Lab Report 4: Voltage Regulator Design on Breadboard

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Aim:

To design, implement, and analyze different types of voltage regulators on a breadboard, including:

- Zener diode shunt voltage regulator
- Fixed 5V regulator using LM7805
- Adjustable voltage regulator using LM317

and to study the line and load regulation characteristics of these circuits.

Components Used:

1. Zener diode (4.7V or 5.6V)
2. Resistors (various values)
3. Potentiometer (2k or 5k)
4. LM7805 voltage regulator IC
5. LM317 adjustable regulator IC
6. Breadboard
7. Connecting wires
8. Digital Multimeter (DMM)
9. DC Power Supply
10. Load resistors (10kΩ and variable)

Procedure:

Part A: Zener Diode Shunt Regulator

1. Connect the Zener diode circuit as shown in Figure 1.
2. Use an input voltage of 15V.
3. Refer to the diode datasheet and note the Zener voltage (V_Z) and Zener current (I_Z).
4. Calculate the biasing resistor using:

$$R_Z = \frac{V_{in} - V_Z}{I_Z + \frac{V_Z}{L}}$$

   where $L = 10k\Omega$ is the load.

5. Now select a resistor value R more than Rz (calculated).
6. Measure the output voltage using the DMM.
7. Record V_{out} for load values ranging from $L = 200\Omega$ to $L = 10k\Omega$ also try measuring without load ($L = \infty$)
8. Note the input current (i_{in}) in all cases.

Part B: Adjustable Regulator (LM317)

1. Connect the LM317 circuit as shown in Figure 3.
2. Use input $V_{in} = 15V$ and aim for output $V_{out} = 10V$.
3. Use the formula:

$$V_{out} = 1.25 \left(1 + \frac{R_2}{R_1}\right)$$

4. Implement $R_1 \approx 240\Omega$ and calculate R_2 accordingly, or use a potentiometer for tuning.
5. Adjust the potentiometer until the measured output reaches approximately 10V.
6. Record:
   - V_{out} with load ($10k\Omega$)
   - V_{out} with no load ($L = \infty$)
   - Input current (i_{in})
   - Voltage between Output and Adjust pins (expected $\approx 1.25V$)

Part C: Fixed Regulator (LM7805)

1. Build the LM7805 circuit as shown in Figure 2.
2. For **Line Regulation:**
   - Vary input voltage (V_{in}) from 0V to 15V in at least five steps.
   - Record the corresponding output voltage (V_{out}).
3. For **Load Regulation:**
   - Keep $V_{in} = 15V$ constant.
   - Vary load resistance (R_L) in at least five steps.
   - Record V_{out} for each R_L.

Circuit Diagrams:

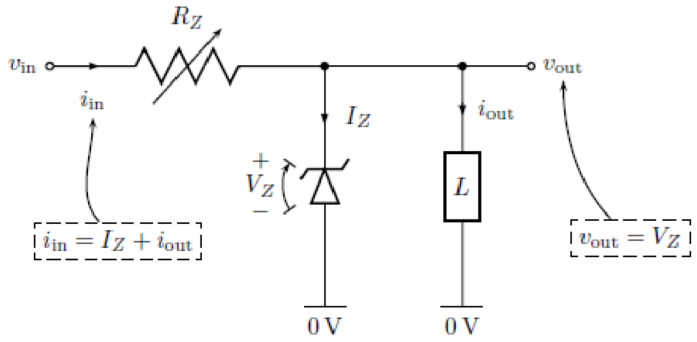
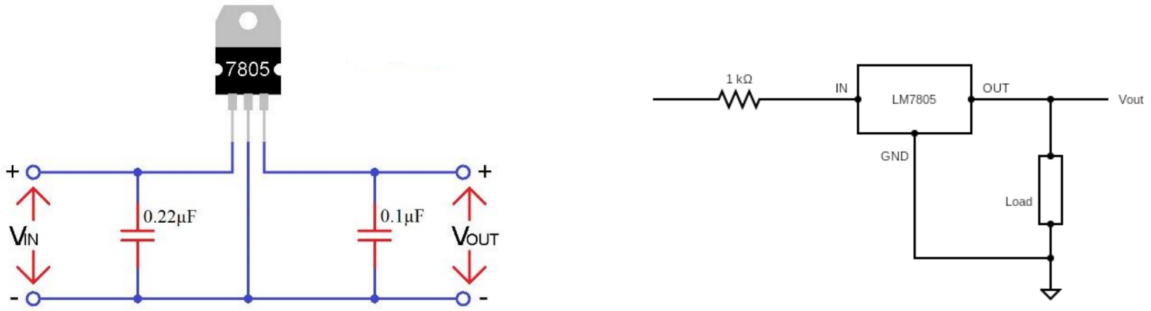


