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Zener diode problems pdf

The word bias is the ultimate social double-edged sword. If you are saying the right things, or look a certain way, or your athletic gifts are impressive enough, people will promote a (forward) favorable bias towards you. However, if you falter in any way within the previously mentioned parameters, then people will develop a (reverse) or unfavorable bias towards you. Depending on which of the discussed parameters you achieved your favorable bias, your proverbial career, lifestyle, or life as you know it could be over if people develop an unfavorable bias towards you. This is basically how a diode interacts with voltage. In a standard diode, we all know that current flows typically in one direction. Also, once that voltage exceeds the acceptable parameters of a standard diode, it equates to irreparable damage. However, that is not the case for a Zener diode because when the reverse-voltage reaches a pre-set value, the Zener diode begins to conduct in the reverse direction. Now, if only there were a Zener diode app that could save some of these celebrities and athletes from themselves. What is a Zener Diode? Within the parameters of standard operation, a general-purpose diode will block the reverse flow of current, and it usually succumbs to premature breakdown or damage if the reverse voltage applied becomes in excess of its limits. Although, as previously discussed, the Zener diode is essentially the same as a standard PN junction diode, they are specially designed to have a low and specified reverse breakdown voltage. This, in turn, allows Zener diodes to take full advantage of any reverse voltage applied to it. In essence, a Zener diode performs just like a standard general-purpose diode consisting of a silicon PN junction, and thus when biased in the forward direction, it behaves just like a standard diode passing the rated current. However, unlike a traditional diode that blocks any flow of current through itself when reverse biased, as soon as the reverse voltage reaches the pre-determined value, the Zener diode begins to conduct in the reverse direction. Note: Forward bias means that the Anode is positive in reference to its Cathode, whereas Reverse bias implies that the Cathode is more positive than the Anode. What is the Zener Voltage of a Zener Diode? In terms of a definition, a Zener diode's breakdown voltage is the same as the Zener Voltage (VZ) when it is connected to a circuit and in reverse bias. In summary, the voltage point at which the voltage across the Zener diode becomes stable is called the Zener voltage, which ranges from less than a volt to hundreds of volts. This is important because once the voltage across a Zener diode exceeds its breakdown voltage, the voltage across the Zener remains constant. This means that even if the current going through the diode continues to increase, the voltage remains the same. Due to the Zener diode's ability to hold its Zener voltage at a stable and constant level, it has enormous potential in circuit applications, especially in terms of voltage regulation. Zener diodes are immensely helpful for voltage regulation. The Characteristics of a Zener Diode Characteristically speaking, if a Zener diode is in forward bias or the reverse bias voltage is less than the breakdown voltage, it operates like an ordinary diode. In other words, in reverse bias, it blocks current, and in forward bias, it permits current to flow. Also, once this voltage surpasses the breakdown point (in reverse bias), the diode enters the Zener region, where it conducts without experiencing damage. Furthermore, the current within this region is called avalanche current and is called Zener current when referring to a Zener diode. Moreover, the moment the voltage begins to decrease, the diode retains its non-conducting condition like a standard diode. The Zener diode's specific and characteristic property of being operational in the reverse bias is due to the rich doping of its semiconductor material. Furthermore, you can set the breakdown voltage by controlling the thickness of the depletion region in the PN junction and the amount of doping (semiconductor material). Applications for Zener Diodes The Zener diode is often in use as a voltage regulator, primarily because the voltage drop across the diode is constant. Furthermore, the supply voltage must exceed the Zener voltage for the circuit to operate. Thereby, any electronic component connected in parallel with these diodes will have the same applied voltage. Moreover, it is as a voltage regulator where a Zener diode finds its ideal application in terms of functionality meets requirements. This is not only due to its ability to produce a stable voltage output but also because it does so with low ripple while under varying load current conditions. With just a small amount of current through the diode from a voltage source, via a suitable current limiting resistor, the Zener diode will conduct sufficient current necessary to sustain a voltage drop of Vout. Note: Regarding ripple; keep in mind that the DC output voltage from say a half or full-wave rectifier contains ripple superimposed onto the DC voltage, and that as the load value changes, so too does the average output voltage. However, by connecting a simple Zener stabilizer circuit across the output of the rectifier, we can obtain a more stable output voltage. Other common uses of Zener diodes include surge protectors (voltage spikes) and in random number generator programs due to the distinct noise they generate within the avalanche breakdown region. The Characteristic Curve of a Zener Diode In a Zener diode, the current that flows through it increases intensely until it reaches its maximum circuit value. However, under normal circumstances, this current is limited by a series resistor. Furthermore, upon reaching it's maximum, this reverse saturation current remains relatively consistent throughout an expanded range of reverse voltages. Also, it is possible to control the necessary voltage required to trigger current flow in a Zener diode, to a degree of less than 1% tolerance. Furthermore, this occurs within the doping stage of the diodes semiconductor construction, giving the diode a specific Zener breakdown voltage (Vz), for example, 5.2V or 8.4V. Graphically speaking, the Zener breakdown voltage on the IV curve is almost a vertical straight line. The Zener voltage is an essential aspect of what makes the Zener diode special. The ability to perform like two different components gives the Zener diode a laundry list of useful applications. However, as I stated earlier, the ideal use seems to be in the field of voltage regulation, where the