Circuits and Electronic Laboratory

Experiment #2

Purpose of Experiment

Gaining the habit of building circuits on the breadboard, learning the relation between ammeter and current on the circuit and experimenting Kirchhoff's current law.

General Information

Kirchhoff's Current Law: This law states that on any circuit at any time t sum of currents that originates form the node and currents that goes into the node is zero.

$$\sum_{k=0}^{n} I_k = 0 \qquad (1)$$

where n is the total number of branches with currents flowing towards or away from the node. Currents that goes into the node have positive sign. Vice versa currents that goes out of the node has negative sign.

A device called ammeter (**Am**per **Meter**) is a measuring instrument used to measure the current in a circuit. Electric currents are measured in amperes. Today there are two different kinds of ammeter which are analog and digital ones. Digital ones are widely used nowadays. An ideal ammeter has an internal resistance of zero. Due to this property it behaves like a short circuit. Practical ammeters usually has 0.01Ω - 0.1Ω Ammeters always connected in series to the component that needs its current to be measured. Caution do not connect ammeter parallel to component. Be sure about the current to be measured is smaller than ammeters maximum current. If not sure, first use biggest current ratio of ammeter to measure.

Nodes: a node in a circuit is defined as a region between two circuit elements. An example of 3 different nodes in a circuit given Figure 1. Each color represents different node.

Tip: If a components current needs to be measured, follow this steps:

Figure 1: Nodes In a Circuit, source: Wikipedia

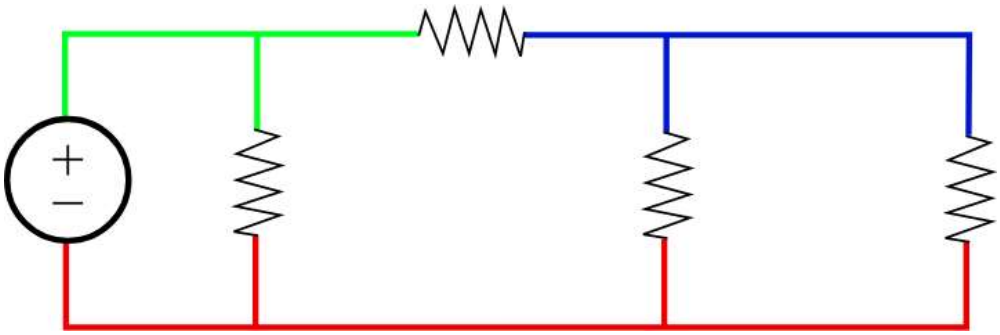
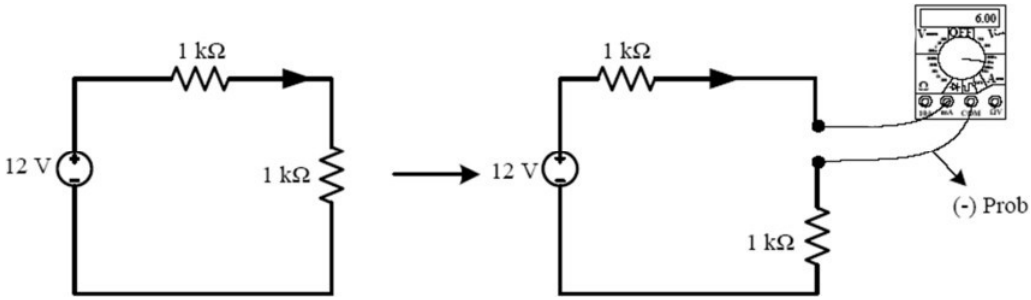


