Circuits and Electronic Laboratory

Experiment #3

Purpose of Experiment

Some of the important theorems of the circuit theory are superposition and multiplicativity. In this experiment, better understanding of these theorems is aimed.

General Information

Multiplicativity and superposition depend on linearity property of circuits. Another way of saying this is if superposition and multiplicativity are valid in a circuit then that circuit is linear.

Superposition Theorem: It helps us to analyze circuits that have mul- tiple sources. In short, it is to calculate the current and voltage for each source independently and then summing the results. There are several key points to consider when using this approach:

- All sources except for the source to be analyzed should be switched off. For voltage sources, this means setting the voltage $0V$ which is short circuit. For current sources, this means setting the current $0A$ which means open circuit.
- Sources that are depend other circuit members should be leaved as they are.

Steps to apply superposition theorem:

1. All sources should be switched off at first, then select a source and activate it. Calculate all node voltages and cycle currents.
2. Repeat the first step for the rest of the sources.
3. Find the results by summing all results for a node current or a cycle voltage.

Multiplicativity Theorem: This is made of just linear elements like resistors, if amplitudes of all sources increased α times then amplitudes of current and voltage outputs of the circuit increases α times.

Tip: The formula $V = IR$ states that if R goes to 0, then the current goes to infinity. Another way of saying this is, current increases as resistance decreases. Most conductors have nearly 0 internal resistance. Due to this fact connecting a wire parallel to a circuit element makes the element **short circuit**ed. **Open circuit** is where R goes to infinity I goes to 0. If two nodes has no connection than it means they have infinity resistance between them. There will be no current flowing.

Preparations Before Experiment

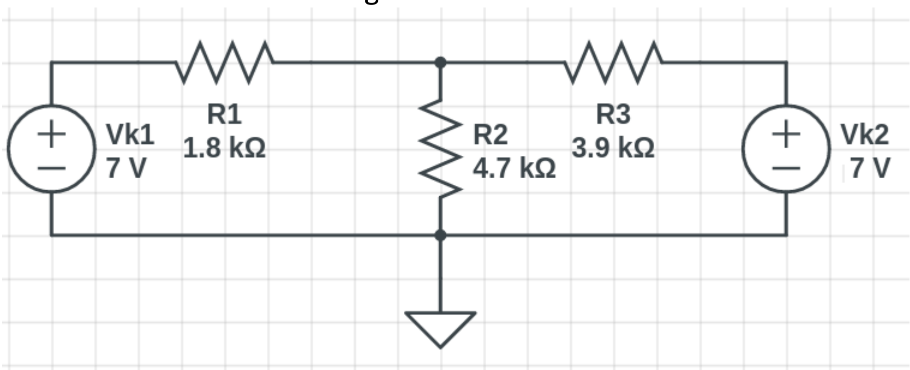
- What are open and short circuit and how to implement them on circuits?
- Why ammeters connected serial to the circuit? What happens when we connect them in parallel?
- What are superposition and multiplicativity theorems?
- Make V_{K2} source short circuit in the circuit depicted in Figure 1. Calculate I_{R2} for V_{K1} values given in Table 1. Fill the Table 1. Check if results holds for multiplicativity theorem.
- Analyze and calculate currents in the circuit depicted in Figure 1 with the superposition aspect. Fill the Table 2. Check if results holds for superposition theorem.
- Simulate all circuits given in this document by considering each demand in the tables. (You should have results for each entry in the tables.)
- Fill *calculated* sections in all tables. Bring results with you.

The preparation section has great value since you will compare your measurements with simulations you made.

Section 1

1. Construct the circuit depicted in Figure 1 on the board. Make V_{K2} source short circuit ($0V$). With the help of a multimeter set V_{K1} source voltage according to Table 1. Measure I_{R2} currents. Fill the Table 1. Show multiplicativity theorem holds.

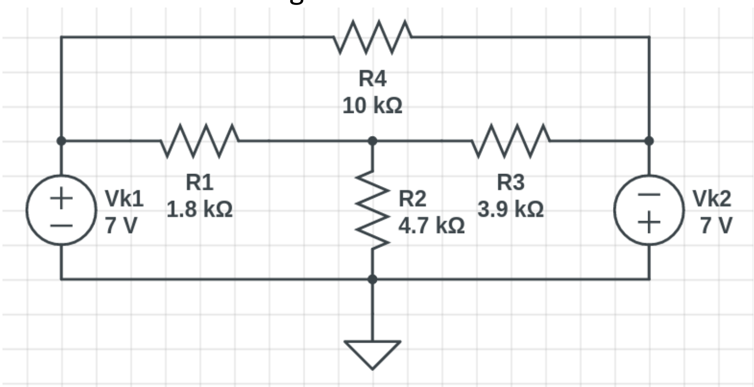
Figure 1: Circuit 1



2. Construct the circuit depicted in Figure 1 on the board. Measure I_{R2} current while both voltage source active. Then measure I_{R2} current while making voltage sources short circuit one by one. Show superpo- sition theorem holds. Fill the Table 2.

