Bilkent University

Electrical and Electronics Department

EE313-02 Lab 2 Final Report:

“Low-Dropout Voltage Regulator”

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Introduction:

This experiment consisted of two parts: A and B. In part A, we were asked to measure the β value of a pnp-transistor BD136. In part B, we were asked to design a low-dropout (LDO) voltage regulator with an output current of 100mA. We used a zener diode (5.1V), two op-amp's (LM358) and a power pnp BJT (BD136) in the circuit. My output voltage is 10.5 Volts because of my ID number.

Hardware Implementation & Analysis:

Part A:

In this part, we were asked to measure the β value of a pnp-transistor BD136. Here are the implemented circuit and the measured I_b and I_c values of the transistor **(Figures 1.1 to 1.3)**:

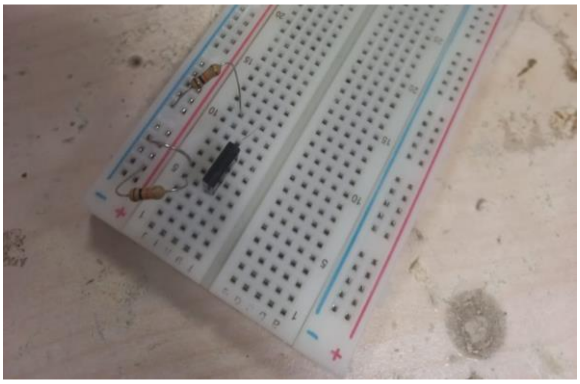

Figure 1.1: The Implemented Circuit on the Breadboard

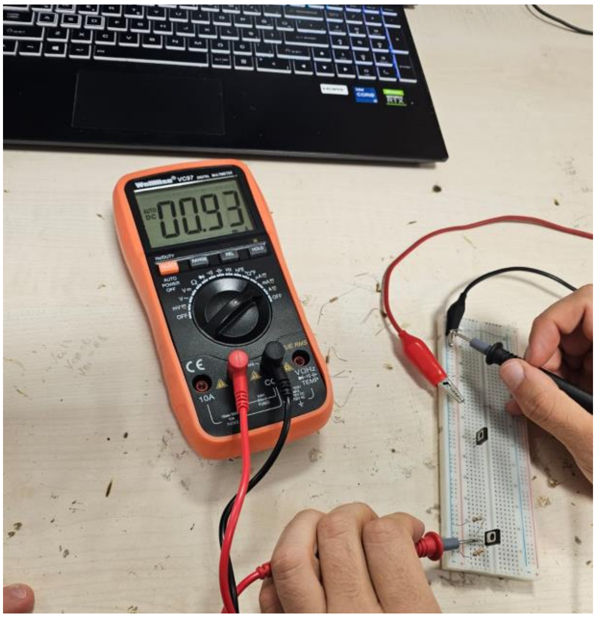

Figure 1.2: The Measurement of the Ib Value as 9.3mA

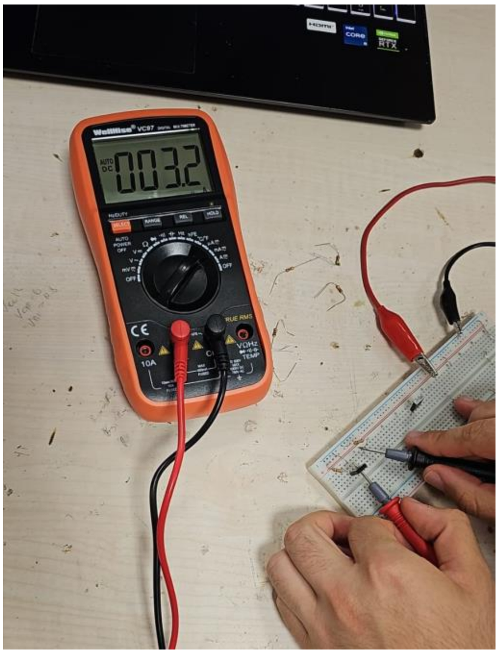

Figure 1.3: The Measurement of the Ic Value as 3.2µA

Table I shows the difference between simulation and hardware values of β. The error is 30.31%.