Figure 1: Zener diode shunt voltage regulator circuit.



(a) LM7805 Line Regulation Circuit (b) LM7805 Load Regulation Circuit

Figure 2: Fixed 5V voltage regulator using LM7805 for (a) line and (b) load regulation.

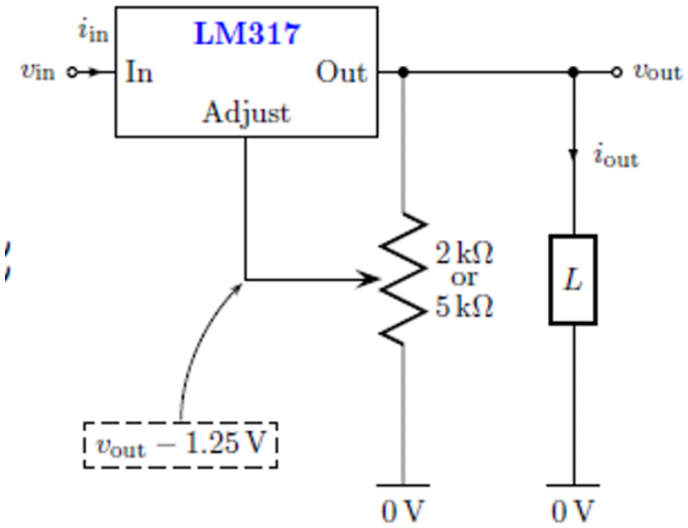
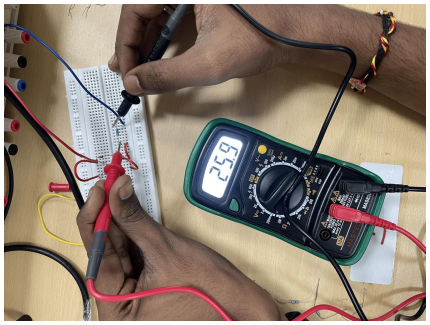


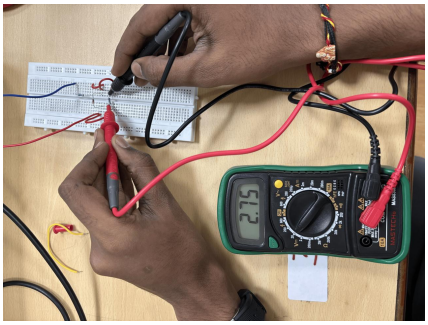
Figure 3: Adjustable voltage regulator using LM317.

Observation:

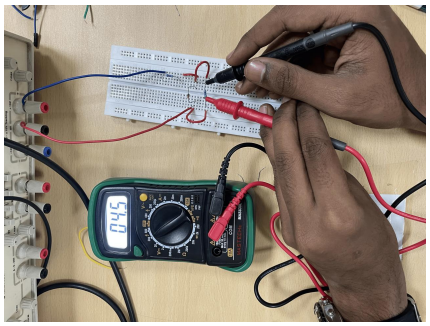
Zener Regulator Output:



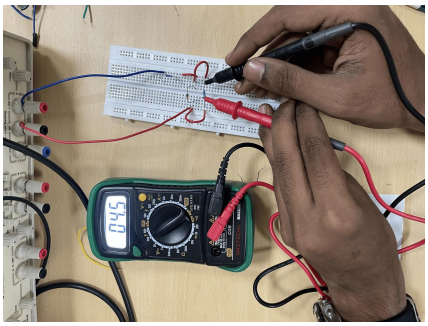
(a) Input (Case 1)



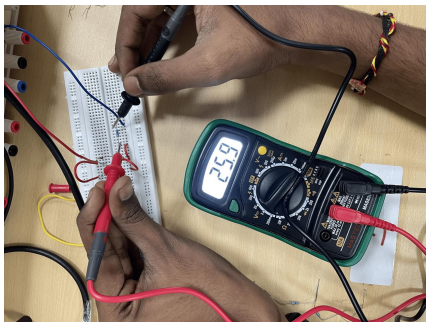
(b) Output (Case 1)



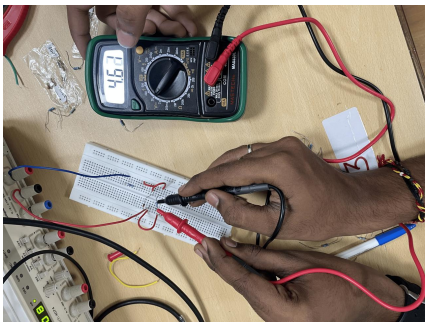
(c) Input (Case 2)



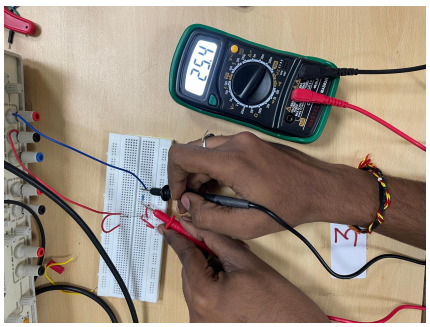
(d) Output (Case 2)



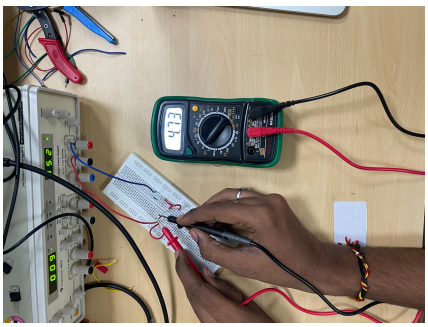
(e) Input (Case 4)



(f) Output (Case 4)



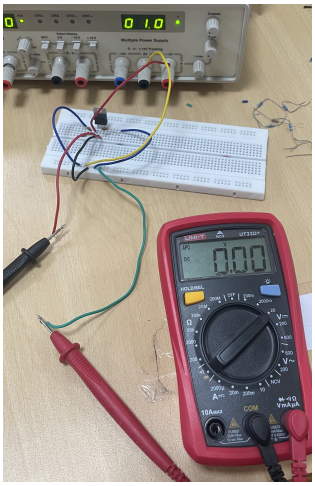
(g) Input (Case 5)



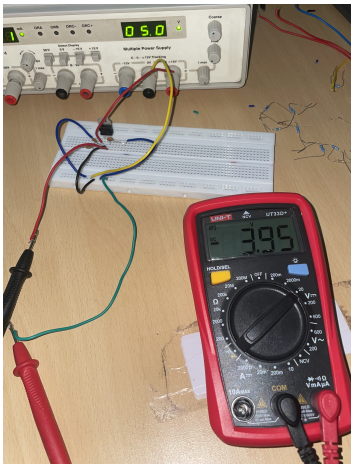
(h) Output (Case 5)

Figure 4: Experimental waveforms for Zener diode voltage regulator.