Multiplicativity Theorem			
$V_{K1}[V]$ Source Voltage	$I_{R2}[mA]$ Calculated	$I_{R2}[mA]$ Measured	Relative Error [%]
1	0,11535mA	0,11535mA	-
2	0,230701mA	0,230701mA	-
4	0,461402mA	0,461402mA	-
Table 1			

Figure 2: Circuit 2



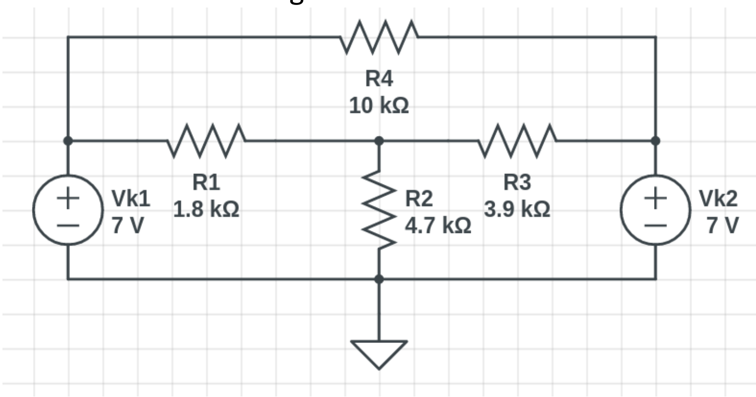
Superposition Theorem				
$V_{K1}[V]$ Source Voltage	$V_{K2}[V]$ Source	$I_{R2}[mA]$ Calculated	$I_{R2}[mA]$ Measured	Relative Error [%]
7	0	I'_{R2} =0,807453mA	=0,807453mA	
0	-7	I''_{R2} =-0.372671mA	=-0.372671mA	
$I'_{R2} + I''_{R2}$ =		0,807453mA+(-0.372671mA)= 0,434782mA		
7	-7	I_{R2} =0.434783mA	I_{R2}=0.434783 mA	
Table 2				

Section 2

- Construct the circuit depicted in Figure 2 on the board. Measure I_{R2} and I_{R4} currents while both voltage source active. Then, measure I_{R2} and I_{R4} currents while short circuiting voltage sources one by one. Show superposition theorem holds. Fill the Table 3.

- Construct the circuit depicted in Figure 3 on the board. First, calcu- late, then measure I_{R4} current while both voltage source active. Then, measure I_{R4} current while short circuiting voltage sources one by one. Show superposition theorem holds. Fill the Table 4.