Table I

LTSpice Simulation Value	Hardware Experimental Value	Error
223	290.6	30.31%

Part B:

The hardware implementation of the voltage regulator circuit can be seen in the following figure **(Figure 2.1)**:

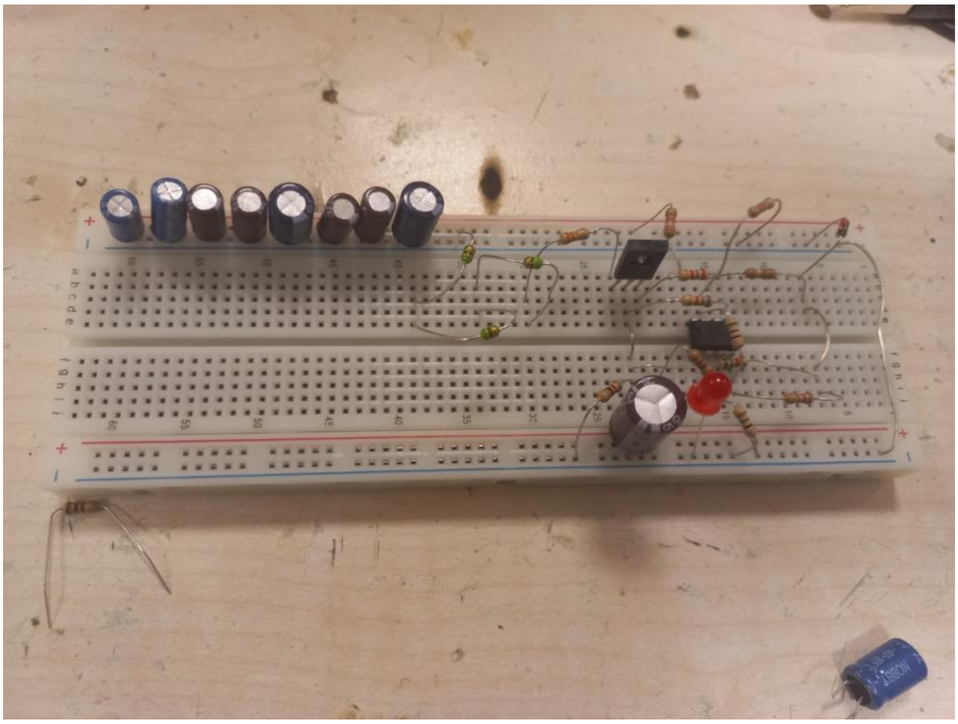

Figure 2.1: The Circuit Implemented on a Breadboard

There are 3 requirements that the circuit should met. These were given in the lab manual **(Figure 2.2)**:

1. Line regulation: When V_{in} is varying between V_{out}+0.7 to V_{out}+6 at 100Hz, the output voltage, V_{out}, changes by no more than 20mV when the output current is 100mA (R_L=V_{out}/0.1).
2. Load regulation: When V_{in}=V_{out}+2, the output voltage, V_{out}, changes no more than 20mV when the output current changes between 0mA and 100mA at 100Hz. (In LTSpice, you can connect a sinusoidal current source at the output varying between 0 and 100mA.)
3. A green LED should turn on if the regulation is achieved. Otherwise, it should turn off, for example, because the input voltage is too low or the output current is too high.

Figure 2.2: The 3 Requirements the Circuit should Meet

Now let's dive deep in each criterion.

Criterion 1 - Line Regulation:

This criterion states that the output voltage should remain within the 20mV limits when the input changes between 11.2V and 16.5V. Here you can see the output voltage staying within the limits when the input voltage varies **(Figures 2.3 to 2.8)**:

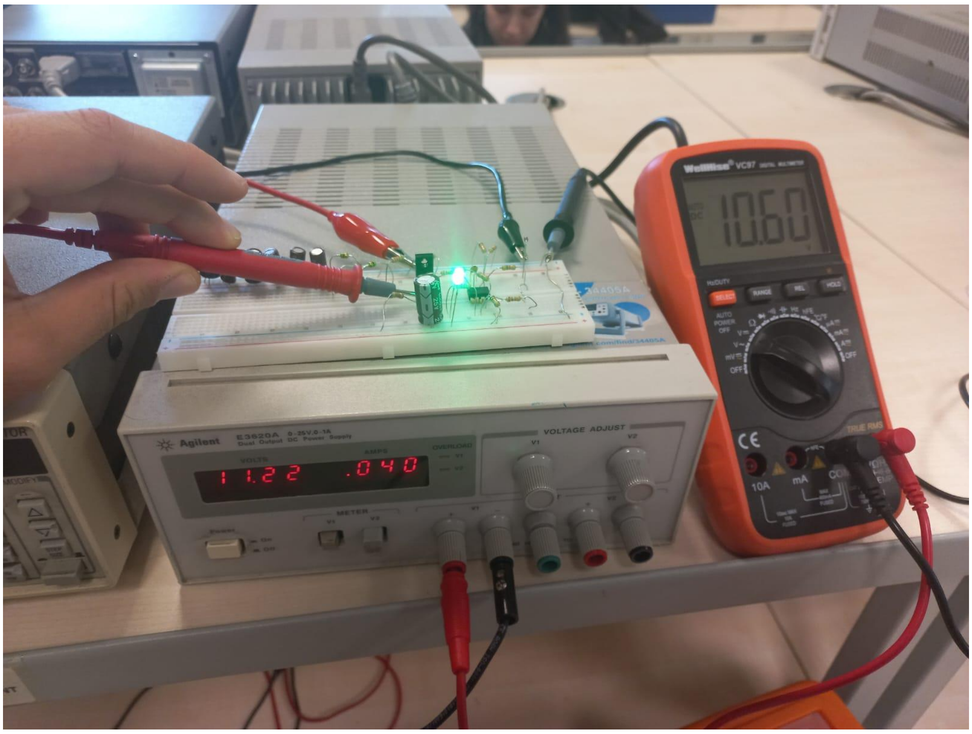

Figure 2.3: Vout = 10.60V when Vin = 11.22V

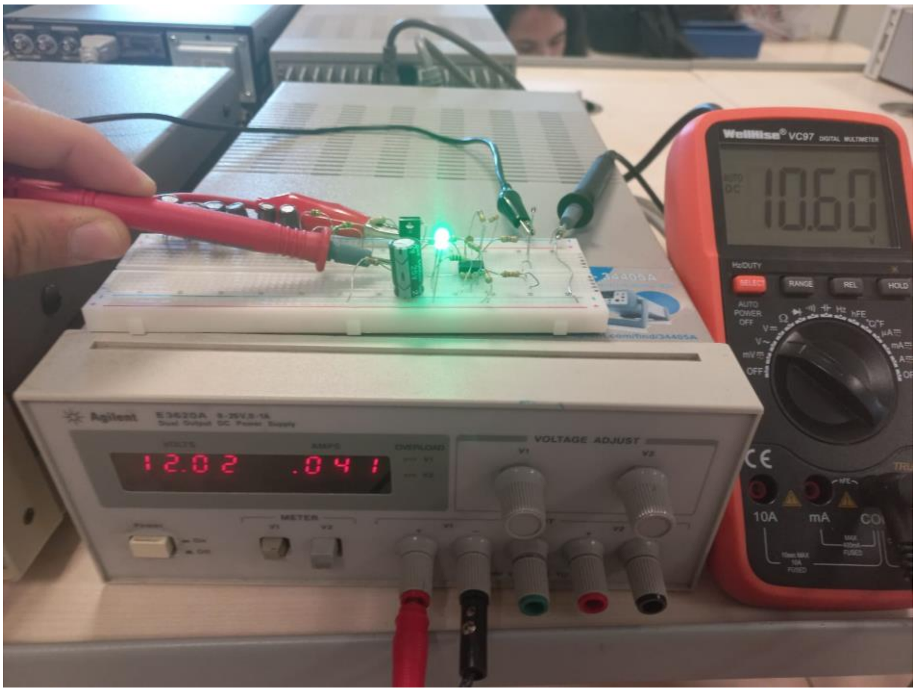

Figure 2.4: Vout = 10.60V when Vin = 12.02V

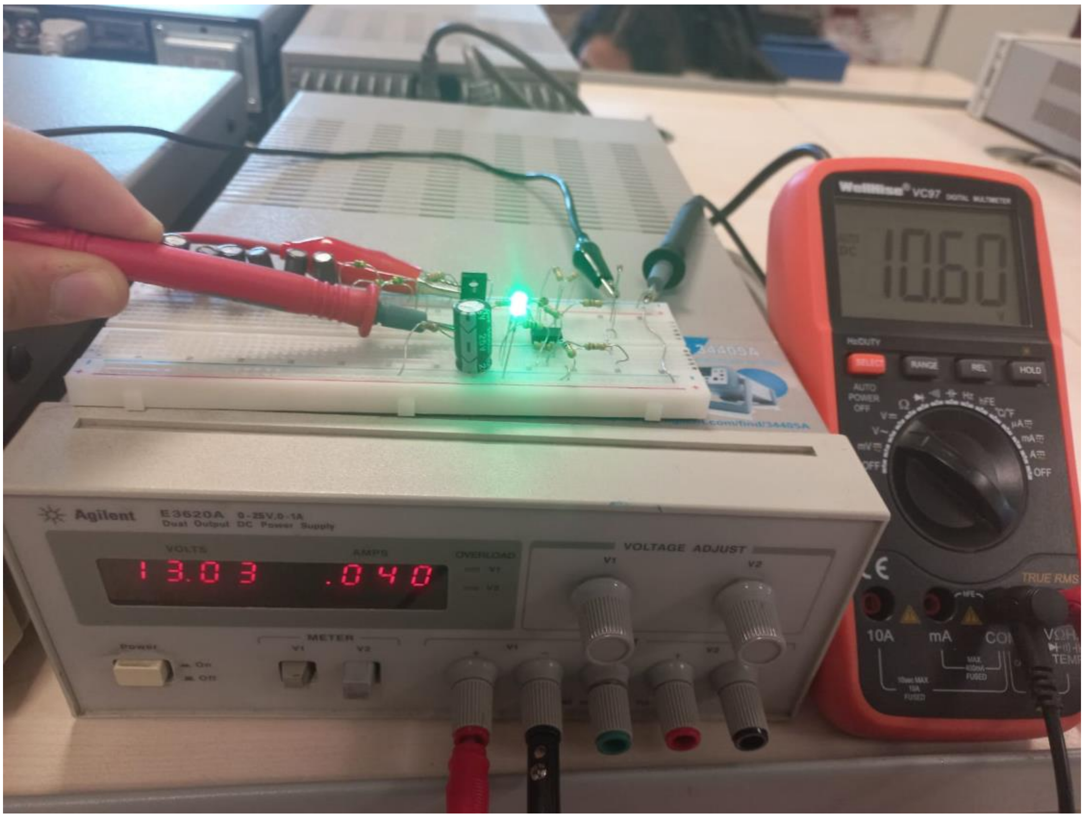

Figure 2.5: Vout = 10.60V when Vin = 13.03V

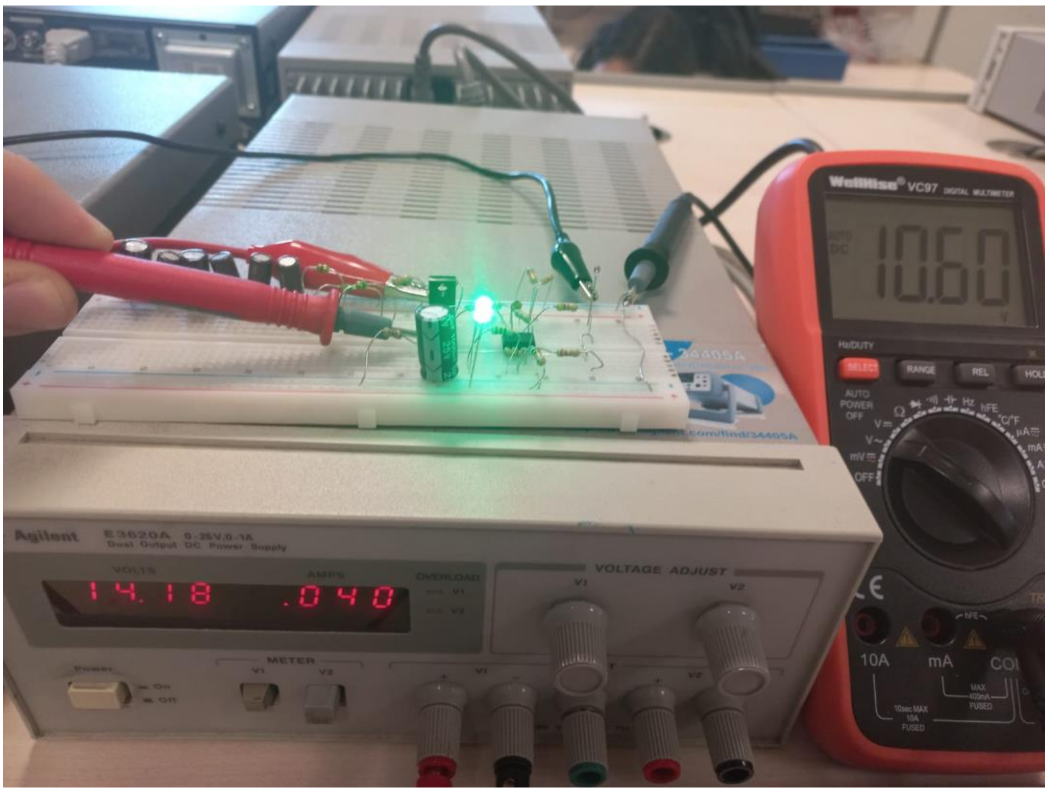

Figure 2.6: Vout = 10.60V when Vin = 14.18V

