Experiment 1b: Series-Parallel Circuit Measurements

Figure 1-13 below shows a series-parallel circuit with its circuit properties labeled.

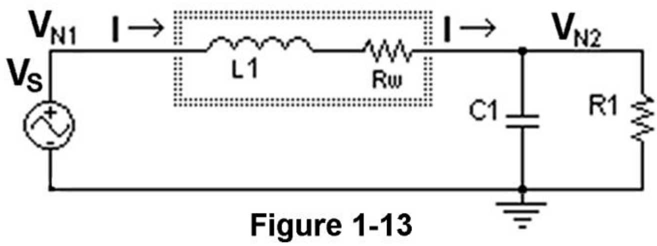

Figure 1-13

A steady-state sinusoidal voltage, $\mathbf{V_S}$, will be applied to the circuit. The amplitude and phase angle of voltages in the circuit will be measured. The measurements will be compared to simulations and theoretical calculations.

The relevant phasor-domain equations are presented below.

$$\mathbf{Z} = \mathrm{Rw} + \mathbf{j}\omega \mathrm{L1} + \mathbf{Z_P} \qquad \mathbf{Z_P} = \frac{-\mathbf{j}\left(\frac{1}{\omega \mathrm{C1}}\right)\mathrm{R1}}{\mathrm{R1} - \mathbf{j}\left(\frac{1}{\omega \mathrm{C1}}\right)} \qquad \mathbf{I} = \frac{|\mathbf{V_S}|\angle 0^0}{\mathbf{Z}} \qquad \mathbf{V_{N2}} = \mathbf{I} \cdot \mathbf{Z_P}$$

$$\text{Node Voltage Method: } \frac{\mathbf{V_{N2}} - |\mathbf{V_S}|\angle 0^0}{\mathrm{Rw} + \mathrm{j}\omega \mathrm{L1}} + \frac{\mathbf{V_{N2}}}{\mathrm{R1}} + \frac{\mathbf{V_{N2}}}{-\mathbf{j}\left(\frac{1}{\omega \mathrm{C1}}\right)} = 0$$

Equipment and Parts

Function Generator, Oscilloscope, and Breadboard.
C1 = 100nF, 5%. R1 = 4700Ω, ¼ watt, 5%. L1 = 100mH, 5%.
Measure the resistance of the inductor, Rw.

Rw = ____________________________

For greater accuracy, measure the values of R1, C1, and inductance of L1

R1 = ______________ C1 = ______________ L1.= ______________

Procedure

1. Connect the circuit in Figure 1-14.

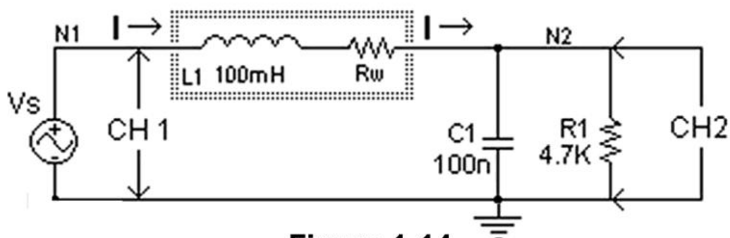

Figure 1-14

2. Connect channel 1 of the oscilloscope to node N1 and channel 2 to N2. Set the trigger to channel 1.
3. Set the function generator to produce a 3.0V p-p, 1600Hz, sine wave and adjust the oscilloscope to accurately measure the waveform amplitudes and phase angles at nodes N1 and N2.

   Measure and record the magnitude and phase angle of the voltage at node N2

   $\mathbf{V_{N2}}$ ________________volts p-p θ_{N2} = __________________degrees

Analysis

1. Calculate the theoretical value (magnitude and phase angle) of the voltage at node N2.
2. Calculate the theoretical value of the current **I.**
3. Calculate the approximate value of the current, **I,** using Ohm's Law, the voltage measured at node N2, and the impedance of R1 and C1 in parallel.
4. Calculate the approximate value of the current, **I,** using Ohm's Law, the voltage measured at node N2, and the impedance of L1.
5. Simulate the circuit and compare the results to your measurements and calculations.

LTspice Simulation Example: Series-Parallel Circuit

Connect the circuit shown in Figure 1-15.

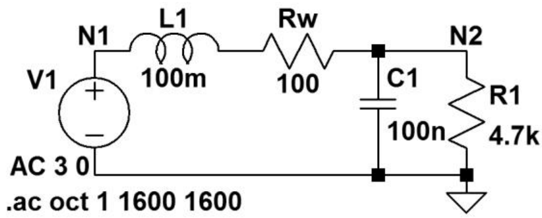

Figure 1-15

Right click on V1 to set its AC value to 3 volts and angle to 0 degrees. Set the AC analysis to 1600Hz.

AC analysis results:

```
        --- AC Analysis ---

   frequency: 1600Hz
   V(n1):     mag:           3    phase:  2.1e-015°  voltage
   V(n001):   mag:     9.78565    phase:-82.4°       voltage
   V(n2):     mag:      9.5357    phase:-88.0°       voltage
   I(C1):     mag: 0.00958633    phase:  1.9°       device_current
   I(L1):     mag: 0.00979868    phase:-10.0°       device_current
   I(R1):     mag: 0.00202887    phase:-88.0°       device_current
   I(Rw):     mag: 0.00979868    phase:-10.0°       device_current
```

PSpice Simulation Example: Series-Parallel Circuit

Connect the circuit as shown in Figure 1-16 below. The printers, “IPRINT” and “VPRINT1”, are in the “SPECIAL” library.

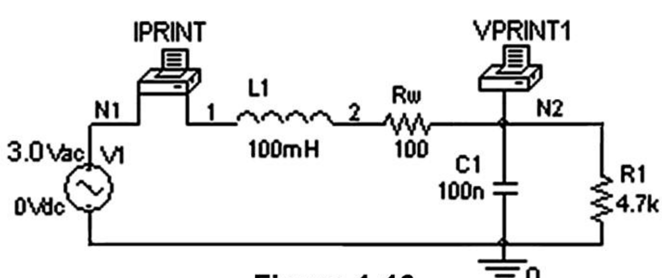

Figure 1-16

Enable the printers by double clicking on each printer to open the property editor. Type “ok” under AC, MAG, and PHASE.

Select *Analysis Type*: AC Sweep/Noise. *AC Sweep Type*: Linear.

Start frequency: 1.6kHz. *Stop frequency*: 1.6kHz. *Total Points*: 1.

Results in Output File:

FREQ	IM(V_PRINT2)	IP(V_PRINT2)
1.600E+03	9.800E-03	-1.001E+01

FREQ	VM(N2)	VP(N2)
1.600E+03	9.536E+00	-8.806E+01

TI-89 example at 1600 Hz:

X_{L1} reactance in ohms:

2*π*1600*.1 ENTER ►1005

X_{C1} reactance in ohms:

1/(2*π*1600*.1E-6) ENTER ► 995

Impedance **Z** in ohms:

100+1005**i**+(-4700*995**i**)/(4700-995**i**) ENTER ► (306.2∠9.91)