Digital Oscilloscope Memo

Zack Garza, Shawn Azam, Nick Lonsdale

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***Abstract*—**
THE purpose of this memo is to discuss several parameters on the digital oscilloscope and how they effect readings and measurements. The oscilloscope will then be used to simultaneously measure two channels of information from an LRC circuit to observe the circuit's response to a range of frequencies.

CONTENTS

I. METHODOLOGY

1) The signal generator was initialized with the frequency given in Table I and connected to channel 1 of the oscilloscope.
2) The self-calibration function on the oscilloscope was activated. The probes were then calibrated as well.
3) The circuit shown in I was constructed, with the initial values described in Table I. Several settings were modified, and the changes and effects were recorded.
4) Using the auto-measuring display, the data in Table **??**.

Table I
GIVEN LAB PARAMETERS

Wave Type	Sine
Frequency	100 kHz
Peak to Peak Voltage	12 V
Resistance	12kΩ
Inductance	17 mH
Capacitance	220μF
DC Offset	0 V

Table II
ACTUAL MEASURED VALUES

Parameter	Measured Value	Percent Error
Frequency	(100 $\pm$0.2) kHz	0.2%
Resistance	12.12 kΩ	1.0%
Inductance	17.1 μH	0.6%
Capacitance	222 μF	0.9%

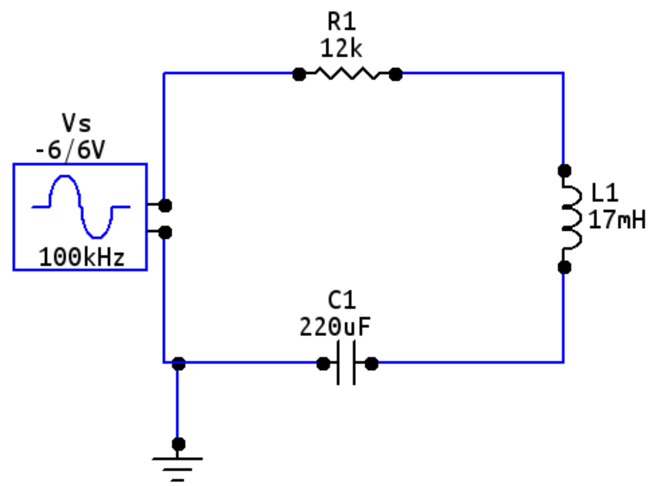

Figure 1. Theoretical Circuit Model

II. DATA

A. Oscilloscope Parameter Variations

The following settings on the oscilloscope were adjusted, and the observed effects are explained below.

AC / DC Coupling:

Changing the coupling mode for this circuit did not exhibit a large change in the oscilloscope reading. This is largely due to the fact that the AC power source used did not have a DC offset. In DC coupling mode, the waveform will tend to oscillate about some positive voltage, i.e, the DC offset. By using AC coupling, the DC portion of the signal is blocked, and the waveform is shown oscillating about 0 volts instead. This can be useful for measuring small perturbations in AC measurements, as it serves as a noise gate that filters the signal and allows for more precise measurements at high magnifications.

1x / 10x Probe:

Setting the probe's physical switch to 10x made all voltages $1/10$ of their original values by making the impedance 10 times larger. The oscilloscope must then be set to display 10 times the voltage read from the probe in order to get a correct reading. This setting can be used to minimize the amount of error caused by the probe's resistance, especially if it is on the same order of magnitude as the resistance being measured. The oscilloscope has probe multiplier settings ranging from 500x to 100,000x, which allows for the measurement of a wide range of circuit elements.

Invert On / Off

Activating this setting on a given channel mirrors the waveform about the x-axis, effectively reversing the sign of the voltages on the channel.

B. Auto Measuring

RMS Voltage: 4.17 V	Peak to Peak Amplitude: 11.8 V
Period: 1 ms	Frequency: (100 ± 0.2) kHz

C. Triggering

Triggering Type:	Edge
Triggering Source:	Ch. 2
Triggering Mode:	Auto

The trigger level dictates at what point the oscilloscope begins measuring a signal. It can be set so that measurement does not begin until some condition is met, such as the presence of a specific level of voltage. This allows for finer control of capturing data. In Edge mode, the trigger is set to activate at the edge of a signal – in this case, when the sine wave rises or falls. The trigger can be set to activate when the voltage condition is met and is either increasing or decreasing. The voltage level at which this occurs can be set via a knob on the scope, and the signal source can be set via the menu system.

