E4
Current, Voltage and Power Measurements in Resistor Networks

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10:00 A.M - 1:00 P.M

1 Introduction:

When setting up a circuit there are two forms of circuits that should be considered, a Series Circuit and a Parallel Circuit, these circuits not only differ visually but also affect the way the current and voltage is transported to each component in the circuit. In this experiment we set up simple circuits involving a power pack and resistors in different variation in an attempt to to understand the difference between the two forms of circuits as well as how they can be used simultaneously.

We attempt to do this by measuring the current in the circuit using an Ammeter which is connected to the circuit in series and measuring the voltage by connecting a voltmeter in parallel. Once we have our results we can then compare the affects that each circuit had on the amount of current and voltage running through each part of the circuits and make definitive claims about the characteristics of Series and Parallel circuits.

2 Method Experimental Set-up:

The first step in the experiment involved finding the Electromotive force E_{mf} of the power pack which will be used over the course of the experiment. We connected a voltmeter into the power pack and recorded the value displayed.

Next we created a simple circuit which involved one 47 Ω Resistor being connected to the power pack in series. The total current in the circuit was recorded using an Ammeter in series and the voltage of the single resistor was found by connecting the voltmeter in parallel. Our power pack also displayed the terminal voltage which was being supplied so it was easy to compare the two voltages.

Next we connected two 47 Ω Resistors in series. Once again we measured the total current in the circuit and also the voltage across each of the two resistors.

After this we set up two more circuits, one containing three 47 Ω resistors in series, and one containing four 47 Ω resistors in series. Also making sure to take the total current and individual voltages for each of these.

Moving on to parallel circuits we once again created a circuit with two 47 Ω resistors, but this time made sure they were in parallel before connecting them back up to the power pack in series. Measuring the total current of the circuit and each resistors voltage.

The above steps were repeated for a circuit with three and four 47 Ω resistors in parallel.

The next circuit was set up as show in Fig. 2.1. The total current of the circuit was recorded, as well as the Ammeter and Voltmeter being connected to the circuit at each point where A and V are seen respectively.

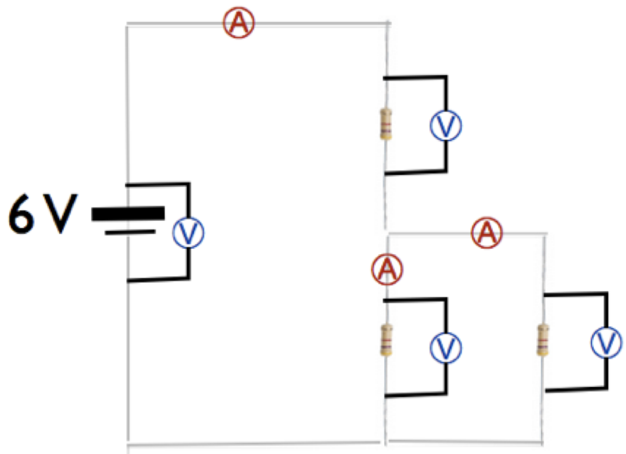

Figure 2.1: Diagram of Parallel Circuit

Another parallel circuit was set up following the diagram shown in Fig. 2.2. This circuit involved 5 resistors each of which had to be measured with the voltmeter once the total current of the circuit had been determined. After which the ammeter was connected in series to each part of the circuit labelled A.

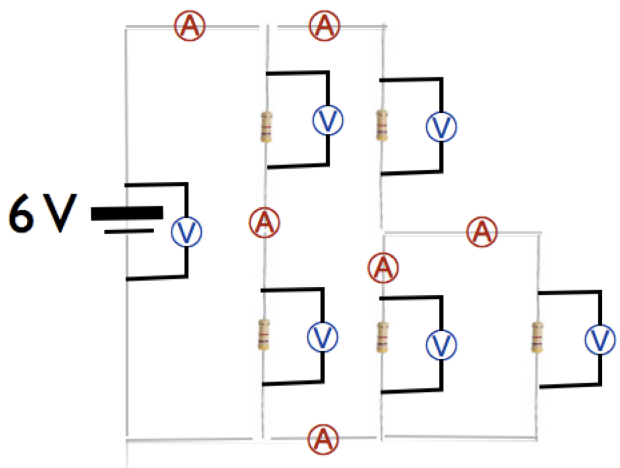

Figure 2.2: Diagram of Parallel Circuit

3 Results:

Experiment 1:

