Nutthawat Panyangnoi Student ID: G08285564

EGR 24L Introduction of Circuit Analysis Laboratory

Professor Yu Zheng

Oct 25,2023

Lab 5: Thevenin equivalent circuit

Introduction:

In this lab, we had learned how to apply the Thevenin theorem to a real-world circuit. Thevenin theorem states that any linear circuit that consisting of multiple voltage sources and resistors into an Thevenin equivalent circuit with a just one voltage source and one resistor connected in series with a load. Thevenin help us understand and analysis the power circuit by provide simplest way to determine voltage, current flow circuit. We also learned about the Thevenin Voltage (Vth) and the Thevenin Resistance (Rth); Thevenin Voltage (Vth) is the voltage that measured across the two terminals of interest in the original circuit. When all voltage sources within the circuit are turn off and replaced by their internal resistances, the circuit is simplified to open-circuit voltage across the terminals. The Thevenin Resistance (Rth) is the equivalent resistance looking into the two terminals of interest when all the voltage sources within the circuit are replaced with short circuits (zero volts). It represents the equivalent resistance that the load, when connected to the terminals of interest.

By performing this experiment, we aimed to verify the theorem's validity and to understand its practical implications in circuit analysis. We begin the experiment by draw a circuit on LT spice, determined the Vth, Rth then, we constructed a circuit containing several components, including resistors and a voltage source. We applied various load resistors and measured the voltage across and the current through these load resistors. Using the collected data, we determined the equivalent Thevenin voltage and Thevenin resistance of the circuit.

Procedure:

1. In the first part of lab, we draw a circuit on LT spice which have all parallel resistors and two voltage sources, measured the load current values and record values. After that we construct a real physical circuit then do the same thing. Then we compare both load current values.
2. Next, we need to find Thevenin Voltage (Vth) by doing open circuit replace all Rload and turn off a voltage source. In this part we also need to find Vth in LTspice, record the value. Then do the same thing on physical circuit. After that we compare both values.

3. Next, we need to find Thevenin Resistance (Rth) by doing open circuit replace all Rload and turn off a voltage source. Connect a test voltage source to the two-load terminal port, apply test voltage to circuit then find current flow out from test voltage source. Rth = Vtest / I test. Then we record the values from experiment compare it to Lt spice.

4. Alternative way to find Thevenin Resistance (Rth), remove all R load, and measure open circuit voltage between two load terminals. Apply zero (voltage short circuit) to source between two load terminals then determine Rth by Rth = Voc / I sc. Then we record the values from experiment compare it to Lt spice.

5. Next, for lab part 2 we measure I load and record the values by doing Vth and Rth that we have from first part of lab. Compare I load from previous part of lab to this part of lab then verify the. Do the same thing on LTspice and physical circuit and compare both values.

6. Lastly, Part 3 we apply power transfer principle by use LT spice simulation the various load resistance value and measure the load power and record the values.

Conclusion:

Our experimental results showed that Thevenin's Theorem holds true for the circuit we examined. The Thevenin equivalent voltage accurately predicted the voltage across the load resistor, and the Thevenin equivalent resistance correctly represented the circuit's behavior with the load resistor removed. These findings align with the fundamental principles of Thevenin's Theorem, which make it a valuable tool in circuit analysis. However, there were some discrepancies, we observed between the theoretical values obtained from our calculations and the experimental results. These discrepancies may be attributed to factors such as imperfect components, measurement inaccuracies, and stray resistances within the circuit. Such discrepancies serve as a reminder that practical circuits may not always perfectly conform to the idealized models presented in theory.

This lab has provided valuable hands-on experience in working with Thevenin's Theorem and has illustrated the importance of bridging theoretical knowledge with practical experimentation in the field of electrical engineering. While there were some discrepancies between theory and practice, the overall success of this experiment reinforces the reliability and utility of Thevenin's Theorem in the world of circuit analysis.

