Experiment Report

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Contents

1.1 Task A: Measuring DC Voltage and Current

1.1.1 Introduction

This experiment intends to measure voltage and current, which requires students to adroitly operate DC power supply and using the multimeter for measurement. In addition, students should know how to construct circuits on the breadboard. Task A demands to construct and measure the circuit shown in Figure 1. After the experiment, students should use PSpice to simulate and verify the result they achieved. This experiment will also test certain equations and they will be shown later in the report.

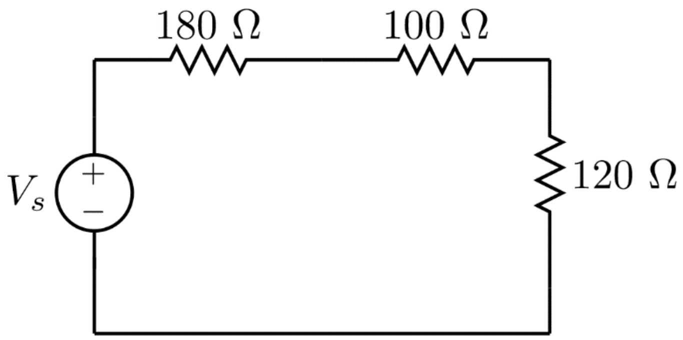


Figure 1

1.1.2 Methodology

Firstly, before constructing the circuit, this group used multimeter to measure the magnitude of all selected resistors and then filled Table 1. Here, R_T^m is the sum of the resistors in the circuit. In addition, V_S is the voltage output and we have:

$$V_S = V_T = V_T' = 10 \text{ V} \tag{1}$$

Table 1: Measured Resistance

Resistor	$R_{180\Omega}$	$R_{100\Omega}$	$R_{100\Omega}$	R_T^m
Measured Resistance (Ω)				

Secondly, we constructed the circuit and set the voltage output to 10 V which was from the DC power supply. Then next step was to use the multimeter to measure the voltage for each resistor and the current and filled Table 2.

Table 2: Measuring 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(A)	$R_T = V_T/I(\Omega)$
10				10		

$$R_T = V_T/I \tag{2}$$

Due to these resistors were series, the current merely needed to be measured once. Then we calculated individual voltage by applying three equations for voltage division:

$$V'_{180\Omega} = \frac{R_{180\Omega}}{R_{180\Omega}+R_{100\Omega}+R_{120\Omega}} \times V'_T \tag{3}$$

$$V'_{100\Omega} = \frac{R_{100\Omega}}{R_{180\Omega}+R_{100\Omega}+R_{120\Omega}} \times V'_T \tag{4}$$

$$V'_{120\Omega} = \frac{R_{120\Omega}}{R_{180\Omega}+R_{100\Omega}+R_{120\Omega}} \times V'_T \tag{5}$$

Then we calculated the current through the resistors by using the formula:

$$I' = \frac{V'_T}{R'_T} \tag{6}$$

After obtaining I', we needed to record data in Table3.

Table 3: Calculate the voltage and current for each resistor

$V_S(V)$	$V'_{100\Omega}$(V)	$V'_{120\Omega}$(V)	$V'_{180\Omega}$(V)	V'_T(V)	$I'(A)$	$V'_{180\Omega}$(V)
10				10		

1.1.3 Results and Discussions

Regarding to the first step, we obtained every magnitude of the resistors, and the data is shown in Table 1.1.

Table 1.1: Measured Resistance

Resistor	$R_{180\Omega}$	$R_{100\Omega}$	$R_{100\Omega}$	R_T^m
Measured Resistance (Ω)	182	100.9	118.6	401.5

After connecting the circuit, we used the multimeter to measure the current and voltage for each resistor, and their data was recorded in Table 2.1.

Table 2.1: Measuring 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(A)	$R_T = V_T/I(\Omega)$
10	4.571	2.538	2.975	10	0.024	416.67

Next, we calculated the voltage and current for each resistor by using the equations (3), (4), (5) and (6), whose data was indicated in Table 3.1.