Voltage of Battery	E_{mf} of battery
5.9 V ± 0.0005	5.89 V ± 0.005

Experiment 2:

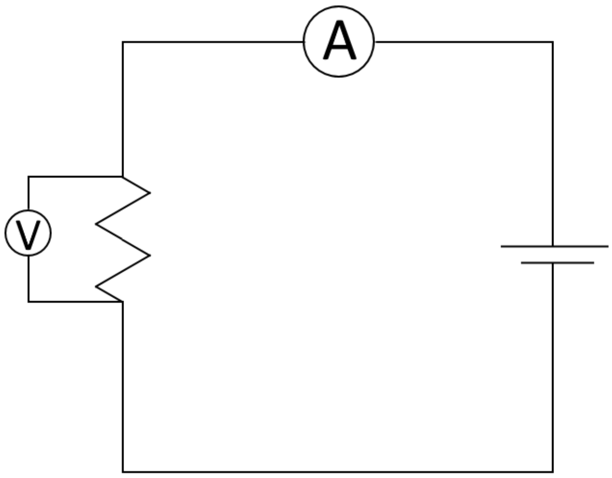

Figure 3.1: Diagram of Circuit 1

Total Current flowing in circuit	Voltage drop across 47 Ω	Terminal voltage of Battery
120 mA ± 0.05	5.66 V ± 0.0005	5.9 V

(Estimate the value of r) =

$$\frac{\Delta R}{R} = \frac{\Delta I}{I} + \frac{\Delta V}{V}$$

$$\frac{\Delta R}{47\Omega} = \frac{0.05}{120mA} + \frac{0.0005}{5.66V}$$

$$\Delta R = \pm 0.02$$

$$47\Omega \pm 0.02$$

$$I = \frac{E_{mf}}{R+r}$$

$$I = \frac{5.9V}{47\Omega + 0.02\Omega} = 120mA$$

$$P = (120 \times 10^{-3} mA)^2 (47\Omega) = 0.67W$$

Experiment 3:

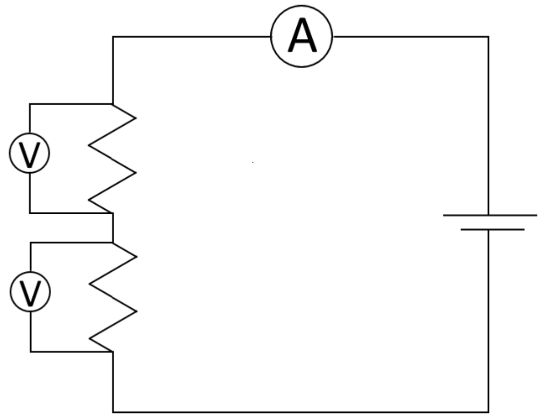

Figure 3.2: Diagram of Circuit 2

Total Current	Voltage drop Ω_1	Voltage drop Ω_2
62.3 mA $\pm$ 0.005	2.935 V $\pm$ 0.0005	2.833 V $\pm$ 0.0005

$R_1 + R_2 = 47\Omega + 47\Omega = 94\Omega$ $\quad$ $R_{eq} = 94\Omega \pm 0.04 \quad I = 62.7mA \quad P = 0.37W$

Experiment 4:

3 $\times$ 47Ω R's:

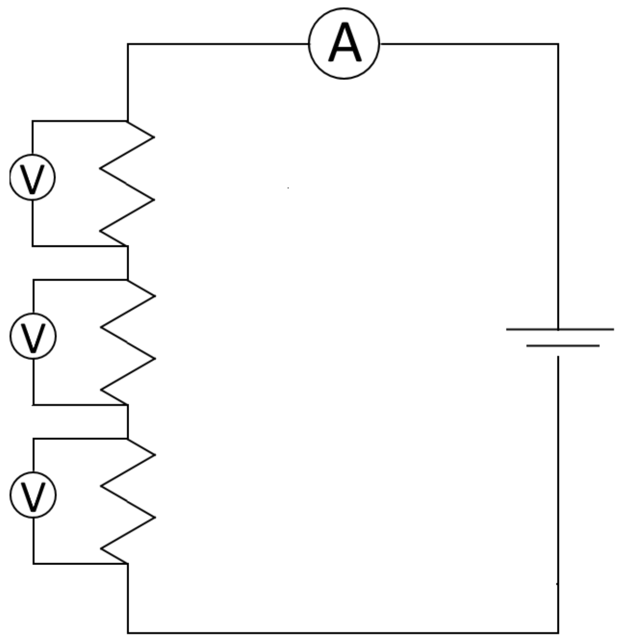

Figure 3.3: Diagram of Circuit 3

Total Current	Voltage drop Ω_1	Voltage drop Ω_2	Voltage drop Ω_3
42.1 mA $\pm$ 0.005	1.978 V $\pm$ 0.0005	1.911 V $\pm$ 0.0005	1.941 V $\pm$ 0.0005

