Experiment 23

Saturday, November 6, 2021 12:34 PM

Objectives:
1. Find the inductance of an unknown coil by measurements and calculations
2. Examine the characteristics of RL circuits
3. Show the effect of DC on an inductor

Procedure Notes:
1. Skip steps 3, 9, 15-17
2. Simulate Fig 23-1 in LTSpice. Use this for step 3

Note: Could not find 1k Ω resistors. Instead of using a 1k resistor we used two 2.2k resistor
Vrms = 1/(2*sqrt(2))*Vpp
Q = XL/R

Steps 1-6:

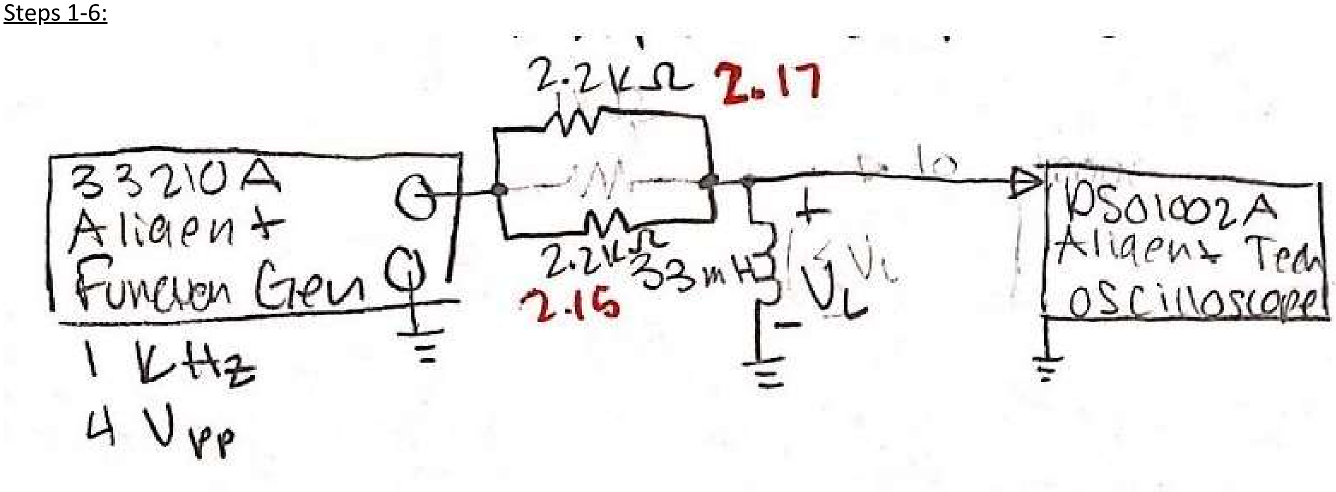
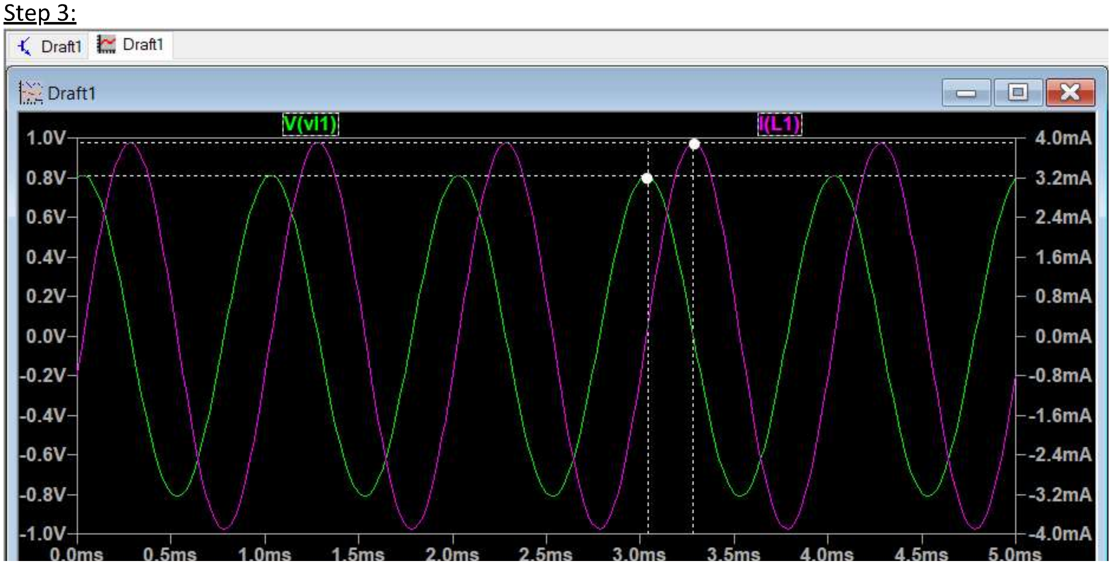