Table 3.1: Calculate the voltage and current for each resistor

$V_S(V)$	$V'_{100\Omega}$(V)	$V'_{120\Omega}$(V)	$V'_{180\Omega}$(V)	V'_T(V)	$I'(A)$	R'_T=R_T^m (Ω)
10	4.5	2.5	3	10	0.025	400

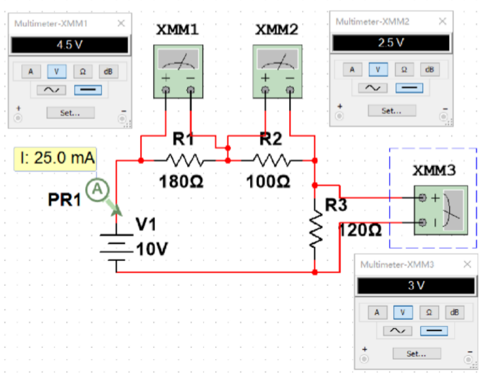
Because of the existence of experimental errors, it can be observed that the data realistic are slightly different from the ideal value. However, the recorded data is in allowable range of error, therefore, the experiment data was totally accurate.

With respect to I and I', the value of I was 0.024 A and I' was 0.025 A, they were approximately equal with each other. In addition, the value of R_T was 416.67 Ω and R'_T was 400 Ω. The reason for R_T was different from R'_T is that R_T was calculated from the equation (6) whose I was measured and R'_T was theoretical value. However, it could be also concluded that R_T was approximately equal to R'_T.

As for the Table 2, if we sum up the voltage across each resistor and call it V_A, V_A is equal to 10.084 V. However, the input voltage was 10 V, which was less than V_A. The cause of this error can be discussed in certain aspects. On one hand, the resistors themselves might change due to the objective factors, such as temperature, pressure and spoilage. On the other hand, the DC power supply might input the higher input voltage which was not corresponding to the figure on the screen. Another factor might be the error on the multimeter. The multimeter has battery, which might influence the measurement.

Figure 2 shows the outcome of using PSpice to simulate this experiment.

Figure 2



From the graph of PSpice, we can find that the voltage on every resistor is the same as the calculated voltage. In addition, the current of the circuit in PSpice is 25.0 mA which is very closed to the measured current. Therefore, we can use PSpice to find the ideal value easily which can omit the calculation steps.

1.1.4 Conclusion

In conclusion, we can verify that in series circuit, the total value of the resistance is equal to the sum of the resistance. Moreover, the total value of the voltage is equal to the sum of the voltage on each resistor. This experiment would be more successful if experimental errors could be reduced.

1.2 Task B: Finding the Thevenin Equivalent Circuit

1.2.1 Introduction

Thevenin theorem is widely applied in circuit analysis, because it simplifies complex circuit, which improves work efficiency. According to the Thevenin theorem, one resistor R_{Th} and a voltage source V_{Th} can represent a circuit which contains any two-terminal network of resistors and voltage sources. The circuit in Figure 1 can be transformed to the circuit in Figure 2 by applying Thevenin theorem. This experiment aims to help students to obtain R_{Th} and V_{Th} and understand how these two circuits are equivalent.