Appendixes:

Data tables

Part 1:

sign error

Load current:

	Load current I_load (mA); from Va to ground
Measured	2.884
Theoretical	3.108

Thevenin open-circuit voltage Vth = Voc

	Thevenin voltage Vth = Voc = Va; unit is V
Measured	18
Theoretical	18.742

Thevenin resistance Method-1

	Vtest (V)	Itest (mA) out of test source into node Va	Rth (kΩ) = Vtest / Itest
Measured	10	6.947	1.439
Theoretical	10	7.149	1.398
Using a DMM to directly measure Rth			1.4

Thevenin resistance Method-2

	Voc (V)	Isc (mA) from Va to Vg	Rth (kΩ) = Voc / Isc
Measured	18	14.102	1.28
Theoretical	18.742	13.4	1.328
Why doesn't Rth method 2 work for circuits that don't have independent sources?		because Thevenin's Theorem relies on the concept of superposition, which assumes that you can find the Thevenin equivalent of a circuit by considering the effect of each independent source separately. When a circuit doesn't have independent sources, it's not possible to apply superposition to find the Thevenin voltage and Thevenin current separately.	

Part 2:

Load current comparison between Thevenin and the original circuits

sign error

Load current I_{Load} (mA) from Thevenin circuit	2.884
Load current I_{Load} (mA) from circuit at Part 1	3.108
Is this Thevenin circuit equivalent to the original circuit? (Yes / No): YES	

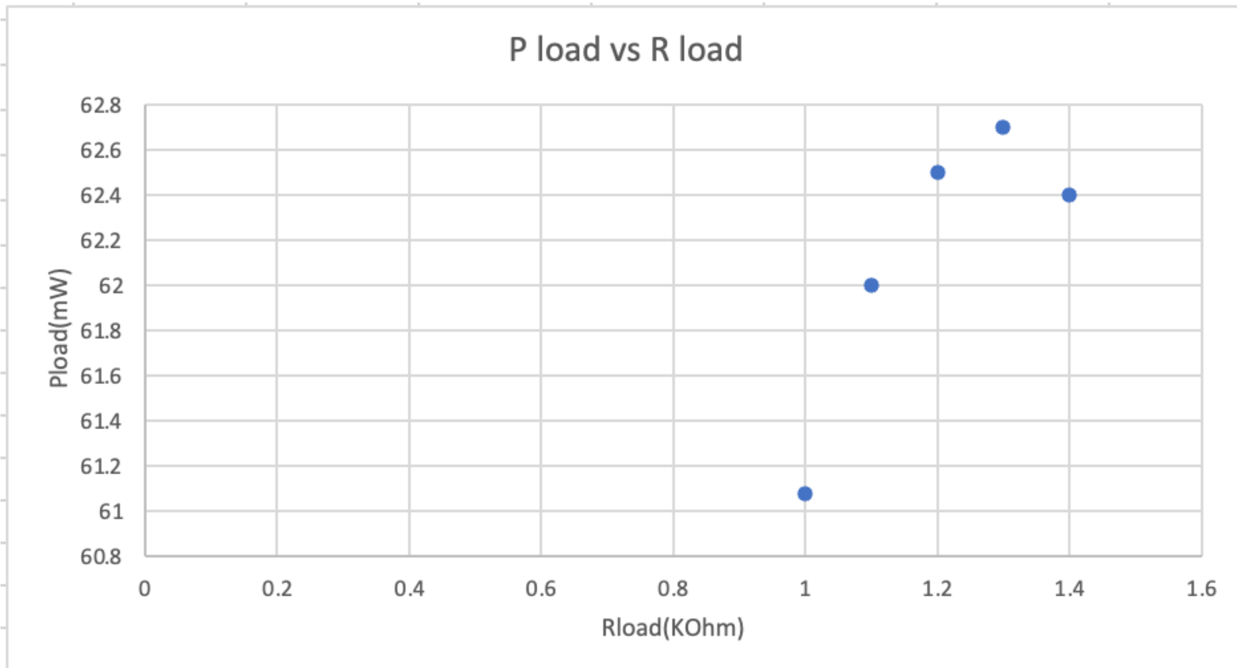
Part 3:

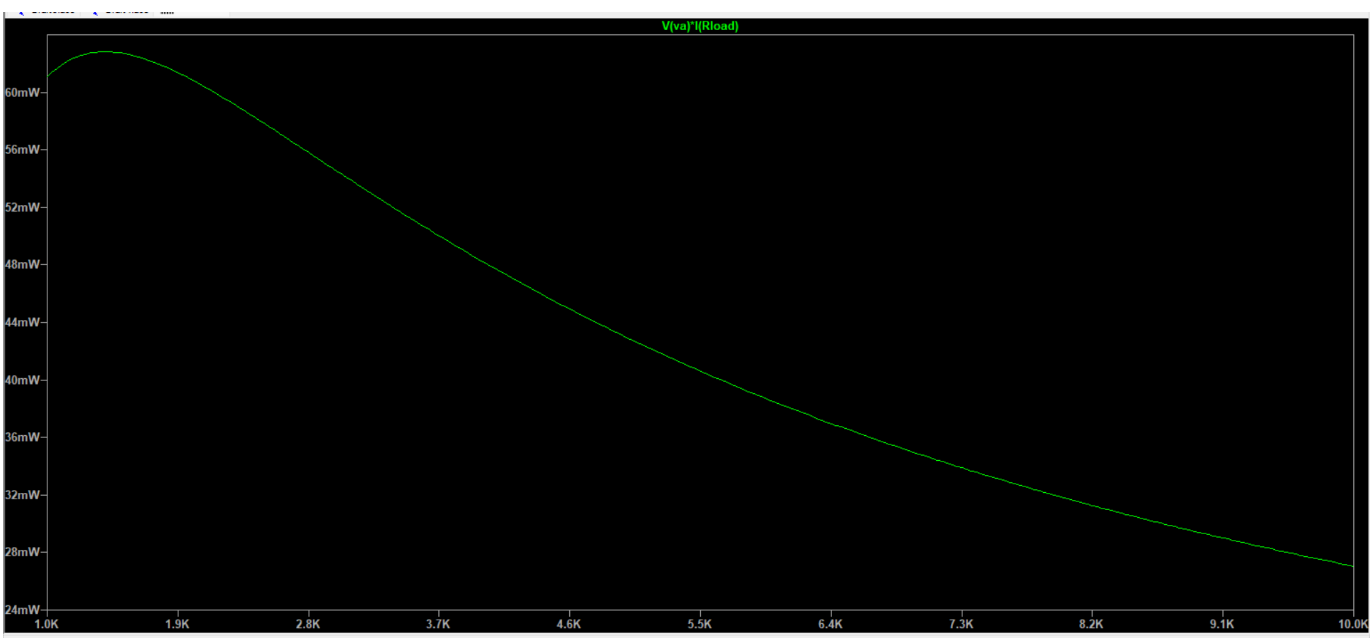
Load power transfer: highlight the load resistance at maximum power transfer to the load

Adjusted RLoad (kOhm)	Measured load voltage V_{Load} (V)	**Optional:** Measured load current I_{Load} (mA)	Calculated P_{Load} (mW)
1	7.8	7.8	61.08
1.1	8.2	7.5	62
1.2	8.8	7.3	62.5
1.3	9	6.9	62.7
1.4	9.4	6.7	62.4

