Objectives

1. Verify the nodal analysis for the given circuit.
2. Verify the mesh analysis for the given circuit.
3. Verify the superposition theorem for the given circuit.
4. Verify Thevenin's & Norton's theorems for the given circuit.
5. Verify Maximum power transfer theorem for the given circuit.

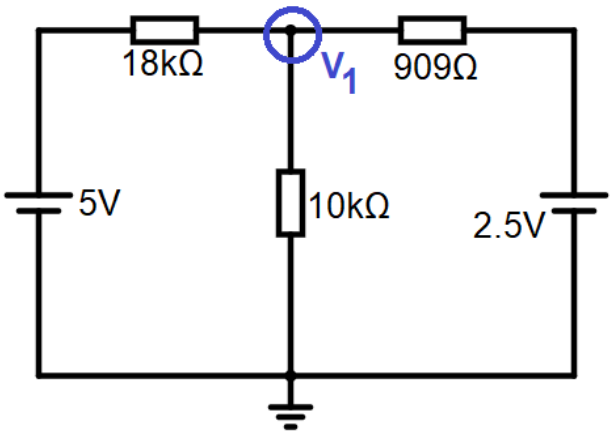
Preparation work

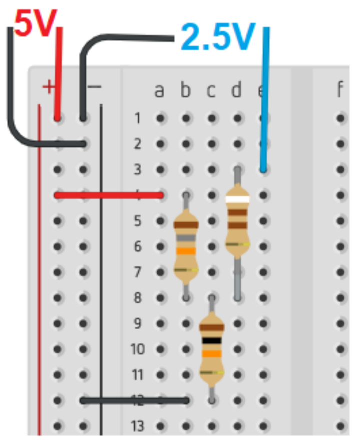
1. Manually calculated the following values:
   1.1. voltage V_1 as indicated in part 1,
   1.2. currents I_1 and I_2 as indicated in part 2,
   1.3. currents I', I'' and their sum (I_R) as indicated in part 3,
   1.4. resistance R_{Th}, voltage V_{Th} and current I_N as indicated in part 4,
   1.5. resistance of variable resistor so it would receive the maximum power in part 5.
2. Use LTspice to simulate the values mentioned above.

Part 1. Verify the nodal analysis for the given circuit

Nodal voltage analysis finds the unknown voltage drops around a circuit between different nodes that provide a common connection for two or more circuit components.

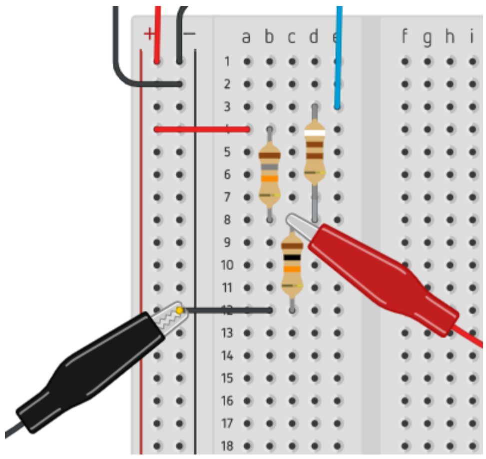
Make the connections as shown in the circuit diagram.





Measure voltage at point V1. To do it, connect one probe to the point V1 and another one to the ground wire. Other ends of the probes connect to a multimeter and select function to measure voltage in DC network. Record your answers to the table below.

Disconnect probes, but keep the circuit.



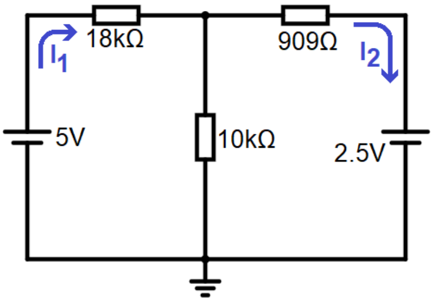
	Voltage V_1
Calculation	
Simulation	
Measurement	

Preparation work

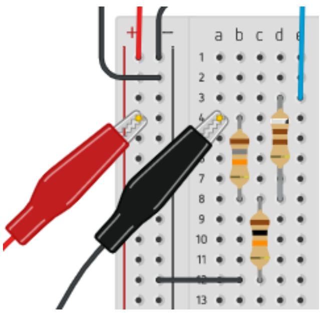
Preparation work

Part 2. Verify the mesh analysis for the given circuit

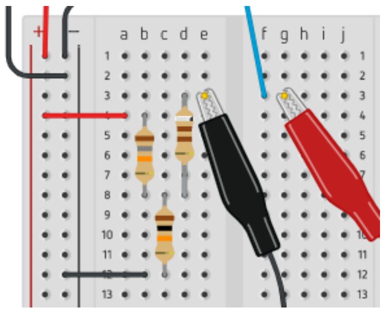
Mesh current analysis is a technique used to find the currents circulating around a loop or mesh within any closed path of a circuit.