Figure 2: Sample connection diagram of a ammeter

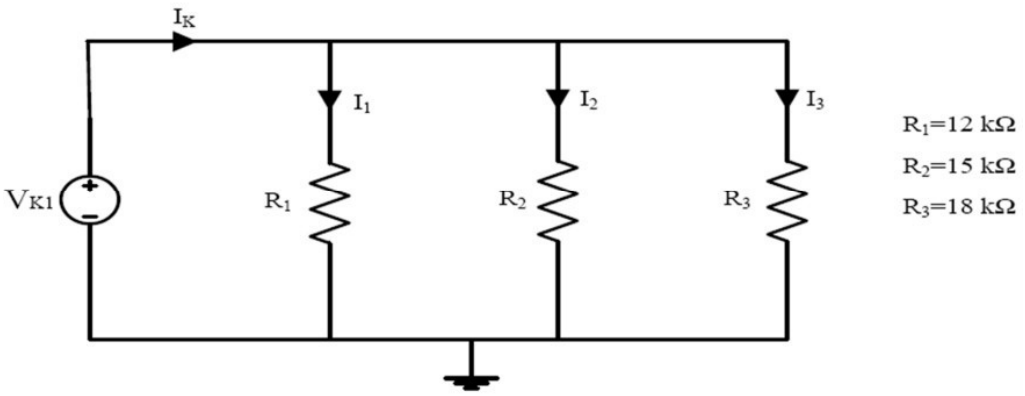


- If using a multi meter, get into the current measurement state
- Put red (+) probe to mA input if current to be measured is smaller than 200ma If it's bigger than that, or current is unknown use A input of multi meter. Put black (-) probe to com input.
- Turn off all voltage sources.
- Disconnect the cable that connects the component.
- Connect ammeter appropriately instead of the cable that disconnected.
- Turn on voltage sources. Read the current value.

Preparations Before Experiment

- For the circuit in Figure 2, calculate currents of components and show that Kirchhoff's current law holds.

Figure 3:



- For the circuit in Figure 3, calculate currents in Table 1 with given voltages.
- Make research about relative error in circuits.

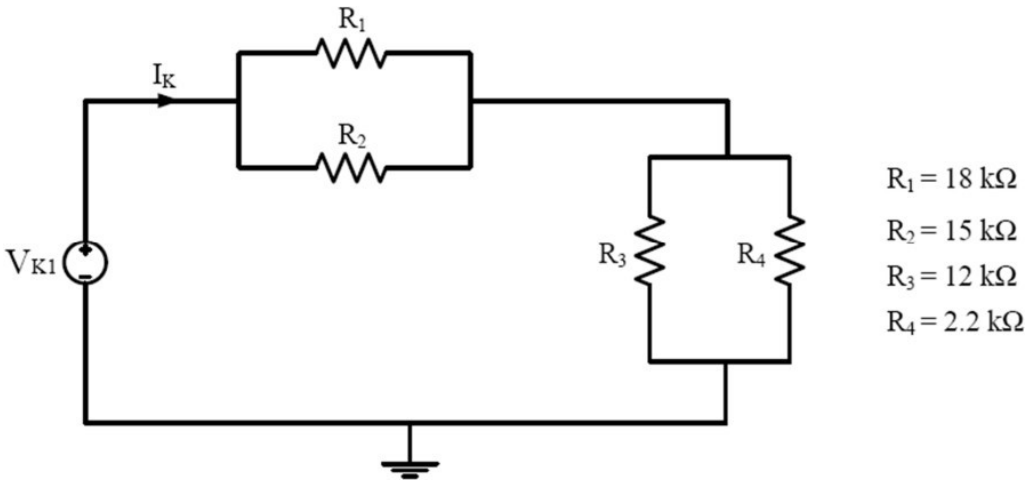
Section 1

1. Construct the circuit given in Figure 3. Set the DC source with the help of voltmeter according to table 1. Measure I_k, I_1, I_2, I_3 with the help of ammeter. Fill the Table 1.

V_{k1}	$I_1[A]$	$I_2[A]$	$I_3[A]$	$I_1 + I_2 + I_3[A]$	$I_k[A]$ (Measured)	$I_k[A]$ (Calculated)	Relative Error [%]
$5V$	416.667 uA	333.333 uA	277.778 uA	1.028mA	1.028mA		
$8V$	666.667 uA	533.333 uA	444.444 uA	1.644mA	1.644mA		
$12V$	1mA	800uA	666.666 uA	2.467mA	2.467mA		
Table 1							

2. In the circuit depicted in figure 4, set source voltage to $12V$. Fill the Table 2 by measuring all component currents. Show that Kirchhoff's current law holds.