$$47\Omega + 47\Omega + 47\Omega = 141\Omega \quad R_{eq} = 141\Omega \pm 0.06 \quad I = 41.8mA \quad P = 0.25W$$

4 × 47Ω R's:

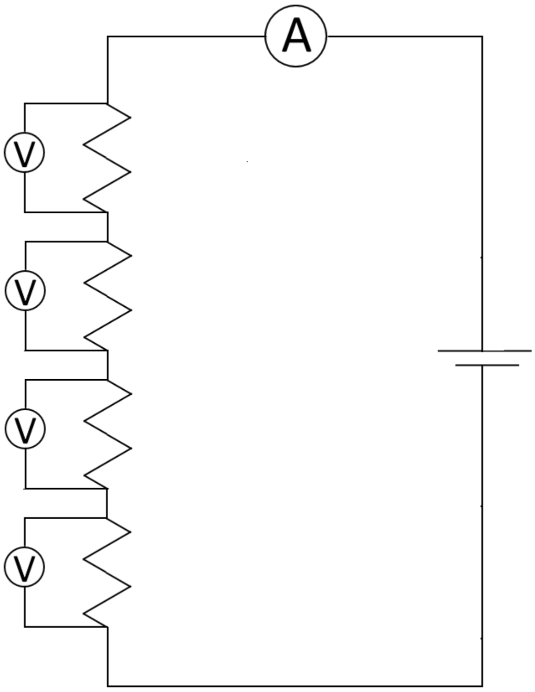

Figure 3.4: Diagram of Circuit 4

Total Current	Voltage drop Ω_1	Voltage drop Ω_2	Voltage drop Ω_3	Voltage drop Ω_4
26.68 mA ± 0.005	1.503 V ± 0.0005	1.444 V ± 0.0005	1.471 V ± 0.0005	1.469 V ± 0.0005

$$47\Omega + 47\Omega + 47\Omega + 47\Omega = 188\Omega \quad R_{eq} = 188\Omega \pm 0.08 \quad I = 31.37mA \quad P = 0.19W$$

Experiment 5:

2 × 47Ω R's Parallel:

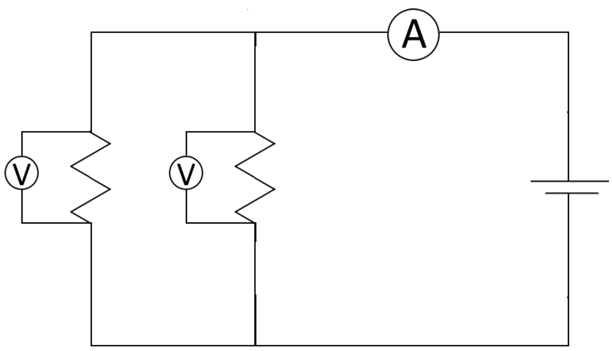

Figure 3.5: Diagram of Circuit 5

Total Current	Voltage drop Ω_1	Voltage drop Ω_2
238.4 mA ± 0.05	5.47 V ± 0.005	5.49 V ± 0.005

$$\frac{1}{47\Omega} + \frac{1}{47\Omega} = \frac{1}{23.5\Omega} \qquad \mathrm{R}_{eq} = 23.5\Omega \pm 0.02 \quad I = 251mA \quad P = 1.48W$$

Experiment 6:

3 × 47Ω R's Parallel:

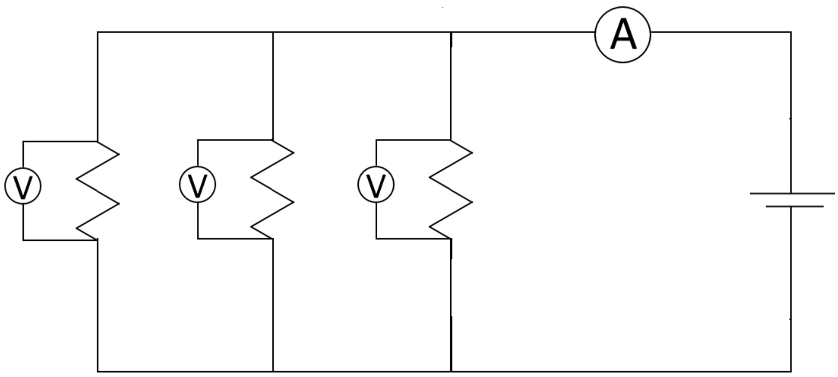

Figure 3.6: Diagram of Circuit 6

Total Current	Voltage drop Ω_1	Voltage drop Ω_2	Voltage drop Ω_3
347.8 mA ± 0.05	5.27 V ± 0.0005	5.28 V ± 0.0005	5.3 V ± 0.0005

$$\frac{1}{47\Omega} + \frac{1}{47\Omega} + \frac{1}{47\Omega} = \frac{1}{15.\dot{6}\Omega} \qquad \mathrm{R}_{eq} = 15.\dot{6}\Omega \pm 0.02 \quad I = 377.7mA \quad P = 2.23W$$

4 × 47Ω R's Parallel:

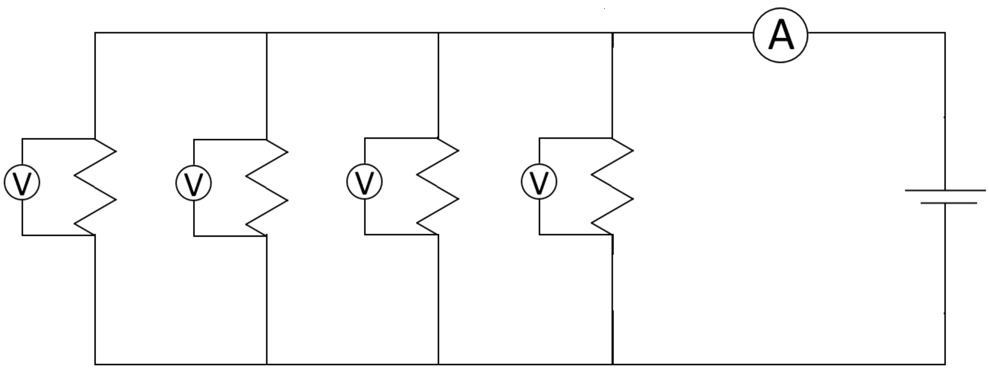

Figure 3.7: Diagram of Circuit 7

Total Current	Voltage drop Ω_1	Voltage drop Ω_2	Voltage drop Ω_3	Voltage drop Ω_4
404.3 mA ± 0.05	4.72 V ± 0.0005	4.78V ± 0.0005	4.66 V ± 0.0005	4.66 V ± 0.0005

$$\frac{1}{47\Omega} + \frac{1}{47\Omega} + \frac{1}{47\Omega} + \frac{1}{47\Omega} = \frac{1}{11.75\Omega} \qquad \mathrm{R}_{eq} = 11.75\Omega \pm 0.02 \quad I = 501.3mA \quad P = 2.95W$$

Experiment 7:

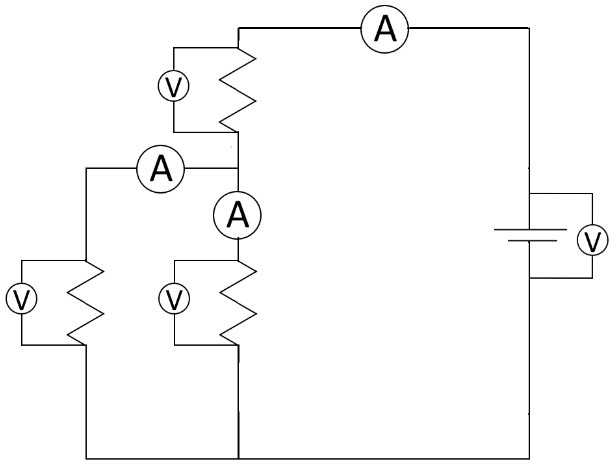

Figure 3.8: Diagram of Circuit 8

$(\frac{1}{47\Omega} + \frac{1}{47\Omega}) = \frac{1}{23.5\Omega} \quad 23.5\Omega + 47\Omega = 70.5\Omega \quad R_{eq} = 70.5\Omega \pm 0.04 \quad I = 83.6mA \quad P = 0.49W$

