Universidade do Vale do Itajaí
Computer Engineering
Basic Electronics

Seventh Assignment for Basic Electronics

Student: Lucas Mateus Gonçalves
Teacher Advisor: Walter Antonio Gontijo

September
2021

Universidade do Vale do Itajaí
Computer Engineering
Basic Electronics

Seventh Assignment for Basic Electronics

Seventh Assignment for Basic Electronics presented for the class of the Seventeenth of September, 2021.

Student: Lucas Mateus Gonçalves

Teacher Advisor: Walter Antonio Gontijo

September
2021

Conteúdo

1 Objective

The analysis of multiple electrical circuits containing `zener` diodes.

2 Introduction

This paper has the purpose of demonstrating and explaining voltage and power regulators using `zener` diodes.

2.1 `Zener` Diodes

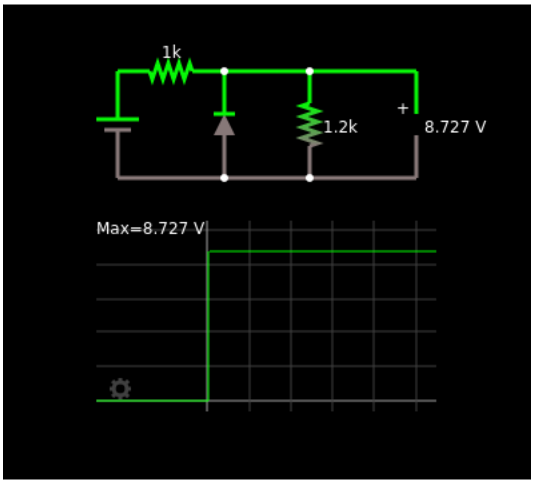
These types of diodes act much like silicon diodes, preventing backwards current, and filtering `AC` signals.

However the `zener` diode is meant to prevent over-voltage in the circuits therein. It is done by allowing some current to flow against the diode when the voltage is high enough.

The diode has a inherent `zener` voltage V_z where if the opposing voltage ever crosses the diode allows some current through to keep it at the `zener` voltage.

This way the peak voltage at the diode cathode never exceeds the `zener` voltage. However the current draw from the power source will increase with the extra voltage, as the diode is allowing current through it as if it were a resistor.

3 First Circuit



$V1_{DC} = 16V$ —— $V_{z_{breakdown}} = 10V$

V_z and *breakdown voltage* are the same when considering `zener` diodes.

In this circuit the current passing through the diode is $171.435nA$, the expected reverse current expected for silicon diodes in a similar arrangement.

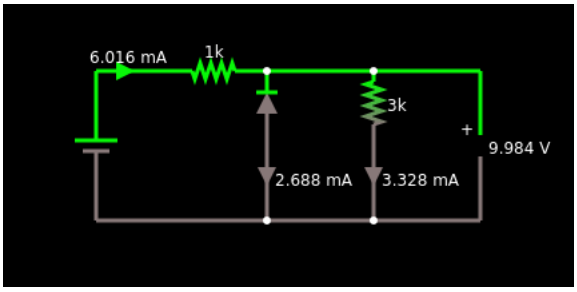
The diode is not conducting since the voltage potential at its nodes are below the V_z, as such it acts as an open circuit.

The total current of the circuit and the voltage at the nodes can be found if the circuit is calculated where the diode is an open circuit, this way the voltage at the nodes can be found and it can be know whether or not the diode is conducting.

$$I_{total} = \frac{16V}{1k\Omega + 1.2k\Omega} = 7.273mA$$

$$V_{1.2k\Omega} = 7.273mA \times 1.2k\Omega = 8.727V$$

4 Second Circuit



$V1_{DC} = 16V$ —— $V_{z_{breakdown}} = 10V$

With the increased resistance the voltage at the nodes, if the diode wasn't present would be as such.

$$I_{total} = \frac{16V}{1k\Omega + 3k\Omega} = 4mA$$
$$V_{3k\Omega} = 4mA \times 3k\Omega = 12V$$

Since $12V > 10V$ the diode conducts to try and contain the voltage below the V_z.

Since one will know the V_z value, the current in the resistors can be found as such.

$$I_{3k\Omega} = \frac{V_z}{3k\Omega} = \frac{10}{3000} = 3.33mA$$

The equation works because the voltage at the entry node of the resistor will never pass $10V$, since the diode will conduct accordingly to maintain the V_z.

Knowing the current at the load resistor, the current on the diode can be found when the current at the current limiting resistor is found.

The current limiting resistor, in this case the $1k\Omega$ resistor serves to not allow too much current through the `zener` diode, as it will allow any current through itself to maintain the V_z, it could explode like a short circuit if not kept safe.

The voltage at the current limiting resistor is as follows.

$$V_{1k\Omega} = V_{DC} - V_{3k\Omega} = 16V - 10V = 6V$$

With it the total current of the circuit can be calculated since this resistor is in series with the supply, and all current goes through it.

$$I_{1k\Omega} = \frac{V_{1k\Omega}}{1k\Omega} = \frac{6V}{1000\Omega} = 6.01mA$$

And by knowing all currents the diode current can be found as follows.

$$I_z = I_{1k\Omega} - I_{3k\Omega} = 6.01mA - 3.33mA = 2.688mA$$

And very importantly, as to know how much power the diode will have to dissipate in this circuit, the power calculation is as follows.

$$P_z = V_z * I_z = 10V * 2.688mA = 26.7mW$$

$26.7mW$ is a serious power dissipation, hence there needs to be great care to know which diode one would need.

However these diodes shine better at filtering out ripple voltages instead of limiting `DC` supplies, as that would be better suited to bigger and heftier *linear voltage regulators*. As such, the power dissipation will be lowered to the $V_{avg_{DC}}$ of the ripple signal to be filtered.

5 Conclusion

This type of diode is useful for filtering ripple voltages and regulating power. Tough the the diode cannot handle too much power regulation as the power dissipation might overwhelm the small component and destroy it, it serves well for small regulations.

The regulator requires a current limiting resistor in series with the regulation path in the circuit which causes power loss through it, but keeps the diode from shorting circuiting the power supply.