

**Answer the following questions (10 points each)**

**1.What is the difference of forward and reverse biased the characteristic curve of a Zener diode.**

A Zener diode is a special type of diode that is designed to operate in the reverse breakdown region, where it exhibits a very sharp breakdown voltage. When a Zener diode is reverse biased, it allows a small amount of current to flow through it until a certain voltage, called the Zener voltage, is reached. At this voltage, the Zener diode begins to conduct current more freely, and this current can flow through the diode without causing damage.

In summary, the main difference between the forward and reverse biased characteristic curves of a Zener diode is that the forward biased curve behaves like a regular diode, while the reverse biased curve shows a sharp increase in current at the Zener voltage, followed by a relatively constant current.

**2.Explain the difference of Zener voltage, current, power rating, voltage tolerance and Zener resistance.**

Zener diodes are specialized diodes that are designed to operate in the reverse breakdown region, where they exhibit a sharp and predictable breakdown voltage known as the Zener voltage. Here are the differences between the various parameters associated with Zener diodes:

1. **Zener Voltage:** The Zener voltage is the reverse breakdown voltage of a Zener diode, which is the voltage at which the diode starts conducting in the reverse direction. The Zener voltage is a key characteristic of Zener diodes, and it is specified by the manufacturer. The Zener voltage is typically in the range of a few volts to several hundred volts.
2. **Zener Current:** The Zener current is the current that flows through a Zener diode when it is operating in the breakdown region. The Zener current is determined by the voltage applied across the diode and the Zener resistance of the diode. The Zener current is typically specified by the manufacturer for a given Zener voltage.
3. **Power Rating:** The power rating of a Zener diode is the maximum power that the diode can safely dissipate without being damaged. The power rating of a Zener diode is determined by its physical size, its thermal characteristics, and the ambient temperature. Exceeding the power rating can cause the diode to fail or become permanently damaged.
4. **Voltage Tolerance:** The voltage tolerance of a Zener diode is the maximum deviation from the specified Zener voltage that is allowed. The voltage tolerance is typically specified as a percentage of the Zener voltage, such as  $\pm 5\%$  or  $\pm 10\%$ . A lower voltage tolerance indicates a more precise Zener voltage and is desirable in applications where accurate voltage regulation is required.
5. **Zener Resistance:** The Zener resistance is the dynamic resistance of a Zener diode when it is operating in the breakdown region. The Zener resistance varies with the applied voltage and the Zener current. The Zener resistance is an important parameter because it affects the stability and accuracy of the Zener diode as a voltage regulator. A lower Zener resistance is desirable because it results in a more stable and accurate voltage regulation.

### **3.Enumerate the safety precaution in using Zener diode.**

Zener diodes are generally safe to use as long as the user follows certain safety precautions. Here are some of the key safety precautions to keep in mind when using Zener diodes:

1. Observe the datasheet: The datasheet of the Zener diode provides important information about its specifications, including the maximum voltage, current, power rating, and operating temperature. Before using a Zener diode, carefully read its datasheet to ensure that you are using it within its safe operating limits.
2. Use appropriate protective gear: When working with Zener diodes, it is recommended to wear appropriate protective gear, such as safety glasses or goggles, to protect your eyes from any potential damage caused by the diode's breakdown or failure.
3. Proper handling and storage: Zener diodes are sensitive electronic components, and they should be handled and stored with care to prevent damage. Avoid dropping or mishandling the diode, and store it in a clean and dry environment.
4. Proper circuit design: When designing a circuit that uses Zener diodes, ensure that the circuit is properly designed and the Zener diode is correctly connected to prevent any potential damage to the diode or the circuit.
5. Current limiting resistor: Zener diodes should always be used with a current limiting resistor to limit the current flowing through the diode and prevent it from being damaged due to excessive current.
6. Use appropriate heat-sinks: When using Zener diodes in high power applications, it is important to use appropriate heat-sinks to dissipate the heat generated by the diode and prevent it from overheating or being damaged.

By following these safety precautions, you can safely use Zener diodes in your electronic projects and applications.