↓ range needs to be wider

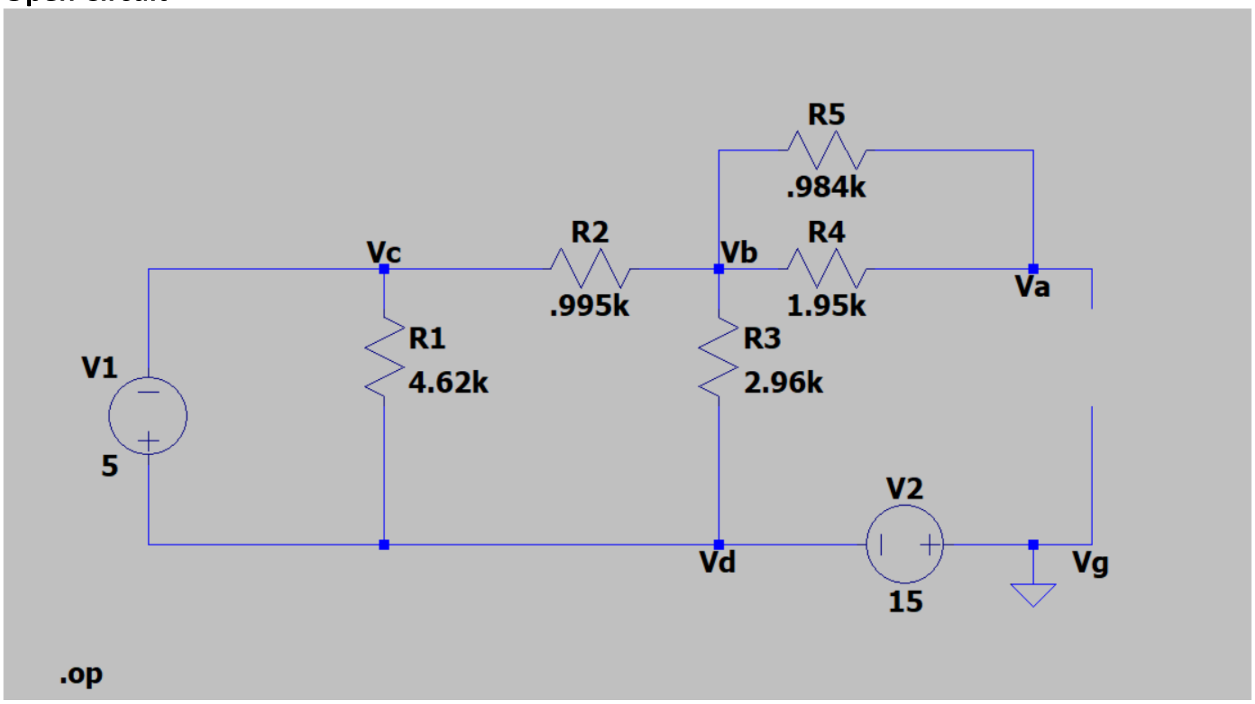
Plot of P_{Load} vs. RLoad:





Attach the screenshots of LTspice circuits and output image.

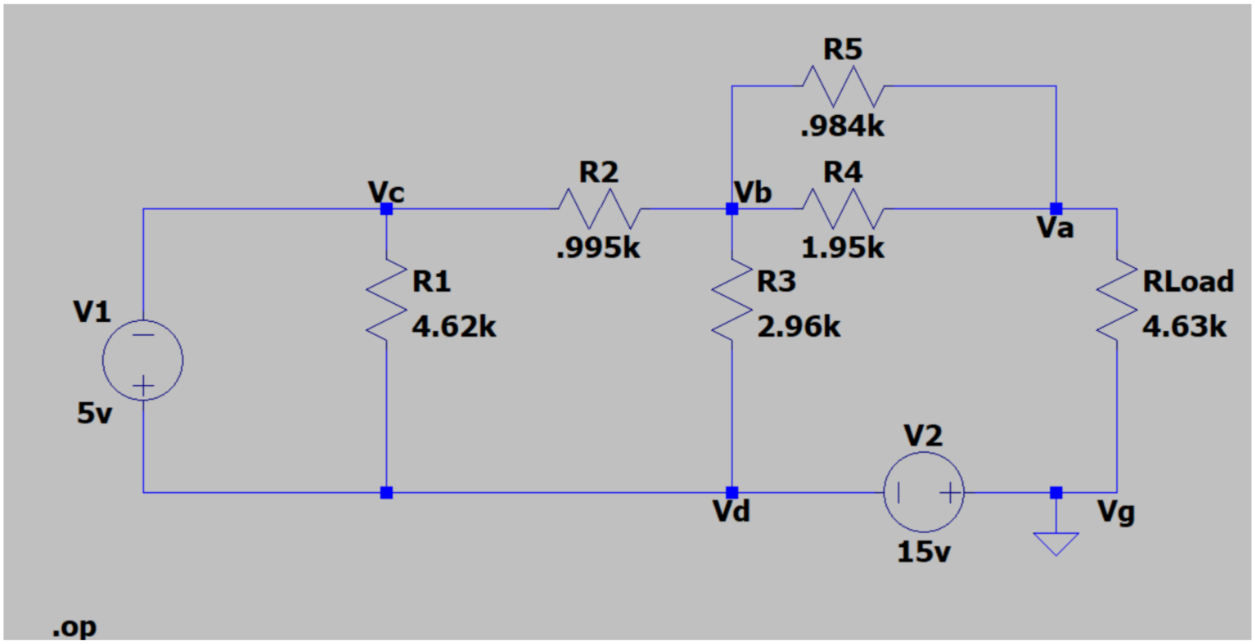
Open Circuit




```
       --- Operating Point ---

V(vc):          -20             voltage
V(vd):          -15             voltage
V(vb):          -18.7421        voltage
V(va):          -18.7421        voltage
I(R1):          -0.00108225     device_current
I(R2):          0.00126422      device_current
I(R3):          -0.00126422     device_current
I(R5):          0               device_current
I(R4):          0               device_current
I(V2):          6.07153e-18     device_current
I(V1):          -0.00234647     device_current
```