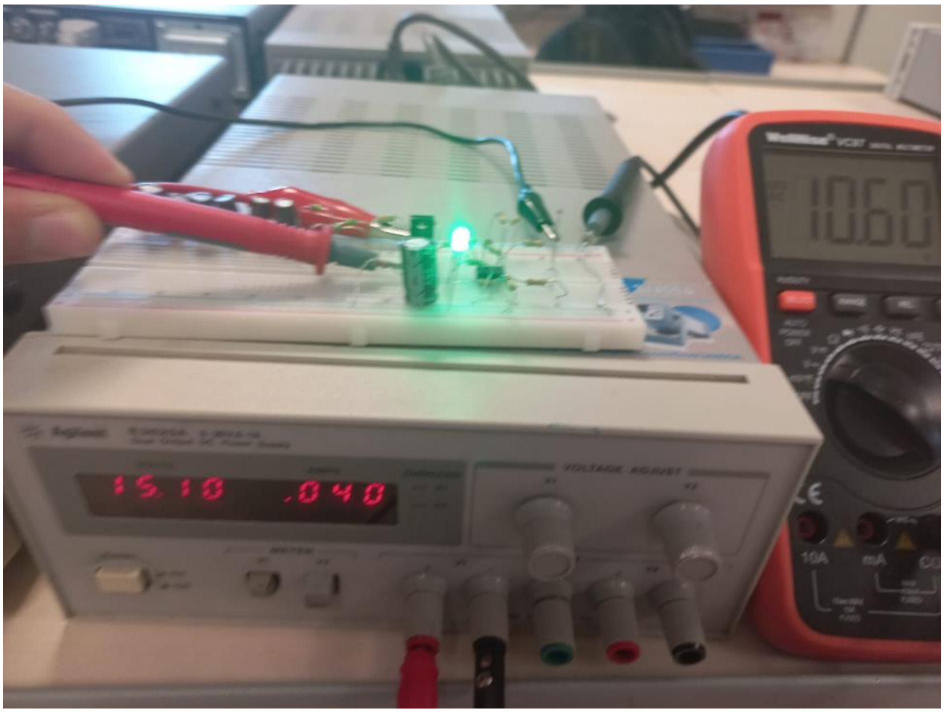

Figure 2.7: Vout = 10.60V when Vin = 15.10V

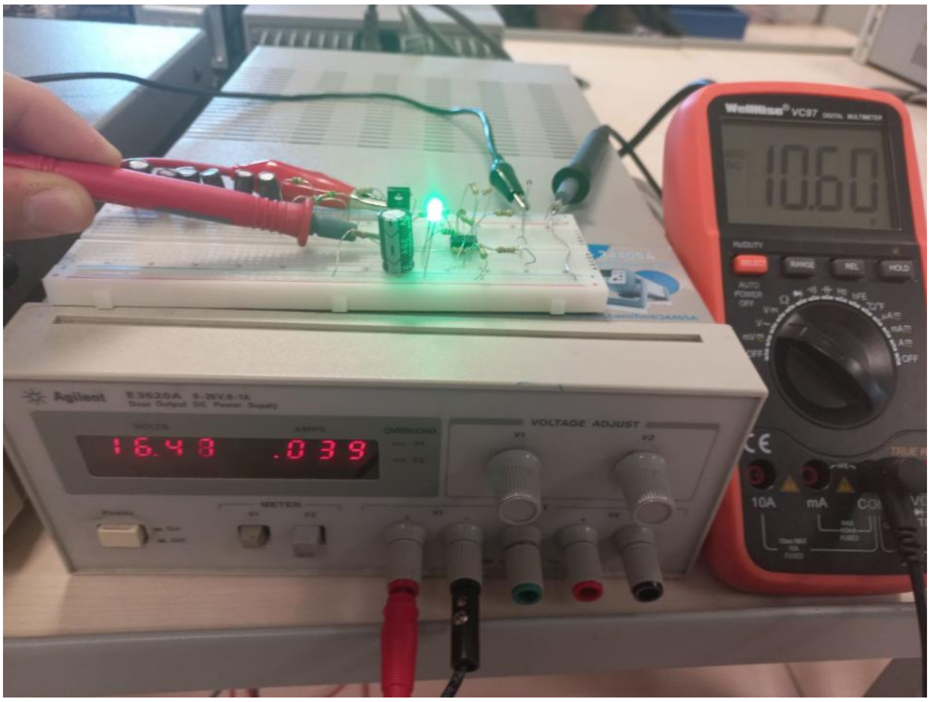

Figure 2.8: Vout = 10.60V when Vin = 16.47V

Table II compares the simulation & experimental data. The line regulation criterion holds with 0.95% error.

Table II

LTSpice Simulation Value	Hardware Experimental Value	Error
10.50V	10.60V	0.95%%

Criterion 2 - Load Regulation:

This criterion states that the output voltage should remain the same if the current on the load resistor varies. We used the circuit below **(Figure 2.9),** which differs from the initial circuit by removing the load resistor and therefore making the current on the load 0 Amperes, to demonstrate that the output voltage remains the same.