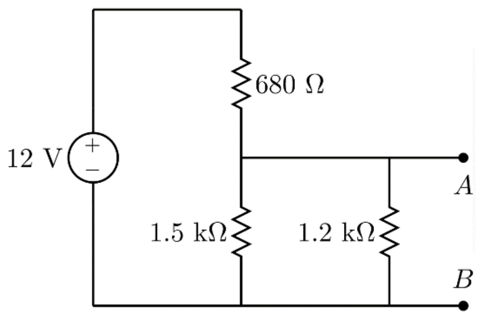


Figure 1

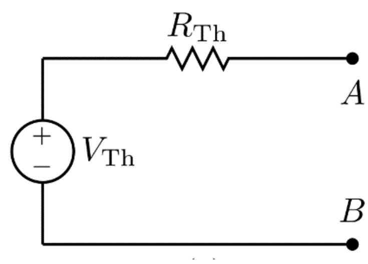


Figure 2

1.2.2 Methodology

The first step was to construct the circuit in Figure 1. Then we used the multimeter to measure the open voltage which was noted as V_{Th} between terminal A and B, then the data should be recorded. The next step was to calculate V_{Th} and record the value. Then we should measure R_{Th}. Firstly, we shout-circuit the DC voltage source and use the multimeter to measure the resistance between terminals A and B and the value is R_{Th}. Having measured R_{Th}, next we need to calculate R_{Th}. The first thing to do was the same as the measurement of R_{Th} which was short-circuit the DC voltage source. Then it could be assumed that these three resistors were parallel, thus it was very easy to calculate R_{Th}. Similarly, we should record this calculated R_{Th}. Next, we connected another 1 kΩ resistor to terminals A and B. Then we used the multimeter to measure the current $I_{1k\Omega}$ through this resistor and record it down. The final step was to construct the circuit as shown in Figure 2. Here we should use the calculated R_{Th} and V_{Th}. Between terminals A and B, wo needed to connect the 1 kΩ resistor again and use a multimeter to measure the current $I_{1k\Omega}$.

1.2.3 Results and Discussions

After the experiment, we organized the recorded data as indicated in Table 1 and Table 2.

Table 1: Values of V_{Th} and R_{Th}

	Measured	Calculated
Thevenin voltage, V_{Th}	5.74	5.94
Thevenin resistor, R_{Th}	337.1	336.63

Table 2: Current through 1 kΩ resistor

	Original Circuit	Thevenin Equivalent Circuit
$I_{1k\Omega}$	0.00425	0.004492

It can be found that the measured V_{Th} and the calculated V_{Th} were approximately equal. Similarly, the difference from the measured R_{Th} and the calculated R_{Th} was comparatively small. These two differences might be caused by experimental errors. Moreover, the current through 1 kΩ resistor in the original circuit and Thevenin equivalent circuit were totally the same.

From the result, we can conclude that we have found the Thevenin equivalent circuit which is shown in Figure 2. In addition, it is sensible to use Thevenin equivalent circuit to replace the original circuit. If we want to study other linear network, without Thevenin equivalent circuit, we must take every parameter of component into calculation, which might be difficult get a linear result. Conversely, using Thevenin equivalent circuit would simplify the circuit and might help people obtain the linear network result because the R_{Th} represents the sum of the irrelevant resistors, subsequently, the circuit can be assumed that the load and R_{Th} are in series.

Figure 3 and Figure 4 are the graph of PSpice for them respectively.

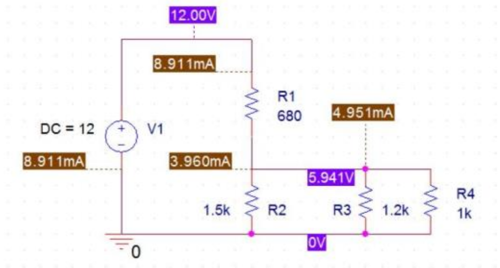


Figure 3

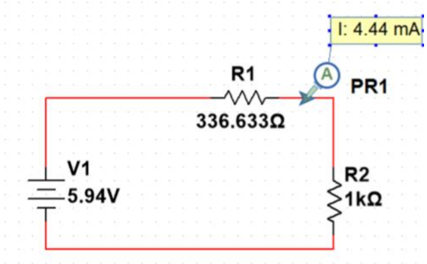


Figure 4

From Figure 3, wo can observe that the voltage on the 1 kΩ is very close to the measured and the calculated voltage. Furthermore, the current through the load is the same. Thus we can also conclude PSpice can simulate the real circuit and it is quite accurate.

1.2.4 Conclusion

From this experiment, we have learned how to obtain Thevenin equivalent circuit and observe how it and the original circuit are equivalent. In brief, Thevenin theorem brings convenience to people to analyze the complex circuit by simplifying the circuit.

2. Experiment II: Using the Oscilloscope

2.1 Introduction

A digital oscilloscope can transform the measured voltage in to digital information. Therefore, this experiment requires students to know how to use the oscilloscope to conduct basic signal calibrations and measurements.

