

1 Introduction

A potentiometer is an electrical component that functions both as a variable resistor and as a voltage divider. It allows for the precise adjustment of electrical resistance and the control of output voltage in a circuit. The aim of the experiments detailed in this report is to analyze the behavior and characteristics of the potentiometer in various circuit configurations.

2 Background/Theory

A potentiometer is a resistor that has three terminals. Two of the terminals constitute the full resistance value, while the third one is a sliding contact. Figure 1 displays the different contacts of the potentiometer.

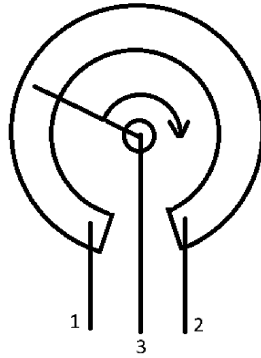


Figure 1: Drawing of a potentiometer with labeled terminals

The resistance between terminals 1 and 2 is constant, while the resistance between 1 and 3 is determined by equation 1:

$$R_{13} = kR \quad (1)$$

Since the potentiometer can be used as a voltage divider, the value of the potential difference between terminals 1 and 3 will be determined using equation 2:

$$V_{13} = kV_{tot} \quad (2)$$

When adding a load resistor in parallel to terminals 1 and 3, the voltage across them can be calculated using equation:

$$V_{13} = \frac{kR_{13}}{R_{13} + k(1-k)R_p} V \quad (3)$$

3 Methods & Materials

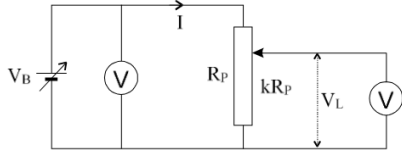
All circuits in the experiments were assembled using the provided connection boards. The electrical measurements, including voltage and current, were performed using the AM-520 HVAC multimeter for precision. A 10-turn potentiometer with a total resistance of $1k\ \Omega$ and a resolution of $\Delta k = 0.001$ was used to vary resistance and control output voltage. The power supply consisted of two 1.5V batteries connected in series. Fixed resistors of $1\ k\Omega$ and $510\ k\Omega$ were utilized as load resistors, along with a decade resistor to provide adjustable resistance for certain measurements.

3.1 Experimental Set-Up unloaded potentiometer

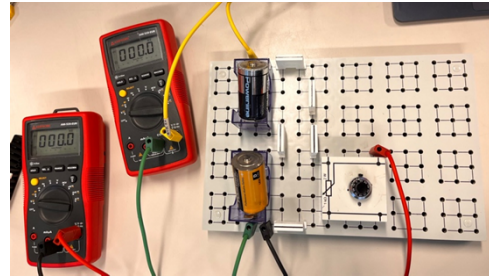
An unloaded potentiometer circuit comprises a voltage source and a potentiometer. Measurements are taken for both the voltage supplied by the power source and the potential difference established between terminals 1 and 3.

In the unloaded potentiometer circuit, measurements are conducted incrementally by varying the parameter k from 1 to 0.1.

Figures 2(a) and 2(b) display both the electrical diagram, and a picture of the physical set-up of the circuit.



(a) Circuit diagram of unloaded potentiometer circuit(refr)



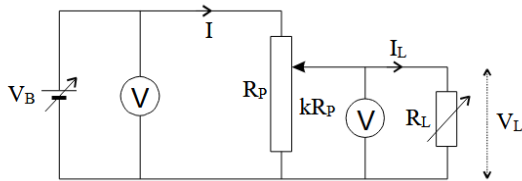
(b) Picture of the unloaded potentiometer circuit

Figure 2: Electrical schema and physical set-up of the unloaded potentiometer circuit

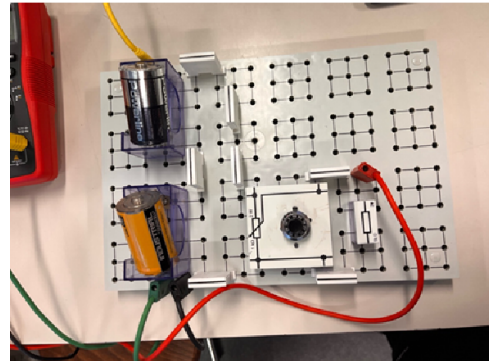
3.2 Experimental Set-Up with fixed resistor

The experimental set-up for the second experiment mirrors that of the first, with the key distinction being the addition of a load resistor connected in parallel across terminals 1 and 3. Specifically, a $510\ \Omega$ resistor and a $1\ \text{k}\Omega$ resistor are incorporated to introduce varying load conditions.