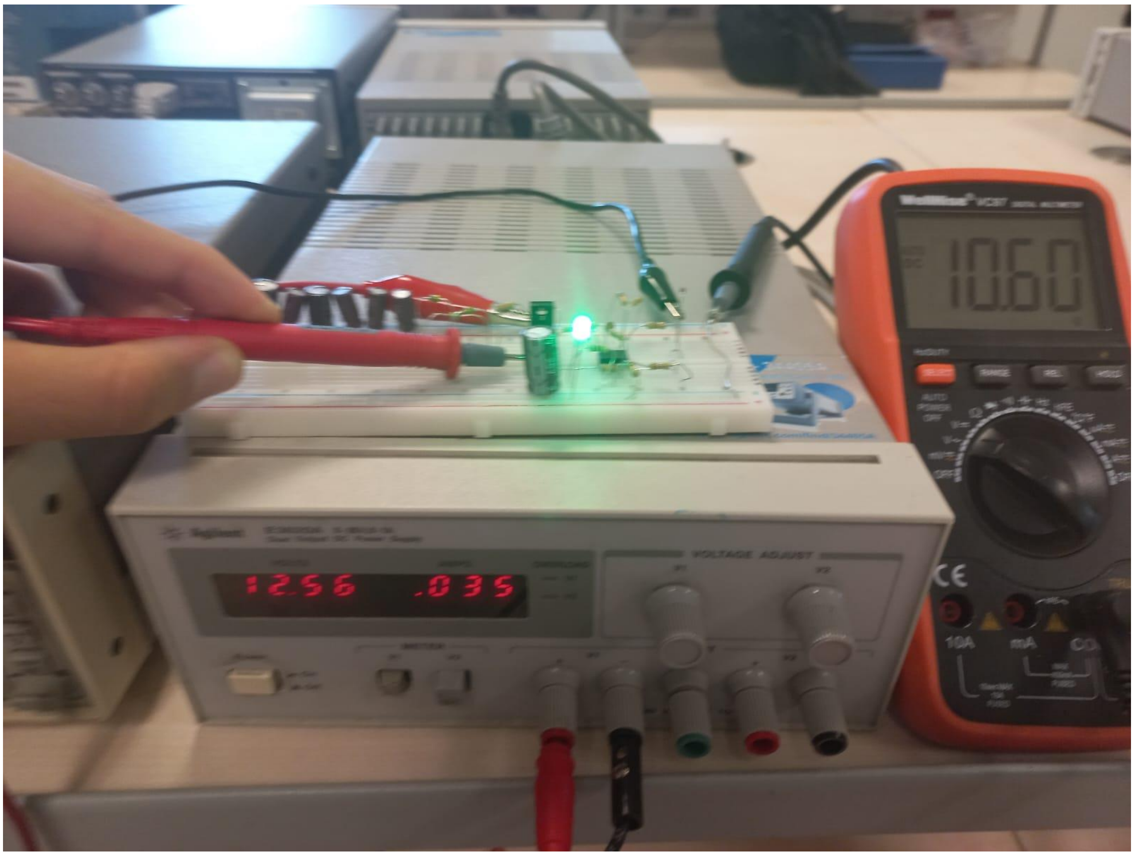

Figure 2.9: Vout = 10.60Volts when the current on the load is 0A

Table III compares the simulation & experimental data. The load regulation criterion holds with 0.95% error.

Table III

LTSpice Simulation Value	Hardware Experimental Value	Error
10.50V	10.60V	0.95%

Criterion 3- LED Turn On-Off:

This criterion states that an LED should turn on when there is regulation, and it should turn off when there is no regulation. In our case the regulation starts at Vin = 11.2V. Here you can see the LED turning on and off for different input limits.

