IC160P-Electrical Systems Around Us Lab

Verification of Kirchhoff’s Current Law (KCL) and Kirchhoff’s Voltage Law (KVL)

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1. Objectives

To Verify KCL and KVL from the given circuits

2. Theory

2.1 Kirchhoff’s Voltage Law

Kirchhoff’s Voltage Law (KVL) states that the algebraic sum of all branch voltages around any closed path in a circuit is always zero at all instants of time. KVL is a consequence of conservation of energy. In Fig. 1, application of KVL results in (1). $Vs = V1 + V2 + V3$

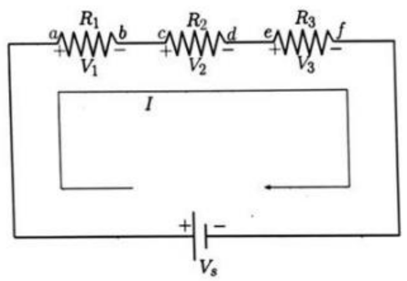


Fig. 1:Circuit 1

2.2 Kirchhoff’s Current Law

Kirchhoff’s Current Law (KCL) states that the sum of the currents entering into a node/point/junction is equal to the sum of the currents leaving that node/point/junction. KCL is a consequence of conservation of charge. In Fig. 2, application of KCL results in (2). $IT = I1 + I2 + I3$

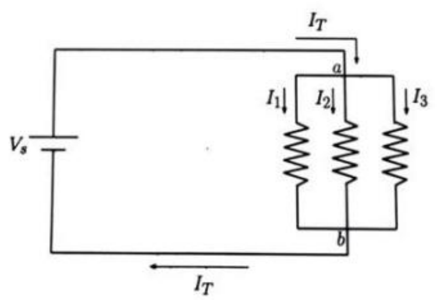


Fig. 2:Circuit 2

3. Procedure and Verification

3.1 Verification of KCL in MATLAB2021a

1. Open matlab2021a which is installed on your computer & once the software is open click on the Simulink icon which is present on the top right and select a blank model and save the model with a suitable name. File names must start with a letter, and can contain letters, digits, or underscores. Avoid using space or special symbols. If you don’t follow proper format for file name, MATLAB may show error.

2. Open library browser on the top left of the Simulink page in-order to access the components required to make the circuit.

3. One can search for the required component in the library browser search space (e.g.: - search for ‘Dc Voltage Source’) or one can select the required components for this experiment from ‘simscape →Electrical→ specialized power system library’ in the library browser. From specialized library you have to add Powergui block into your model. You will get voltage source, resistors, measurements block from sub-libraries i.e. Sources, Passive, Sensor and Measurements under specialized power system library.

4. Drag and drop required blocks from library browsers into your model, also you can add block to your model by making right click on the block and then selecting add block to your model (your model’s name) option. Double Click on the blocks and then it gives you an option what your parameter value should be (e.g., amplitude (V), resistance (ohms)). If your parameter value is same as default value, then you can go with the default value or you can put your required value in the parameter box.

5. Once all the components are available make the connections as per the circuit diagram given in the manual (figure 4). To make a connection you have to simply drag a signal from a block to a block next to it

6. To vary the supply voltage, double click on dc voltage source and change the amplitude(V) by entering different values in the parameter box of amplitude(V) and take the corresponding readings of IL, I1 and I2 using current measurement and display blocks.

7. Verify the readings against the theoretically calculated values. Present your observations in a tabular form as given below.

KCL

CIRCUIT DIAGRAM:

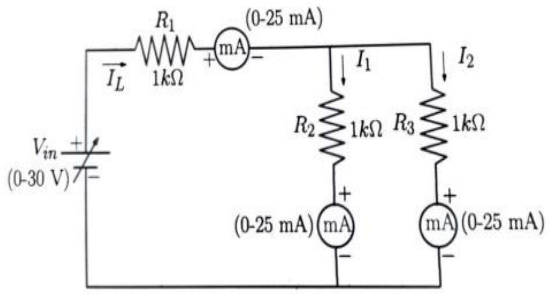
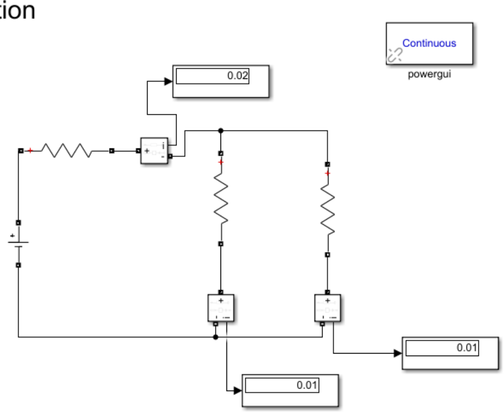


Fig. 3: Circuit for verification of KCL

KCL Verification



Observations:

Vin (V)	I1(mA)		I2(mA)		IL=I1+I2(mA)	
	Theoretical	Ideal Simulation	Theoretical	Ideal Simulation	Theoretical	Ideal Simulation
30	10	10	10	10	20	20
40	13.33	13.33	13.33	13.33	26.67	26.67
50	16.67	16.67	16.67	16.67	33.33	33.33
20	6.67	6.67	6.67	6.67	13.33	13.33
10	3.33	3.33	3.33	3.33	6.67	6.67

Conclusion:

From the above observations, it is clear that the sum of total current in all the branches of the circuit (I1 + I2) is equal to the total current in the circuit which is the Kirchoff's Current Law. Hence, KCL is verified.

