UM–SJTU Joint Institute

Electronic Circuits
(VE311)

Laboratory Report

Lab 1

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Contents

1 Objectives

- Test the behavior that the resistance has to temperature, humidity, high current and voltage.
- Understand what happened when a series of capacitors behave at different conditions.
- Analyze the behavior of a simple array of resistors.

2 Experiment procedures

2.1 Resistor behavior

We are going to test the behavior that the resistance has to temperature, humidity, high current and voltage. By using a resistor of $220\,\Omega$, $10\,\mathrm{k}\Omega$ and the closest to $1\,\Omega$, perform the follow set of tests.

- By using a wave generator and an oscilloscope, measure the resistor response for a voltage of 1, 5, 10 and 15 V by sweeping the frequency from 10 Hz up to 50 MHz in each case.
- In each case heat or warm the resistance and see if there is any change in the oscilloscope signal.
- "Carefully" reduce the temperature of the resistance and see what happen to the signal.

2.2 Capacitors

The second part considers the use of capacitors. In here, we are going to use a series of capacitors and to understand what happened when they behave at different conditions.

- Use the capacitors: $3.3\,\mu$F, 0.082 μF and 5 pF. Each one of the capacitors is to be in series with a 10 kΩ resistor. By applying 1 V_{pp} you're going to sweep the frequency ranging from 50 MHz or the highest to 60 Hz.
- Invert the order of the devices and perform the same test.

2.3 Inductor

Finally, with an inductor, we are going to perform a set of experiments. By using a simple array of a 10 kΩ resistor in series with an inductor, we're going to analyze the behavior of the array. By using the wave generator, we are sweeping a range of frequencies from 50 MHz up to 1 Hz with a 1 V_{pp} .

3 Experimental results and discussion

3.1 Resistor behavior

We use the $10\,\mathrm{k}\Omega$ resistor, which has the most apparent behavior. The voltage figure for the origin resistor was shown in Figure 1.

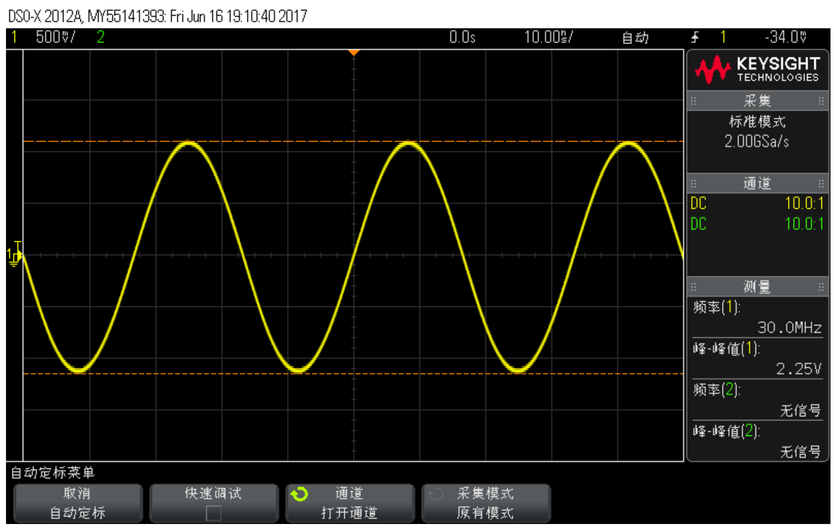
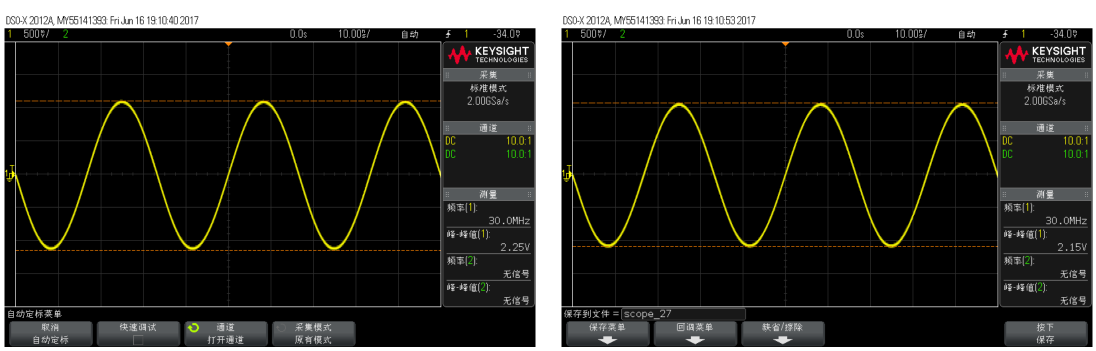


Figure 1: Origin voltage figure of $R = 10\,\mathrm{k}\Omega$

When the temperature was raised, the comparison of the origin figure and the new figure was shown in Figure 2.