Circuit



Measurement of I_1



Measurement of I_2

Measure current that flows through resistor 18kΩ and a current that flows through resistor 909Ω. Remember that you need to disconnect the circuit to connect an ammeter. Record your answers to the table. Disconnect probes, but keep the circuit.

	Current I_1	Current I_2
Calculation		
Simulation		
Measurement		

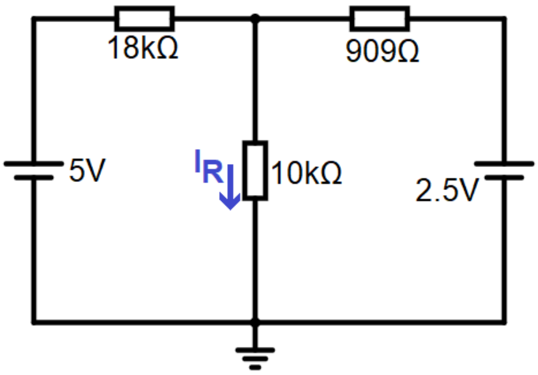
Preparation work

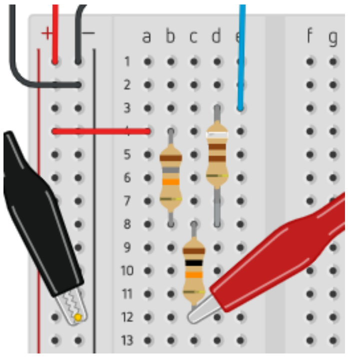
Preparation work

Part 3. Verify the superposition theorem for the given circuit

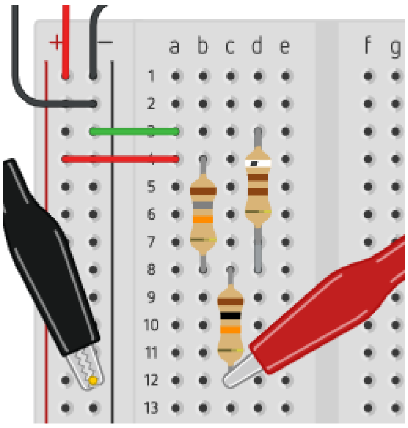
Superposition theorem states that in any linear, active, bilateral network having more than one source, the response across any element is the sum of the responses obtained from each source considered separately and all other sources are replaced by their internal resistance.

Measure current I_R over resistor 10kΩ directly. Record your answer to the table below.

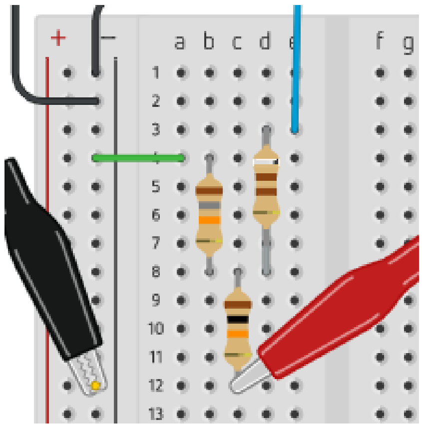




Replace source of 5v with a short circuit, and measure current I' over resistor 10kΩ. Pay attention to polarity. Record your answer to the table below. Return 5v voltage source and replace the source of 2.5v with a short circuit, and measure current I'' over resistor 10kΩ. Pay attention to polarity. Record your answer to the table below.



Measurement of I'



Measurement of I''

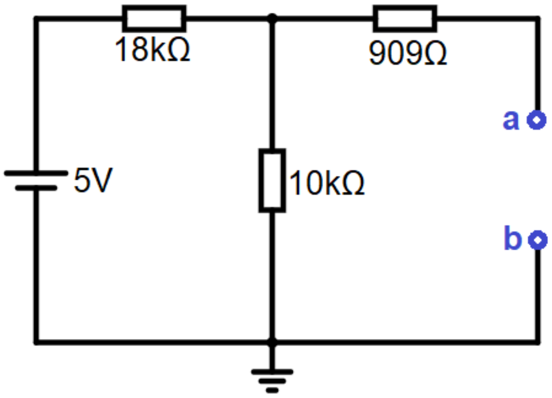
		Current I_R	Current I'	Current I''
Preparation work	**Calculation**			
Preparation work	**Simulation**			
	Measurement			

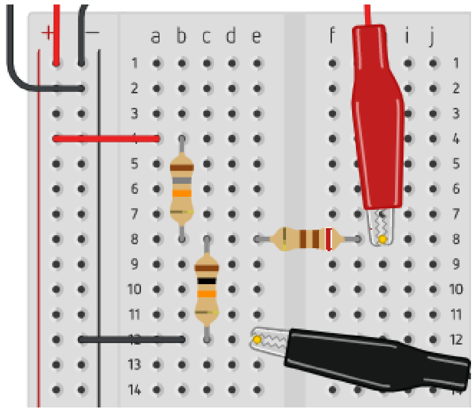
Is a sum of currents I' and I'' the same with I_R?