2.2 Methodology

The first part was to calibrate the oscilloscope, and this part is divided into several steps. The first step was to connect the probe of oscilloscope which is switched to $\times 1$ to CH1, and attach the probe to the 3V square-wave calibration point. Then we pressed CH1 button to set the DC coupling to CH1. Subsequently, we needed to change the V/div knob to 0.5 V/div to observe this waveform more accurately. Then we recorded the output signal. Now, we needed to switch our probe to $\times 10$ mode. The next step was to calibrate the point of 3V point. Next, we needed to use the probe tool to slightly adjust the probe head capacitance until the wave was square. Again, we recorded the V/div value in the graph. The next step was to set the AC signal generator to 100 HZ, 8 Vpp and set the slope to trigger on the positive slope. Then set the slope to the negative slope and observe the difference. The final step was to adjust the trigger level knob and record the trigger voltage whereby the signal starts to drift. The second part was to construct the circuit in Figure 1. Then we set the AC signal generator to 100 HZ, 8 Vpp. After certain basic operations, we needed to draw two signals in the graph below with the information of V/div and sec/div. Finally, we needed to change the circuit into the circuit shown in Figure 2.

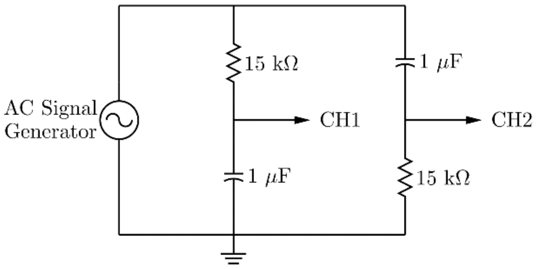


Figure 1

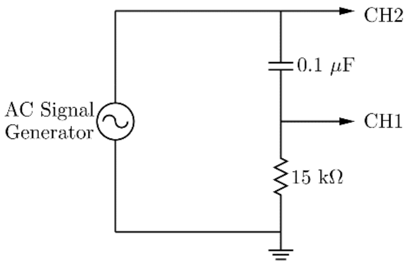
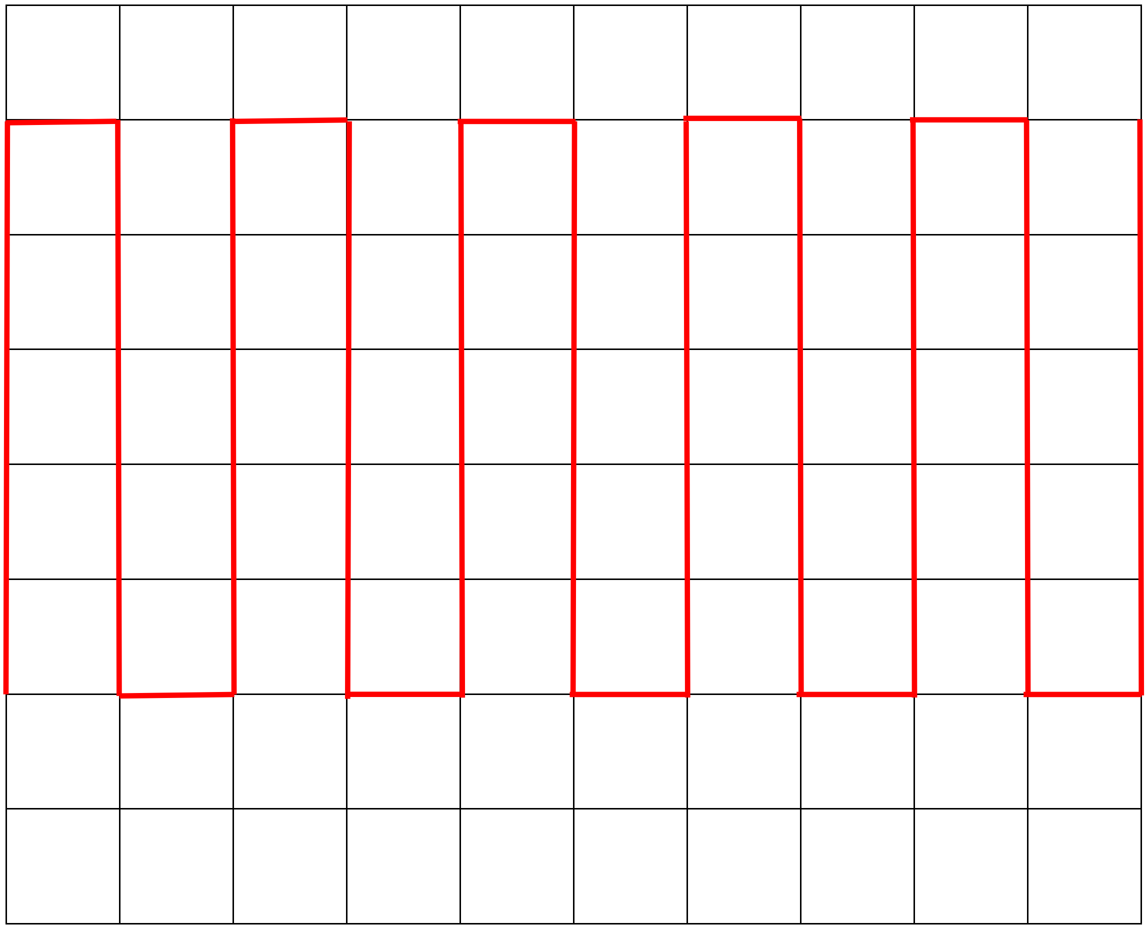