Figure 4:



$I_{R1}[A]$	$I_{R2}[A]$	I_{R1} + $I_{R2}[A]$	$I_{R3}[A]$	$I_{R4}[A]$	I_{R3} + $I_{R4}[A]$	$I_k[A]$
543.229 uA	651.874 uA	1.195 mA	1.01mA	185.157uA	1.195mA	0
Table 2						

Section 2

1. Remove R_1 and R_2 in circuit 4 and insert equivalent resistor in place of R_1 and R_2. Connect -12V voltage source in series with R_4. Calculate currents across all resistors and also calculate cycle currents. Fill the Table 3.

2. Connect R_5 = 3.3k with parallel to equivalent resistor that connected in place of R_1 and R_2 Calculate currents across all resistors and also calculate node currents. Fill the Table 4. Show that Kirchhoff's current law hold for each node. Fill the Table 5 with Kirchhoff's current law equations for the nodes. Annotate nodes starting from voltage source with left to right. Ex: Node 1 is the node between voltage source and $R_{1\&2eqv}$

3. Measure all voltages across every resistor in the last circuit you built,. Fill the Table 6. Show that Kirchhoff's voltage law holds. Fill the Table 7 with Kirchhoff's voltage law equations.

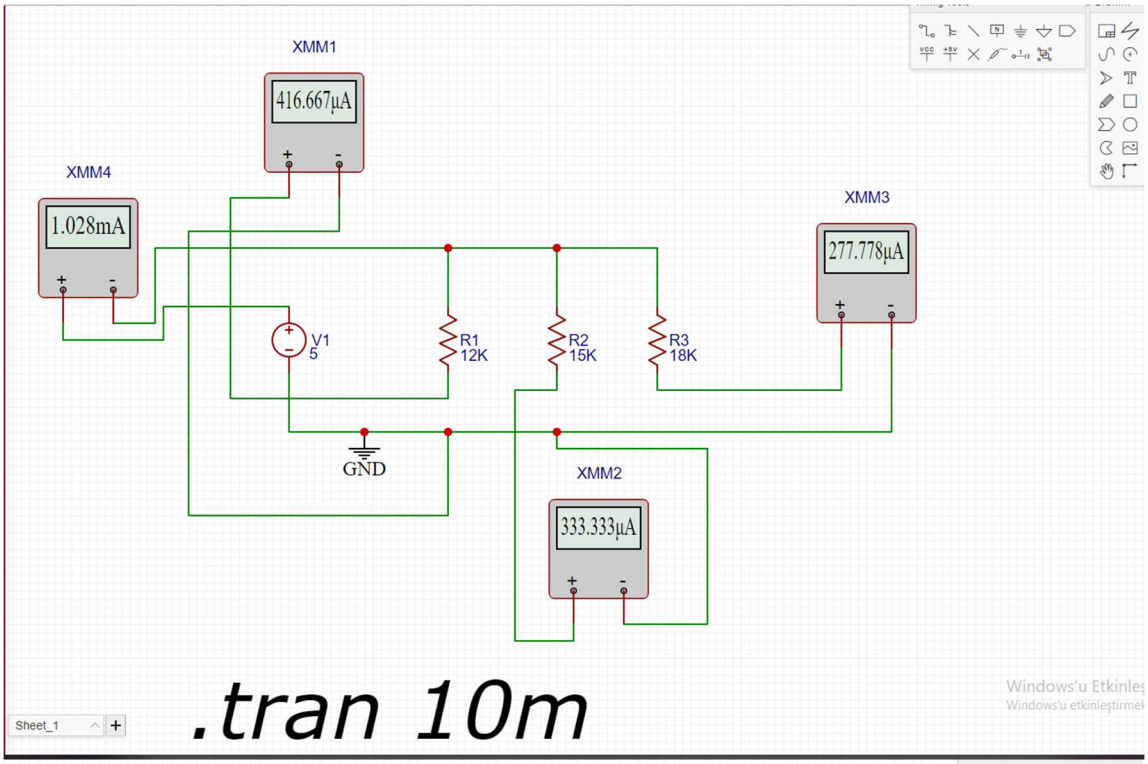
$I_{C1}[A]$	$I_{C2}[A]$	$I_{R1,2eqv}[A]$	$I_{R3}[A]$	$I_{R4}[A]$
		2.205mA	-503.381uA	2.709mA
Table 3				