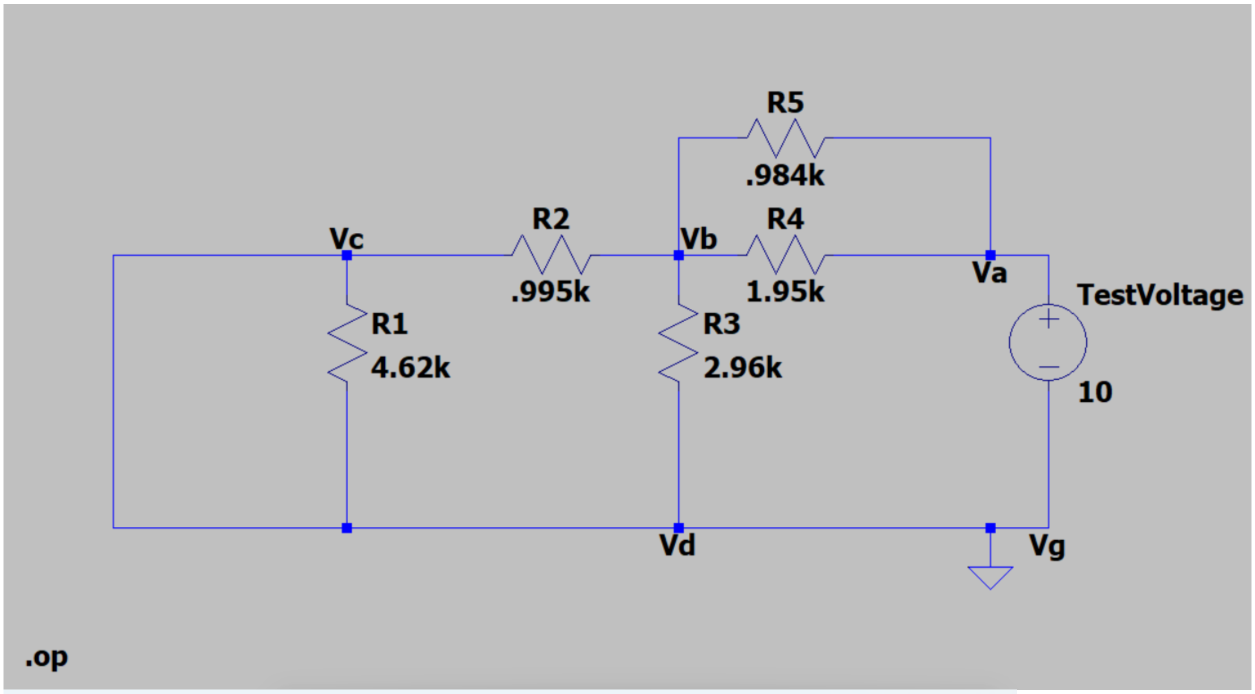
Find Load Current (I)




```
       --- Operating Point ---

V(vc):          -20             voltage
V(vd):          -15             voltage
V(vb):          -16.427         voltage
V(va):          -14.3939        voltage
I(R1):          -0.00108225     device_current
I(R2):          0.00359093      device_current
I(R3):          -0.000482102    device_current
I(R5):          0.0020662       device_current
I(R4):          0.00104263      device_current
I(Rload):       -0.00310883     device_current
I(V2):          -0.00310883     device_current
I(V1):          -0.00467318     device_current
```