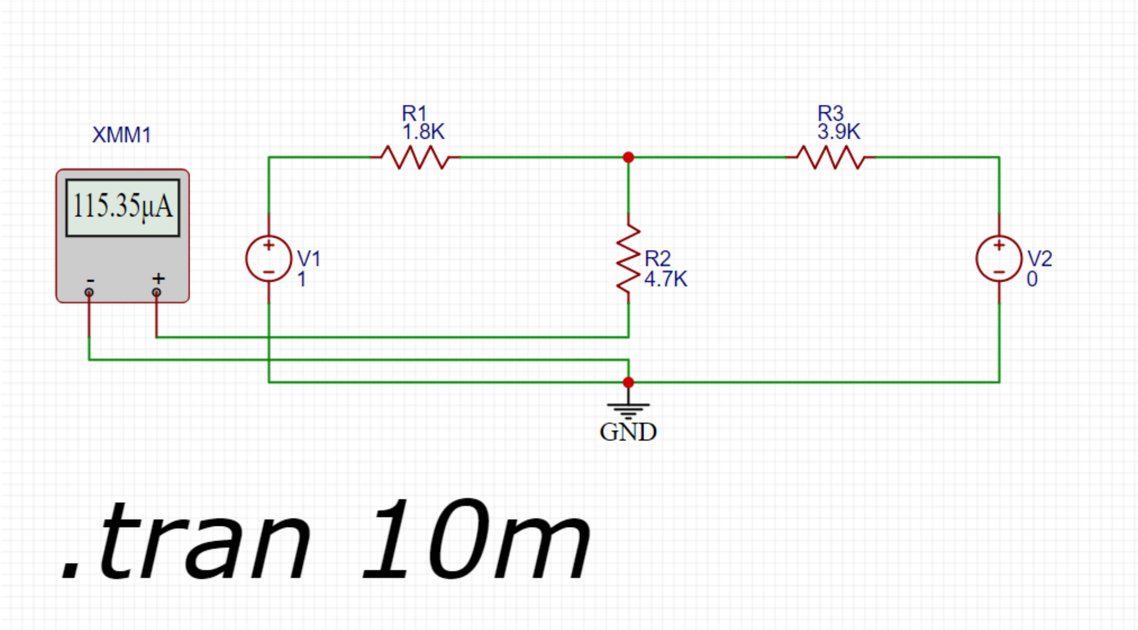
Figure 3: Circuit 3

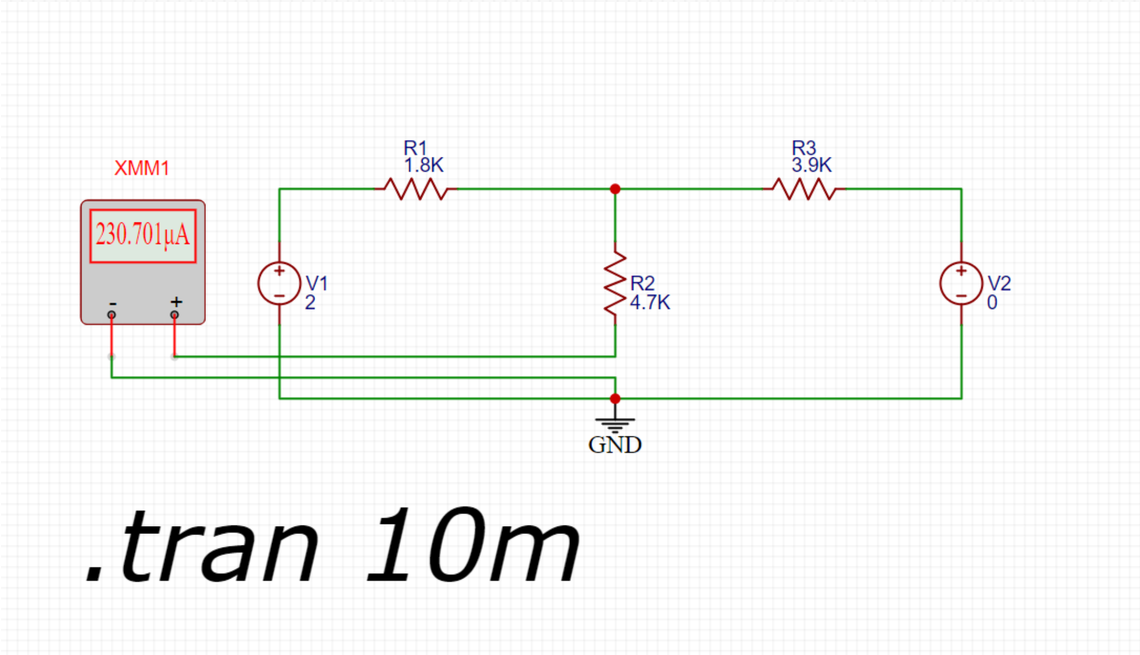


$V_{K1}[V]$ Source Voltage	$V_{K2}[V]$ Source Voltage	$I_{R2}[mA]$ Measured	$I_{R4}[mA]$ Measured	Relative Error [%]
7	0	I'_{R2} =0.807453mA	I'_{R4} =0.700000mA	
0	-7	I''_{R2} =0.372671mA	I''_{R4} =-0.700000mA	
$I'_{R2} + I''_{R2}$ =		1.18mA		
$I'_{R4} + I''_{R4}$ =		0A		
7	-7	I_{R2} =1.18mA	I_{R4} =0A	
Table 3				

$V_{K1}[V]$ Source Voltage	$V_{K2}[V]$ Source Voltage	$I_{R4}[mA]$ Calculated	$I_{R4}[mA]$ Measured	Relative Error [%]
7	0	I'_{R4} =0.700000mA	I'_{R4} =0.700000mA	
0	7	I''_{R4} =-0.700000	I''_{R4} =-0.700000	
7	7	I_{R4} =0A	I_{R4} =0A	
Table 4				

