Department of Electrical and Electronic Engineering

EEE103 ELECTRICAL CIRCUIT 1

Laboratory Report

Name : Zhongnan Li
Student ID : 1931254

Experiment 1: Voltage and Current Measurement, and Thevenin Equivalent Circuit

Task A: Measuring DC Voltage and Current

1. Introduction

To measure DC voltage and current, Ohm's law which states that the voltage across a conductor is directly proportional to the current flowing through it, provided all physical conditions and temperature, remain constant is applied and the equation of it is V = IR, where V is the voltage across the conductor, I is the current flowing through the conductor and R is the resistance provided by the conductor to the flow of current.

2. Methodology

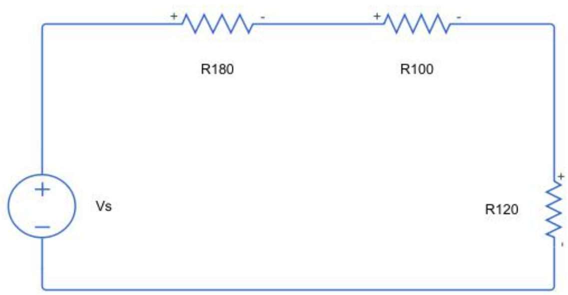


Figure 1

First, a circuit shown in figure 1 should be created on the breadboard and then the values of each resistance should be measured by a multimeter. Use the equation $R_T^m = R_{180\Omega} + R_{100\Omega} + R_{120\Omega}$ to calculate the resistance R_T^m. Secondly, the voltage output should be set to 10 V and then the voltage across each resistor and current are supposed to be measured and recorded. Ohm's law $R_T = \frac{V_T}{I}$ should be used to calculate the total resistance. Finally, Ohm's law should be used again to calculate the individual voltage and current as the equations follows: $V'_{180\Omega} = \frac{R_{180\Omega}}{R_{180\Omega}+R_{100\Omega}+R_{120\Omega}} \times V'_T$ and $I' = \frac{V'_T}{R'_T}$.

3. Results and Discussions

During the experiment, we first measured the resistance of three different resistor and got the values shown in the table 1. And then we used the equation $R_T^m = R_{180\Omega} + R_{100\Omega} + R_{120\Omega}$ to calculate the total resistance which was also filled in the table 1.

Table 1: Measured Resistance

Resistor	$R_{180\Omega}$	$R_{100\Omega}$	$R_{120\Omega}$	R_T^m

Measured Resistance (Ω)	178.4	100.2	120.4	399

After that, we created the circuit, put the voltage source at 10V, and measured the voltage across each resistor and current. The values are filled in the table 2.

Table 2: Measureing the current and voltage for each resistor

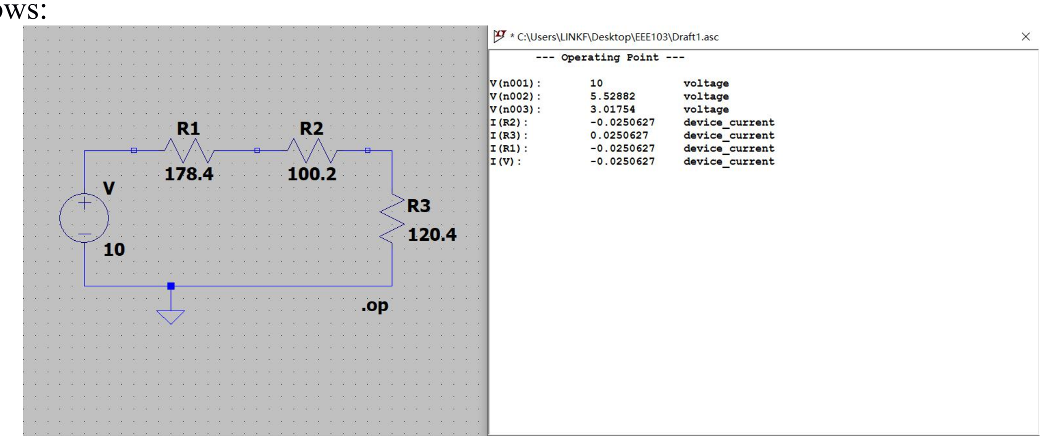
V_s (V)	$V_{180\Omega}$ (V)	$V_{100\Omega}$ (V)	$V_{120\Omega}$ (V)	V_T (V)	I (mA)	$R_T = {}^{V_T}/_{I}$
10	4.49	2.49	2.97	10	25.0	400

