Thevenin Analysis Of Direct Current Resistive Circuit By Theoretical And Experimental Approach

Ishak Annuar, Mazlina Mansor Hassan, Ahmad Nurrizal Muhammad, Bibi Sarpinah Sheikh Naimullah, Noor Azland Jainudin, Dzufi Iszura Ispawi

Abstract: The paper presents the calculated and measured of direct current resistive circuit using Thevenin method supplied at different positive voltages (5V, 10V, and 15 V). A breadboard, three different values of resistors (100Ω, 200Ω 10kΩ), and jumper wire were used for constructed the direct current resistive circuit. The voltmeter, and ammeter were used for measuring the voltage and resistance, respectively. The result showed, the calculated and the measured of Thevenin voltage at different positive voltages increased with increased of positive voltage increased from 4.54 V to 9.09 V, and 4.48 to 13.64 V, respectively. Meanwhile, the measured of Thevenin resistance is consistent with the calculated value. The result showed the measured of Thevenin voltage and resistance are consistent with the theoretical calculated measurement.

Index Terms: Thevenin method, resistive circuits, DC circuit, Thevenin resistance, Thevenin voltage

1 INTRODUCTION

Thévenin's theorem is the powerful theorem to simplify a complex circuit by an equivalent Thevenin voltage (Vth) in series connection with an equivalent resistance or Thevenin resistance (Rth). The theorem was independently derived in 1853 by the German scientist Hermann von Helmholtz and in 1883 by Léon Charles Thévenin (1857–1926), an electrical engineer with France's national Postes et Télégraphes telecommunications organization. Thévenin's theorem is widely used to make circuit analysis simpler and to study a circuit's initial-condition and steady-state response. The theorem can also be applied to frequency domain AC circuits consisting of reactive and resistive impedances. In the case of direct current resistive circuit, the Vth is obtained at open circuited terminals where the load has been removed from the circuit. In addition, the Thevenin resistance, Rth is the total resistance looking from the terminal (i.e A-B) of load that was removed. Note that, all independent sources exist in the circuit are set to be zero (any current source removed from the circuit while direct current voltage source also removed from the circuit but replaced by wire). The calculated of Thevenin voltage and resistance is again connected in series with the removed of the load. If terminals A and B are connected to one another, the current flowing from A to B will be Vth/Rth. This means that Rth could alternatively be calculated as Vth divided by the short-circuit current between A and B when they are connected. In circuit theory terms, the theorem allows any one-port network to be reduced to a single voltage source and single impedance [1-5].

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Thévenin's theorem can be used to convert any circuit's sources and impedances to a Thévenin equivalent; use of the theorem may in some cases be more convenient than use of Kirchhoff's circuit laws [6-12]. However, in this study, we used different values of DC voltage source. In this study, we will study the Thevenin equivalent circuit at supplied at different voltage sources. The Thevenin equivalent circuit at different voltage source are rarely been reported.

2 METHODOLOGIES

2.1 Calculation and Experimental Approach

The experimental and calculated of direct current resistive circuit is shown in Fig. 1. In this calculation and experimental set up study, 3 different values of resistor R1, R2, and R3, were used respectively. For experimental and calculated of direct current resistive circuit as shown in Fig. 1, a breadboard, jumper wire, resistors (R1=1 kΩ, R3=10 kΩ, and R2=200 Ω), ohmmeter, voltmeter, and dc voltage are used for constructed circuit and measurement. DC power supply is varied from 5 to 12 V to investigate the Thevenin voltage and Thevenin resistance, restively. The Thevenin resistance, Thevenin voltage of direct current (DC) resistive circuit is compared by calculating and measurement approach.

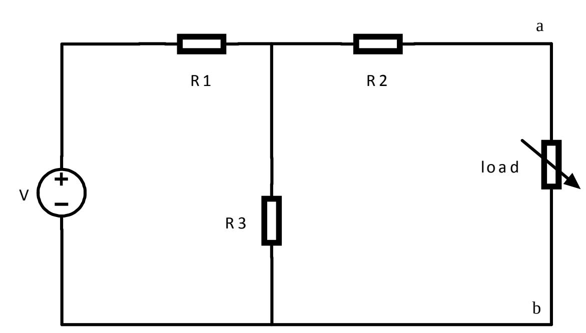

Fig. 1. *The experimental and calculated of direct current resistive circuit*

The Thevenin voltage and Thevenin resistance are connected in series with load resistance. In addition, the Thevenin voltage is theoretically calculated at terminal a-b as shown in Fig. 2 by removing the load resistance. The terminal a-b is the open circuit voltage and symbol as Vth. The Thevenin voltage is the voltage drop across resistance R3 since the voltage drop across R2 is zero volt. The voltage divider rule on the other hand, is further used to calculate the voltage drop across R3.

