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EEE313 Lab Report 2

Introduction:

The aim of this experiment is to investigate voltage regulation concept by primarily focusing on using zener diode. Zener diode behaves as a regular didode during forward biasing, in other Word permits current flow up to a certain value of voltage. Compared to regular diodes brekadown voltage of zener diode is significantly low meaning that zener diode permits the current flow from n to p side if reverse voltage is applied. Zener diodes are vastly used in voltage regulation circuits. In these type of circuits there are two key concepts named as source regulation and load regulation. The ability of the circuit to provide constant voltage at the output as a reaction to changes in the input voltage while keeping other parameters constant is referred as source regulation. Load regulation focuses on providing a constant voltage at the output as a result of change in load resistance while other parameters remain constant. The following figure is the voltage regulation circuit that will be established in this lab.

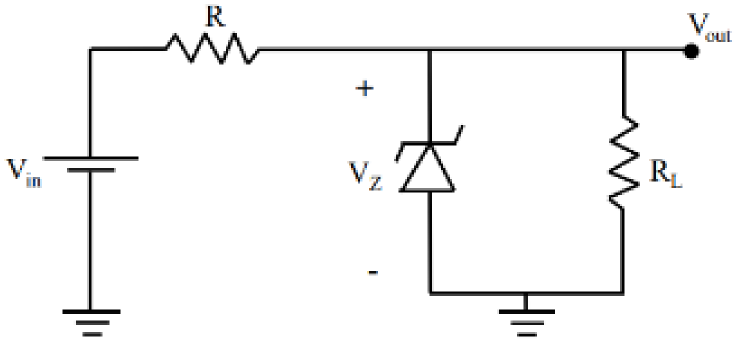

Fig1.1 voltage regulation circuit

It should be highlighted that p side of the zener diode is grounded which forces zener diode to operate in the breakdown voltage. In the breakdown state, zener diode maintains output voltage at its breakdown voltage by this way voltage regulation is achieved. This lab consists of 3 parts, in part a after determining the R value, current that passes through zener diode is calculated when 9V and 11V applied respectively. In part b and c source and load regulation concept is investigated.

Hardware Implementation and Analysis:

Part a

Objective is to determine such R that current through zener diode will be between 10mA-100mA. R_L value is specified as 500Ω and KCL equations for 9V and 11V is solved accordingly.

KCL with $V_{in} = 9V$

$$\frac{V_{out} - V_{in}}{R} + i_{zener} + \frac{V_{out}}{R_L} = 0$$

$$V_{in} = 9V, R_L = 500\Omega, V_{out} = 5.1V$$

$$i_{zener} = -\frac{5.1V - 9V}{R} - \frac{5.1V}{500\Omega}$$

$$10mA \le i_{zener} \le 100mA$$

$$10mA \leq -\frac{5.1V - 9V}{R} - \frac{5.1V}{500\Omega} \leq 100mA$$

$$35.39\Omega \leq R \leq 193.06\Omega$$

KCL with $V_{in} = 11V$

$$\frac{V_{out} - V_{in}}{R} + i_{zener} + \frac{V_{out}}{R_L} = 0$$

$$V_{in} = 11V, R_L = 500\Omega, V_{out} = 5.1V$$

$$i_{zener} = -\frac{5.1V - 11V}{R} - \frac{5.1V}{500\Omega}$$

$$10mA \leq i_{zener} \leq 100mA$$

$$10mA \leq -\frac{5.1V - 11V}{R} - \frac{5.1V}{500\Omega} \leq 100mA$$

$$53.53\Omega \leq R \leq 292.07\Omega$$

Combining two inequalities in order to have obtain an interval for R

$$53.53\Omega \leq R \leq 193.06\Omega$$

R is selected as 150Ω and circuit is impleented on breadboard as desired. The power supply generates a current which is displayed on the screen of the power generator. This value will be handy in calculating experimental values of i_{zener}.