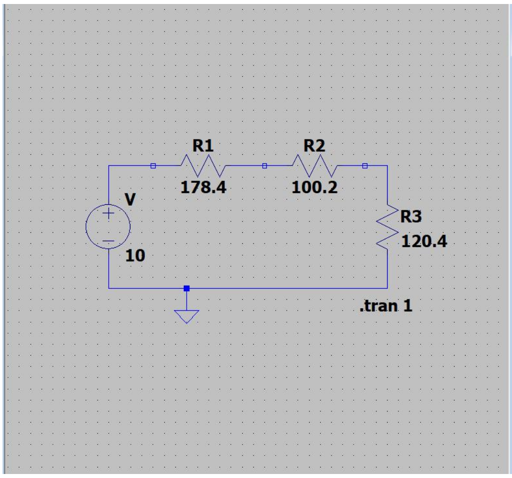
At last, we used the voltage division and Ohm's law as equation $V'_{180\Omega} = \frac{R_{180\Omega}}{R_{180\Omega}+R_{100\Omega}+R_{120\Omega}} \times V'_T$ and $I' = \frac{V'_T}{R'_T}$ to calculate the theoretical value of voltage across each resistor and current. The values we got are filled in the table 3.

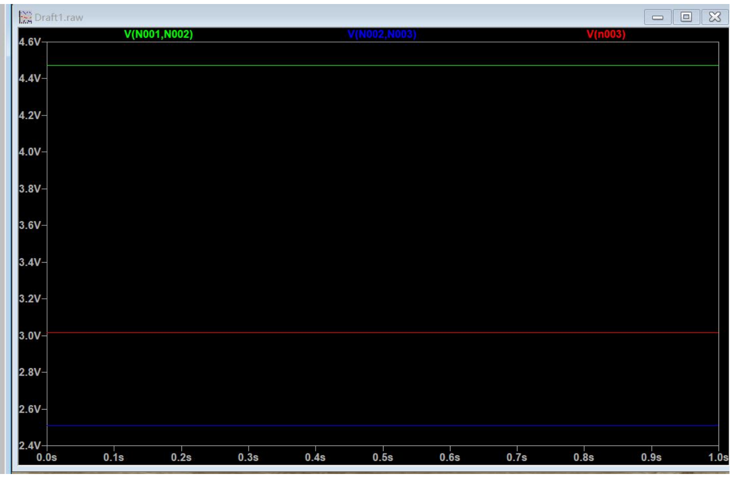
Table 3: Calculate the voltage and current for each resistor

V_s (V)	$V'_{180\Omega}$ (V)	$V'_{100\Omega}$ (V)	$V'_{120\Omega}$ (V)	V'_T (V)	I' (mA)	$R'_T = {}^{V_T}/_{I}$
10	4.47	2.51	3.01	10	25.1	399

To get a more precise theoretical value, we used LTspice to simulate the circuit. The figure is as follows:







These are all the results we got, next we will bagin a discussion about the results.

From table 1, we can easily get that the measured value of resistance is a little bigger than the theoretical value. The percentage of error can be expressed as:

$$\delta_1 = \frac{R_T - R_T^{'}}{R_T^{'}} \times 100\% = 0.25\%$$

The measured value of current is a little smaller than the theoretical value. The percentage of error can be expressed as:

$$\delta_2 = \frac{I - I^{'}}{I^{'}} \times 100\% = - 0.40\%$$

The reasons of difference between R_T and $R_T^{'}$, I and $I^{'}$ are as follows: 1. Any measuring instrument has a certain accuracy level, and there will be measurement errors.
2. The actual value of any actual yuan return cannot be strictly equal to the nominal value, and there are errors.
3. The actual value of any actual component will not remain unchanged, and is affected by temperature, humidity, voltage, and current. For example, the higher the carbon film resistance temperature, the lower the resistance, and the higher the metal film resistance temperature, the greater the resistance.

From table 2, we added all the voltage together and got the $V_{total} = V_{180\Omega} + V_{100\Omega} + V_{120\Omega}$ =9.95V which is smaller than V_s which is 10V, the reason we thought is that the resistance of the wire is not 0, therefore the current passing through the wire will distribute some voltage on the wire, resulting the smaller voltage on the resistors.

4. Conclusions

In this experiment, we measured the resistance of three different resistor and the voltage and current across them, and we also calculated the theoretical value of these. By comparation, we concluded the reasons why there are some difference between measured value and theoretical value. In conclusion, we obtaioned the approach to measure resistance, voltage and current in the DC circuit by using a multimeter.