TABLE 1


XMM1
115.35µA
R1
1.8K
R3
3.9K
V1
1
R2
4.7K
V2
0
GND
.tran 10m


XMM1
230.701µA
R1
1.8K
R3
3.9K
V1
2
R2
4.7K
V2
0
GND
.tran 10m

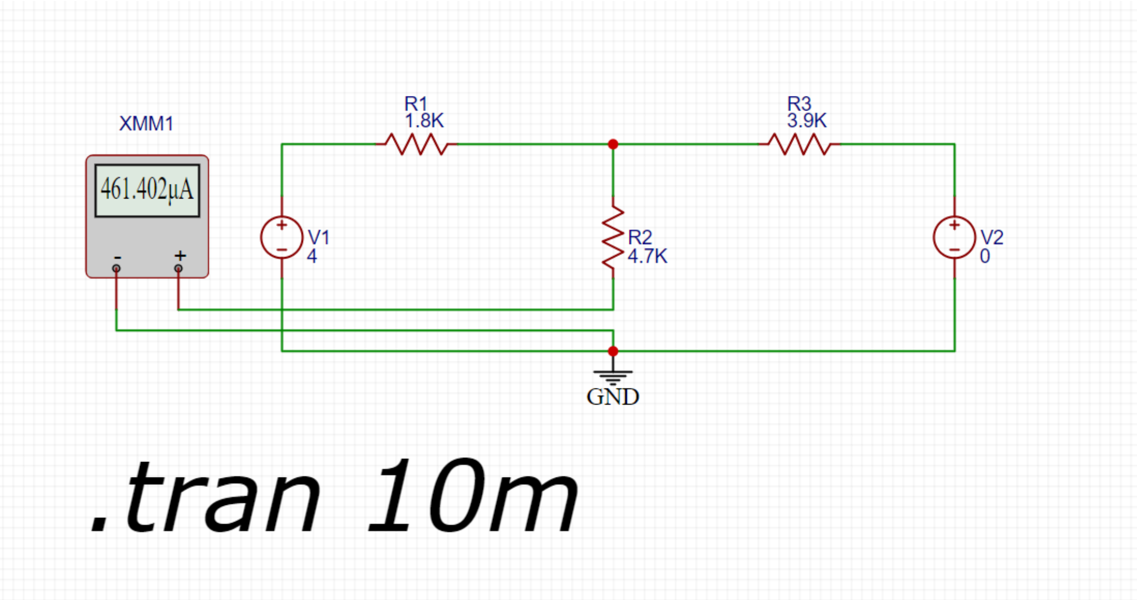
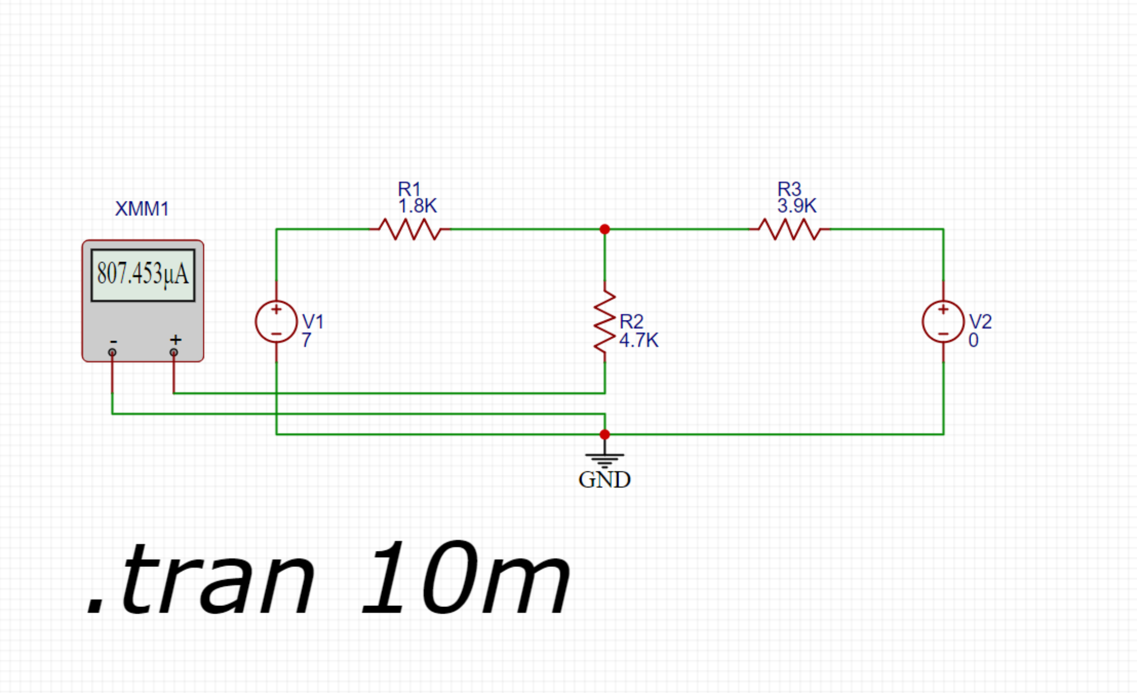
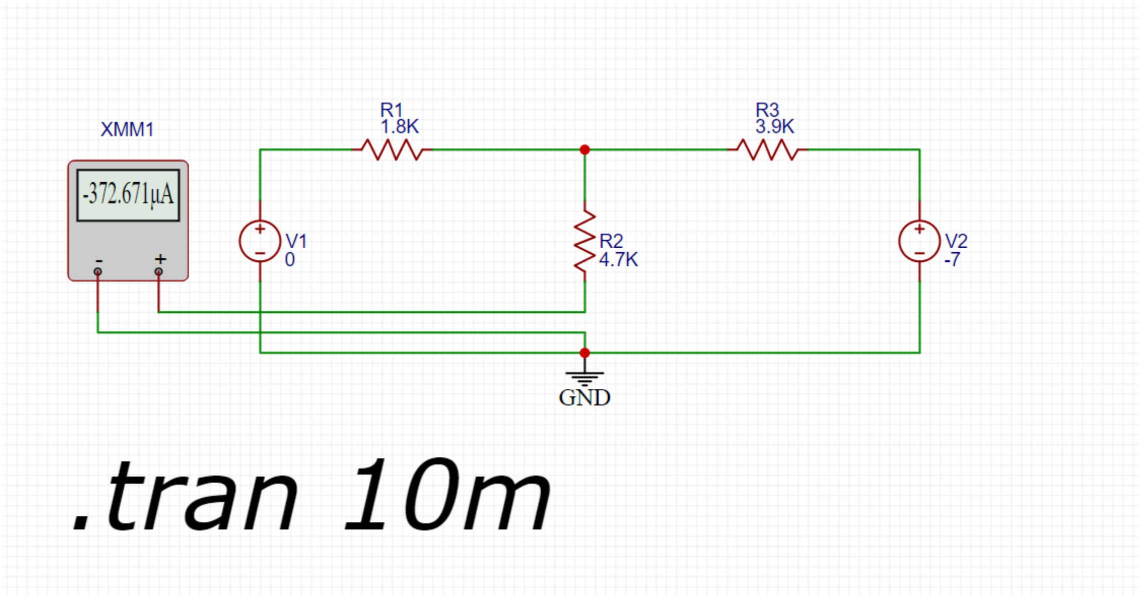

