**Faculty of Engineering and Technology**

**ENEE3102, Electronics Lab.**

**Experiment #10 Report**

**Zener Diodes and Voltage Reulators**

**Name : Fadi Abughazaleh**

**ID# : 1141961**

**Abstract:**

The aim of this experiment is to examine voltage regulators of different kinds, and to test their functions while changing parameters in the circuits like the load or input resistance. Furthermore the characteristic of the Zener diode in forward and reverse bias was determined.

**Theory:**

Voltage regulators are circuits used to regulate voltage with small ripple into a constant DC output voltage. They are mainly used in the last stage of a DC power supply.

The simplest voltage regulator is a reverse biased Zener diode, which is the least effective voltage regulator. More complex voltage regulators involve transistors, these kinds can be split into many categories depending on a number of differences. First these regulators can be linear, meaning that their transistors operate in the active region. On The Other Hand they can be switching regulators which operate their transistors as switches, usually implementing a pulse width modulation to control the output voltage of the regulator. Second they can be categorized depending on how the transistor is connected with the load, either series or shunt. Third the voltage regulator can be made of discrete components, or it can be an integrated circuit. Finally if the regulator is an integrated circuit it could be used to give a fixed output voltage or an adjustable one. An example of a fixed output integrated circuit series linear voltage regulator is the 7805, which gives a fixed +5 DC volts output if the input does not drop below 7.3 volts.

The effectiveness of a voltage regulator can be determined by considering two quantities:

-Load Regulation: $\frac{ΔVo}{ΔIL}$ Which describes how the output voltage changes when the load draws more current.

-Line Regulation: $\frac{ΔVo}{ΔVi} $ Which describes how the output voltage changes when the input voltage changes.

**Procedure and results:**

**I.Zener Diode:**

The circuit in fig.(10-1) was connected, then the output voltage, resistor voltage and current were measured for different values of input voltage.



|  |  |  |  |
| --- | --- | --- | --- |
| **E(V)** | **VR(V)** | **VZ(V)** | **I(m A)** |
| **0.1** | 0 | 0 | 0 |
| **0.2** | 0 | 0 | 0 |
| **0.3** | 0 | 0.39 | 0 |
| **0.4** | 0.00053 | 0.438 | 0 |
| **0.5** | 0.0014 | 0.49 | 0 |
| **0.6** | 0.011 | 0.58 | 0 |
| **0.7** | 0.058 | 0.638 | 0.04 |
| **0.8** | 0.14 | 0.66 | 0.13 |
| **0.9** | 0.213 | 0.67 | 0.196 |
| **1** | 0.343 | 0.689 | 0.31 |
| **2** | 1.29 | 0.72 | 1.18 |
| **3** | 2.26 | 0.73 | 2.24 |
| **4** | 3.29 | 0.74 | 3.27 |

The Zener diode was then flipped as shown in fig.(10-2), the same measurements were taken, except for the resistor voltage.



|  |  |  |
| --- | --- | --- |
| **E(V)** | **VZ(V)** | **I(m A)** |
| **0.1** | 0.09 | 0 |
| **0.5** | 0.57 | 0 |
| **1** | 1.06 | 0.017 |
| **2** | 1.91 | 0.78 |
| **3** | 2.78 | 2 |
| **4** | 3.15 | 8.9 |
| **5** | 3.07 | 18.8 |
| **6** | 3.08 | 30.5 |
| **7** | 3.19 | 38.3 |
| **8** | 3.3 | 46.4 |
| **9** | 3.45 | 56.9 |
| **10** | 3.55 | 65.4 |
| **11** | 3.6 | 74.8 |
| **12** | 3.72 | 83.8 |
| **13** | 3.74 | 94 |
| **14** | 3.58 | 106 |
| **15** | 3.61 | 115 |



Figure 1 : Zener diode Characteristic

In fig.1 the measured characteristic of the Zener diode is drawn. It can be seen that when forward biased the Zener diode acts just like a normal diode it becomes on at about 0.7 volt allowing current to flow, and below 0.7 volt it acts like an open circuit. When reverse biased the Zener diode changes its voltage very slowly to the changing current through it; acting like a voltage regulator.

The circuit in fig.(10-3) was connected and then the output voltage was measured while changing the input voltage and then the load resistance.



|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| E | 10 | 11 | 12 | 13 | 14 |
| VL | 2.68 | 2.72 | 2.77 | 2.8 | 2.83 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| RL | 8.2k | 6.8k | 4.7k | 2.2k |
| VL | 2.67 | 2.67 | 2.67 | 2.65 |

When the input voltage is increased, the current flowing through the Zener increases thus increases the output voltage. On The Other Hand when the load resistance is reduced, the current flowing through the Zener decreases thus decreasing the output voltage; but this happens very slowly.