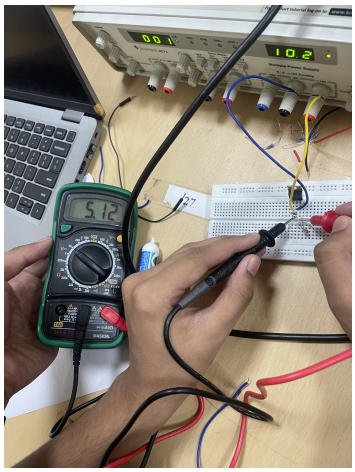
LM7805 Line Regulation:



(a) Line Regulation Setup 1



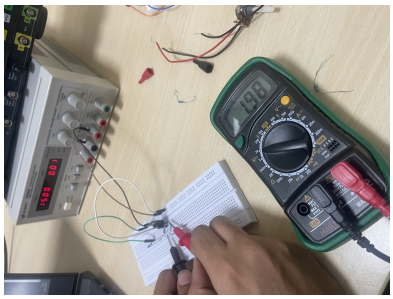
(b) Line Regulation Setup 2



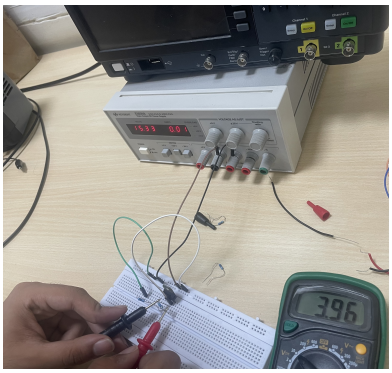
(c) Line Regulation Setup 3

Figure 5: LM7805 Line Regulation experimental setups.

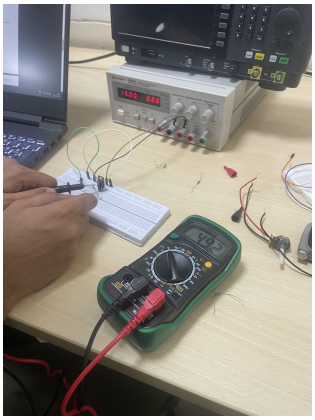
LM7805 Load Regulation:



(a) Load Regulation Setup 1



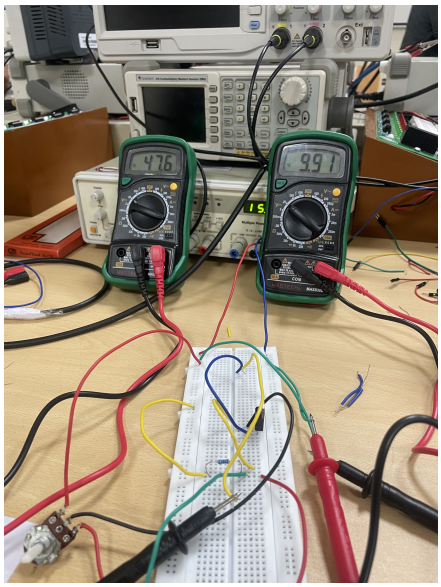
(b) Load Regulation Setup 2



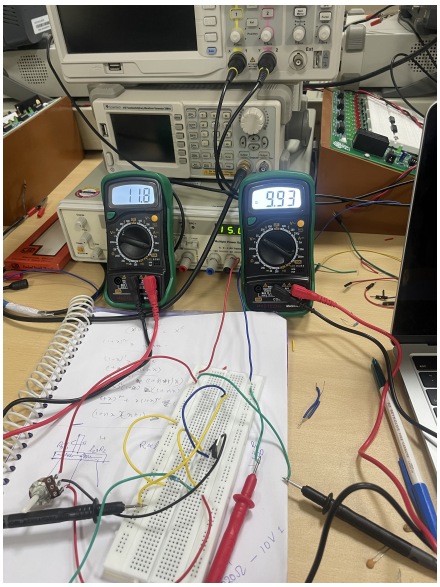
(c) Load Regulation Setup 3

Figure 6: LM7805 Load Regulation experimental setups.