XMM1
461.402µA
R1
1.8K
R3
3.9K
V1
4
R2
4.7K
V2
0
GND
.tran 10m

TABLE2


XMM1
807.453µA
R1
1.8K
R3
3.9K
V1
7
R2
4.7K
V2
0
GND
.tran 10m


XMM1
-372.671µA
R1
1.8K
R3
3.9K
V1
0
R2
4.7K
V2
-7
GND
.tran 10m

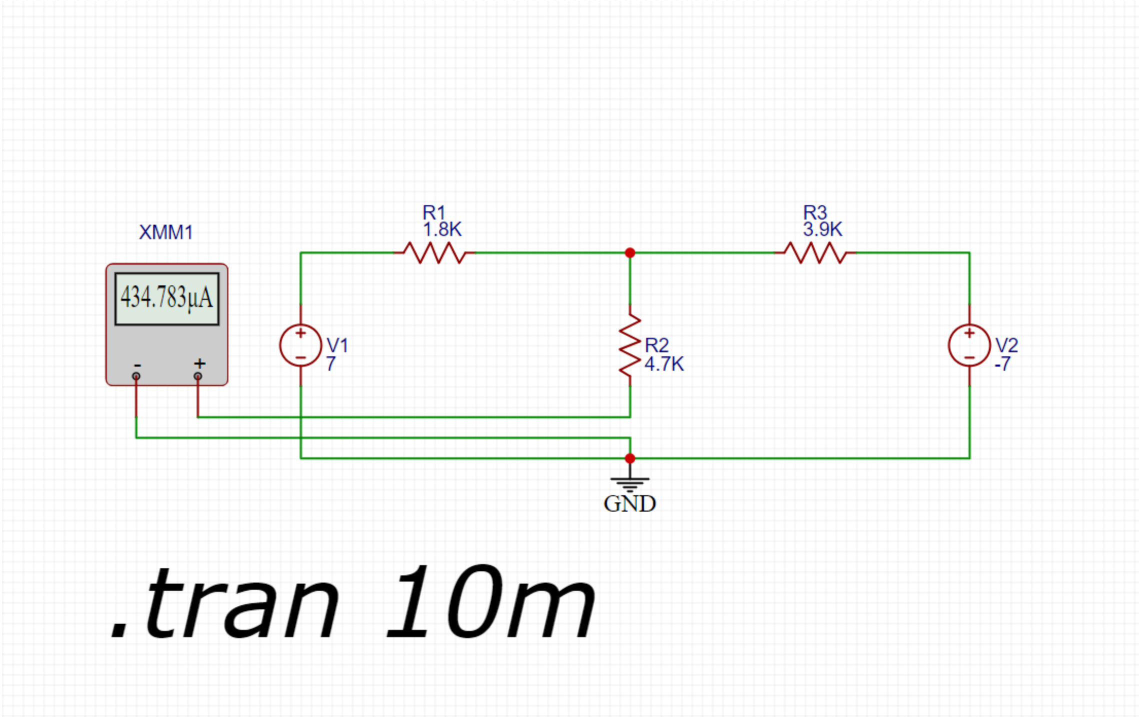
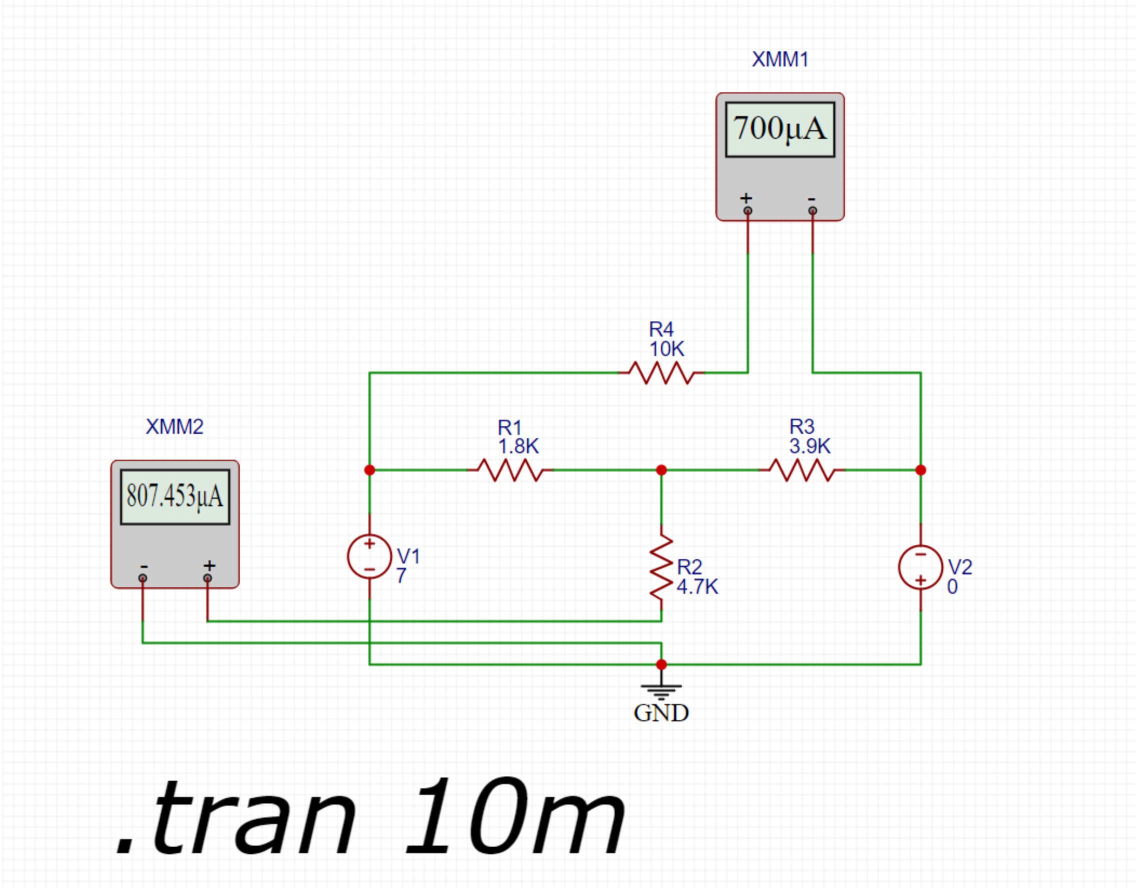
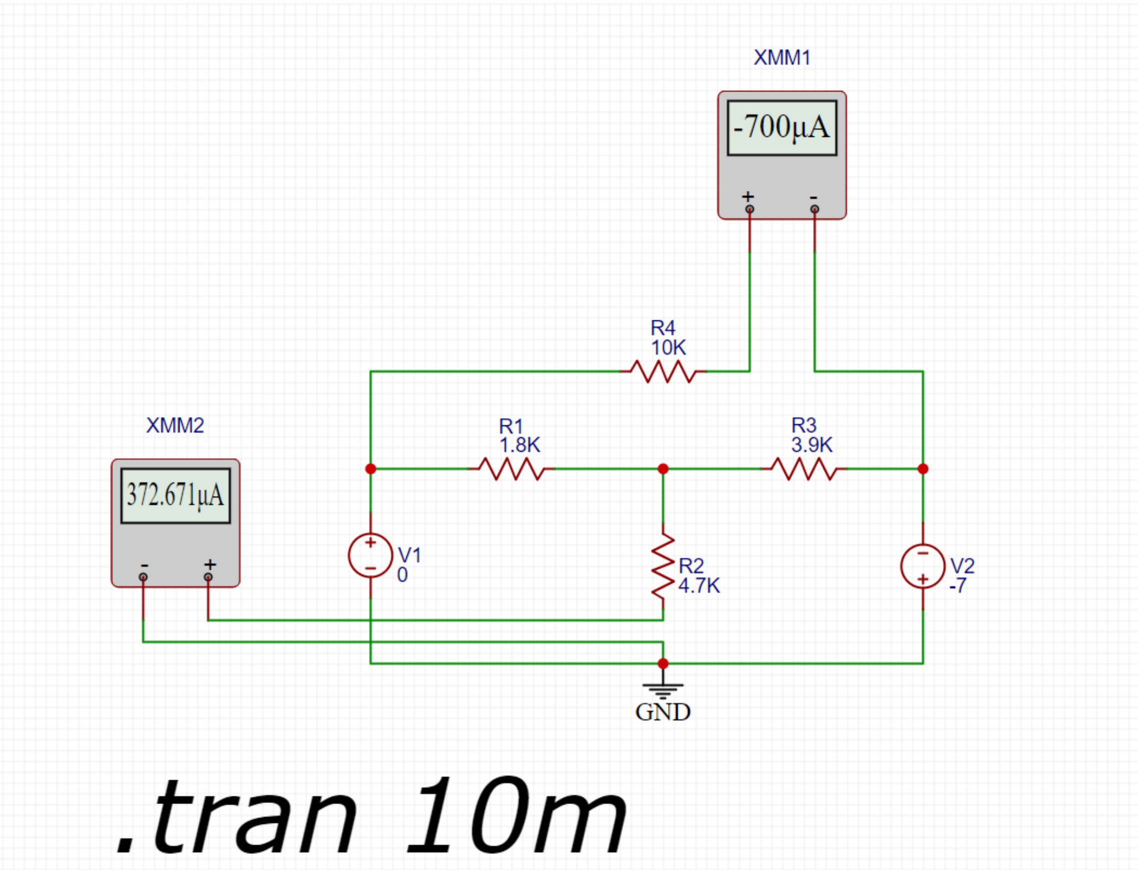

