Lab 02 – Voltage Regulators

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ELE404 – Electronics I

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Introduction:

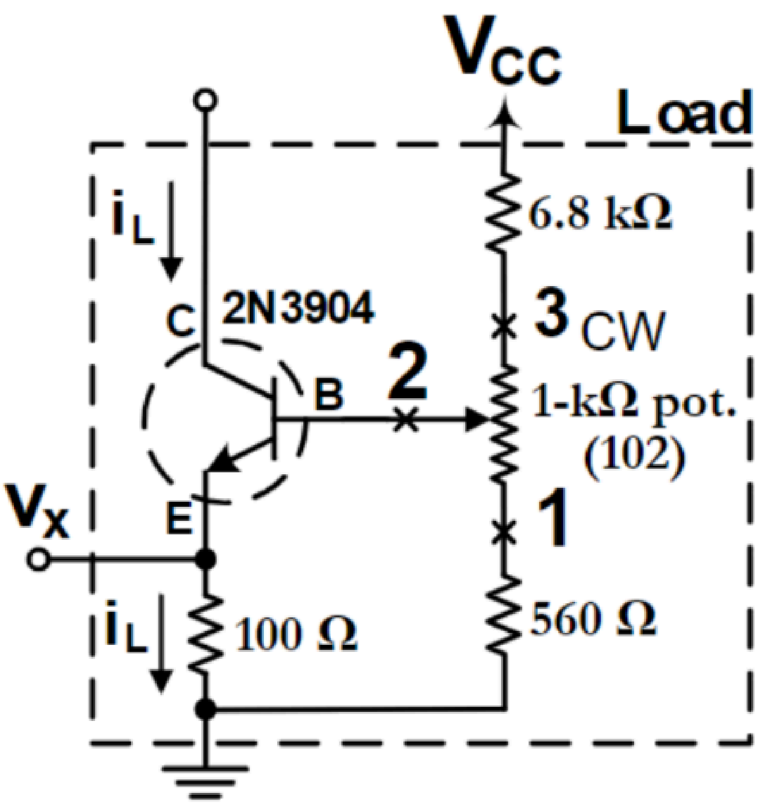
In this lab, we examined the fundamental ideas and load regulation properties of three fundamental types of voltage regulators: resistive voltage dividers, diode-based regulators, and Zener diode regulators. This allowed us to better understand the significant role that voltage regulators play in electronic circuits. Every type of regulator provides a method for preserving a steady output voltage under various load demands and input conditions. We hope to learn more about the practical uses, constraints, and operational effectiveness of these regulators through testing.

Objective:

Our goal in this lab is to investigate how well three basic voltage regulator designs can regulate load. There are three stages to the experiment. First, we put the load circuit together. This prepares the groundwork for the subsequent stages, in which we will build and incorporate each of the three varieties of voltage regulators into the load circuit that has been created. We will concentrate on monitoring and recording the output voltage for every kind of voltage regulator as we change the load current during these stages. This experiment gives us a fundamental insight of the operational efficiency and applicability of various voltage regulators in real-world use situations by demonstrating how they react to variations in load.

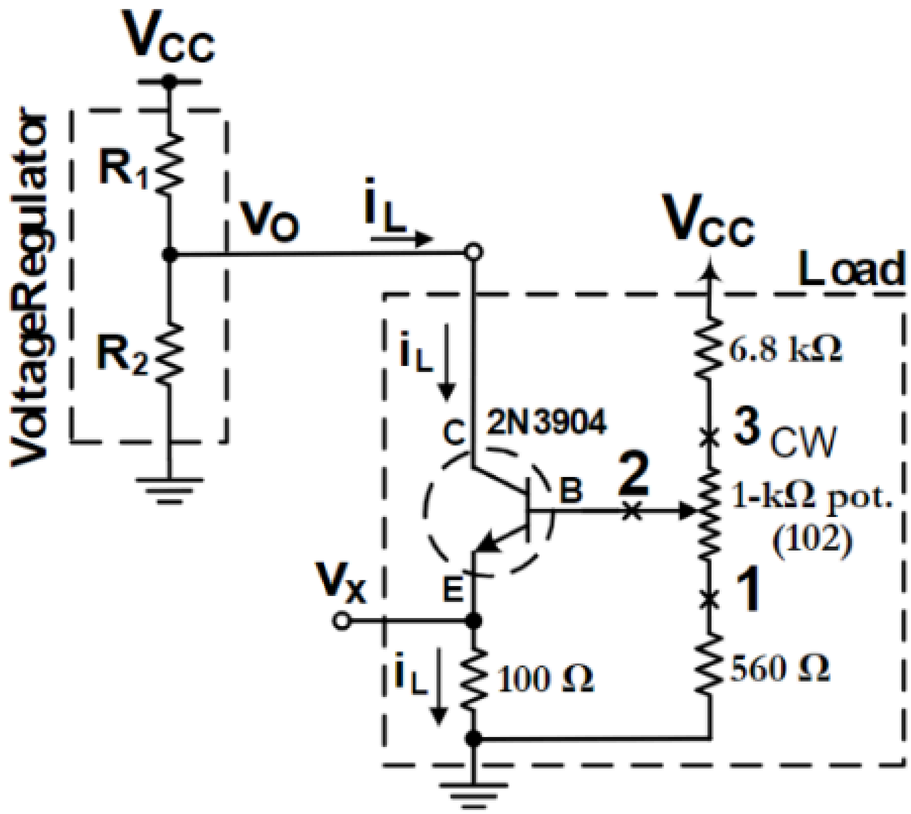
Circuit Under Test:

The load circuit, which basically acts as the load for our voltage regulators, was the first of four circuits we constructed in this lab. A transistor (BJT), a potentiometer, and three resistors with values of 100 Ω, 560 Ω, and 6.8 kΩ make up this specific circuit. Assuming a supply voltage, Vcc, of 10 volts, we can use the potentiometer to change the load current, iL, from zero to 10 mA. With iL measured in milliamperes (mA) and Vx in volts, this correction reveals a direct link that can be expressed as iL = 10Vx. Thus, we may efficiently manage iL through various experiments by adjusting Vx. Because the circuit is driven by a voltage supply, Vcc, it is categorized as an active load.

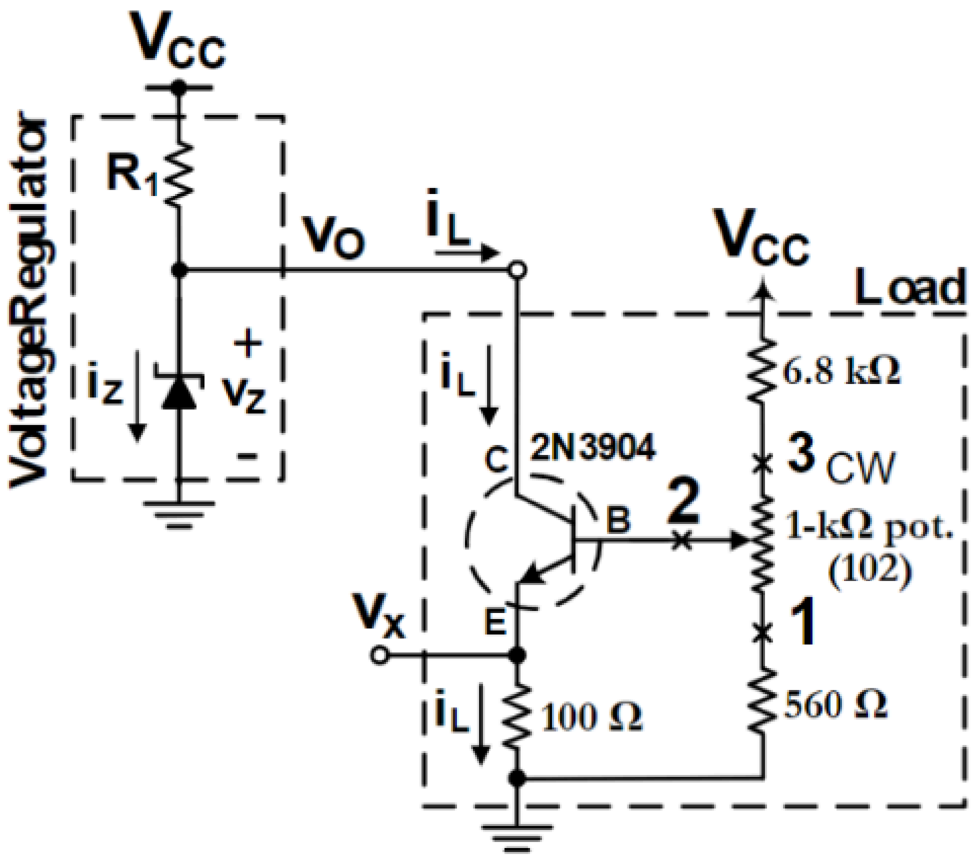


V_CC
Load
i_L
C
2N3904
B
2
E
V_X
i_L
100 Ω
6.8 kΩ
3
CW
1-kΩ pot.
(102)
1
560 Ω

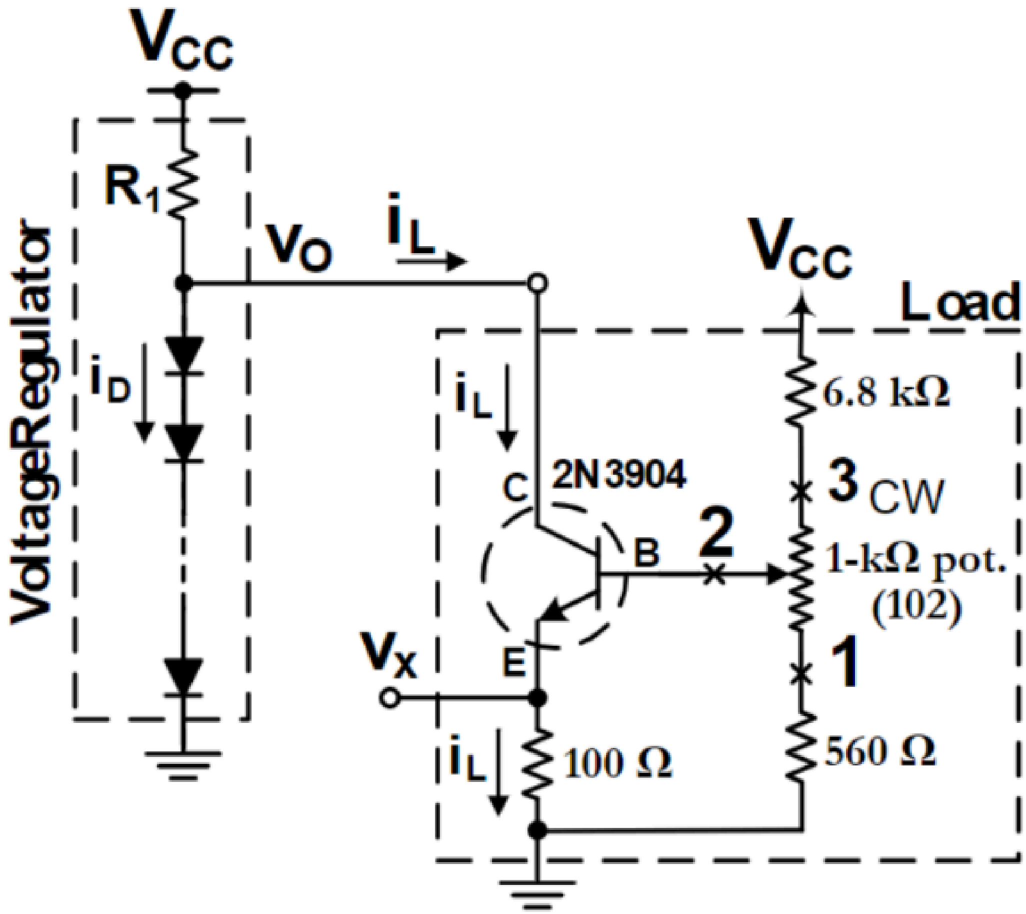
Our attention switches to building three distinct voltage regulators and combining the aforementioned load circuit for measurement purposes in the next three circuits. Using two series resistors with values of R1 = 560 Ω and R2 = 910 Ω, we construct a simple resistive voltage divider as our first regulator. The supply voltage, Vcc, is kept constant at 10 volts. We set the desired load current, iL, to record the output voltage, Vo, after adjusting the potentiometer to reach the target voltage, Vx, for each iteration.



The voltage regulator in the third circuit operates by means of Zener diodes. In order to put this arrangement together, we use a Zener diode in place of resistor R2 from the resistive voltage divider circuit. After making this change, we record the output voltage, Vo, and alter the settings using the same procedure as before.



We switch from the Zener diode design to a regulator that uses a number of diodes for the fourth and last arrangement. An approximate output voltage of 6.3 volts across the diode series is achieved by making this change. We attach the load and turn on the power supply after adding enough diodes (about nine diodes) to achieve the desired output voltage. We can record the output voltage, Vo, at different iterations with this configuration. This voltage regulator is based on series diodes, as seen in the diagram below.