Figure 2

2.3 Results and Discussions

After the experiment, we organized the data and graphs. The first graph of calibration is shown in Figure 3.

Figure 3

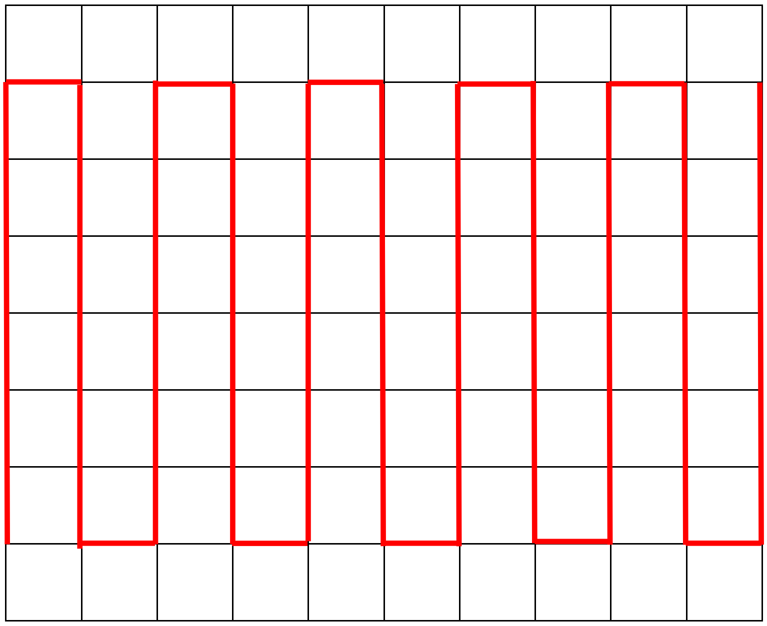


CH1: 1V

t: 500 μs

The second and the third graph are indicated in Figure 4 and Figure 5.

