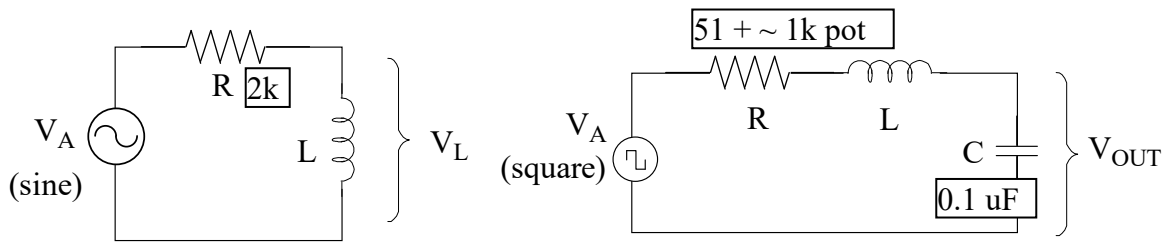<div style="background:yellow">

LAB 9 - RLC STEP RESPONSE & RL REACTANCE (1.5 h)

</div>

RL INDUCTIVE REACTANCE   RLC STEP RESPONSE

In this lab we will observe the step response of an RLC circuit and the effect of changing resistance on the response. We will demonstrate that changes in R will change the step response shape through the different cases (over damped, critically damped, under-damped). The step input will be obtained, as before, with a square wave output from the FG.

Inductive reactance is effectively the frequency-dependence "resistance" (or more accurately "impedance") of an inductor. The inductive reactance causes the sinusoidal voltage on the inductor to be phase shifted from the applied voltage sine wave. We will measure this phase shift and us it to compute the value of the unknown inductor value L. We can do this because the impedance phasor diagram has the same phase as the voltage phasor diagram. Since we know the frequency, resistance, and now the phase, we should be able to back out the value of L.

9.1   EQUIPMENT LIST

1. Trainer
2. Oscilloscope
3. Function Generator
4. Resistors: 51 Ω (green-brown-black)(**NO MORE?**), 2 kΩ (red-black-red)
5. Capacitor: 0.1 μF
6. Inductor (unknown value)
7. 1 kΩ pot or similar small value to change damping on response.
8. (*******) Measure component values with DMM
9. STUDENTS BRING A USB FLASH DRIVE

9.2   RLC STEP RESPONSE
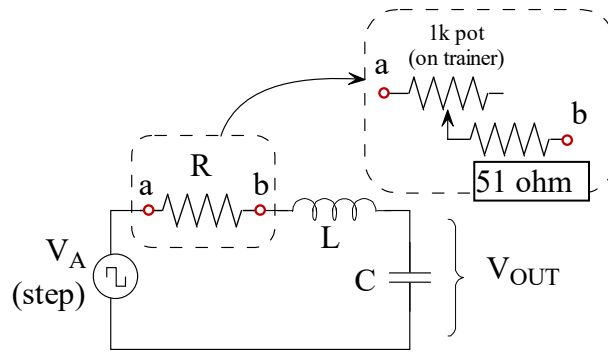
STEPS
1. Construct the circuit shown (power off). C is closest to GND.
2. R is a pot and small resistance in series.
3. Apply a SQUARE wave from FG (2 Vpp, 300 Hz, 0 offset). Measure with CH 1 on scope.
4. Measure V_C with the scope (CH 2).
5. Verify probe attenuation is correct (1x for co-ax cable, 10x for scope probe).
6. Display both channels on scope. Initially zero vertical and horizontal positions. Do not use Autoset.
7. Adjust horizontal position and time scale so a half period fills the display.
8. Turn the pot and observe the how the response trace changes its shape. Keep voltages overlaid.
9. (***) Adjust pot to maximize R. Capture trace.
10. (***) Adjust pot to minimize R. Capture trace.