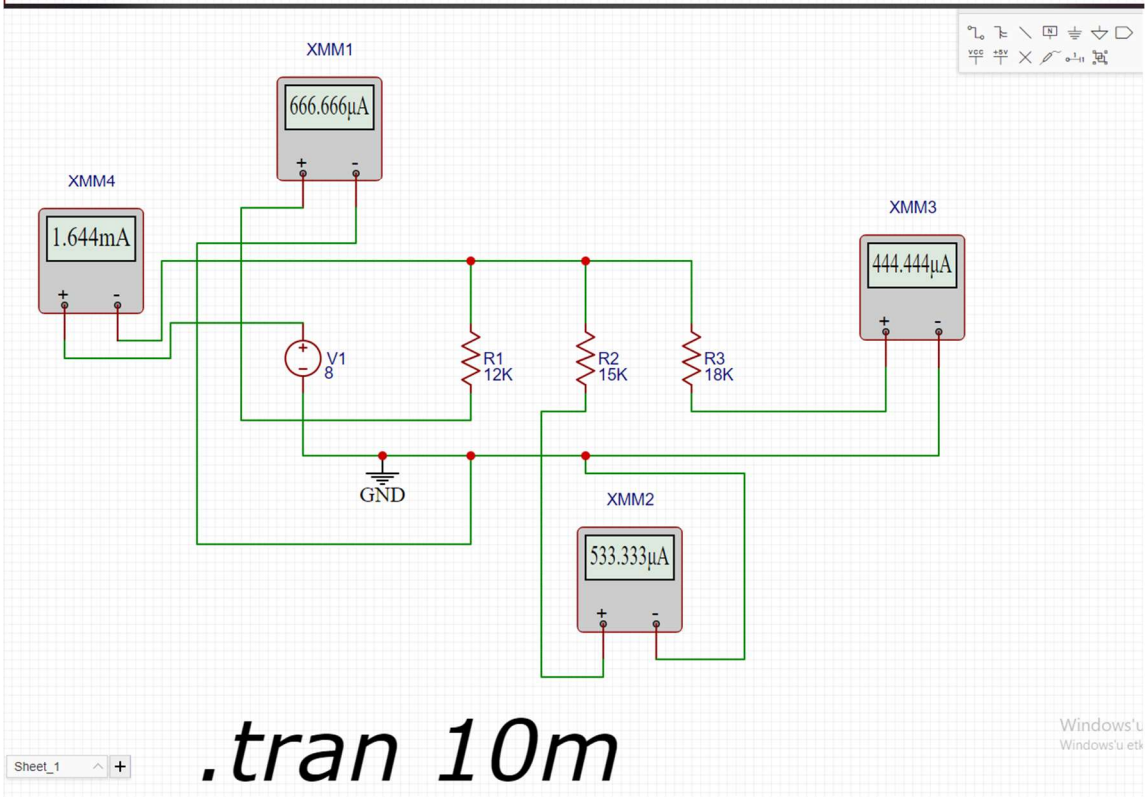
$I_{N1}[A]$	$I_{N2}[A]$	$I_{N3}[A]$	$I_{R1,2eqv}[A]$	$I_{R3}[A]$	$I_{R4}[A]$	$I_{R5}[A]$
5.258mA	-5.258mA	5.258mA	1.512mA	-30.385uA	5.289mA	3.747mA
Table 4						