KVL

Circuit Diagram:

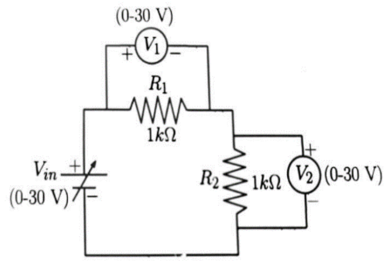
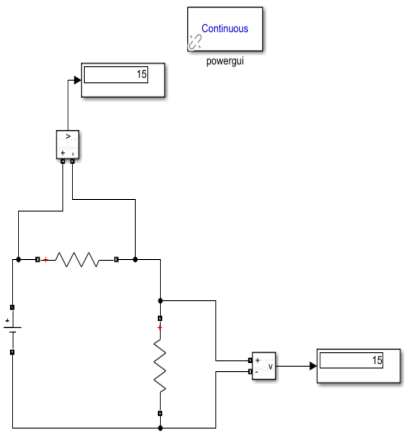


Fig. 4: Circuit for verification of KVL

KVL Verification



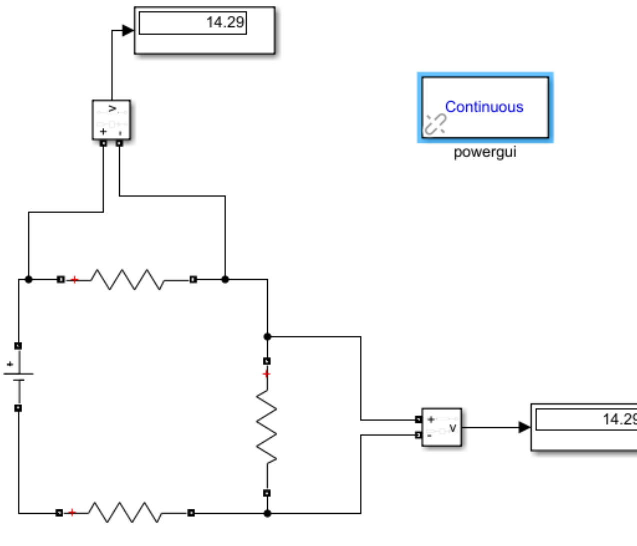
Observations:

Vin (V)	V1(V)		V1(V)		Vin=V1+V2 (V)	
	Theoretical	Ideal Simulation	Theoretical	Ideal Simulation	Theoretical	Ideal Simulation
30	15	15	15	15	30	30
40	20	20	20	20	40	40
50	25	25	25	25	50	50
20	10	10	10	10	20	20
10	5	5	5	5	10	10

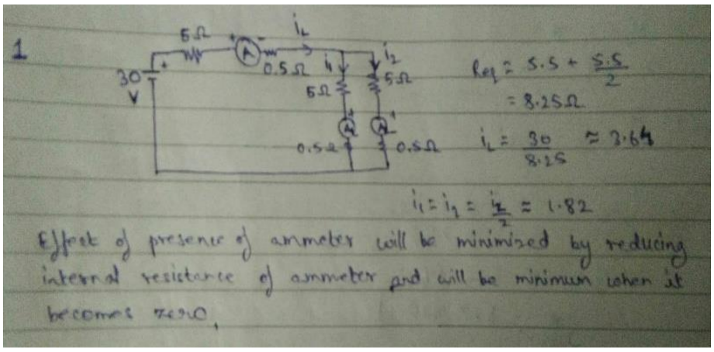
Conclusion:

From the above observations, it is clear that the algebraic sum of the voltages of all segments of the loop in the circuit (V1+V2) is equal to the total potential drop across the input voltage source which is Kirchoff's Voltage Law. Hence, KVL is verified.

4.Questions



1. In the circuit for verification of KCL (Fig. 3), assume all resistances are of 5 Ω. If the internal resistance of all ammeters is 0.5 Ω, show by calculations the effect of presence of ammeters in the circuit on measured current values against the theoretical values. When will this effect be minimum?



$R_{eq} = 5.5 + \frac{5.5}{2}$

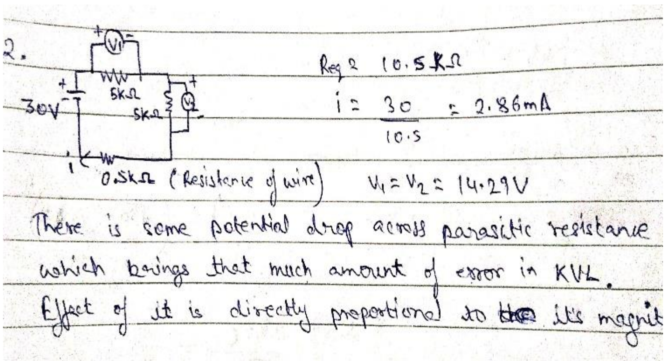
$= 8.25\Omega$

$i_L = \frac{30}{8.25} \approx 3.64$

$i_1 = i_2 = \frac{i_L}{2} = 1.82$

Effect of presence of ammeter will be minimized by reducing internal resistance of ammeter and will be minimum when it becomes zero.

2. Redraw the circuit in Fig.4 and incorporate a parasitic resistance Rp of 0.5 kΩ (which basically represents the total resistance of connecting wire and internal resistance of dc voltage source etc.) in series with the other circuit elements just after the dc voltage source and repeat the calculation for finding voltage across resistor $R1$ (5 kΩ) and $R2$ (5 kΩ) and also simulate the circuit in MATLAB/Simulink, note down the reading from your voltage measurements display. You can take the value dc voltage source of 100 volts. Comment on the effect of parasitic resistance in your circuit.



$R_{eq} = 10.5 k\Omega$

$i = \frac{30}{10.5} = 2.86mA$

0.5kΩ (Resistance of wire) $V_1 = V_2 = 14.29V$

There is some potential drop across parasitic resistance which brings that much amount of error in KVL.

Effect of it is directly proportional to ~~the~~ it's magnit