9.3   RL INDUCTIVE REACTANCE (TO FIND L)

We will measure the phase shift between V_A and V_L and the inductive reactance of the R_L circuit. We will use this data to deduce the unknown value of L.
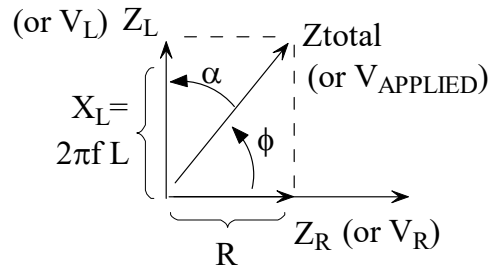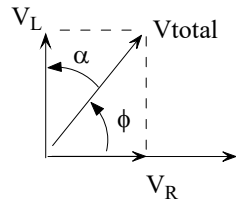
STEPS
1. Construct the RL series circuit above with L closest to ground.
2. Set FG to output to a SINE wave (1 Vpp (**2-4 Vpp?**), 60 kHz, 0 DC offset). Apply to circuit as V_A.
3. Display V_A (CH 1) & V_L (CH 2) on scope.
4. Verify probe attenuation is correct (1x for co-ax cable, 10x for scope probe).
5. Zero vertical and horizontal positions for both signals. Do not use Autoset.
6. Trigger based on V_A. (Trigger menu > Source > CH 1 > adjust with F2 key).
7. Set trigger level to zero by adjusting trigger level knob.
8. (***) Use cursors to measure the phase shift (Δt) between the 2 sine waves (time between the peaks)
9. (***) Record measured sine wave period (T) (Measure > display period) (this corresponds to 360 deg)

COMPUTE PHASE SHIFT AND L
1. (***) Convert phase shift Δt into degrees (by knowing period T recorded above correlates to 360 degrees)
2. (***) Record phase shift (in degrees). This is angle α in figure shown.
3. (***) COMPUTE L (see paragraph below).

You have measured α in the voltage phasors, but the impedance phasor has the same phase angle! See the diagram shown. In lecture, we derived an expression for ANOTHER phase angle (ϕ). Do not confuse α & ϕ. Use the diagram's geometry to find an expression relating R, f, L, and α. Re-arrange the equation to solve L. Record L. Show your work.

V_L ⟍ ⟍ ⟍ Vtotal

α

φ

V_R

(or V_L) Z_L ⟍ ⟍ ⟍ ⟍ Ztotal

(or $V_{APPLIED}$)

α

$X_L=$
$2\pi f\ L$

φ

R

Z_R (or V_R)

LAB 9 - ANSWER SHEET
RLC STEP RESPONSE & INDUCTIVE REACTANCE

Team Number: _____

Name 1: _____   Name 2: _____

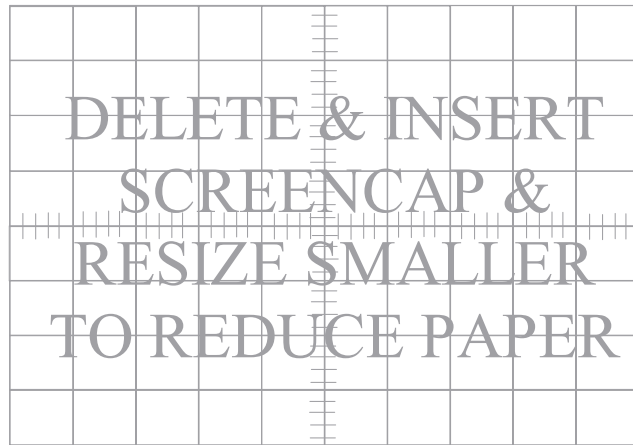## 9.1   Component Values

R (51 ohm) _____   R (2 k) _____   C (0.1 uF) _____   L (unknown)

9.2   RLC Step Response

DELETE & INSERT SCREENCAP & RESIZE SMALLER TO REDUCE PAPER

DELETE & INSERT SCREENCAP & RESIZE SMALLER TO REDUCE PAPER

RLC Step Response (max R)   RLC Step Response (min R)

9.3   RL & Inductive Reactance

_____ . Δt between sine waves

_____ .   Period T of sine waves

_____ .   Phase shift α (in degrees)

_____ .   Computed value of L (show work below)