XMM1
434.783µA
R1
1.8K
R3
3.9K
V1
7
R2
4.7K
V2
-7
GND
.tran 10m

TABLE 3


XMM1
700µA
+
-
R4
10K
XMM2
807.453µA
-
+
R1
1.8K
R3
3.9K
V1
7
R2
4.7K
V2
0
GND
.tran 10m


XMM1
-700µA
R4
10K
R1
1.8K
R3
3.9K
XMM2
372.671µA
V1
0
R2
4.7K
V2
-7
GND
.tran 10m

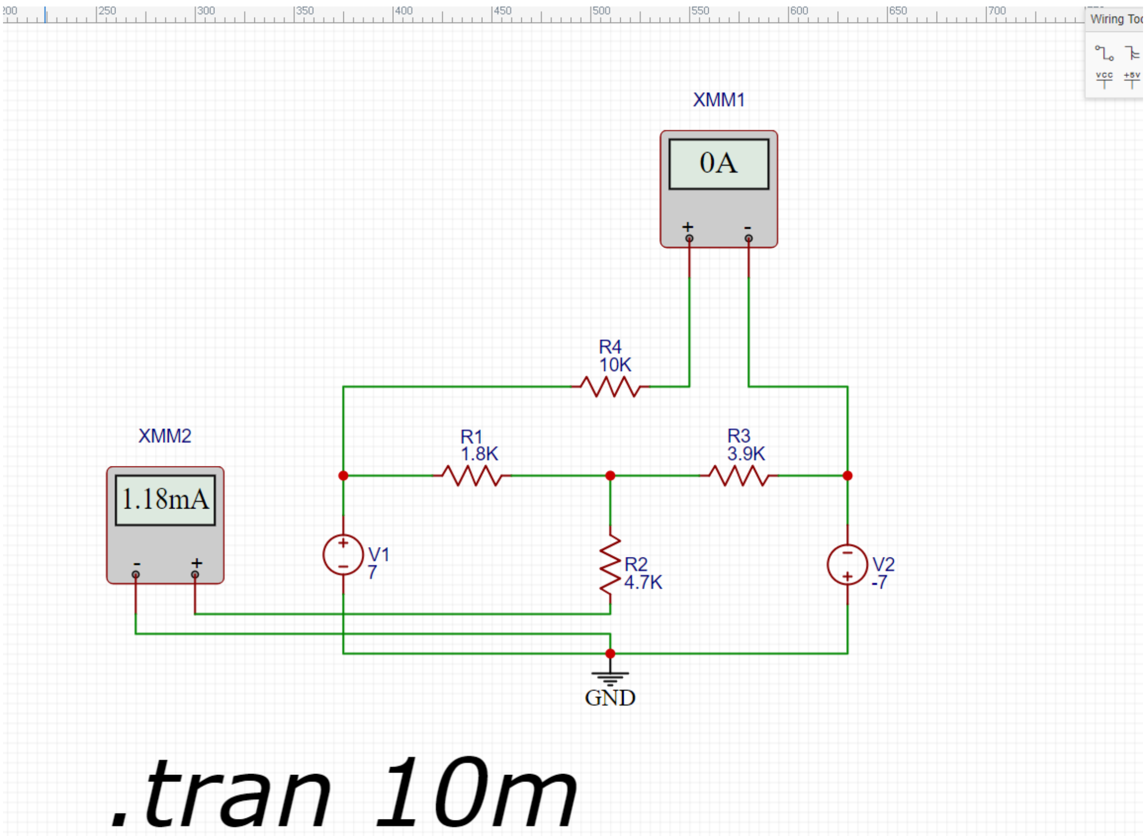
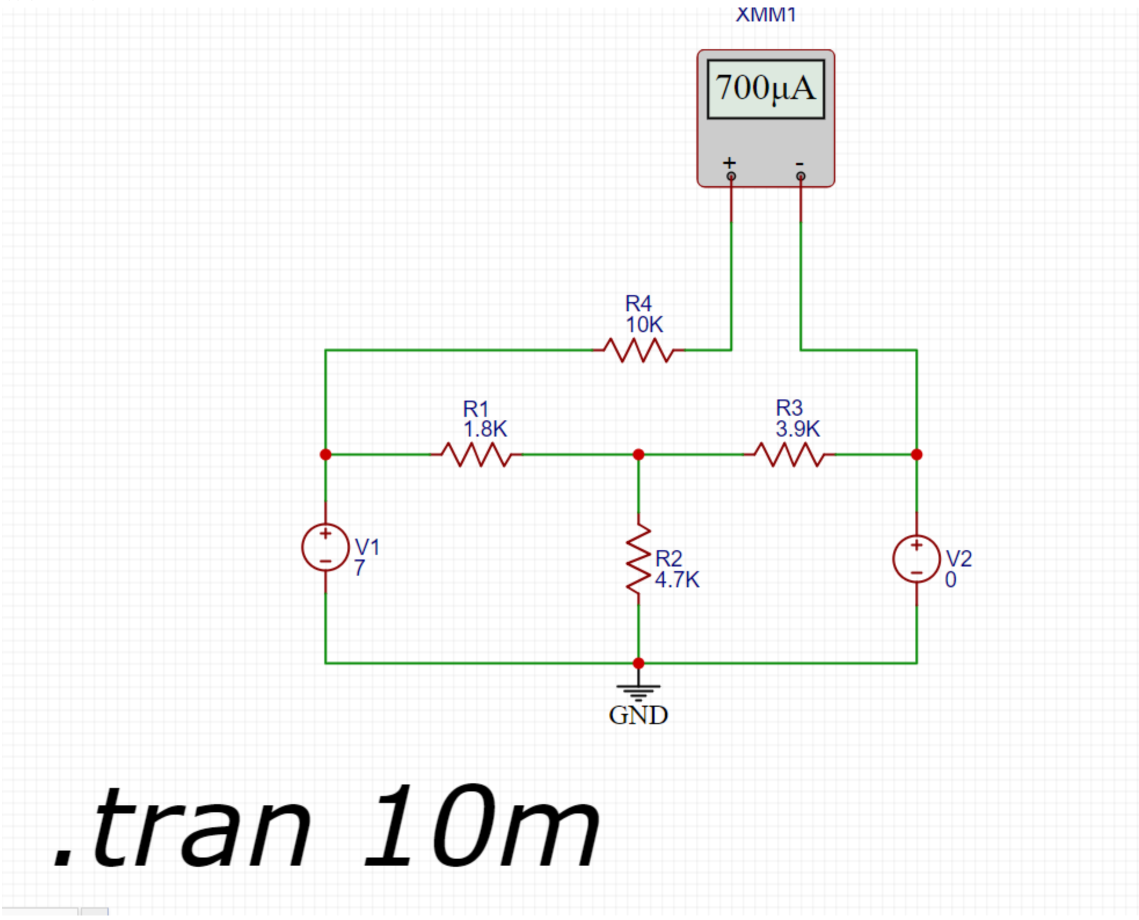
