Lab 1: Ohms Law, Serial Circuit and Parallel Circuit, Kirchoff's Law

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Purpose:

1) Get familiar with and be able to use measurement tools (multimeter), circuit components (resistors, LED, breadboard, power supply) to build circuit, take measurements(ohms, voltage and current);
2) Understand Ohms Law, parallel circuit and series circuit and design a circuit of Voltage Divider based on Ohms Law;
3) Understand Kirchoff's law and using it to check the validity of voltage measurements taken in Mystery Circuit during lab

Content:

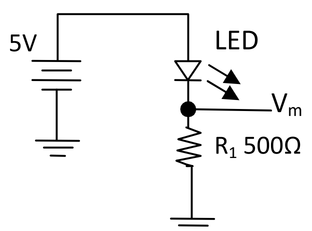
1) Measuring resistances: get familiar with resistor color code, multimeter

Resistor 1(100 ohms)		Resistor 2 (1000 ohms)	
1	97.8 ohms	1	999 ohms
2	97.9 ohms	2	990 ohms
3	97.7 ohms	3	976 ohms

From above table, It can been seen that resistance of each resistor has deviation from its labeled value of resistance, this will result in the difference between the measured value(Voltage, Current etc) and theoretical value.

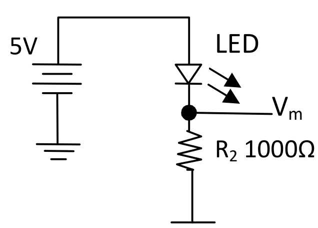
2) LED and Resistor circuit

a. The serial circuit of LED and resistor with resistance of 500 Ω



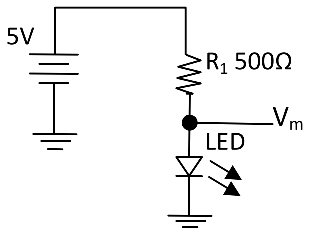
In the left circuit, V_m=3.015V (measured with multimeter)
According to Ohms Law
$I_{R1}=I_{LED}=V_m/R_1$=3.015V/500Ω=6.03mA
Then According to Kirchoff's voltage Law
$V_{LED}=5-V_m$=5-3.015=1.985V≈2V

b. The serial circuit of LED and resistor with resistance of 1000 Ω



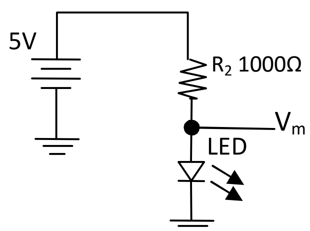
In the left circuit, V_m=3.088V (measured with multimeter)
According to Ohms Law
$I_{R2}=I_{LED}=V_m/R_2$=3.088V/1000Ω=3.09mA
According to Kirchoff's Voltage Law
$V_{LED}=5-V_m$=5-3.088=1.912V≈2V

c. The Circuit in "a" with the change of order of LED and R_1



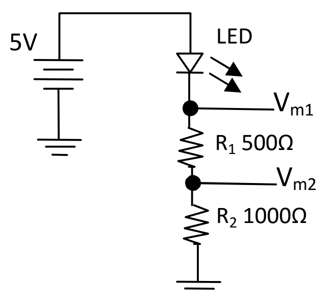
In the left circuit, V_m=1.979 (measured with multimeter)
The Voltage drop of R_1: $V_{R1}=5-V_m=5-1.979=3.021V$
According to Ohms Law
$I_{R1}=I_{LED}=V_{R1}/R_1=3.021/500\Omega=6.04mA$
According to Kirchoff's Voltage Law
$V_{LED}=V_m-0=1.979V\approx 2V$

d. The circuit in "b" with change of order of LED and R_2



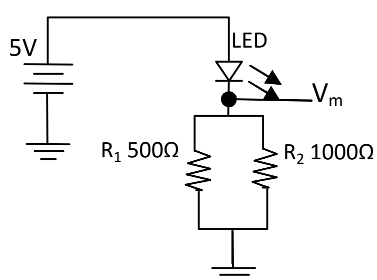
In the left circuit, V_m=1.906 (measured with multimeter)
The Voltage drop of R_2: $V_{R2}=5-V_m=5-1.906=3.094V$
According toOhms Law
$I_{R2}=I_{LED}=V_{R2}/R_2=3.094/1000\Omega=3.01mA$
$V_{LED}=V_m-0=1.906V\approx 2V$

e. In the following circuit, R_1series with R_2 and then connects with LED in series