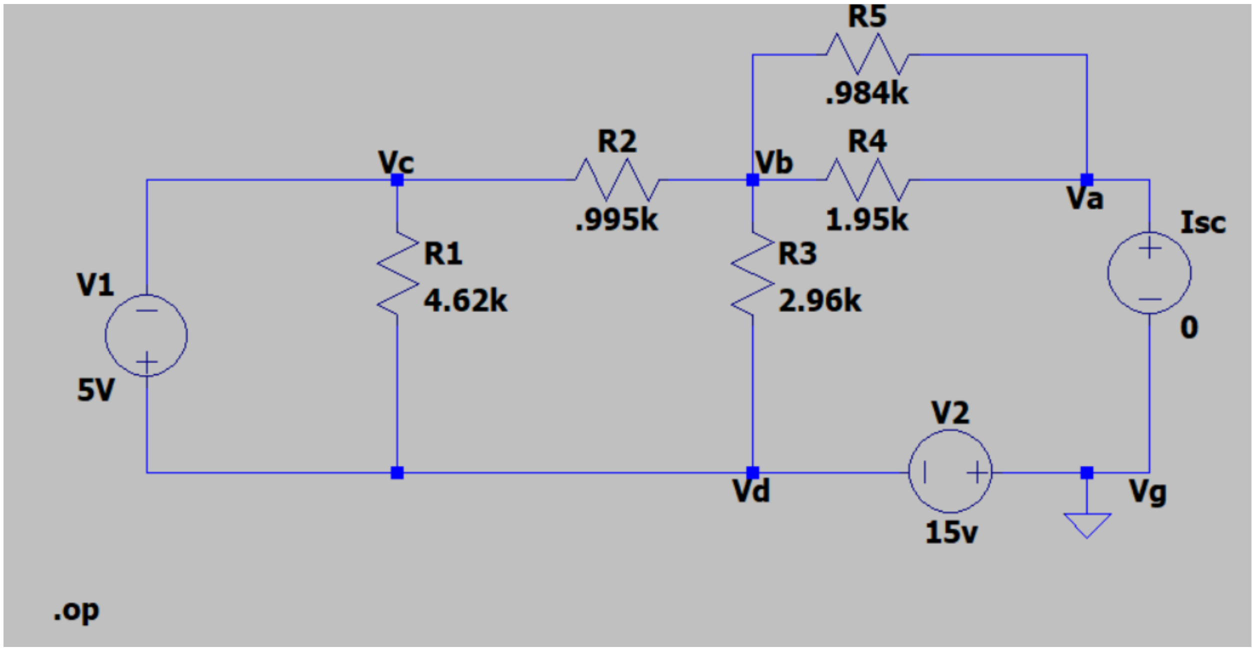
Thevenin resistance Method-1 with Test Voltage



--- Operating Point ---

V(vb):	5.3242	voltage
V(va):	10	voltage
I(R2):	0.00535096	device_current
I(R3):	0.00179872	device_current
I(R5):	0.00475183	device_current
I(R4):	0.00239785	device_current
I(Testvoltage):	-0.00714967	device_current

Thevenin resistance Method-2



--- Operating Point ---

V(vc):	-20	voltage
V(vd):	-15	voltage
V(vb):	-8.76343	voltage
V(va):	0	voltage
I(R1):	-0.00108225	device_current
I(R2):	0.011293	device_current
I(R3):	0.00210695	device_current
I(R5):	0.00890592	device_current
I(R4):	0.00449407	device_current
I(V2):	-0.0134	device_current
I(V1):	-0.0123753	device_current
I(Isc):	-0.0134	device_current

Part 3- Load power transfer