Current A_1	Current A_2	Current A_3
0.01 mA ± 0.00005	82 mA ± 0.005	40.8 mA ± 0.005
Voltage drop Ω_1	Voltage drop Ω_2	Voltage drop Ω_3
1.922 V ± 0.0005	1.919 V ± 0.0005	3.796 V ± 0.0005

Experiment 8:

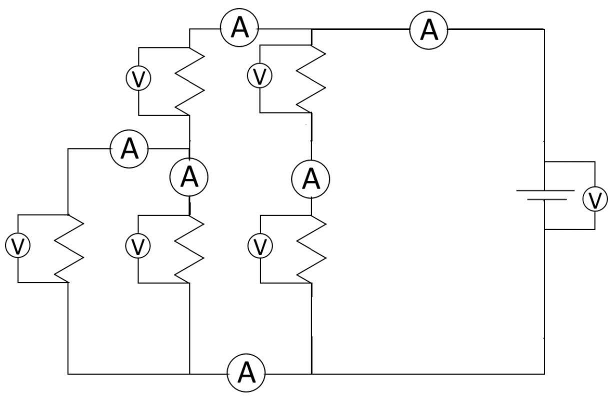

Figure 3.9: Diagram of Circuit 9

Current A_1	Current A_2	Current A_3	Current A_4	Current A_5	Current A_6
0.19 mA ± 0.00005	0.3 A ± 0.00005	0.2 A ± 0.00005	0.4 A ± 0.00005	0.2 mA ± 0.00005	0.5 A ± 0.00005

Voltage drop Ω_1	Voltage drop Ω_2	Voltage drop Ω_3	Voltage drop Ω_4	Voltage drop Ω_5	Voltage drop Ω_6
5.93 V ± 0.0005	2.978 V± 0.0005	2.937± 0.0005	2.003 V ± 0.0005	3.91 V ± 0.0005	1.999 V ± 0.0005

$\frac{1}{47\Omega} + \frac{1}{47\Omega} + \frac{1}{47\Omega} + \frac{1}{47\Omega} + \frac{1}{47\Omega} = \frac{1}{9.4\Omega} \quad R_{eq} = 9.4\Omega \pm 0.02 \quad I = 626.3mA \quad P = 3.69W$

4 Discussion:

Throughout the experiment there were noticeable trends in the results which we can analyse and define as characteristics of either Series circuits or Parallel circuits depending on where the trends are found.

The first noticeable trend in the results is the total current in the system, as more resistors were added in series the total current of the system was decreasing. Initially the total current was 120 mA, when a second resistor was added this dropped to 62.3 mA which is almost half, a third resistor was added which brought the current down to 42.1 mA which is almost a third of the initial current. Finally a fourth resistor was added and the total current in the system dropped again to 26.68 mA which is less than a fourth of the initial current.

From this we can conclude that as the number of components in series increases, the total current in the circuit is divided by that amount.

Contrastingly when we look at the parallel circuit, the opposite appears to be true. In the two resistor circuit we see the total current is 238.4 mA, which is almost double the 120 mA found in the two series resistor circuit, as the number of resistors increases, so too does the total current. From this we can conclude that as the number of components in parallel increases, the total current in the circuit also increases.

When we look at voltages we see a similar story, as the number of resistors in the series circuit increases, we see that the voltage across each resistor drops. Interestingly if we get the sum of all the voltages in a series circuit we end up with a value extremely close to the value of the voltage coming from the power pack, this implies that the voltage is being split evenly among each of the resistors in the series circuit.
In the parallel circuits the voltages across each resistor appears to be equal

The complex circuit made in Experiment 7 and 8 verify these implications by combining both parallel and series circuits, which we can tell based on the results, in Experiment 7 there is two resistors in series and one in parallel, in the results table, there are two voltages which add to give a similar voltage to the third resistor.

5 Conclusion

Upon completing this experiment we can definitively determine that
The characteristics of series circuits is: the total current decreases as components are added, Voltage is split equally among each component in a circuit and resistance increases proportional to the number of components.
The characteristics of a parallel circuit is: the total current increases as components are added, the same voltage flows through each component and resistance remains constant regardless of the number of components