In the left circuit, V_{m1}=3.106V, V_{m2}=1.061V (measured with multimeter)
According to Ohms Law $I_{R1}=I_{R2}=I_{LED}=(V_{m2}-0)/R_2=1.061V/1000\Omega=1.06mA$
$V_{LED}=5-V_m=5-3.015=1.985V\approx 2V$

f. In the following circuit, R_1parelles with R_2 and then connects with LED in series

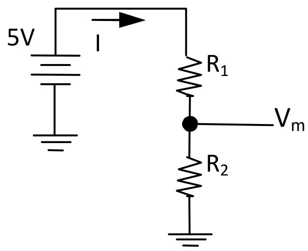


In the left circuit, V_m=2.967V (measured with multimeter)
According to Kirchoff's Current Law $I_{LED}=I_{R1}+I_{R2}=(V_m-0)/R_1+(V_m-0)/R_2=2.967V/500\ \Omega+2.967/1000\ \Omega=5.93mA+2.967mA=9.897mA$
$V_{LED}=5V-V_m=5V-2.967V=2.033V\approx 2V$

Conclusion: from previous circuits and corresponding analysis, it can be seen that the operating voltage of LED is about 2V. In practical application of LED, in order to avoid being damaged by large current, high voltage, the LED should be connected with a resistor to limit the operating current and reduce the voltage imposed on LED.

3) A Voltage Divider

For a given fixed input voltage, we can use resistors to get a desired fraction output voltage. In, the following circuit, to get a desired voltage of 3.6V,



In the left circuit:

The voltage drop of R_1:V_{R1}=5-Vm; The Voltage drop of R_2: $V_{R2}=V_m$

According to Ohms Law:

$I_{R1}=V_{R1}/R_1=(5-V_m)/R_1$; $I_{R2}=V_m/R_2$

Because $I_{R1}=I_{R2}=I$, so $(5-V_m)/R_1=V_m/R_2$

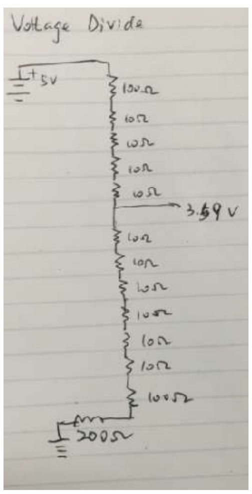
$\Rightarrow (5-V_m)/V_m = R_1/R_2 \Rightarrow (R_1+R_2)/R_2=5/V_m$

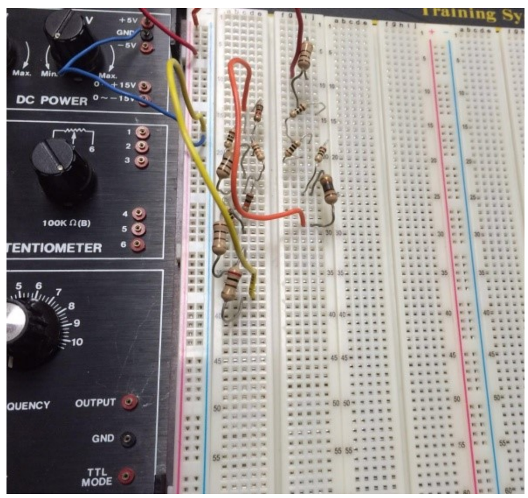
In order to get $V_m=3.6$: $(R_1+R_2)/R_2=5/3.6$