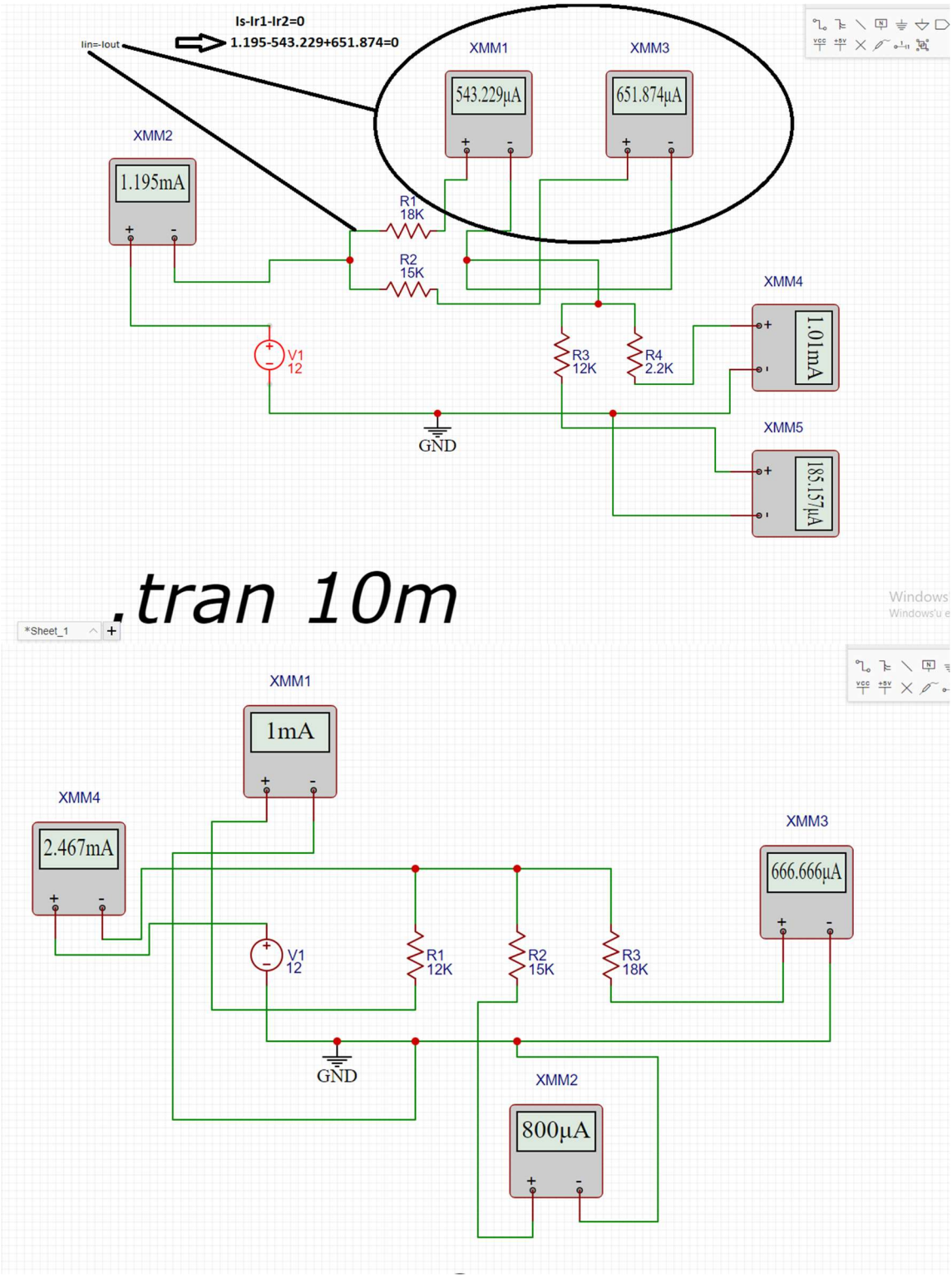
Node 1	İs=5.258mA
Node 2	İs-ir1-ir2=0 -> 5.258-1.512-3.747=0 Iin=-Iout Iout=-5.258mA
Node 3	Is=5.258mA
Node 4	İs-ir1-ir2=0 -> 5.258-5.289 +(-30.385)=0 Iin=-Iout Iout=-5.258mA
Table 5	