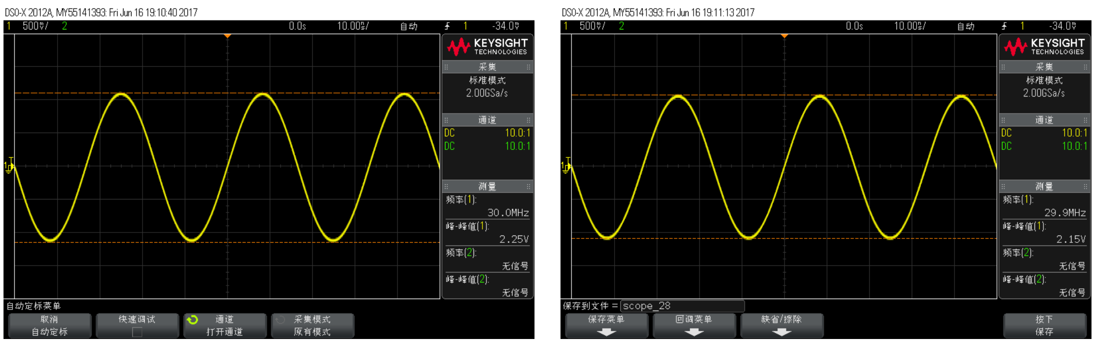
(a) origin

(b) higher temperature

Figure 2: Comparison between origin figure and higher temperature

We can find that when the temperature rises, the voltage on the source become slightly lower, which means that the resistance becomes lower.

When the humidity was raised, the comparison of the origin figure and the new figure was shown in Figure 3.



(a) origin

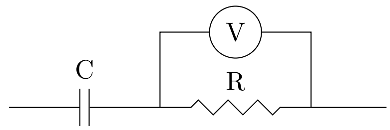
(b) higher humidity

Figure 3: Comparison between origin figure and higher humidity

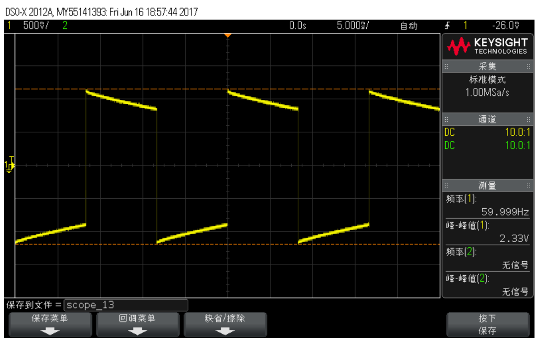
We can find that when the humidity rises, the voltage on the source become slightly lower, which means that the resistance becomes lower.

3.2 Capacitors

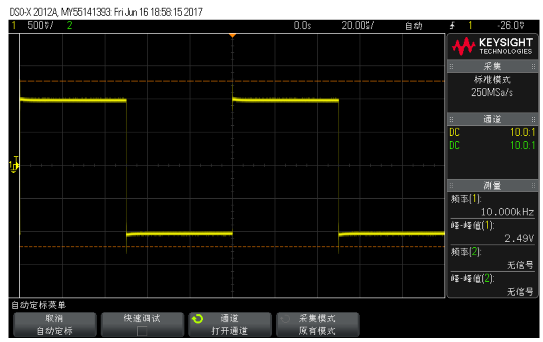
We choose two capacitors, $3.3\,\mu$F and $0.082\,\mu$F and use the follwing circuit.



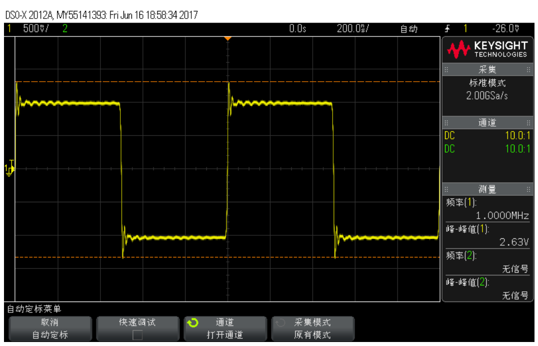
For the $3.3\,\mu$F capacitor, the figure was shown in Figure 4.