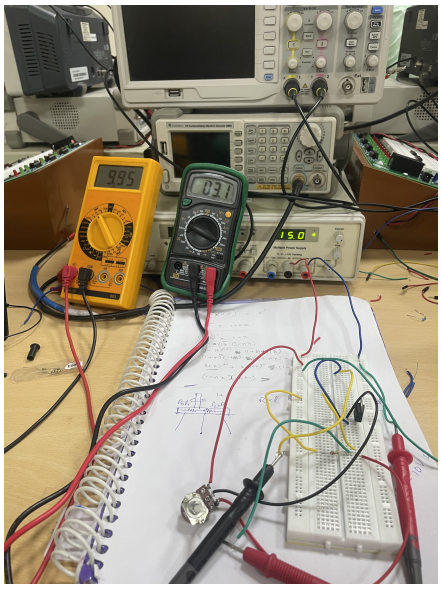
LM317 Adjustable Regulator:



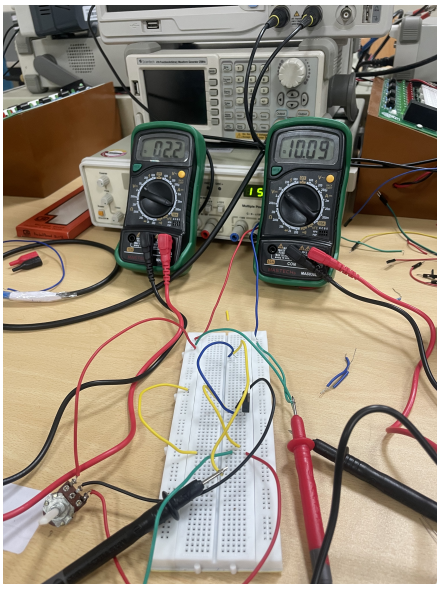
(a) LM317 Regulator Setup 1



(b) LM317 Regulator Setup 2



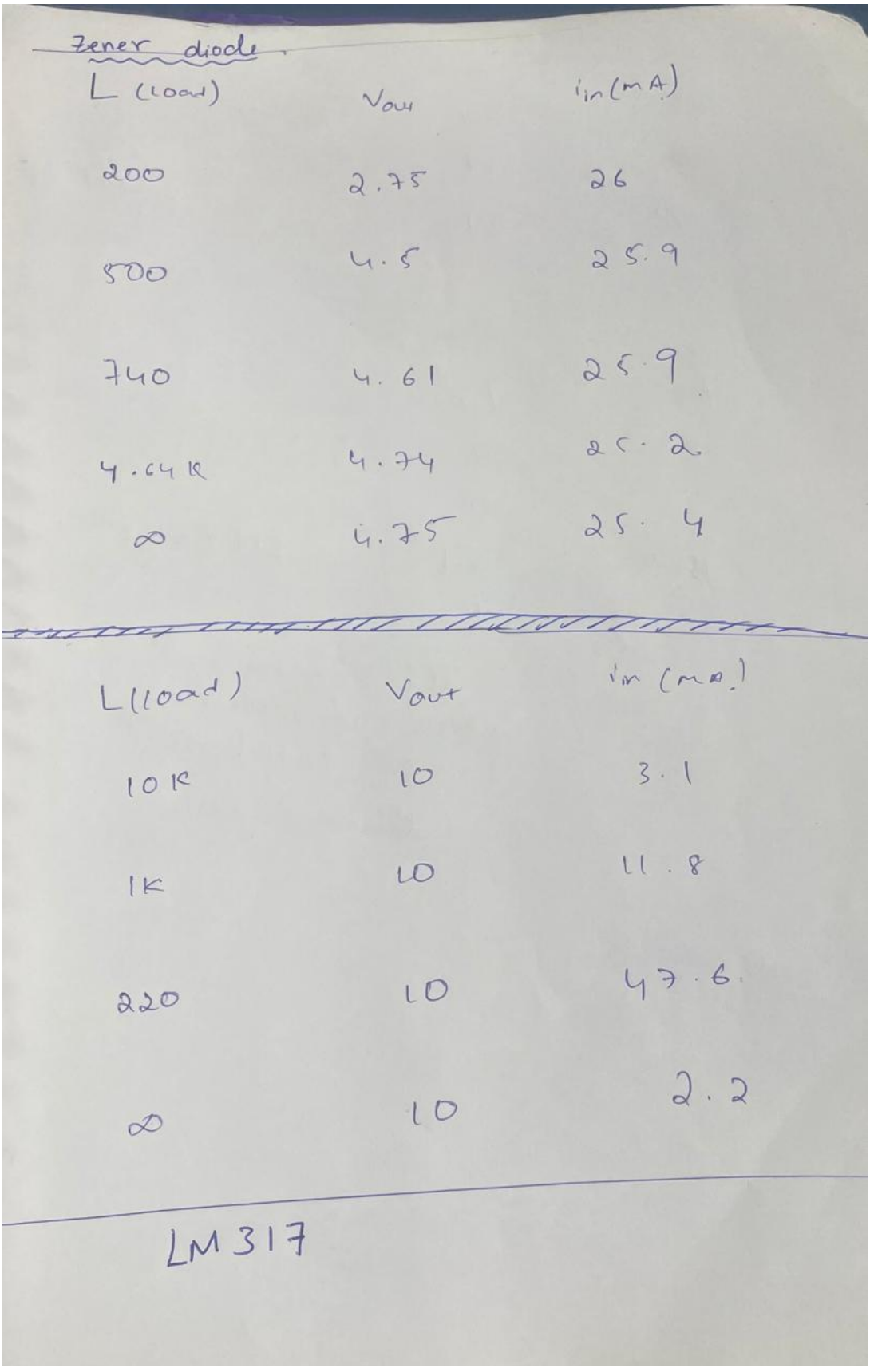
(c) LM317 Regulator Setup 3



(d) LM317 Regulator Setup 4

Figure 7: LM317 adjustable voltage regulator on breadboard.

Observation Tables:



Zener diode

L (load)	V_{out}	i_{in} (mA)
200	2.75	26
500	4.5	25.9
740	4.61	25.9
4.64 K	4.74	25.2
∞	4.75	25.4

L (load)	V_{out}	i_{in} (mA)
10 K	10	3.1
1K	10	11.8
220	10	47.6
∞	10	2.2

LM317

Figure 8: Observation Table 1: Zener and LM317 data.