### **4.How to test Zener diode if it's still working or not?**

To test a Zener diode and determine if it is still working or not, you can use a multimeter in the following steps:

1. Set the multimeter to the diode test mode or to the resistance mode.
2. Connect the black (negative) probe of the multimeter to the cathode of the Zener diode (the end with the bar), and the red (positive) probe to the anode (the end without the bar).
3. Check the reading on the multimeter. If the Zener diode is working properly, it should have a reading close to its specified Zener voltage, which is typically indicated on the diode's datasheet.
4. If the reading is close to zero, the diode may be shorted, indicating that it has failed. If the reading is close to the supply voltage, the diode may be open, indicating that it is not conducting and has failed.
5. Reverse the probes and measure again. The reading should now be close to infinity, indicating that the diode is not conducting in reverse bias.
6. If the readings obtained are significantly different from the specified Zener voltage, or if there is no reading at all, the Zener diode may be faulty and should be replaced.

It is important to note that the multimeter test only checks if the Zener diode is conducting and within its specified voltage range, and it does not check the diode's actual breakdown voltage or its stability under varying conditions. Therefore, it is recommended to use a more advanced testing method or equipment, such as a curve tracer, to check the Zener diode's performance and characteristics more accurately.

### **5.What are the operating limits of Zener diode and how it is being determine?**

The operating limits of a Zener diode are determined by its datasheet, which provides information on its electrical specifications and characteristics. Here are some of the key operating limits of a Zener diode and how they are determined:

1. Zener voltage: The Zener voltage is the voltage at which the diode begins to conduct in reverse bias and maintain a constant voltage across its terminals. This voltage is determined by the diode's doping concentration and can be specified by the manufacturer in the datasheet.
2. Maximum power dissipation: The maximum power dissipation of a Zener diode is the maximum amount of power that can be dissipated by the diode without causing it to overheat or fail. This value is determined by the diode's construction and thermal characteristics and is typically specified in the datasheet.
3. Maximum current: The maximum current of a Zener diode is the maximum amount of current that can flow through the diode without causing it to overheat or fail. This value is determined by the diode's construction and is typically specified in the datasheet.
4. Voltage tolerance: The voltage tolerance of a Zener diode is the maximum deviation of the actual Zener voltage from the specified Zener voltage. This value is typically specified as a percentage of the specified Zener voltage in the datasheet.
5. Temperature range: The temperature range of a Zener diode is the range of temperatures over which the diode can safely operate without being damaged or failing. This range is determined by the diode's thermal characteristics and is typically specified in the datasheet.

It is important to ensure that the Zener diode is operated within its specified limits to avoid damage or failure. The operating limits can be determined by referring to the datasheet provided by the manufacturer.

### **EXTEND**

**1.Based on what you have learned in this module about Zener diode, it is used as voltage regulator or stabilizer is a circuit that provides a stabilized and constant voltage even if the source voltage fluctuates or spikes. How can you relate this in onboard ship application knowing that control circuits have different voltage rating? (50 Points)**

Zener diodes can be used as voltage regulators or stabilizers in onboard ship applications to provide a constant voltage to control circuits, even if the source voltage fluctuates or spikes. Control circuits on a ship may have different voltage ratings, and it is important to ensure that the voltage supplied to these circuits is within their specified voltage range.

Zener diodes can be used in voltage regulation circuits to provide a stable voltage output that is independent of the input voltage. By selecting a Zener diode with a Zener voltage equal to the desired output voltage, the Zener diode will maintain a constant voltage across its terminals as long as the input voltage is above the Zener voltage. This can help to protect the control circuits from voltage fluctuations and spikes in the ship's electrical system.

In addition to Zener diodes, other types of voltage regulators can also be used in onboard ship applications, such as linear regulators and switching regulators. The choice of voltage regulator will depend on the specific requirements of the control circuits and the ship's electrical system. It is important to ensure that the voltage regulators and control circuits are properly installed and maintained to ensure safe and reliable operation. Regular testing and inspection of the ship's electrical system can help to identify potential issues and prevent electrical failures that could pose a safety hazard.