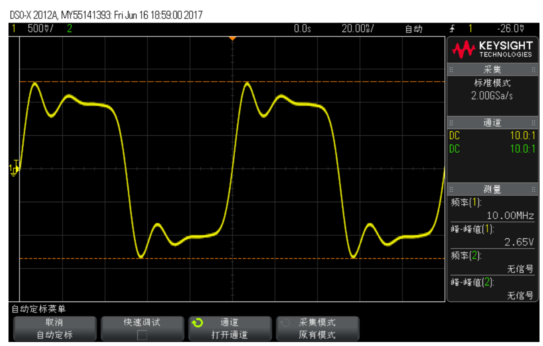
(a) 60 Hz



(b) 10 kHz



(c) 1 MHz



(d) 10 MHz

Figure 4: $3.3\,\mu$F capacitor

In an RC circuit, we have the equation

$$x(t) = K_1 e^{-t/RC} + K_2$$

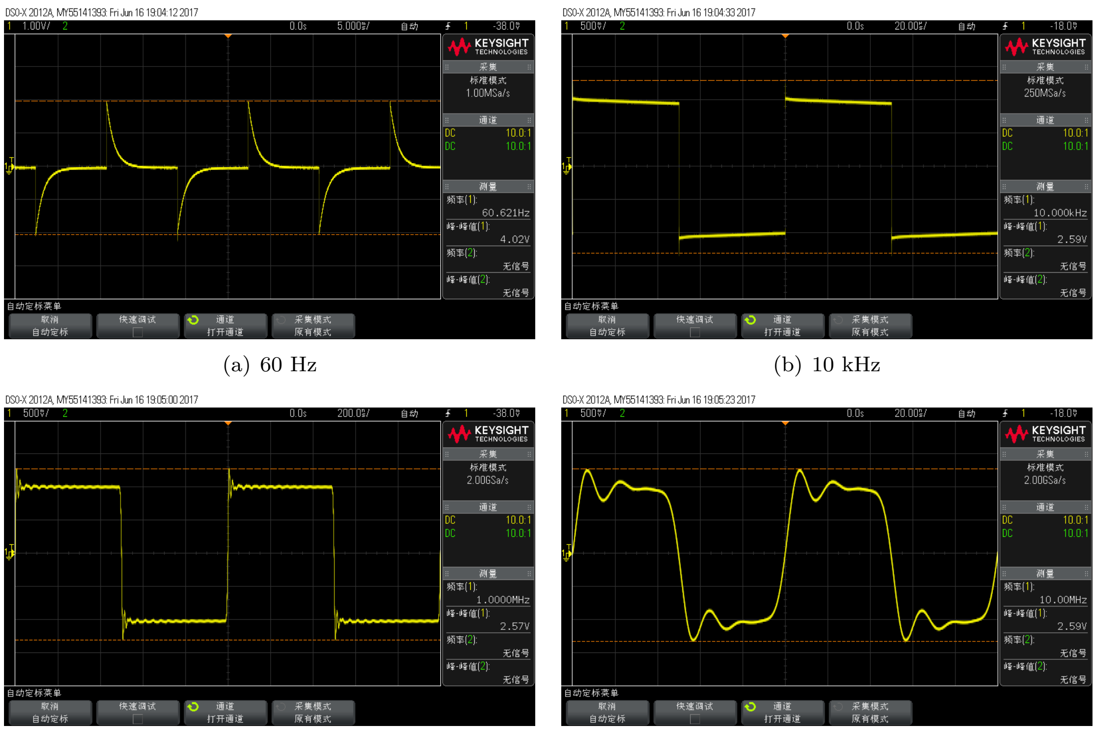
In Figure 4(a), $(f = 60\,\text{Hz})$, $RC = 10^4\,\Omega \cdot 3.3\,\mu\text{F} = 0.033\,\text{k}\Omega \cdot \text{F}$, $t \in [0, \frac{1}{120}]\,$s, so $\frac{t}{RC}$ is not very small, we can find some exponential curves in the figure.

In Figure 4(b), $t \in [0, 5 \times 10^{-5}]\,$s, $\frac{t}{RC}$ becomes very small, so the exponential curve converges to a straight line.

In Figure 4(c), $\dfrac{t}{RC}$ becomes even smaller. However, it is out of our expectation that the curve begins to behave a damping status. In theorem, it is impossible to happen according to the equation above.

In Figure 4(d), the curve becomes more strange, and it converges to a sine wave.

For the 0.082 μF capacitor, the figure was shown in Figure 5.