Part 4. Verify the Thevenin's & Norton's theorem for the given circuit

Any linear bilateral, active two terminal network can be replaced by an equivalent voltage source (V_{Th}) in series with resistance R_{Th}. Any linear, bilateral, active two terminal network can be replaced by an equivalent current source (I_N) in parallel with Norton's resistance (R_N).

Remove the 2.5V voltage source and measure the voltage of the open circuit (between points a and b) using multimeter (V_{Th}). Record your answer to the table below.





Next measure I_N. To do so, we need to short circuit the terminals and add an ammeter. But does the multimeter already shortening the circuit? Measure current that flows from a to b and record your answer to the table below.

To find Thevenin's resistance (or Norton's resistance), remove the voltage source and short circuit it and find the R_{Th} between points a and b using multimeter. Record your answer to the table below.

		Thevenin's voltage source V_{Th}	Norton's current source I_N	Thevenin's resistance R_{Th}=I_N
Preparation work	**Calculation**			
Preparation work	**Simulation**			
	Measurement			

Add any resistor with a value less than 1kΩ and add it to the circuit between points a and b. Measure its voltage and current. Record the values below.

R=________________ **V_R**=________________ **I_R**=____________________

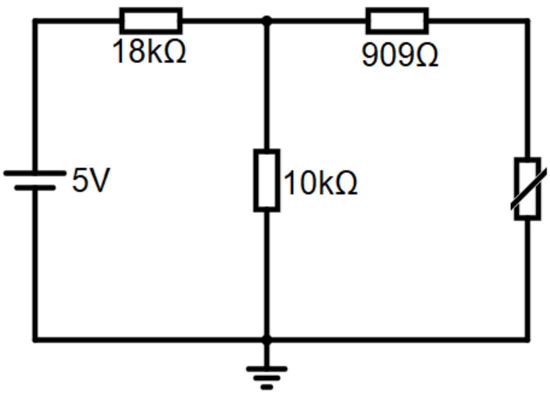
Build a new circuit (but do not disassemble the original circuit) with Thevenin's voltage source, a resistor that is equal to Thevenin's resistance (round the value or use several resistors in series to get the right value) and your chosen resistor. Measure its voltage and current. Record the values below. Disassemble the new circuit.

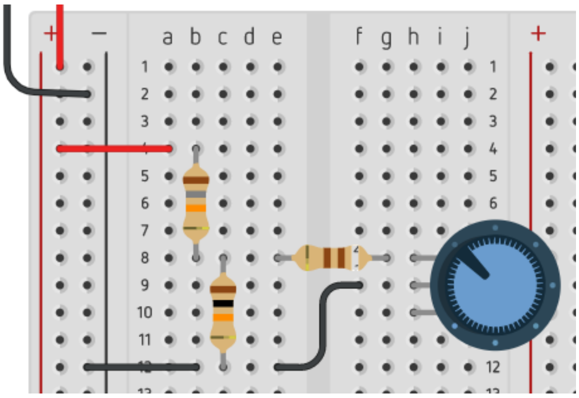
R=________________ **V_R**=________________ **I_R**=____________________

Part 5. Verify maximum power transfer theorem for the given circuit

In a linear, bilateral circuit the maximum power will be transferred to the load when load resistance is equal to source resistance.

A potentiometer is a three-terminal resistor with a rotating contact. If only two terminals are used, one end and the middle terminal, it acts as a variable resistor. Add a potentiometer between points a and b. Turn the potentiometer's knob to maximum clockwise or counterclockwise.





Use a multimeter to measure current. Take an additional multimeter and measure voltage at the same time. Record it as N1. Slightly rotate the potentiometer's knob. Record new values as N2. Do 10 measurements in total. Record your answers to the table below. Rotate the potentiometer's knob in such way that voltage is equal to $0.5V_{Th}$. Record measured voltage and current as N11.

	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11
I											
V											

Use Ohm's law to find resistance and calculate power for each set of measurements.

R											
P											

Plot power's relationship to resistance.

What is the value of the potentiometer, at which P is maximum?

Preparation work

Calculated value_________________________

Preparation work

Simulated value_________________________

Measured value_________________________

Power's relationship to resistance