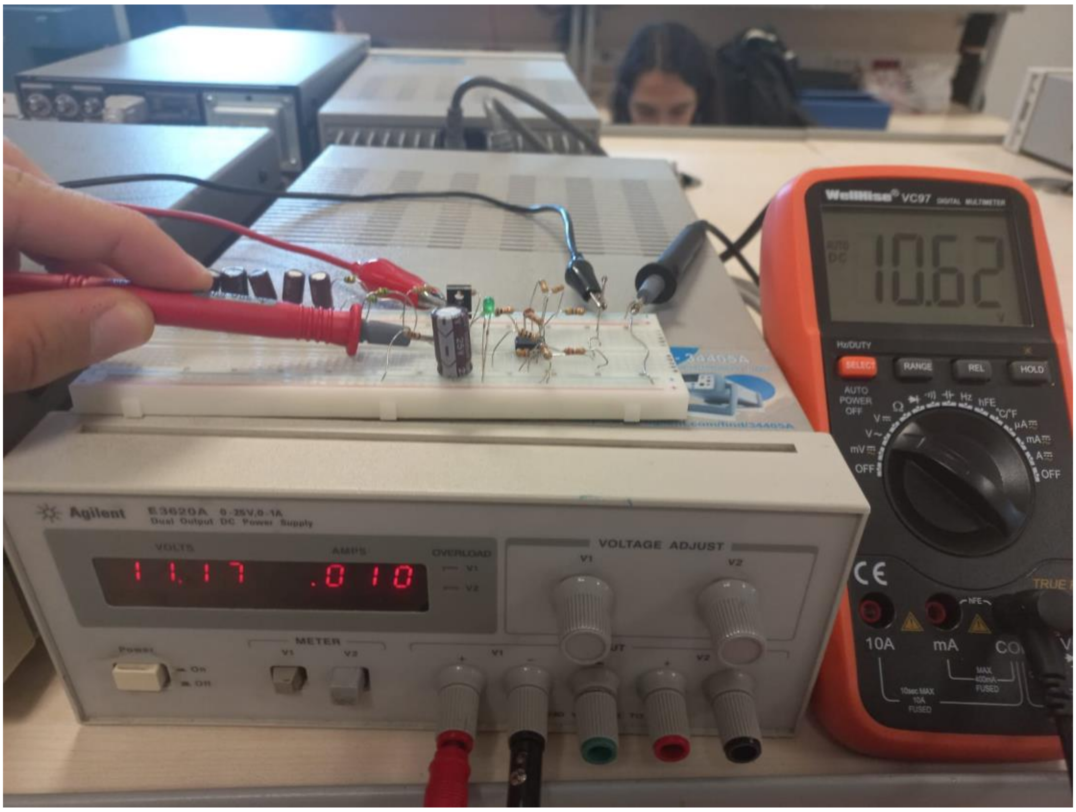

Figure 2.10: LED Off at Vin = 11.17V

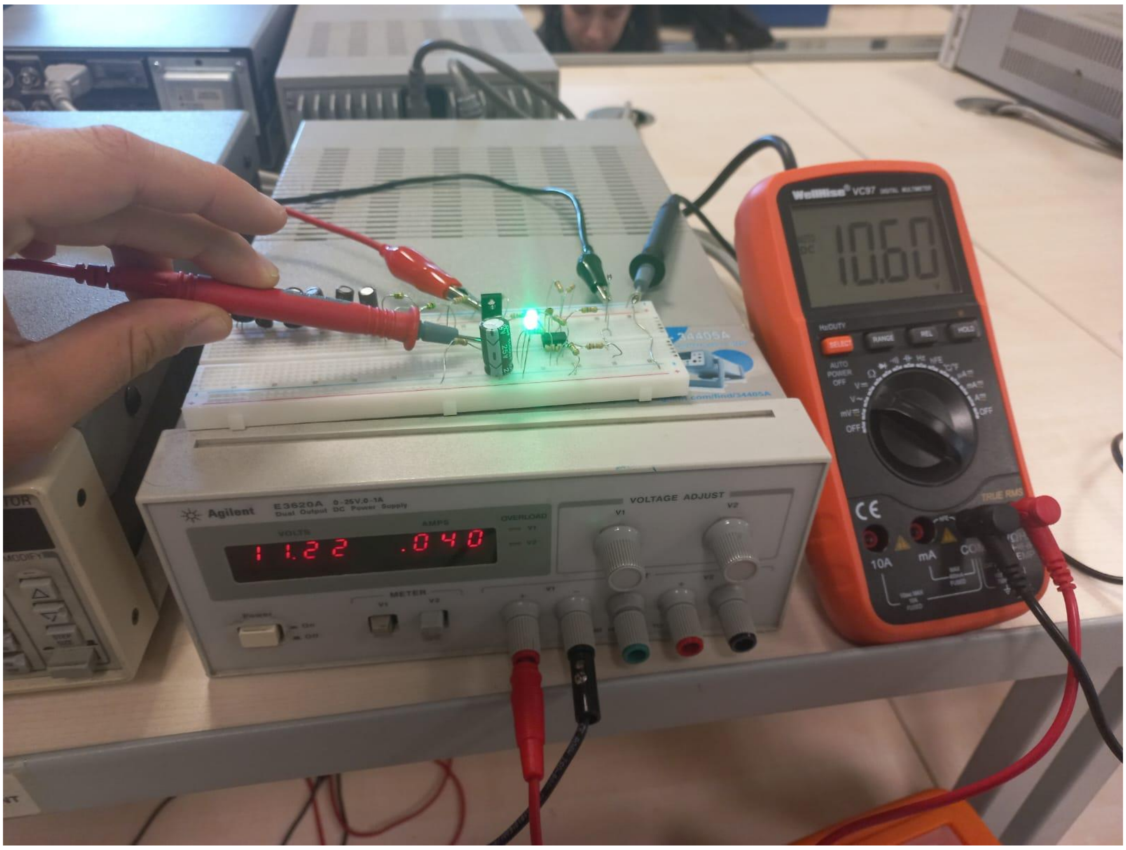

Figure 2.11: LED Off at Vin = 11.22V

Table IV shows the difference between experimental & simulation data. The LED Turn On-Off criterion is successfully satisfied.

Table IV

Simulation Turn-On Value	Hardware Turn-On Value	Criterion
11.2V	11.2V	Satisfied

Conclusion & Comments:

This experiment consisted of two parts: A and B. In part A, we were asked to measure the β value of a pnp-transistor BD136. In part B, we were asked to design a low-dropout (LDO) voltage regulator with an output current of 100mA. We used a zener diode (5.1V), two op-amp's (LM358) and a power pnp BJT (BD136) in the circuit. My output voltage is 10.5 Volts because of my ID number.

In part A, the β value was measured with a not-so-low error of 30%. The reasons for this huge error might be because of the corrupted structure of the BJT or some component or breadboard related issues.

In part B, we successfully managed to regulate Vout at 10.60V with no AC at the output. This was a **HUGE SUCCESS** in my opinion. I worked really hard to create the perfect circuit for the criterions specified in the manual. The error for the DC part of the regulation was 10mV. This was very well under the limits. I am very proud and satisfied with what I have done.

To conclude, the lab was a success. Errors were under the limits. Voltage regulator was successfully implemented. All 3 conditions were met.