**II.The Voltage Regulated Power Supply:**

The circuit in fig.(10-4) was connected. The output current and voltage were measured while changing the load resistance.



|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| RL | open | 1k | 680  | 470  | 220  | 100  |
| Vo | 5.16 | 5.16 | 5.16 | 5.16 | 5.16 | 5.14 |
| Io[mA] | 0 | 5.1 | 7.4 | 10.7 | 23.29 | 50.3 |

RL was changed back to 1k, and R2 to 470, Vo = 8V. Then R2 was changed to 2.2k,

Vo = 3.73V.

The voltage output of this regulator changes very slightly when changing the load resistance, which indicates that it has a very low load regulation.

Then The circuit in fig.(10-5) was connected and the same procedure was followed.



|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| RL | open | 1k | 680  | 470  | 220  | 100  | 50  |
| Vo | 5 | 5 | 5.02 | 5.01 | 5.01 | 5.05 | 4.29 |
| Io[mA] | 0 | 4.9 | 7.26 | 10.4 | 22.5 | 49.6 | 83.13 |

When the current through Q1 exceeds the allowed Imax (Imax= Vbe/10) the second transistor becomes on and the current stays at that value. In this case Vbe seems to be 8.31 volts. Imax is 83.13 mA.

**III.Three Terminal Fixed Voltage Regulator 7805:**

The circuit in fig.(10-6) was connected. Then the output voltage and current were measured while changing the load resistance and then the input voltage.



For Vi=10 V

|  |  |  |
| --- | --- | --- |
| **RL(Ω)** | **VL(V)** | **IL(m A)** |
| **25** | 5.03 | 159.2 |
| **50** | 5.04 | 97.6 |
| **100** | 5.04 | 49.6 |
| **200** | 5.04 | 24.8 |
| **400** | 5 | 12.42 |
| **600** | 5.01 | 8.27 |
| **800** | 5.01 | 6.19 |
| **1000** | 5.01 | 4.9 |

Load regulation= $\frac{ΔVo}{ΔIL}$ ≈0

For RL=100 ohm

|  |  |  |
| --- | --- | --- |
| **Vi(V)** | **VL(V)** | **IL(m A)** |
| **8** | 4.95 | 49 |
| **9** | 4.95 | 49.3 |
| **10** | 4.95 | 49.3 |
| **11** | 4.95 | 49.3 |
| **12** | 4.95 | 49.3 |
| **13** | 4.95 | 49.3 |
| **14** | 4.95 | 49.3 |
| **15** | 4.95 | 49.3 |

Line Regulation=$\frac{ΔVo}{ΔVi} $ =0

Both the load- and line regulation are zero meaning that this voltage regulator is very effective.

**IV.The LM317 Adjustable Voltage Regulator:**

The circuit in fig.(10-7) was connected. The load current and output voltage were measured while changing the R2 resistance then the load resistance then the input voltage.



Vi=10 V, R1=100 ohm, RL=1k ohm

|  |  |  |
| --- | --- | --- |
| **R2(Ω)** | **VL(V)** | **IL(m A)** |
| **0** | 1.27 | 1.21 |
| **100** | 2.55 | 2.5 |
| **200** | 3.83 | 3.8 |
| **300** | 5.11 | 5.09 |
| **500** | 7.67 | 7.68 |
| **700** | 8.43 | 8.46 |

By changing R2 one is able to adjust the output voltage. The formula for the output voltage: $1.25 (1+\frac{R1}{R2})$ V.

R2=220 ohm, R1=100 ohm, RL=1k ohm

|  |  |  |
| --- | --- | --- |
| **Vi(V)** | **VL(V)** | **IL(m A)** |
| **10** | 4.08 | 4.06 |
| **12** | 4.08 | 4.06 |
| **14** | 4.09 | 4.06 |
| **15** | 4.09 | 4.06 |
| **16** | 4.09 | 4.06 |
| **17** | 4.09 | 4.06 |

Line Regulation=$\frac{ΔVo}{ΔVi} $ ≈0

The line regulation is zero meaning that this voltage regulator is very effective.

Vi=i0 V, R1=100 ohm, R2=220

|  |  |  |
| --- | --- | --- |
| **RL(Ω)** | **VL(V)** | **IL(m A)** |
| **100** | 4.05 | 39.68 |
| **200** | 4.06 | 20 |
| **400** | 4.05 | 10 |
| **500** | 4.06 | 8 |
| **600** | 4.05 | 6.66 |
| **700** | 4.06 | 5.7 |
| **1000** | 4.06 | 3.98 |

Load regulation= $\frac{ΔVo}{ΔIL}$ ≈0

The load regulation is zero meaning that this voltage regulator is very effective.

**Conclusion:**

The data obtained in this experiment agrees with the expected theoretical laws. Errors were present in this experiment due to imperfect devices and measurement tools, but they were negligible. The output voltage changes due to changes in the circuit-parameters indicated which voltage regulator is the best of the different voltage regulators. The IC voltage regulators (7805, 317) were seen as the best ones since they have perfect load- and line regulation; their output voltage does not depend on the load resistance or the input voltage to a certain degree.