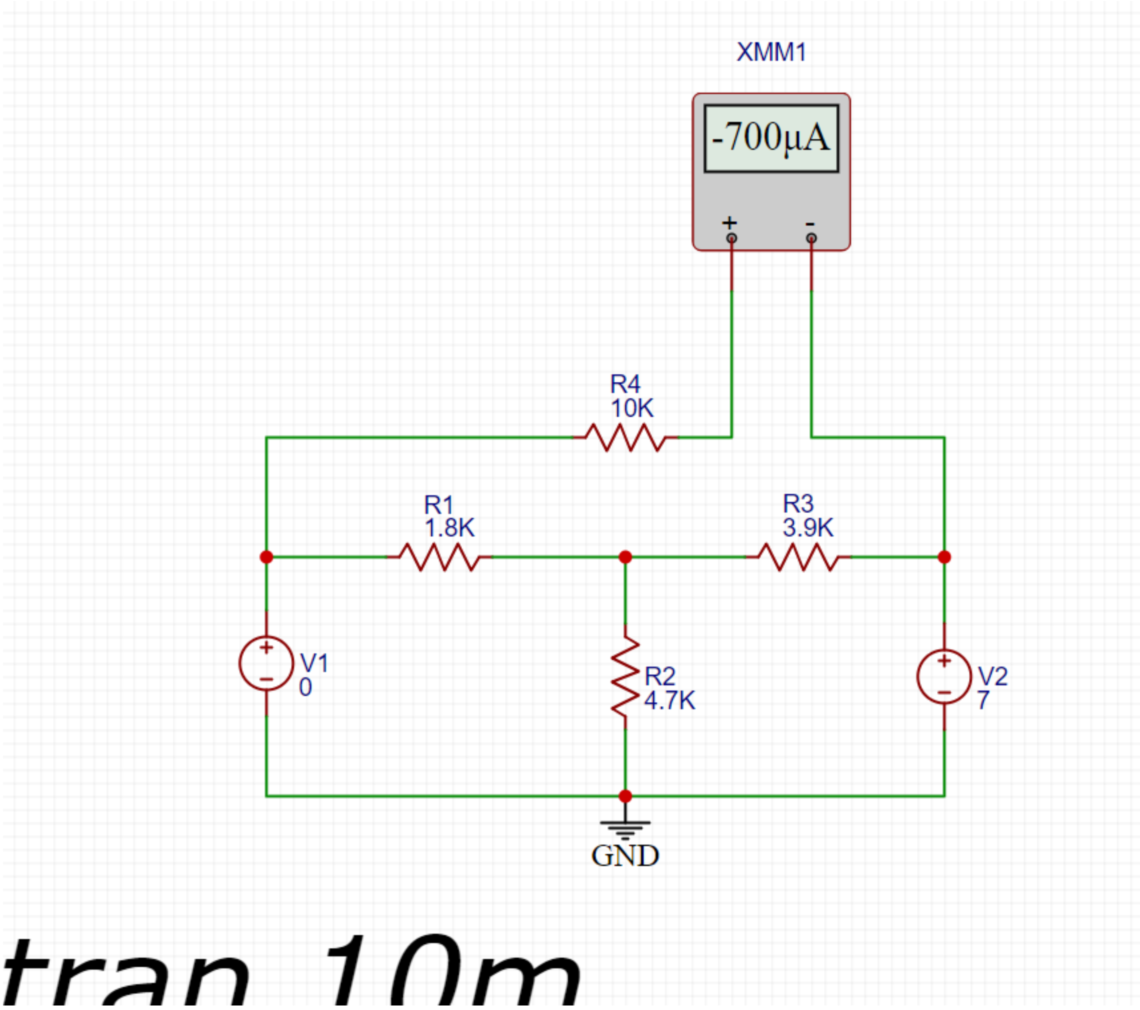
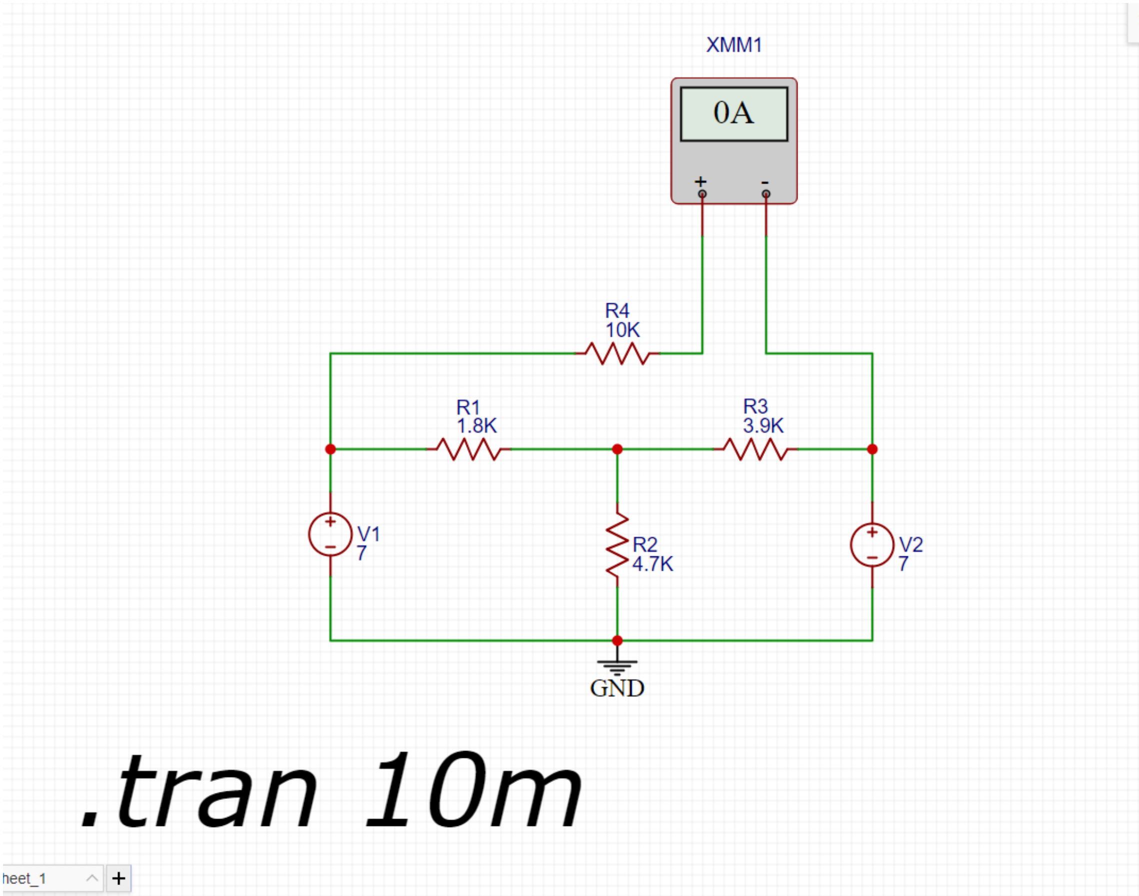

Wiring Too
XMM1
0A
R4
10K
R1
1.8K
R3
3.9K
XMM2
1.18mA
V1
7
R2
4.7K
V2
-7
GND
.tran 10m

TABLE 4




XMM1
-700µA
+
-
R4
10K
R1
1.8K
R3
3.9K
V1
0
R2
4.7K
V2
7
GND
tran 10m


XMM1
0A
R4
10K
R1
1.8K
R3
3.9K
V1
7
R2
4.7K
V2
7
GND
.tran 10m
heet_1