uniqueness of its Zener voltage is most useful. It almost defies logic that a diode can safely conduct in reverse bias, but science is all about challenging what is possible. Utilizing smart SPICE technology can enable circuit design with Zener diodes efficiently and effectively. First, by starting with a model library of over 34,000 pieces, you're bound to have a large sample size of readily available Zener diodes to choose from. By running transient simulations, you can determine expected output and breakdown voltages for your diodes, as well as determine series resistances or capacitance. Implement proper Zener voltage strategies for all of your PCB designs with Cadence's suite of design and analysis tools. With any kind of Zener diode usage, OrCAD PSpice Simulator can be certain to map any necessary breakdown voltages clearly and accurately. If you're looking to learn more about how Cadence has the solution for you, talk to us and our team of experts. Cadence PCB solutions is a complete front to back design tool to enable fast and efficient product creation. Cadence enables users accurately shorten design cycles to hand off to manufacturing through modern, IPC-2581 industry standard. Follow on LinkedIn Visit Website More Content by Cadence PCB Solutions In our previous topics relating to diodes, we've discussed the operation of a Zener diode as well as its important specifications. We've learned that a Zener diode is a special-purpose diode which works as a normal diode when forward biased but also permits current to flow when reverse biased, if its Zener voltage is surpassed. When its Zener voltage is surpassed, it maintains a stable reference voltage across it. With this characteristic, Zener diodes are often used as a simple voltage regulator and we'll go over the practical usage of Zener diodes in this way.What is a Voltage Regulator?A voltage regulator is a device or a circuit with the purpose of creating a specific voltage while minimizing output variations with respect to variations in input, temperature, and load requirements. The most common use of a regulator are in power supplies, but any circuit that incorporates regulatory technique to give a controlled output or function can be considered as a regulator. Simply put, a regulator "regulates" the voltage to provide a constant DC voltage across the load.Zener Equivalent CircuitWhen a Zener diode is used as a voltage regulator, ideally, it has a constant voltage drop equal to its nominal Zener voltage. This constant voltage drop across the Zener diode produced by reverse breakdown is represented by a DC voltage symbol (figure 1) even though the Zener diode does not produce a voltage. An ideal characteristic curve of the Zener diode is also shown below. (figure 2) Figure 1. Zener diode (ideal model) represented by a DC voltage symbol. Figure 2. Zener diode (ideal model) characteristic curve.However, in reality, there exists a Zener impedance ZZ and the actual voltage curve is not perfectly vertical. There is a change in Zener current ΔIZ that produces a small change in Zener voltage ΔVZ. By Ohm's law, the Zener impedance is equal to the ratio of ΔVZ to ΔIZ.ZZ is usually specified at the Zener test current. Most of the time, ZZ is a small constant over a full range of Zener current values. However, if the Zener diode is operated near the knee of the curve, the Zener impedance changes drastically. Therefore, it's better to operate the Zener diode beyond the knee of the curve to get a more stable Zener impedance. Below is the practical model and characteristic curve of a Zener diode with its Zener impedance taken into account. Figure 3. Zener Diode (Practical Model). Figure 4. Zener diode (practical model) characteristic curve.Using Zener Diode as a Voltage RegulatorAs mentioned, when a reverse bias that is equal or above the Zener voltage is applied to the Zener diode, the diode can maintain a stable voltage across it. With this characteristic, Zener diodes are used to regulate voltage in some circuits. The Zener diode voltage regulator is very economical as it is very inexpensive, simple and easy to build.Before you build your own voltage regulator using Zener diodes, here are some important parameters to be considered. These parameters can be found in the datasheet, so it is very important to look at the datasheet of your Zener diode to ensure proper operation. 1. First, take note of the Zener diode's rated breakdown voltage or Zener voltage. In the datasheet, it is denoted as VZ. This parameter specifies the amount of reverse-biased voltage that causes the diode to conduct current. For the diode to operate, the voltage applied across the Zener diode must be equal or greater than VZ. 2. Second, make sure that the minimum current IZK is exceeded. This is to keep the diode in breakdown for voltage regulation. It is not recommended to operate the Zener diode near the knee current because of the effect of Zener impedance. 3. Third, see to it that you do not exceed the maximum current IZM. Exceeding IZM may damage the Zener diode.Drawbacks of a Zener Diode Voltage RegulatorThough Zener diodes are used as voltage regulators, they have a low efficiency for heavy load currents. It is because if the load current is large, there will be considerable power loss in the series limiting resistance (Rs). When the power dissipated on Rs exceeds its power rating, this will eventually damage the resistor. This is a common problem of a Zener diode voltage regulator. Also, in reality the output voltage slightly varies due to Zener impedance as Vout = VZ + IZ ZZ. Changes in load current produce changes in Zener current. Consequently, the output voltage also changes. Therefore, the use of this circuit is limited to only such applications where variations in load current and input voltage are small. In general, Zener diode regulators can provide a reasonably stable DC voltage at the output, but they are not particularly efficient. Its regulating ability is somewhat limited by the change in Zener voltage over a range of current values, which restricts the load current that it can handle. For this reason, they are limited to applications that require only low current to the load. To achieve better regulation and provide for greater variations in load current, the Zener diode is combined as a key element with other circuit components to create a 3-terminal linear voltage regulator.Hopefully this theoretical yet practical overview of Zener diodes is helpful and either gives you a good foundation for further usage of Zener diodes or clarifies some questions that you've had! If you have questions, please leave it in the comments below. See you in our next tutorial!

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