Task B: Finding the Thevenin Equivalent Circuit

1. Introduction

In this experiment, Thevenin's theorem which states that any two terminal linear network or circuit can be represented with an equivalent network or circuit, which consists of a voltage source in series with a resistor should be applied. The apparatus should be prepared are: DC power supply, breadboard, multimeter, banana cables for DC power supply, a pair of probes for multimeter, resistors and jumper wires.

2. Methodology

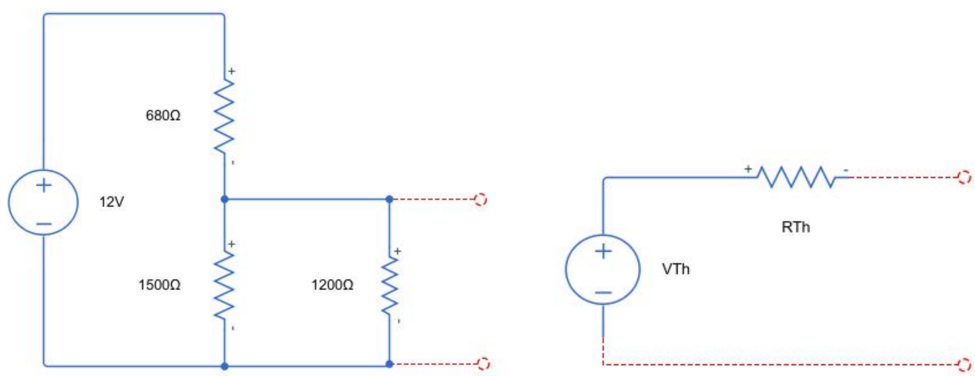


Figure 2: (a) Original circuit, (b) Thevenin Equivalent circuit

First, a circuit such as the figure 2 should be created on the breadboard. Secondly, the open voltage between terminal A and B should be measured by a multimeter and be recorded as the measured V_{TH}. After that, use voltage and current laws to calculate the open voltage and be record it as calculated V_{TH}. Thirdly, the voltage source should be short-circuited in figure 2(a) and the resistance between terminal A and B should be measured and be recorded as the measured resistance R_{TH}. After that, the resistance should be calculated and be recorded as the calculated resistance R_{TH}. Fourth, a 1kΩ resistor should be connected to terminal A and B in figure 2(a) and the current $I_{1k\Omega}$ should be measured and recorded. Finally, the circuit shown in figure 2(b) should be created on the breadboard by using the calculated V_{TH} and R_{TH}. Repeat the fourth part and record the result.