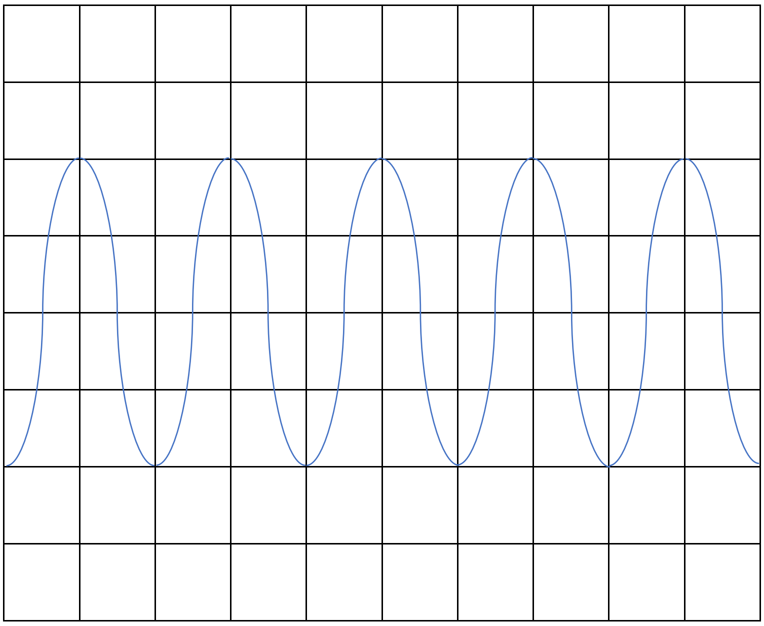
Figure 4



CH1 = 50 mV

t = 500 μs

Figure 5

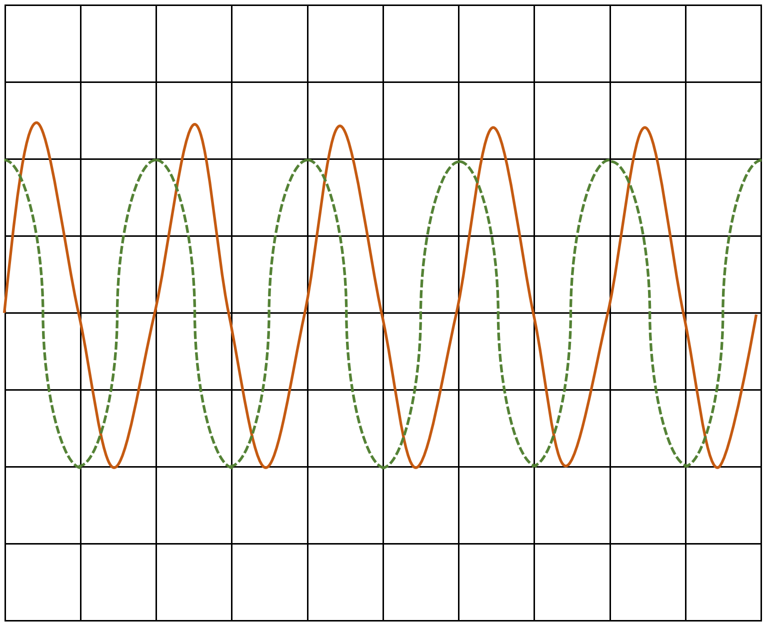


CH1 = 200 mV

t= 1 ms

As for the graphs of the second part, it is shown in Figure 1 and Figure 2. In addition, the trigger voltage whereby the signal starts to drift was 4.16 V and -4.08 V.

Figure 1



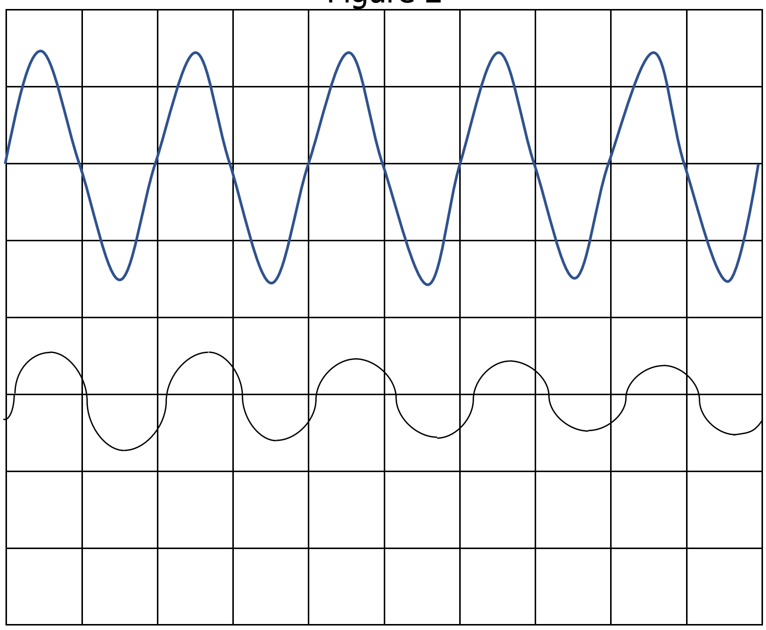
CH1 = 200 mV CH2 = 200 mV t = 5 ms

Figure 2

CH1: 2V

CH2: 5V

t: 5.00 ms



From the both graphs of the circuit, we can see CH1 and CH2 were different. The reason for the two voltages were different might be their capacitors were different. Furthermore, their peak voltage, frequency, trigger and period were different, which might influence the result as well. Experimental errors might be another factor to affect the result.

2.4 Conclusion

From this experiment, we have known how to use the oscilloscope to conduct basic signal calibrations and measurements. It is believed that after this experiment, we can better understand and apply the oscilloscope on the practice.