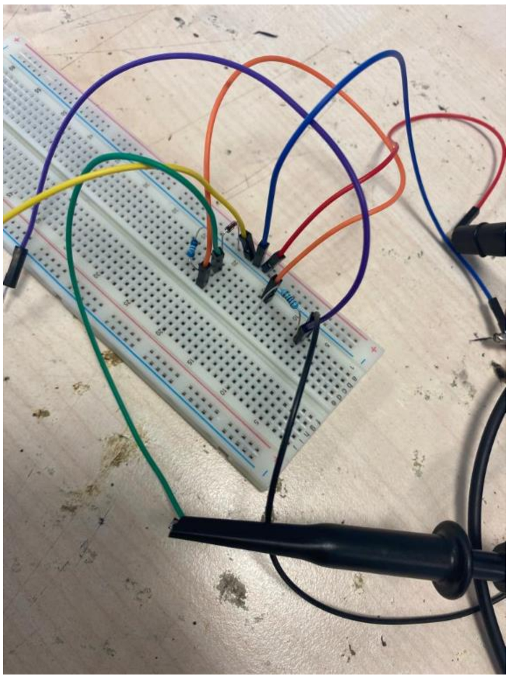

Fig2.1 hardware circuit

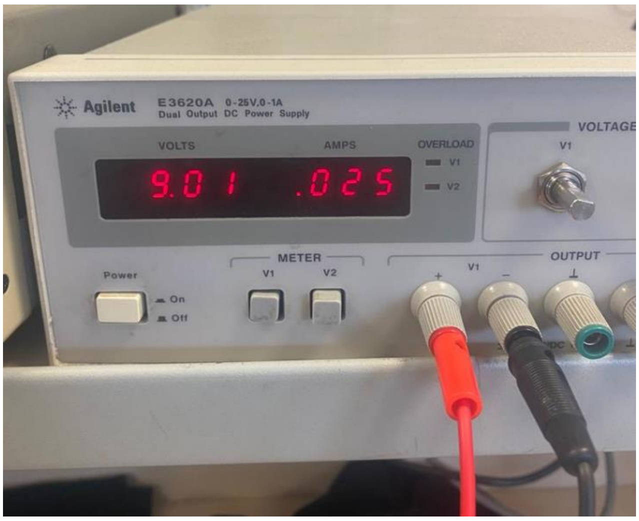

Fig2.2 9V signal generator input

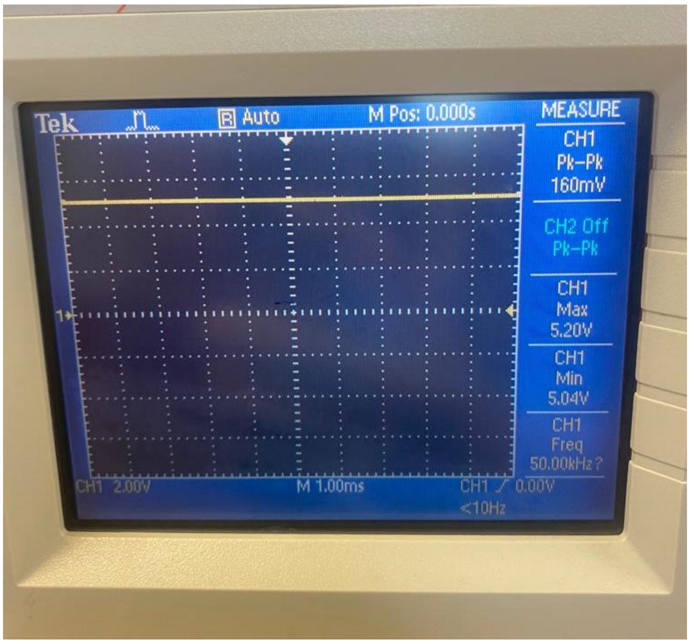

Fig2.3 signal at output node

$$i_{zener} = 25mA - \frac{5.20V}{500\Omega} = 14.6mA$$

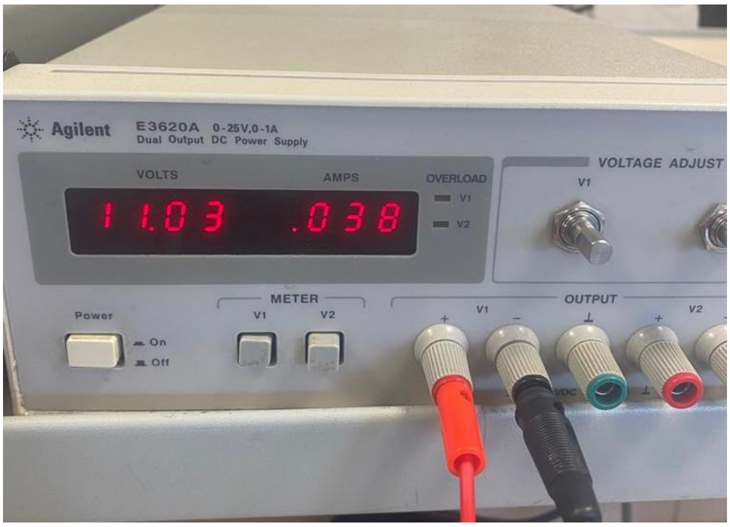

Fig2.4 11V input signal generator

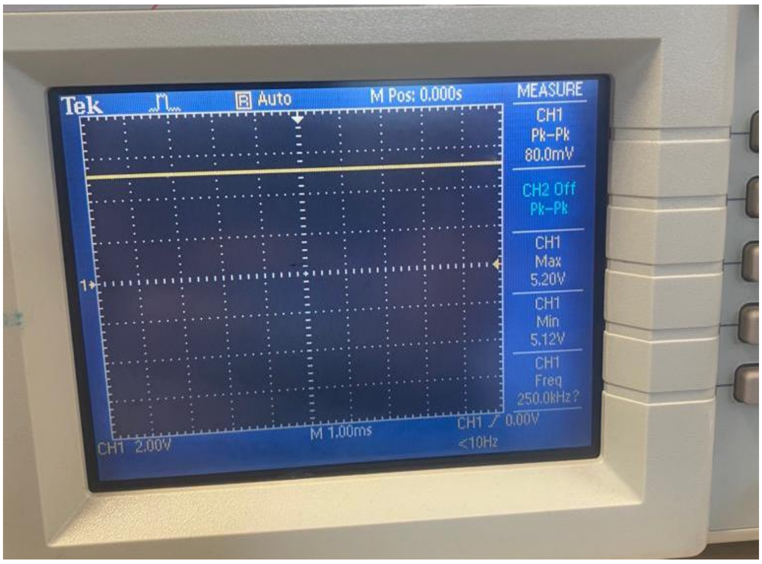

Fig2.5 signal at output node

$$i_{zener} = 38mA - \frac{5.20V}{500\Omega} = 27.6mA$$

