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High Precision Experimental Exploration of Wheatstone Bridge Resistance Measurement

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Abstract

As is known to everyone, Wheatstone bridge has played a very important role in resistance measurement. This work has improved the accuracy of self-organized bridge and box bridge, so that the resistance measurement accuracy of the two types of bridges can arrive at an unprecedented level, and the measured value of the same resistance by the two types of bridges tends to be quite consistent, which performs the measurement of resistance value in the most accurate way.

Keywords: Wheatstone Bridge; Self-Organizing Bridge; Box Bridge; High-precision

Introduction

It is well known that the bridge method is a very accurate means of measuring resistance because this kind of resistance measurement has eliminated the experimental discrepencies brought about through the internal-connection method and external-connection method [1]. As one of the most important items in college-physics experiment, Wheatstone bridge experiment also serves as a typical representative in direct-current (DC) bridge [2,3]. According to the principle of Wheatstone bridge, the box-type bridge, such as the QJ-23 box-type bridge, has been designed and sold in the market. At the same time, the self-organized bridge, which can also be used for measuring resistance, has become another aspect of Wheatstone bridge resistance measurement because of its distinctive designing concept and good accuracy [4-7].

After understanding the characteristics of self-organized bridge and box-type bridge, people realize that the measured result of the same resistance should be completely consistent when measuring the same resistance using both the self-organized bridge and box-type bridge. Nevertheless, the measured resistance value of the same resistance by the two types of bridges, which is obtained in the college-physics experiment, is not always in good agreement with each other. Although the measured resistance value by the two types of bridges is not quite different, the deviation deserves noticing and should be minimized because one specific resistance has only one resistance value and the two types of bridges are measuring the same resistance with only one resistance value. In the present work, the measured consistency of the self-organized bridge and box-type bridge is enhanced to an unprecedented level. The purpose of such an improvement is to make the measured resistance value be most accurate. To the largest extent, the measured resistance value of the same resistance by the two types of bridges tends to be consistent.

Improved Experimental Methods

In the present work, some factors, which may cause the inaccuracy of measured data through the two types of bridges, have been analyzed carefully. Great efforts have been devoted to finding effective ways of further improving the precision and accuracy of resistance measurement by

Wheatstone bridge. The power supply voltage of original experiment was generally set at "3V" position in the box-type bridge. In this work, the power supply voltage was increased to 9V position. The position of sensitivity knob was always set at "Center" or lower position in the original experiment, whereas the position of sensitivity knob was scrolled to the maximum in the new experiment. In the subsequent work, the voltage of box-type bridge was set to the maximum value at "15V" position. The position of the override gear was set at 10-1. As a matter of fact, a more sensitive galvanometer, for example AZ-19 direct-current (DC) galvanometer, can be connected outside of the box-type bridge. All the measures mentioned above have played pivotal roles in improving the sensitivity and precision of the box-type bridge experiment.

After analyzing the experimental circuit of the self-organized bridge, the intial attempts were focused on reducing the resistance of conductance wires so as to further eliminate the experimental inaccuracy. Nevertheless, it was observed that there was no fluctuation in the galvanometer used. Therefore, the power supply with a higher voltage and the galvanometer with higher sensitivity are demanded. In order to accomplish this goal, the WYK-302B DC stabilized power supply was used in the experiment, with the voltages set at 5V, 10V and 15V, respectively. Additionally, the AZ-19 direct current (DC) Galvanometer with higher sensitivity was utilized in the experiment. All the measures mentioned above have greatly improved the experimental accuracy of self-organized bridge.

Experimental Results and Data Analyses

The results measured by box-type bridge at different power supply operating voltages are listed as follows (Table 1):

Power supply voltage (V)	R_{x1}	R_{x2}
3	4661	1957
9	4654	1954
15	4635	1947

Table 1: Box-type bridge at different power supply operating voltages.

It can be seen that the measured resistance value decreases gradually with the increase of power supply voltage. The sensitivity of the box bridge is adjusted to the highest value in the measured process.

The results gained at self-assembled bridge by means of different galvanometers are listed in the table below, in which "original" represents the original galvanometer and "new" stands for the AZ-19 DC galvanometer. Different power supply voltages have also been used in the measurement (Table 2).

Power Supply Voltage (V)	R_{01}*	R_{01}	R_{x1}	R_{02}	R_{02*}	R_{x2}	
3	1020	211.1	464.03	430.1	87.1	193.55	original
3	1019.25	210.35	463.03	425.25	88.15	193.61	New improvements
5	1015.9	121.1	464.19	423.7	87.25	192.27	original
5	1015.55	212.3	464.33	424.95	87.95	193.32	New improvements
10	1005.6	213.35	463.19	417.3	90.95	194.82	original
10	1007.26	214.05	464.33	419.05	91.05	195.33	New improvements
15	993.3	214.45	461.53	410.9	93.05	195.54	original
15	993.35	215.35	462.51	410.25	93.15	195.49	New improvements

Table 2: Self-assembled Bridge by means of different galvanometers.

It can be seen that the measured resistance value for RX2 increases with the rise of power supply voltages whereas Rx1 follows a similar trend, but decrease in the region from 10V-15V. Overall, the precision of the measurement has been further improved with the introduction of the AZ-19 DC galvanometer during the experiment.

Discussion and Conclusion

The measured accuracy of self-organizing bridge has been further improved by means of the adoption of a more sensitive AZ-19 DC galvanometer. The measured value of the same resistance by both the self-organizing bridge and the box-type bridge is nearly consistent when increasing the working voltage of the power supply. It can be seen that the measured resistance of Rx2 by the two types of bridges tends to be consistent when the power supply operating voltage is around 9V. Because the measured sensitivity of the two types of bridges has been improved greatly, the limited precision of the resistance box has prevented the accurate measurement of the resistance. Therefore, using a resistance box with higher precision will be an important step for further improving the accuracy of resistance measurement by Wheatstone bridge in the future.

In summary, this work aims to improve the measured accuracy and precision of self-organized bridge and box bridge. The experimental results obtained thus far have reached an unprecedented high level for high-precision measurement. To the largest extent for a specific resistance, both the self-organized bridge and box bridge have gained the most consistent measured value.

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