It is possible for a circuit to never meet the initial trigger conditions – in this case, the AUTO triggering setting forces the oscilloscope to automatically trigger after a certain amount of time, even if the input conditions are not met. This ensures that a minimum amount of measurements per second will be taken.

D. Dual Signals

The component from the circuit chosen for measurement on Channel 2 was the 17 mH capacitor. The frequency was lowered in order to exhibit a discernible response in the capacitor, and the following measurements were taken with a 35.2 Hz sine wave.

Peak to Peak measurements for both channels:

Ch.1 Peak to Peak (Source):	12.0 V
Ch.2 Peak to Peak (Capacitor):	23.4 mV
Period	28.44 ms

Phase shift between both channels:

$$\Delta t = 7.000\text{ms} \qquad \theta \approx 1.546 \text{ rad} = 88.58^\circ$$

Where θ is given by $2\pi\frac{\Delta t}{T}$ or $2\pi f \Delta t$ in radians ($360\frac{\Delta t}{T}$ in degrees), Δt is the distance in the time domain between two identical points on the adjacent waves, T is the period (time in seconds between identical points on a waveform), and f is the frequency of the generator..

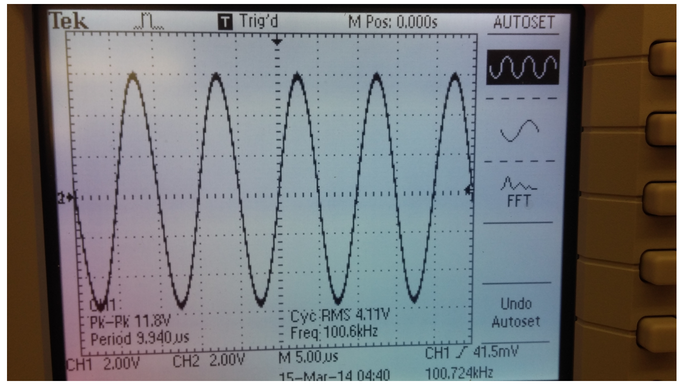

Figure 2. Display of Source Waveform

III. Analysis

Inductive Reactance: $X_L = 2\pi f L$.
Capacitive Reactance: $X_C = 1/2\pi f C$.
Resonant Frequency: $f_0 = 1/2\pi\sqrt{LC}$

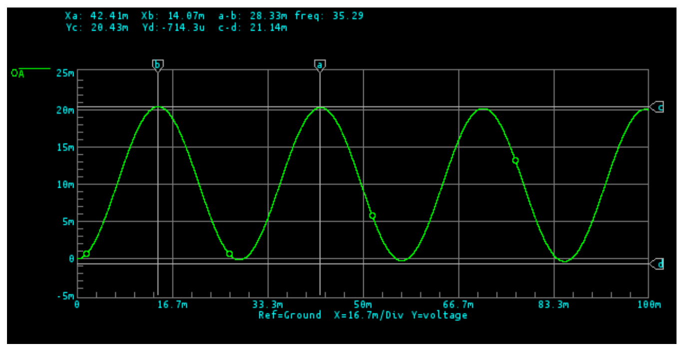

Figure 3. Theoretical Capacitor Voltage, Modeled in CircuitMaker

Table III
Measured vs. Theoretical Results from Capacitor Voltage Measurements

Parameter	Measured Value	Theoretical Value	Percent Difference
V Peak to Peak	23.4 mV	21.14mV	10%
Period	28.44 ms	28.33 mS	0.39%

Appendix A
Circuit

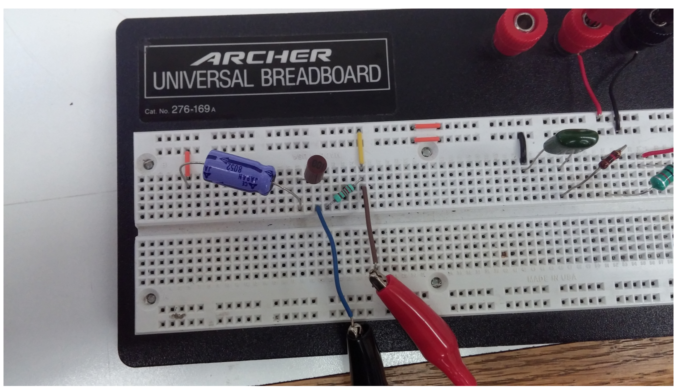

Figure 4. Photograph of Circuit Used