Figures 3(a) and 3(b) display both the electrical diagram and a picture of the physical set-up of the circuit.



(a) Circuit diagram of the loaded potentiometer circuit



(b) Picture of the loaded potentiometer circuit with fixed resistance

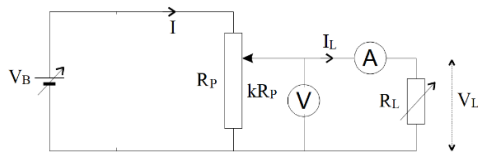
Figure 3: Electrical schema and physical set-up of the loaded potentiometer with fixed resistance

3.3 Experimental Set-Up with fixed load current

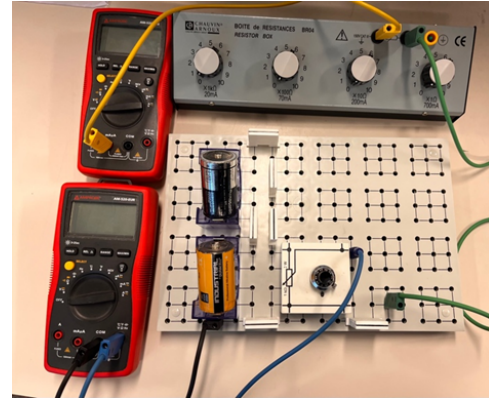
The set-up for the third experiment omits the voltmeter measuring the power source, replacing it with an ammeter in line with the load resistor. The load resistor being used becomes a decade resistor.

The experimental flow is also changed, as now with a change in the k -value, the decade resistor is adjusted in order for the current load to remain the same, then the resistance of the decade resistor, and the voltage drop is measured.

Figures 4(a), and 4(b) display the circuit diagram and picture of this experiment.



(a) Circuit diagram of the constant current load circuit(refr)



(b) Picture of the constant current load circuit

4 The Unloaded Potentiometer

4.1 Measurement Results

Table 1 presents the measured voltage values corresponding to different values of the parameter k , alongside the theoretical voltage values and the associated measurement error for the unloaded potentiometer circuit.

Table 1: Measured and expected voltage in terms of the parameter k of the potentiometer

k	$V_{unloaded}$ (V)	$\Delta V_{unloaded}$ (V)	$V_{expected}$ (V)
0.1	0.302	0.009	0.296
0.2	0.594	0.009	0.592
0.3	0.89	0.017	0.888
0.4	1.184	0.014	1.184
0.5	1.481	0.013	1.480
0.6	1.776	0.021	1.775
0.7	2.076	0.023	2.071
0.8	2.365	0.024	2.367
0.9	2.663	0.025	2.663
1	2.957	0.031	2.959

4.2 Graphs

Figure 4 illustrates the relationship between the measured voltage and the parameter k in the unloaded potentiometer circuit.

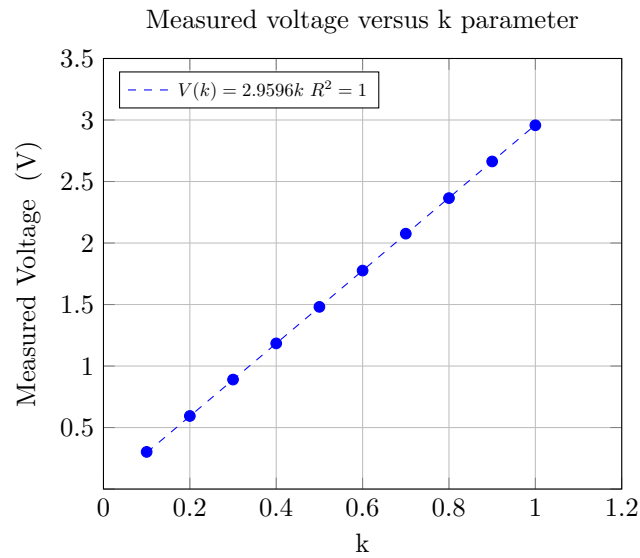


Figure 5: Measured voltage (V) drop in terms of the k parameter

4.3 Discussion

The main goal of this experiment was to determine the effect of changing the k -value of the potentiometer on the voltage load of the varying resistance. When looking at the graphical representation of these values seen on figure 3, we see a linear relationship between the k -value and the voltage drop on the potentiometer.