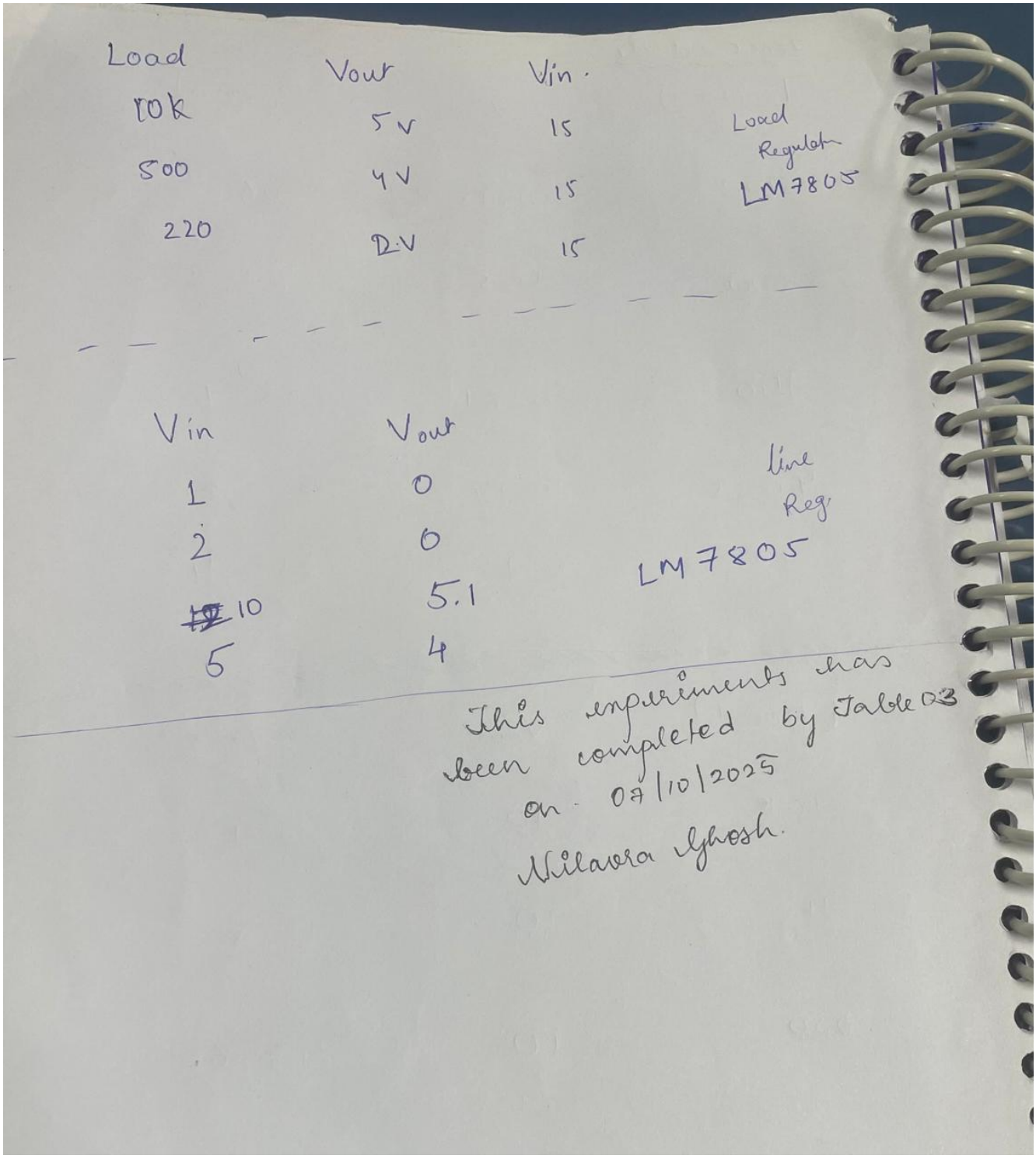


Figure 9: Observation Table 2: LM780 data.

Explanation:

Zener Diode Regulator:

A Zener diode maintains a nearly constant voltage (V_Z) across itself when reverse biased in breakdown region. The biasing resistor R_Z limits current and ensures the Zener remains in its regulation region.

$$R_Z = \frac{V_{in} - V_Z}{I_Z + \frac{V_Z}{L}}$$

At light loads (large L), most current flows through the Zener. At heavy loads (small L), less current flows through the Zener, and regulation worsens.

LM7805 Fixed Regulator:

The LM7805 maintains a fixed 5V output irrespective of input voltage or load changes (within limits). **Line regulation** measures change in V_{out} with varying V_{in}, and **Load regulation** measures change in V_{out} with varying load R_L. Ideally, both are small, showing stable regulation.

LM317 Adjustable Regulator:

The LM317 provides a variable output set by the external resistor divider:

$$V_{out} = 1.25 \left(1 + \frac{R_2}{R_1}\right)$$

It keeps about 1.25V between the output and adjust pins. By tuning R_2, a desired V_{out} is achieved. However, it requires a minimum voltage difference of $\approx 3V$ between input and output for proper operation.

Conclusion:

- Designed and implemented Zener, LM7805, and LM317 regulator circuits.
- Verified the regulation characteristics of each circuit.
- Observed that:
  - Zener diode gives basic regulation but less stability with varying load.
  - LM7805 provides excellent fixed 5V regulation.
  - LM317 allows adjustable voltage with good precision.
- Understood the concepts of line and load regulation.
- Minor deviations from theoretical values are due to component tolerances and measurement errors.

References:

- Lab manual: Voltage Regulator Design on Breadboard (Lab 4 Handout)
- Electronic Devices and Circuit Theory by Boylestad and Nashelsky
- LM7805 and LM317 datasheets