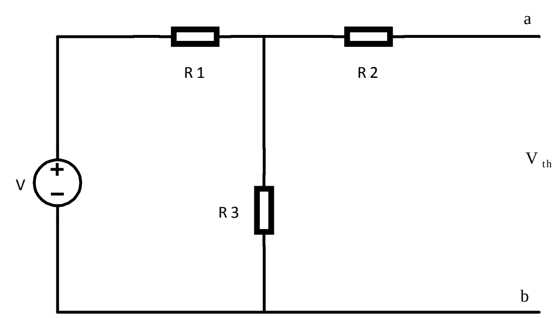

Fig.2 *The theoretical calculated of Thevenin voltage*

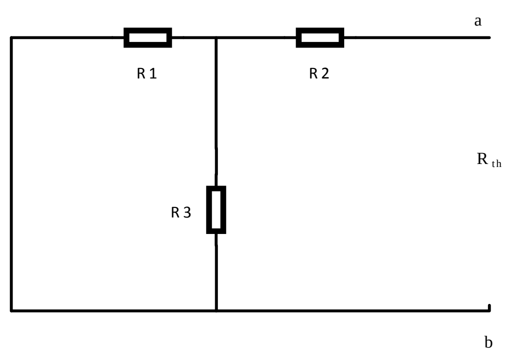

Fig.3 *The theoretical calculated of Thevenin resistance*

Meanwhile, the Thevenin resistance is obtained by calculating the resistance looking at point a-b by setting all independent sources to zero. Note that, all the DC voltage source is set to be zero volt by replacing with wire. Ohmmeter and voltmeter are used to measure the Thevenin voltage and Thevenin resistance, respectively as shown in Fig. 2 and 3, respectively. The direct current resistive circuit configuration for measure the Thevenin resistance and Thevenin voltage theoretically and experimentally are depicted in Fig. 2 and 3.

5 RESULTS AND DISCUSSION

The Thevenin voltage of DC circuit is shown in Fig. 4. As can be seen in Fig. 4. Three different values of resistors 1kΩ, 200 Ω, and 10 kΩ are used at different DC voltage (5V,10V, and 15V). The calculated Thevenin voltage (V_{th1}, V_{th2}, and V_{th3}) is calculated by using voltage divider rule as shown below;

$V_{th1}=R_3/((R_3+R_1))\ (5) = 4.54\ V$

$V_{th2}=R_3/((R_3+R_1))\ (10)= 9.09\ V$

$V_{th3}=R_3/((R_3+R_1))\ (15)= 13.64\ V$

Thevenin resistance

$R_{th}=(\ 〖(R_3) *(R_1))/((R_3+R\_1))+R_2= 1.11\ k\Omega$

Since no current flow through R2 (200 Ω), the voltage dropped across 200Ω is zero and therefore the V_{th} is the voltage drop across R3. The complete result of the calculated and measured Thevenin voltage and resistance are tabulated in Table 1 and Table 2, respectively.

Table 1. *The theoretical values of Thevenin voltage and resistance at different DC voltages*

DC voltage (V)	Calculated	
	V_{th} (V)	R_{th} (kΩ)
5	4.54	1.11
10	9.09	1.11
15	13.64	1.11

It is observed that, the calculated of Thevenin voltage increased from 4.54V to 13.64V as the positive voltage increased from 5V to 15V. However, the Thevenin resistance did not change as voltage increased. This phenomenon is consistent with theoretical as reported by others [2,6,9] justify the Thevenin resistance is independently with the increased of positive voltage source supplied to the circuit since the Thevenin equivalent circuit did not exist the voltage source. The same phenomenon has also been observed in experimental approach where constant value of the Thevenin resistance approximately 1.125 Ω

Table 2. *The experimental values of Thevenin voltage and resistance at different positive voltages*

DC voltage (V)	Measured	
	V_{th} (V)	Rth (kΩ)
4.93	4.48	1.125
10.09	10.06	1.125
14.88	14.44	1.125

The measuring Thevenin voltage and Thevenin resistance is shown in Table 1. The result indicated the value is comparable with theoretical approach confirmed the measurement method is correct. Small tolerance indicates the difference value of resistance comparing with the exact value of resistance. Another factor that contribute to the small tolerance is the measurement instrument such as ohmmeter and voltmeter had internal resistance which slightly affect the result. The exact value by theoretical approach did not considered the instrument and real value of resistor. Hence the value has some small tolerance around 5%. This phenomenon is consistent with theoretical calculated result as reported by others [2,6,9]. The small error is due to the equipment such as supplied voltage source, voltmeter, ammeter, and connecter, breadboard and resistors which contribute the error in measurement.

6 CONCLUSIONS

The paper discussed the calculated and experimental Thevenin equivalent circuit on direct current resistive circuit supplied at different positive voltage (5V to 15V). The result showed calculated and measured of Thevenin voltage increased as positive voltage increased signified the consistent of experimental with theoretical result. The result showed, the calculated and the measured of Thevenin voltage at different positive voltages increased with increased of positive voltage increased from 4.54 V to 9.09 V, and 4.56 to 13.64 V, respectively. Meanwhile, the measured of Thevenin resistance is consistent with the calculated value. The measured Thevenin voltage value and resistance value are consistent with the theoretical calculated.

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