Both of the i_{zener} values satisfy the inequality $10mA \leq i_{zener} \leq 100mA$ meaning that the circuit is operating as desired and the selected value of R is appropriate.

Part b

In this part input voltage is combination of AC and DC voltages where DC signal is equal to 9.5V, AC signal has an amplitude of 0.1V with a frequency of 100 Hz. It is important to notice that when AC signal is generated an internal serial impedance of 50Ω involves to the circuit hence, R is replaced with 100 Ω. The objective is to calculate source regulation of the circuit.

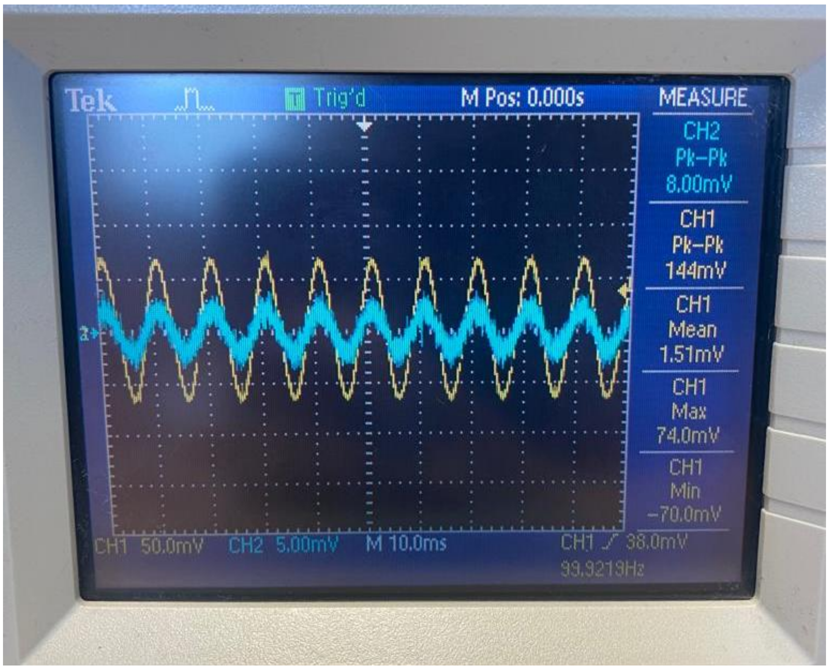

Fig3.1 input(yellow) vs output(blue)