Experimental Results:

My colleague and I had to first construct a load on the breadboard using a transistor (BJT), a potentiometer, and three resistors for this lab. Then, using this load, we constructed and employed three different kinds of voltage regulators: a voltage divider, a diode-based regulator, and a zener diode-based regulator. We had to use the load to determine the output voltage after connecting each voltage regulator to the load we created. We entered a predetermined voltage for each voltage regulator and load in order to get our current in the load to fall between 0 and 8 mA. After the load was operating at a certain current, let's say 3 mA, we would measure the output voltage from the load attached to the voltage regulator of our choice. These metrics were then entered into the charts that follow.

Table E2. Output voltage as a function of load current in the circuit of **Figure 6.**

i_L [mA}	0	1	2	3	4	5	6	7	8
v_o[V]	6.164	5.992	5.460	5.108	4.814	4.458	4.410	3.794	3.446

Table E3. Output voltage as a function of load current in the circuit of **Figure 7.**

i_L [mA}	0	1	2	3	4	5	6	7	8
v_o[V]	6.207	6.204	6.197	6.190	6.187	6.178	6.169	6.126	5.521

Table E4. Output voltage as a function of load current in the circuit of **Figure 8.**

i_L [mA}	0	1	2	3	4	5	6	7	8
v_o[V]	6.382	6.311	6.243	6.182	6.046	5.937	5.759	5.528	5.262

Conclusion & Remark:

C1

To complete table c1, we used the equation $R_L = \frac{V_O}{I_L}$

Table C1. Equivalent load resistance for the voltage divider of **Figure 1.**

i_L [mA}	0	1	2	3	4	5	6	7	8
v_o[V]	6.19	5.86	5.57	5.30	5.06	4.84	4.63	4.28	3.76
R_L[kΩ]	∞	5.86	2.785	1.767	1.265	0.968	0.772	0.611	0.470

In a voltage divider circuit, the RL should be much greater than the circuit's Thevenin resistance in order to reduce the output voltage's divergence from its no-load value. This keeps the output voltage around its optimal level by ensuring that the majority of current passes via Rth rather than RL. In essence, the output voltage stabilizes to become more similar to the no-load voltage as RL rises in relation to Rth, making it less sensitive to variations in the load. In summary, this relationship between RL and Rth is essential for producing a constant output voltage because changes in load could otherwise cause noticeable voltage swings.

C2

Table C2. Percent error between the calculated and measured output voltages of the voltage divider of **Figure 1.**

i_L [mA}	0	1	2	3	4	5	6	7	8
v_o[V] (Table P1)	6.19	5.86	5.57	5.30	5.06	4.84	4.63	4.28	3.76
v_o[V] (Table E2)	6.164	5.992	5.460	5.108	4.814	4.458	4.410	3.794	3.446
e%	0.420%	2.253%	1.975%	3.623%	4.862%	7.893%	4.751%	11.355%	8.351%

Although the maximum mistake percentage is 11.355%, these percentage errors are allowed because they are still rather small. The 11.355% percentage error might result from a mathematical error involving 8 mA or from failing to account for the voltage threshold at 0.7 volts. Despite these tiny percentage inaccuracies, the measured and computed values are accurate and acceptable.