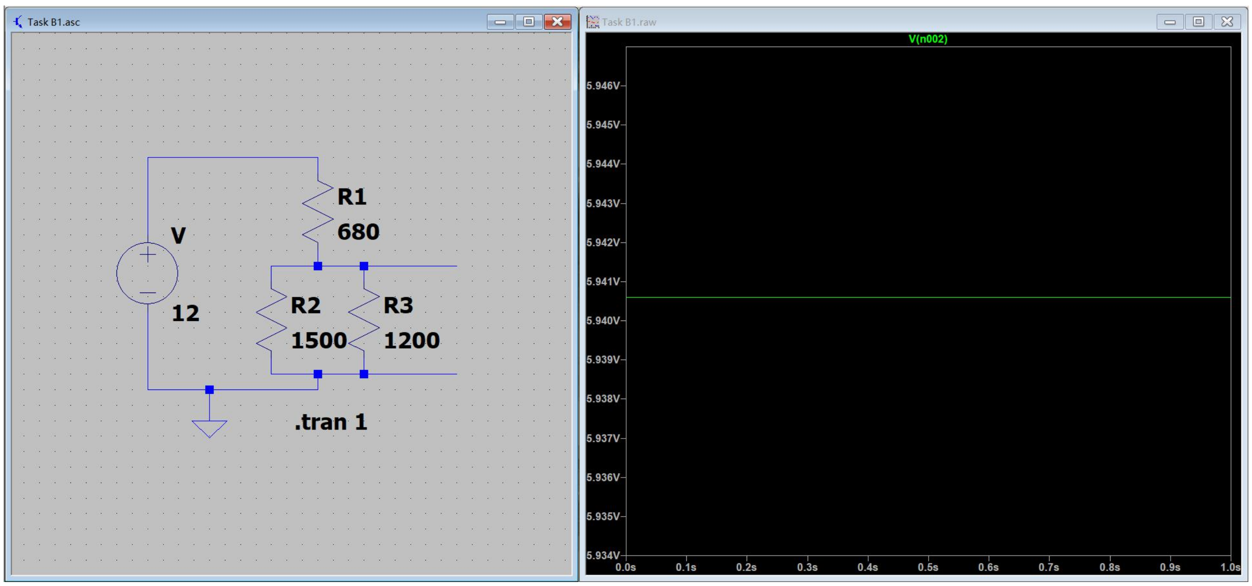
3. Results and Discussions

During the experiment, we first measured the open circuit voltage and calculated it by using voltage and current laws. And then we short-circuited the voltage source and measured the resistance between terminals A and B and calculated it by using Thevenin theorem. All the values are filled in the table 4.

Table 4: Values of V_{TH} and R_{TH}

	Measured	Calculated
Thevenin voltage, V_{TH}	5.94V	5.94V
Thevenin resistor, R_{TH}	336.7Ω	336.6Ω

To get a more precise theoretical value, we used LTspice to simulate the circuit. The figure is as follows:

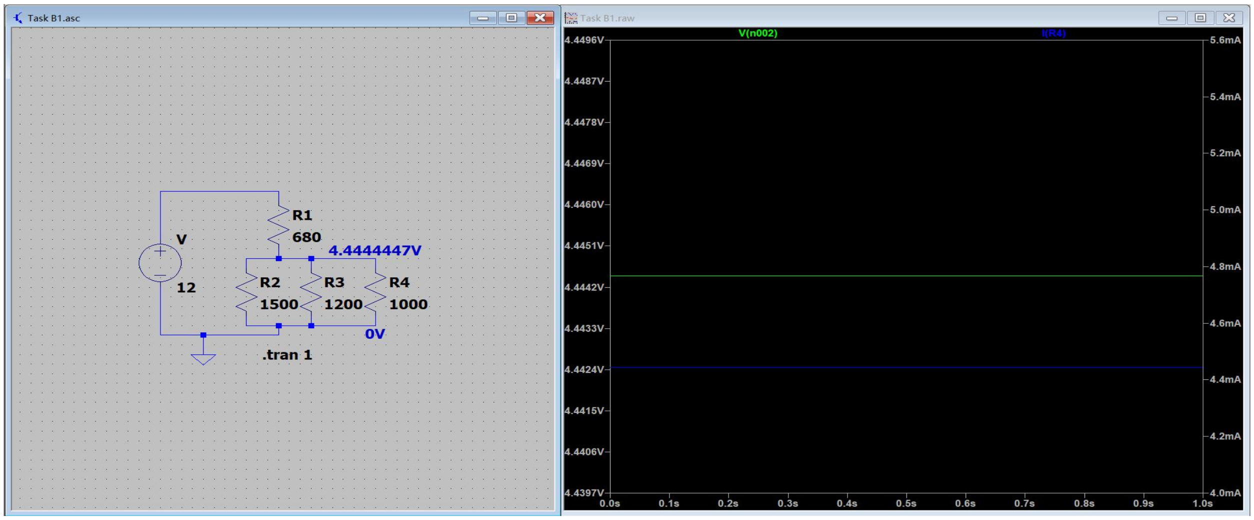


Additionally, we connected a 1kΩ resistor to terminal A and B and measured the current by using a mutimeter. Finally, we created another circuit on the breadbroad, repeated to connected a 1kΩ resistor to terminal A and B and measured the current by using a mutimeter. The values we measured are filled in the table 5.

Table 5: Current through 1 kΩ resistor

	Original Circuit	Thevenin Equivalent Circuit
$I_{1k\Omega}$	4.43A	4.45A

To get a more precise theoretical value, we used LTspice to simulate the circuit. The figure is as follows:



These are all the results we got, next we will bagin a discussion about the results.

From table 4, we can easily get that there are a little difference between the measured value and calculated value. It can be seen from the analysis of the above two figures that the equivalent circuit has the same characteristics as the original circuit within the allowable range of experimental measurement error. Therefore, the Thevenin voltage V_{TH} and Thevenin resistor R_{TH} is equal to the original one, which means it can replace the compination of voltage source and resistance with two terminals with a Thevenin equivalent circuit.

However, we cannot just simply use the Thevenin equivalent circuit to replace all the complex circuits. Although the output of the thevenin equivalent voltage is similar to the original one, the inside voltage and network are different from the original voltage source. By calculation, the linear network connected between terminals A and B can not be studied using Thevenin equivalent circuit.