Source regulation is calculated with the following formula.

$$\frac{\Delta V_{out}}{\Delta V_{in}}100 = \frac{8.00mV}{144mV}100 = \%5.55$$

The resistance of zener diode is calculated as following.

$$\Delta V_{out} = \Delta V_{in}\frac{r_z//R_L}{R + (r_z//R_L)}$$

Plugging in the values $r_z = 8.982\Omega$.

Since there is no theoratical r_z value is present value for SR can only be calculated experimantally by using experimental value of r_z.

Part c

In this part, the signal only consists of DC voltage with an amplitude of 10V. Since there is no serial impedance, R is replaced with the initial value which is 150Ω. Furthermore load resistance is replaced with 100Ω. The objective is to find theoratical and experimental values of load regulation of the circuit. Theoratical value is calculated accordingly.

$$\frac{(V_{noload} - V_{load})}{V_{noload}} * 100 = LR$$

With load:

$$\frac{-10V + V_{out}}{150\Omega} + \frac{V_{out} - 5.1V}{8.982\Omega} + \frac{V_{out}}{100\Omega} = 0$$

$$V_{out} = 4.957V$$

Without load:

$$\frac{-10V + V_{out}}{150\Omega} + \frac{V_{out} - 5.1V}{8.982\Omega} = 0$$

$$V_{out} = 5.377V$$

$$LR = \%7.811$$

Theoratical value is obtained as $= \%7.811$. Now experimental value is going to be investigated with 2 stages, with load and without load.