Considering the availability of resistors, I choose

$R_1+R_2=500\Omega$, then $R_2=360\Omega$, $R_1=500\Omega-360\Omega=140\Omega$

The designed circuit and picture of bread circuit are shown as following

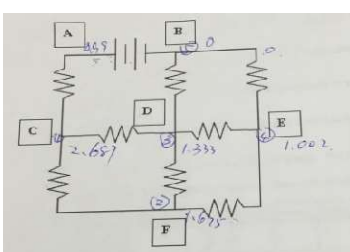


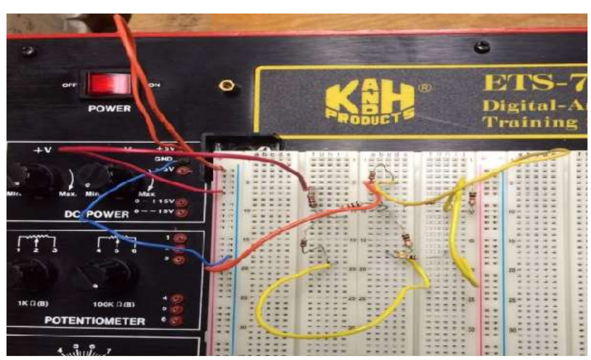


Conclusion: in a resistor circuit, because the ratio of voltage drops of resistors is equal to the ratio of resistors, so we can use this character to design a voltage divider, namely , for a given fixed input voltage or source voltage, we can use a number of resistors connected in series to get a desired fraction output voltage.

4) A Mystery Circuit

In the following circuit,

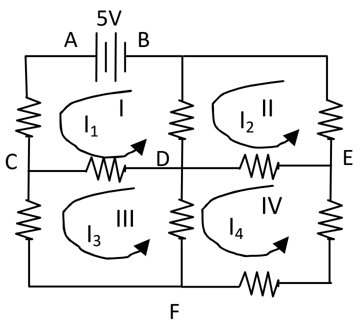




In the above circuit, each resistor is 1KΩ, the voltage of each point (as shown in the picture) were measured as following :

V_A=4.99V; V_B=0 V; V_C=2.687V; V_D=1.333V; V_E=1.002V; V_F=1.675V;

This mystery circuit is analyzed as following: the circuit is redrew as following, as shown in the circuit, there are four sub-circuits labeled as I, II, III and IV, the currents of these sub-circuits are I_1,I_2, I_3 and I_4 respectively, the direction of I_1,I_2, I_3 and I_4 are shown in the following circuit



In the left circuit, all resistors have same resistance of 1KΩ, according Kirchoff's Voltage Law, for each sub-circuits (I, II, III and IV), it have:

1) I_1*1KΩ +(I_1-I_3)* 1KΩ +(I_1-I_2)* 1KΩ =5V
2) (I_2-I_1) *1KΩ +(I_2-I_4)*1KΩ +I_2* 1KΩ =0
3) (I_3-I_1) *1KΩ +I_3*1KΩ +(I_3-I_4)* 1KΩ =0
4) (I_4-I_2) *1KΩ +(I_4-I_3)*1KΩ +I_4* 1KΩ +I_4*1KΩ=0

The solution of previous four equation is as following

I_1=2.273mA, I_2=0.909mA, I_3=0.909mA, I_4=0.455mA

So, V_C=5-I_1*1KΩ=2.727V, V_D=V_c-(I_1-I_3)* 1KΩ=1.364V

V_E=V_D-(I_2-I_4)* 1KΩ=0.909V; V_F=V_C-I_3*1KΩ=1.818V

Conclusion: from theoretical analysis above, it can be seen that theoretical voltage values of C, D, E,F points are almost equal to measured values, it demonstrated that Kirchoff's Current Law and Kirchoff's Voltage Law are effective tools to analyze complicated circuit. Though there are deviation between the theoretical value and measured one, the error maybe caused by the resistance of each resistor is not exactly equal to 1KΩ, just like the first part of this lab shown.