 1 or channel 2. Note that you can trigger off either but not both at once.
- By varying the frequency of your signal try and tune your signal signal to the same frequency as the instructors, twice the frequency, etc.
- Try and measure the phase difference between the two signals that are nearly the same frequency. (In practice, this may be difficult because the signals may not be stable enough.) Even if you cannot make the measurement, can you explain what you observe when trying?
- Use the XY mode on your scope to display a 'Lissajous' figure of the two signals. Note the sensitivity to amplitude, frequency, and phase differences between the two signals. (Note: the XY mode function is somewhat hidden on these scopes).
- Measure the internal resistance of the function generator with a suitable resistor.

4. RC Circuits

- Tailor a 0–5 V square wave with your function generator. Build an RC **differentiator** circuit on your breadboard. Examining the input square wave and the output voltage of this circuit, measure its time constant, verify the value of C, and verify the expected behavior of the output voltage. Why is this circuit called a differentiator? Try using different types of input signals (i.e., triangle wave, sine wave) and explain what happens. Try using different values of resistors and see what happens.
- Construct an RC **integrator** circuit on your breadboard and observe its characteristics. Experiment with different values of resistors and input signals noting the effects.

5. RL Circuits

- Construct an RL series circuit on your breadboard using the available 10 mH inductor and a 1 kΩ resistor. Verify the behavior of this circuit and measure the time constant. As before, monitor the source voltage simultaneously.
- Change to a lower valued resistor (e.g., 47 Ω) and observe the loading of the signal generator. By measuring the voltage on either side of the inductor, you should be able to infer both the output resistance of the function generator and the internal resistance of the inductor. Check the former against your earlier measurement and the latter with the ohmmeter.

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6. Optional Exercises (time permitting)

- Attempt to measure the leakage in sample capacitors; i.e., the effective parallel resistance.
- Examine an electrolytic capacitor and see what happens when the voltage is applied backwards across. (**Be careful to use a resistor to limit the current!**)
- Measure the impedance of the scope, both resistive and reactive.