(a) 60 Hz

(b) 10 kHz

(c) 1 MHz

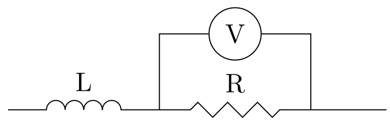
(d) 10 MHz

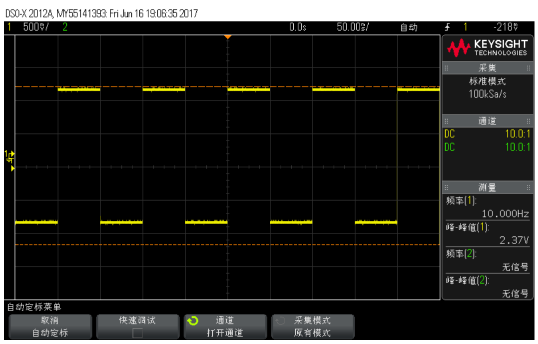
Figure 5: 0.082 μF capacitor

When the capacity of the capacitor becomes smaller, the overview of the figures doesn't change much. And in Figure 5(a), the appearance of a more identical exponential curve is related to the increase of $\dfrac{t}{RC}$.

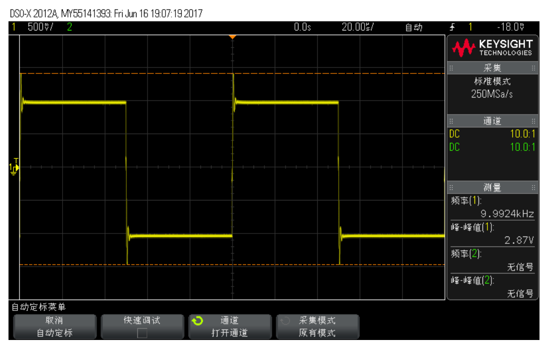
3.3 Inductor

We use the follwing circuit.

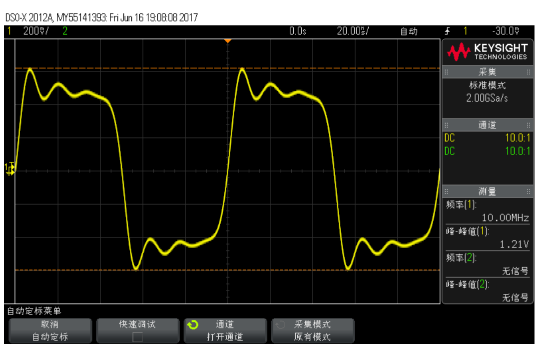




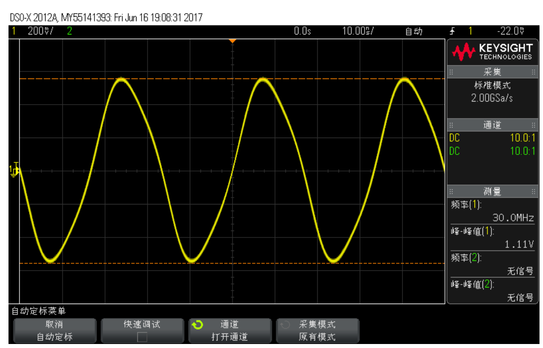
(a) 10 Hz



(b) 10 kHz



(c) 10 MHz



(d) 30 MHz

Figure 6: Inductor

In an RL circuit, we have the equation

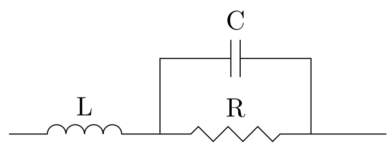
$$v(t) = K_1 e^{-Rt/L} + K_2$$

Similar to the capacitors, Figure 6(a) and Figure 6(b) satisfy the equation. However, with the increasing of frequency, the figure also converges to the sine wave.

4 Conclusion

In the first part, we find that when the temperature and humidity rises, the resistance of the tested resistor becomes lower. According to the physics principles, a resistor made in non-metal has such property, so we guess that the resistor is made in carbon or some other non-metal materials.

In the second and third part, it seems confusing to find that there is a damping, or a sine wave shown in the figure. Since the frequency is very large, the resistor in the circuit can't be identified as ideal resistor. In a non-ideal mode, a resistor can be equivalent to the following circuit.



For a typical resistor, $C \approx 1\,\mathrm{pF}$, $L \approx 14\,\mathrm{nH}$, when the frequency is extremely high, the circuit would become a second order RLC circuit, which have $\omega_0 = \dfrac{1}{\sqrt{LC}}$, so the circuit may have a overdamped response like Figure 5(a), or a underdamped response like Figure 6(d).

5 Reference

5.1 References

1. Lab1 Manual