4. Conclusions

In this experiment, we proved the correctness of the Thevenin theorem and deepen the understanding of it by learning the way of replacing a two terminal linear network by a Thevenin equivalent network. We also acquired the skills to measure resistors and found that some accidental errors are mainly caused by improper experimental operation, differences in readings, imprecision of the experimental instrument itself, etc.

Experiment 2: Using the Oscilloscope

1. Introduction

In this experiment, the oscilloscope we will use mainly includes three parts: an electron gun, a deflection system, and a phosphor screen, all of which are sealed in a glass shell and evacuated into a high vacuum. The oscilloscope itself is equivalent to a multi-range voltmeter, this function is realized by the signal amplifier and attenuator. In task B, we will concentrate on how to use the oscilloscope to help us with more details about the circuit.

2. Methodology

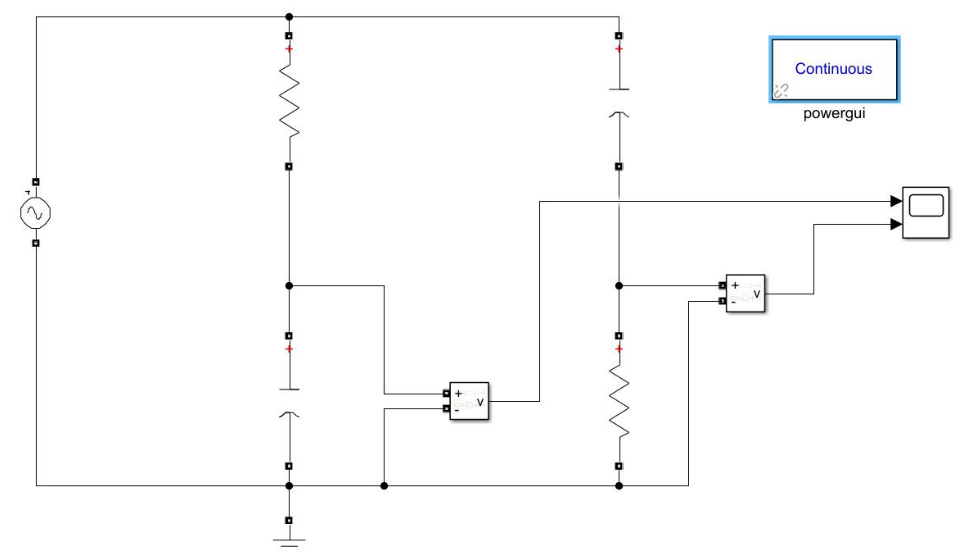


Figure 3: π/2 radian phase shifting circuit

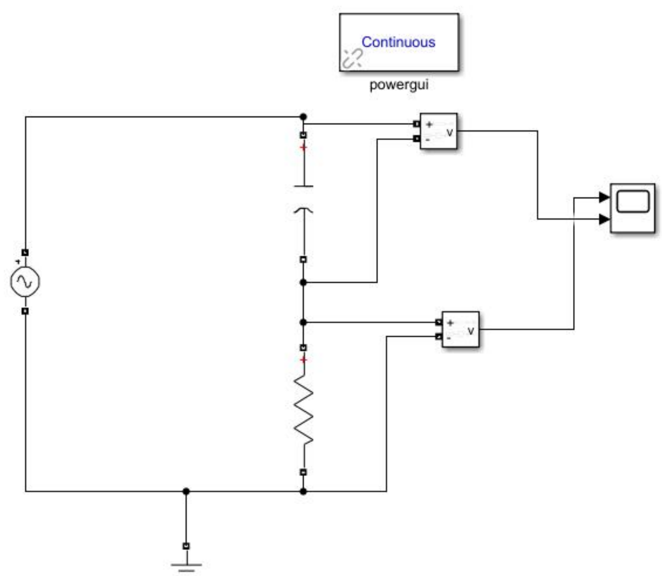


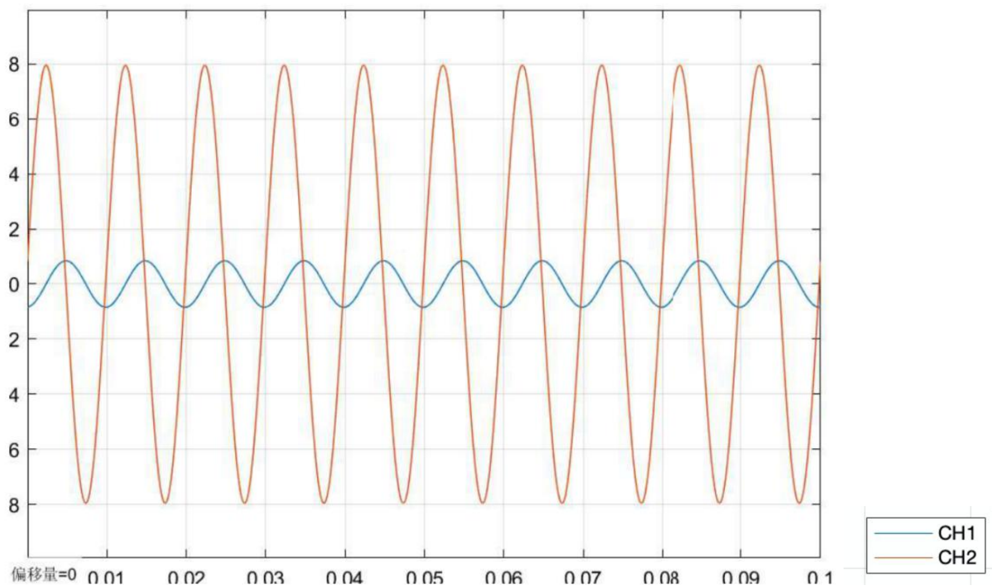
Figure 4: Phase shifting circuit

First, a circuit shown as figure 3 should be created. Then the AC signal generator is supposed to be adjusted to 100 Hz, and the output from 1 μF should be connected to CH1 and output from 15 μF should be connected to CH2 of the oscilloscope. Secondly, the AUTO button should be pressed for a quick setting of V/div and sec/div. Two signals should be drawn in the graph.