Figure 23-1: Circuit for steps 1-6 (resistor in series with function generator)

Oscilloscope Measurements:
(PP) VL = 660 mV
(RMS) VL = 224 mV
T = 1 ms

DMM Measurements:
RL = 62.5 Ω

Step 3:



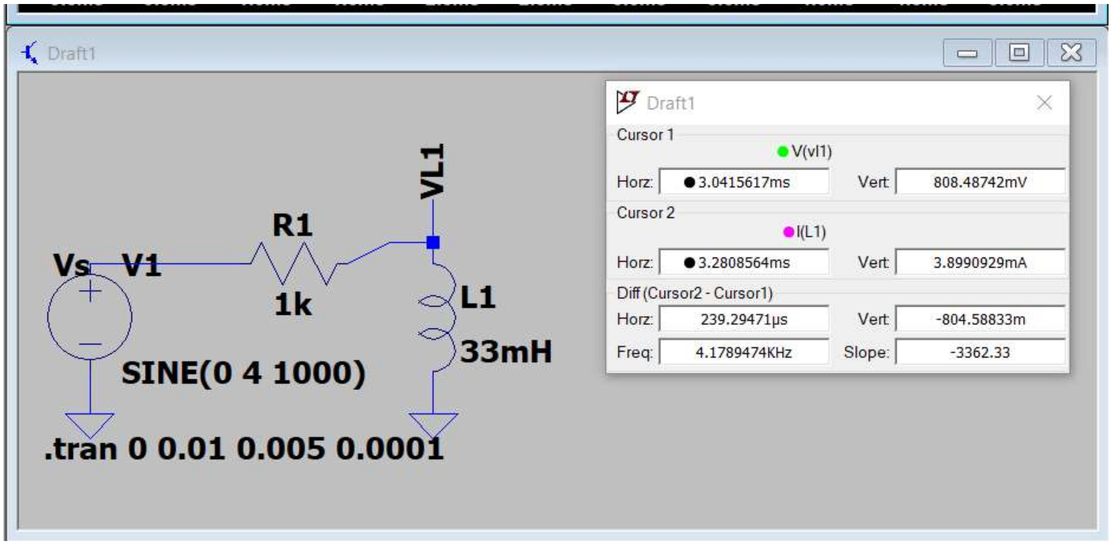


Figure 23-4: LTSpice demonstration of phase shift between current and voltage for Figure 23-1 (replace for step 3)

Step 7:

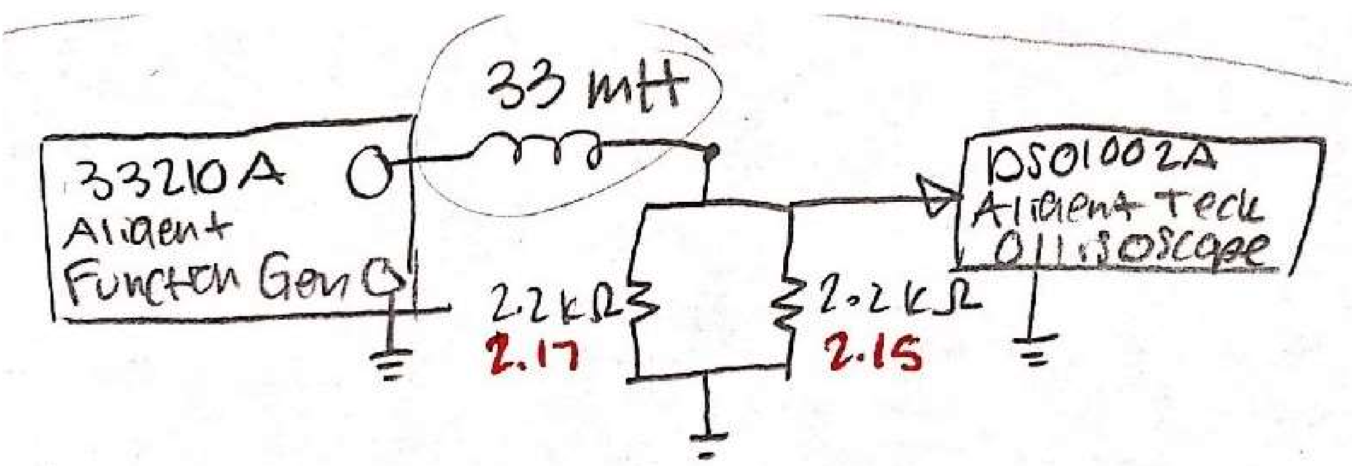


Figure 23-2: Circuit for step 7 (inductor in series with function generator)

Oscilloscope Measurements:
(PP) VR = 3.68 V
(RMS) VR = 1.26 V
T = 1 ms

DMM Measurements:
R = 1080 Ω

Step 8:
XL = 2πfL=2π(1000)(33m)
XL = j207.345 Ω
Vrms = 1.41414 V (using 4 Vpp and rms equation)
T = 1 ms (oscilliscope)
Δx = 16 µs (oscilliscope)

Zeq = (1080+j207.345)Ω
Rt = 1080 Ω + 62.5 Ω = 1142.5 Ω
Irms= Vrms/XL = 0.006821 A
Theta = 360*Δx/T = 0.00576°

Step 9:

I = 0.0812 A

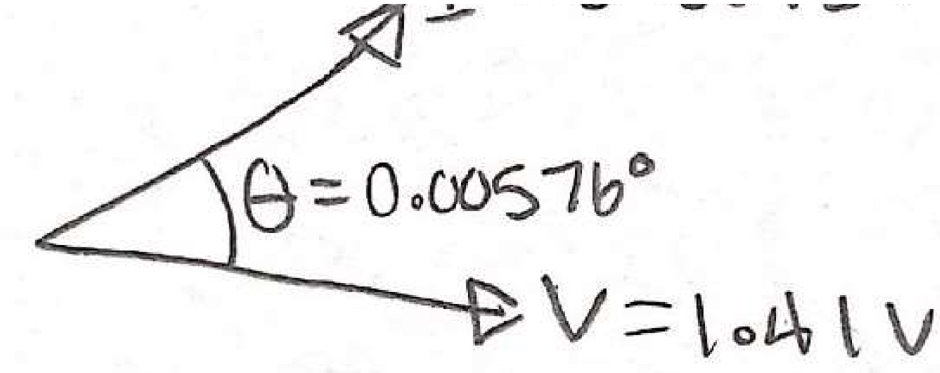


Figure 23-5: Current/Voltage Phasor Diagram

Step 10:

$$V_R = \frac{R}{R+X_L} V_s \leftarrow \text{Voltage Divider}$$

$$1.26\ V_{rms} = \frac{1080}{1080+\underbrace{(j2\pi(1k)L)}_{j6283.19L}} \cdot (1.41214)$$

$$\boxed{\begin{gathered} L = 0.32162 - 0.187114i \\ \text{or} \\ 0.189858 \angle -80.247^\circ \end{gathered}}$$

Without including imaginary numbers, L = 0.0207 H

Step 11:
Qcircuit = XL/Req =2π(1000)(33m)/1142.5
Qcircuit = 0.181484

Step 12:
Ocilliscope Measurements 5kH:
(PP) VR = 2.52 V
(RMS) VR = 1.24 V

(PP) VL = 2.46 V
(RMS) VL = 1.01 V

T = 0.2 ms
Δx = 100 µs

Calculations:
Vrms = 1.7677 V

Irms = 0.001364 A

XL = 2πfL=2π(5000)(33m)
XL = j1036.73 Ω
Zeq = (1080+j1036) Ω

Theta = 0.000002°

Questions:

1. Increasing the frequency of the voltage applied to a series RL circuit causes the current to:
   - Decrease
2. Why is the voltage across the inductor higher than the calculations indicate?
   - There is a chance that the inductor is absorbing more power than anticipated. In the equation P = IV, we can see that power and voltage are directly proportional. That means, if the inductor is absorbing more power than expected, there will be more voltage across the inductor than anticipated.
3. What is the current in the inductor when 5V are applied?
   Irms = Vrms / XL
   Irms = ((1/2sqrt(2))*5V)/(2π*1000*33m)
   Irms = 0.008526 A