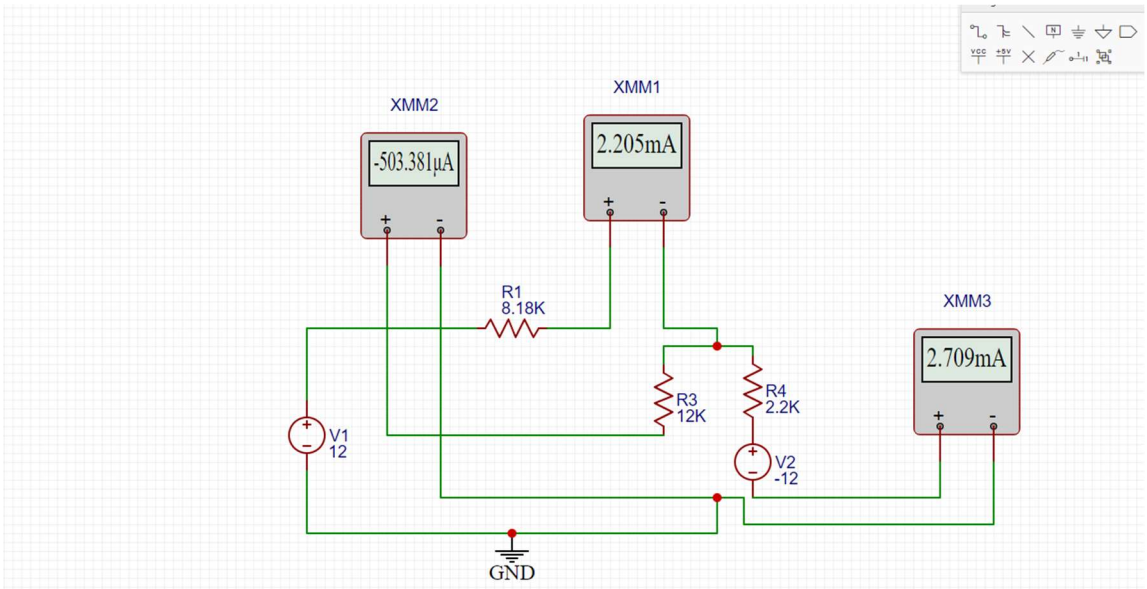
$V_{R1,2eqv}[V]$	$V_{R3}[V]$	$V_{R4}[V]$	$V_{R5}[V]$
12.365V	0.365V	0.365V	12.365V
Table 6			