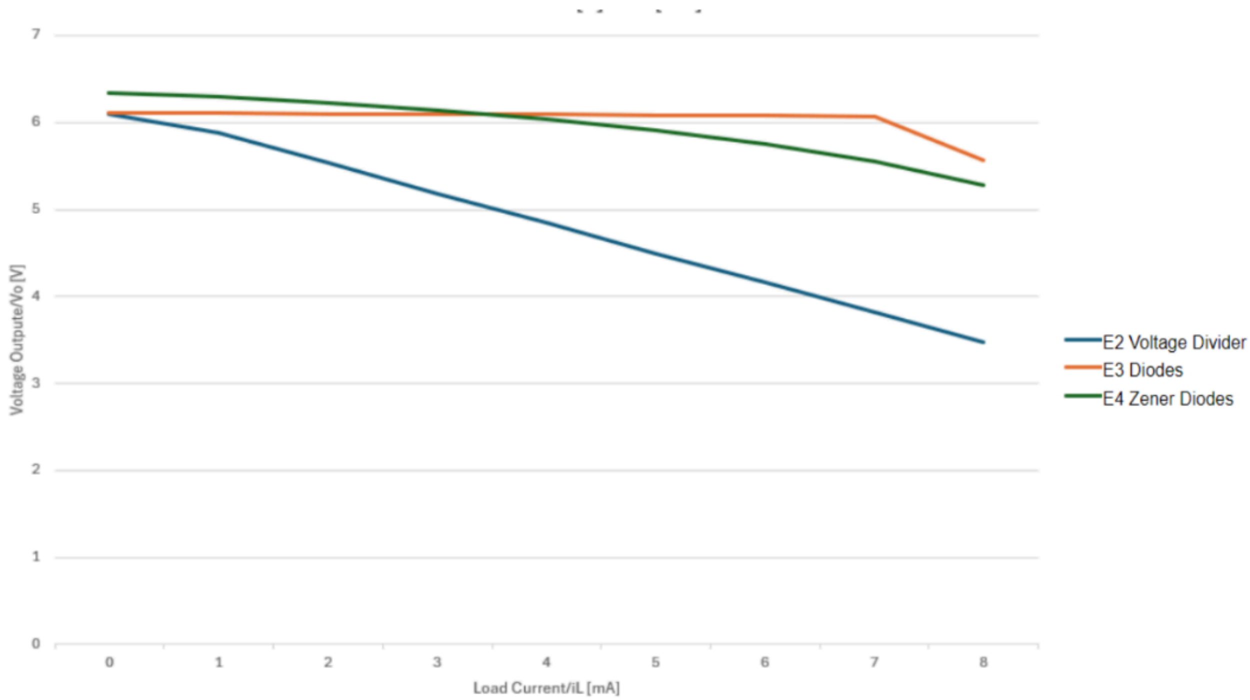
C3

Table C2. Percent error between the calculated and measured output voltages of the voltage divider of **Figure 1.**

i_L [mA}	0	1	2	3	4	5	6	7	8
v_o[V] (Table P2)	6.21	6.21	6.21	6.21	6.21	6.21	6.10	6.08	5.52
v_o[V] (Table E3)	6.207	6.204	6.197	6.190	6.187	6.178	6.169	6.126	5.521
e%	0.048%	0.097%	0.209%	0.322%	0.370%	0.515%	1.131%	0.757%	0.018%

The calculated and measured data is correct and acceptable because these percentage errors are less than 1.131%, which is a very modest error percentage.

C4



Voltage Divider: When the load's current rises, the output voltage falls. A steep linear curve descends as a result of this decline occurring at a linear pace. The voltage divider has a steeper curve and a larger decreasing rate than diode-based and zener diode-based ones, which is bad because it loses a lot of voltage in the output.

Diodes-Based: As the load's current rises, the output voltage rises until it hits the 7 mA cutoff, at which point the output voltage abruptly drops. This produces an ascending curve that is generally flatter. The curve is flatter than that of voltage dividers and zener diodes. It remains more stable, which means that it can tolerate a certain amount of current increase from the load (up to 0.7 mA) without significantly lowering the output voltage.

Based on zener diodes, the output voltage has a smoother downward curve when the load current increases at a very slow rate. The curve is flatter than that of voltage dividers and diode-based devices. It steadily decreases, enabling it to manage a rise in the load's current with minimal output voltage loss.

C5

Once the Zener breakdown voltage is attained, the Zener-diode regulator maintains a steady voltage throughout a broad range of currents, providing precise voltage regulation. Because of this, it can be used in applications that need steady reference voltages. Furthermore, unlike a regular diode, which does not permit reverse current flow under typical operating conditions, a Zener diode permits current to flow in both directions: forward when it functions normally and reverse when it hits its Zener voltage. Conversely, the diode-based regulator, which employs a number of conventional diodes, controls voltage by utilizing the cumulative forward voltage drops of these diodes. Because ordinary diodes' forward voltage drop might fluctuate somewhat with current, this method is typically less accurate. Furthermore, the Zener diode regulator can efficiently control voltage in both load and no-load scenarios, but the less accurate series diode regulator may exhibit greater performance variations with load variations.

Remark

We gained a lot of knowledge about the various kinds of voltage regulators that are suitable for any load by the end of this lab. We also looked at the patterns when we used the various voltage regulators—such as diode-based, zener-diode-based, and voltage dividers—to graphically compare the output voltage and the load current. Overall, these voltage regulators are useful in many situations and applications, to the extent that they can be used generically.