Analyzing the difference between the measured and expected voltage, we see that the measured values are accurate, as the difference between them and the expected values falls within the measurement error.

5 Potentiometer loaded with fixed resistor

5.1 Measurement results

Table 2 presents the measurements for k , including the unloaded potentiometer value and the values corresponding to both loads, $1k\Omega$ as load 1 and 510Ω as load 2. The table provides both the measured (V_{L1}) and (V_{L2}) and theoretical values (V_{L1t}) and (V_{L2t}), along with the calculated percent deviations (PD_1 and PD_2).

Table 2: Measured and theoretical voltage for $1k\Omega$ and 510Ω load values in terms of k

k	$V_{unloaded}$ (V)	V_{L1} (V)	V_{L1t} (V)	PD_1 (%)	V_{L2} (V)	V_{L2t} (V)	PD_2 (%)
0.1	2.959	0.274	0.156	75.85	0.253	0.111	56.02
0.2	2.959	0.514	0.329	56.27	0.451	0.239	46.98
0.3	2.959	0.739	0.522	41.46	0.628	0.388	38.28
0.4	2.959	0.957	0.740	29.32	0.809	0.562	30.53
0.5	2.959	1.184	0.987	20.00	0.993	0.770	22.47
0.6	2.959	1.433	1.269	12.97	1.21	1.022	15.55
0.7	2.959	1.717	1.594	7.74	1.47	1.334	9.27
0.8	2.959	2.039	1.973	3.35	1.801	1.730	3.97
0.9	2.959	2.448	2.421	1.11	2.268	2.249	0.86
1	2.959	2.952	2.959	0.24	2.948	2.959	0.37

5.2 Graphs

Figure 5 displays the voltage across the load resistor in terms of K , comparing them to the theoretical values, and the voltage drop on the unloaded potentiometer.

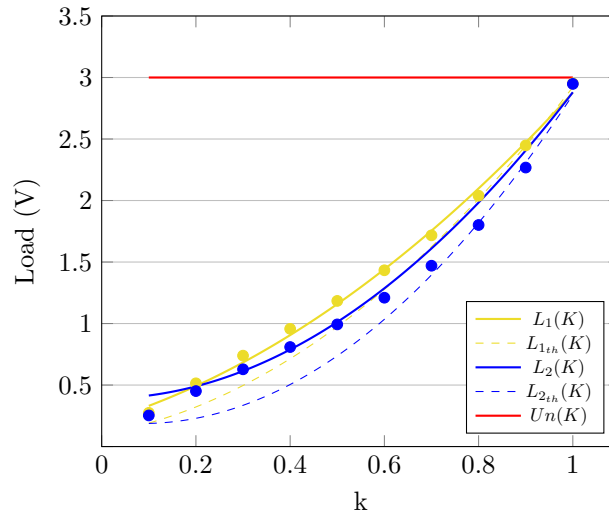


Figure 6: Loads in terms of k

Figure 6 displays the relationship between percent deviation and K .

5.3 Calculations

5.4 Discussion

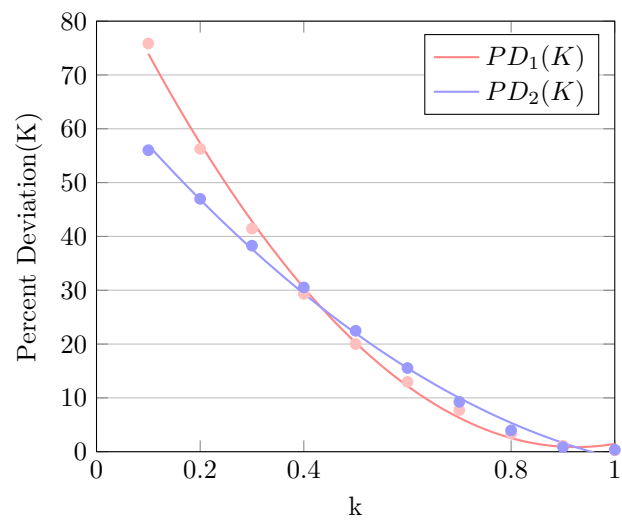


Figure 7: Percent deviation in terms of k