Cycle 1	
Cycle 2	
Cycle 3	
Table 7	

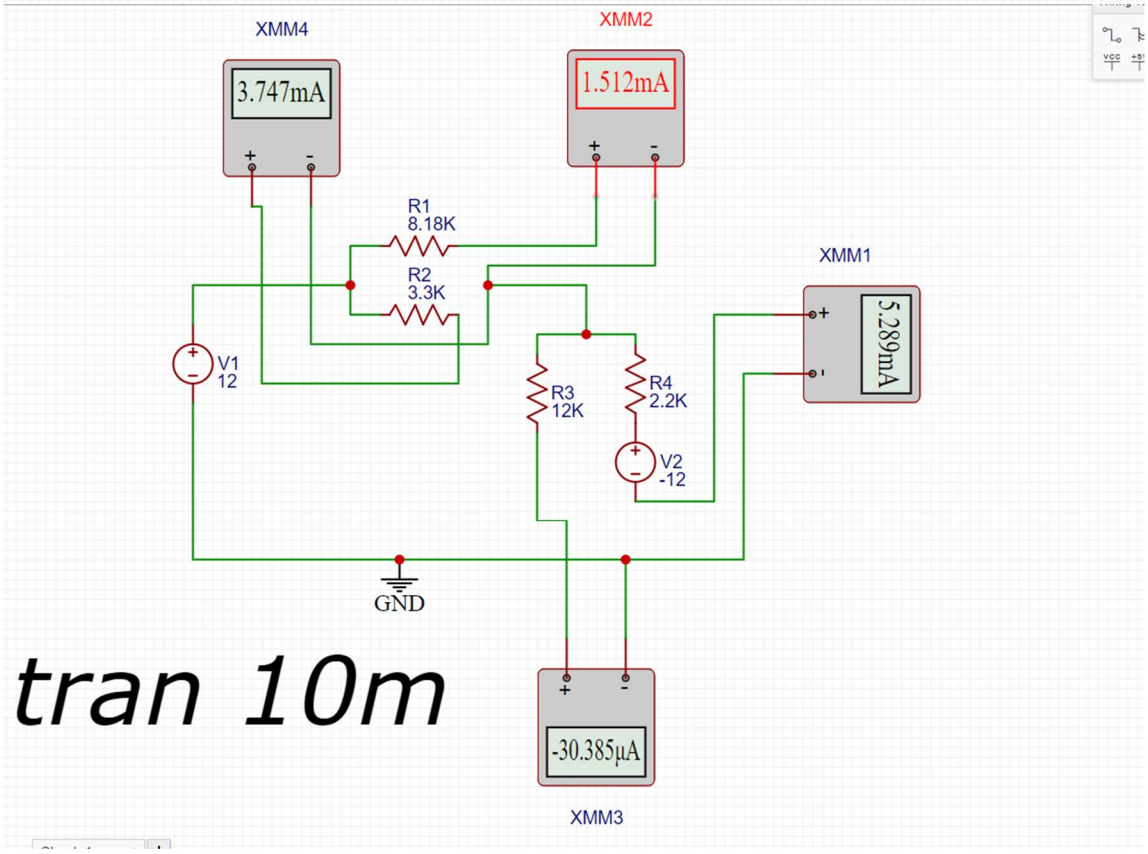

XMM1
416.667µA
XMM4
1.028mA
XMM3
277.778µA
V1
5
R1
12K
R2
15K
R3
18K
GND
XMM2
333.333µA
.tran 10m
Sheet_1


XMM1
666.666µA
XMM4
1.644mA
XMM3
444.444µA
V1
8
R1
12K
R2
15K
R3
18K
GND
XMM2
533.333µA
.tran 10m
Sheet_1

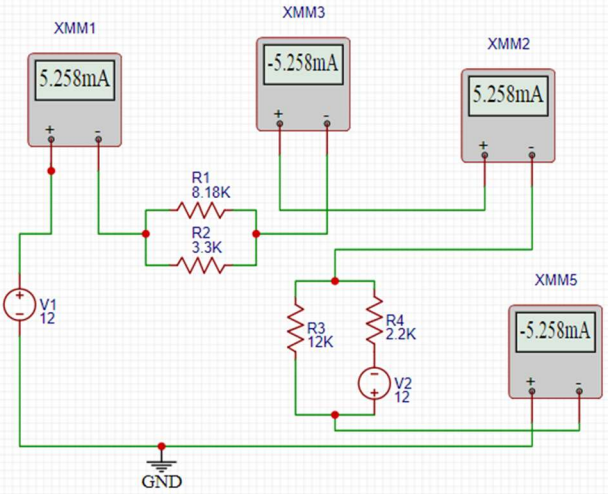

Is-Ir1-Ir2=0
1.195-543.229+651.874=0
Iin=-Iout
XMM1
543.229µA
XMM3
651.874µA
XMM2
1.195mA
R1
18K
R2
15K
XMM4
1.01mA
V1
12
R3
12K
R4
2.2K
GND
XMM5
185.157µA
.tran 10m
*Sheet_1
XMM1
1mA
XMM4
2.467mA
XMM3
666.666µA
V1
12
R1
12K
R2
15K
R3
18K
GND
XMM2
800µA



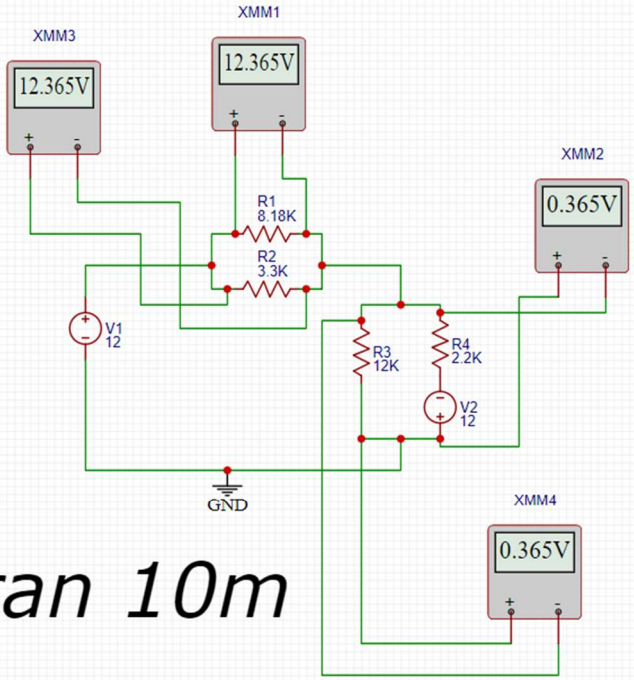
.tran 10m



tran 10m



.tran 10m



.tran 10m