Finally, the circuit should be changed to a new one shown as figure 4. Two new signals should be drawn in the graph.

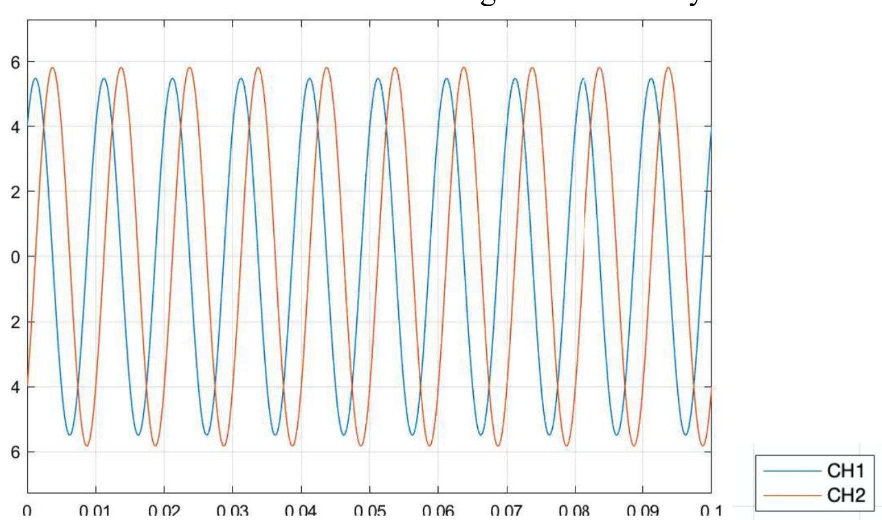
3. Results and Discussions

We first connected the original circuit shown as figure 3 and followed the instructions to operate the oscilloscope. The diagram presented on the screem is drawn by Matlab as follows:



From the diagram, we can get some results. First, the voltage across two branch should be the same for two parts are connected to the other one in parallel. Second, the figure shown in the diagram are all sine wave, because of AC power generate sine signals. Finally, the difference between two wave we think is the influence of potential decline from CH1 to CH2, which means there are some voltage loss in the first 15kΩ resistor. These are all what we found in the first diagram.

And then we created a new circuit and two new signals is drawn by Mat as follows:



The period of the two sine waves in the figure is 5ms, and there is 1/4T Phase difference between two waves.

4. Conclusions

In this experiment, we are able to use the oscilloscope to conduct basic signal measurements including waveform vlotage amplitude and frequency. By using the oscilloscope, we have a more understanding of circuit features and the principle of components of the apparatus which will help us to learn more about circuit.