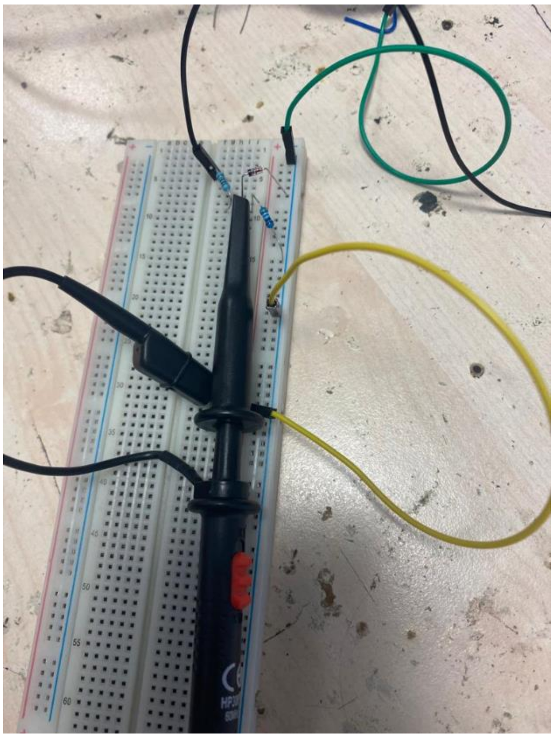

Fig4.1 hardware circuit with load

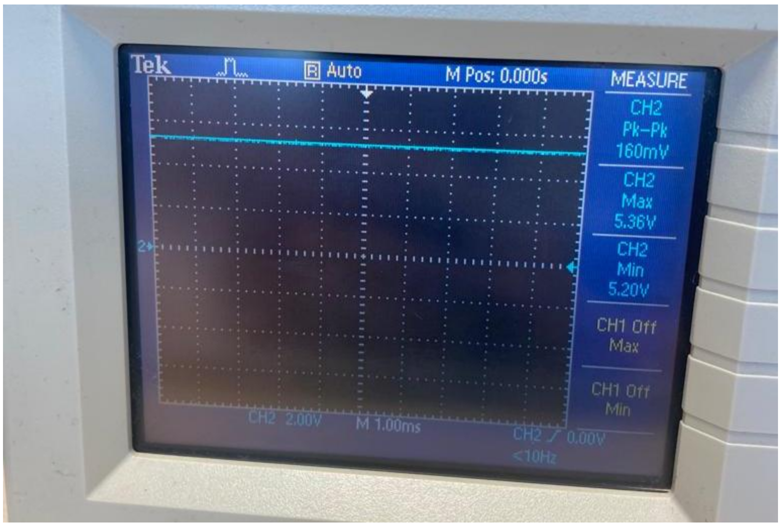

Fig4.2 output of the circuit with load

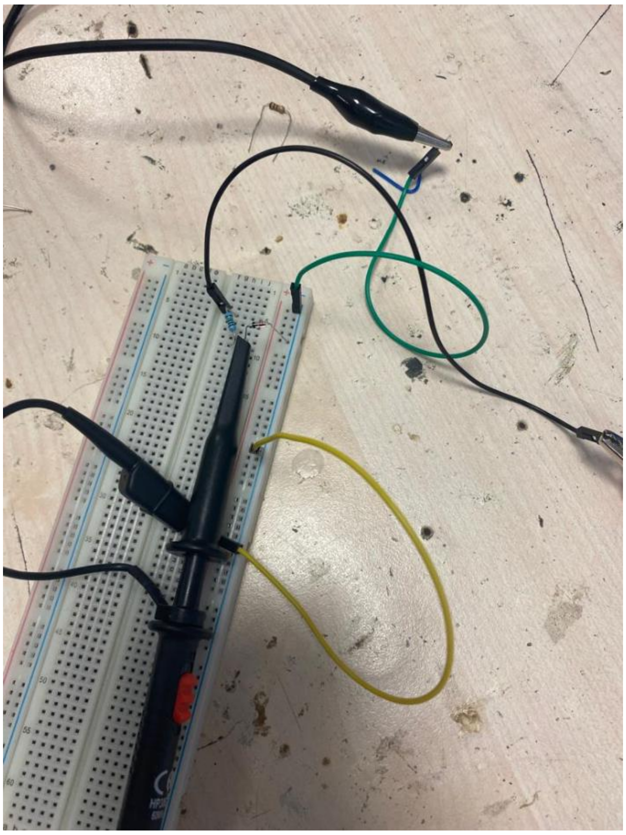

Fig4.3 hardware circuit without load

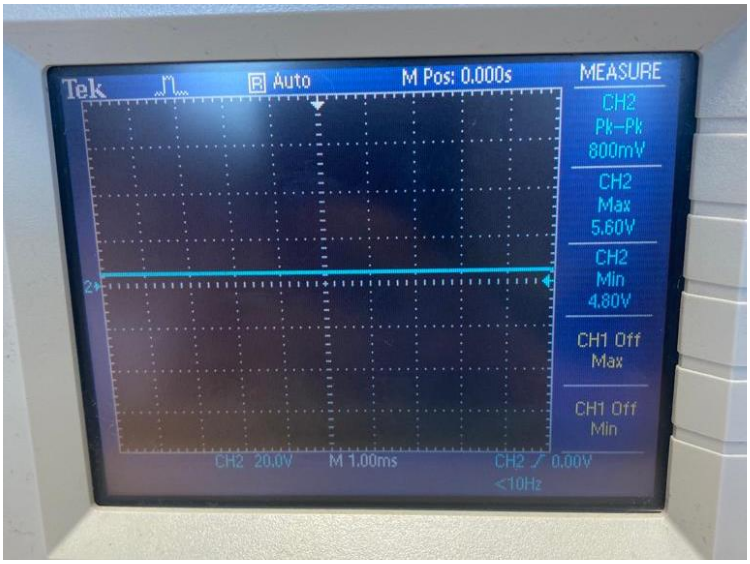

Fig4.4 output of the circuit without load

$$LR_{experimental} = \frac{(5.60V - 5.36V)}{5.60V} * 100 = \%4.285$$

Conclusion:

This lab work covers fundamental concepts of voltage regulatory circuits such as load regulation and soruce regulation. Throughout the lab work, a voltage regulatory circuit established by the zener diode is investigated hence besides gaining more insight about source and load regulation concepts, knowledge about zener diodes is also reinforced. As expected, there are some errors which can be observed in comparison of theoretical value and experimental value of load regulation. Errors may be a consequence of uncertainity of power generator, probe, oscilloscobe, or excessive resistance occured due to jumper cables. Overall the regulatory circuit operated as desired.

References:

[1] D. A. Neamen, Microelectronics: Circuit analysis and design, Fourth Edition. New York,