100V/12V Charging Unit using Zener Diode

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Abstract:
Zener diodes operate in reverse-biased mode beyond their breakdown voltage, providing a stable output voltage when properly chosen and configured. Key considerations include selecting a Zener diode with a breakdown voltage close to the desired output, managing power dissipation to prevent overheating, and understanding limitations in load regulation compared to other types of voltage regulators. This method offers simplicity but requires careful attention to ensure adequate performance and reliability in high-voltage charging applications. Using a Zener diode as a voltage regulator in a 100V charger circuit involves selecting a Zener diode with a breakdown voltage slightly higher than the desired output voltage, such as 12V for a 12Voutput. The Zener diode is connected in reverse bias across the output terminals with a series resistor to limit current and ensure stable operation within safe limits. A load resistor in parallel simulates the actual load. Careful consideration of power dissipation is crucial to avoid overheating the Zener diode; power dissipation (\(P_Z = V_Z \times I_Z \)) can be managed by adjusting the series resistor or using a heat sink if necessary. While Zener diodes offer simplicity and cost- effectiveness, their regulation is less precise compared to IC regulators, and their voltage reference can drift with temperature changes. Despite these limitations, Zener diodes remain practical for applications where moderate voltage regulation suffices and careful design considerations are applied to ensure reliable performance.

Key words:
Bridge rectifier, Zener Diode, 100V Charger and 12V Charger

Introduction:

A 100V/12V charger is a specialized power supply unit designed to provide a stable 100/12-volt output for charging applications, crucial in various high-demand sectors. These chargers are commonly used in industrial settings, electric vehicles, renewable energy systems, and telecommunications infrastructure, where higher voltage levels are essential for efficient energy transfer and rapid charging. Typically, they feature advanced safety mechanisms such as overvoltage protection, overcurrent protection, and thermal management to ensure safe and reliable operation. Additionally, many 100V/12V chargers incorporate intelligent charging technology to optimize the charging process based on the battery's state of charge and health, enhancing overall efficiency and battery longevity. Their robust design often includes durability features to withstand harsh environmental conditions, making them suitable for both indoor and outdoor industrial applications. Despite their higher cost compared to standard chargers, the benefits of faster charging times, greater energy efficiency, and scalability for large-scale power requirements make 100V chargers an indispensable component in modern electrical and industrial systems.

Zener Diode:

A silicon semiconductor with a p-n junction that is specifically made to function in a reverse biased state is called a zener diode. It functions like a typical signal diode when forward biased, but when the reverse voltage is applied, it maintains a steady voltage across a broad current range. It is utilized as a voltage regulator in d.c. circuits because of this property. Maintaining a steady voltage is the major goal of the Zener diode as a voltage regulator. Assume that a 5 V Zener voltage is applied. In that case, the voltage remains constant at 5 V.

Zener Diode Working:

In order to increase a Zener diode's conductivity in comparison to other p-n junction diodes, high level impurities are added to the diode. These contaminants cause the Zener diode's depletion layer to thin out. As a result, even at very low voltages, this diode functions.When the Zener diode is not biased, all of the electrons build up in the p-type semiconductor material's valence band, preventing any current passage through the diode.When reverse bias conditions are met, the diode conducts electricity in the reverse

V-I Characteristics of Zener Diode

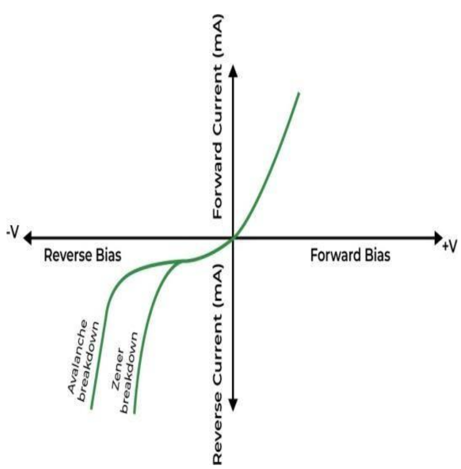

Figure 1: V-I Characteristics of Zener Diode

Forward Characteristics of Zener Diode:

Forward characteristics of the Zener Diode are similar to the forward characteristics of any normal diode. It is clearly evident from the bias direction if the Zener voltage is equal to the supply voltage. The depletion layer fully varnishes when the Zener voltage matches the supply voltage.

Zener Diode Working in Reverse Biased:

The Zener Diode functions similarly to a regular diode when it is forward-biased, but when it is reverse-biased, a tiny leak current passes through the diode. The reverse voltage eventually exceeds the breakdown voltage as we continue to increase it. The breakdown voltage, denoted as Vz, is the point at which the diode's current begins to flow. The current increases significantly after the breakdown voltage until it reaches a steady value. There are two types of breakdowns that can happen to a Zener diode under reverse bias conditions: avalanche breakdown and Zener breakdown above diagram in the first quadrant that the VI forward characteristics are similar to other P-N junction diodes.

Reverse Characteristics of Zener Diode:

In reverse voltage conditions a small amount of current flows through the Zener diode. This current is because of the electrons which are thermally generated in the Zener diode. As we keep increasing the reverse voltage at any particular value of reverse voltage the reverse current increases suddenly at the breakdown point this voltage is called Zener Voltage and is represented as V_Z.

Zener diode as Voltage Regulator:

Zener diode is utilized as a Shunt voltage controller form anaging voltage across little loads. The breakdown voltage of Zener diodes will be steady for a wide scope of current. The Zener diode is associated with corresponding to the heap to make it switch predisposition and when the Zener diode surpasses knee voltage, the voltage across the heap will become consistent.

Zener Diode in Over-Voltage Protection:

At the point when the info voltage is higher than the Zener breakage voltage, the voltage across the resistor drops bringing about a short-out. This can be kept away from by utilizing the Zener diode.

Block diagram:

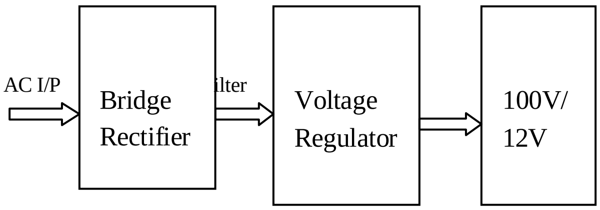

Figure 2: Block Diagram Charging unit

Block diagram Explanation:

Bridge Circuit:

The input stage of the charger circuit accepts either 100V AC or 12V AC, depending on the specific design. The rectifier stage converts the AC input to DC, using a bridge rectifier or other suitable topology. The resulting DC output is then filtered to remove any unwanted ripple or noise, using a capacitor or other filtering components.

Voltage Regulator:

The zener regulator circuit is the heart of the charger, and is responsible for regulating the output voltage to a precise 12V. This is achieved using a zener diode, which is chosen to have a breakdown voltage of 12V. The zener diode is connected in series with a resistor (R1), which limits the current through the diode. The output voltage is taken across the zener diode, and is precisely regulated at 12V.The voltage regulator block represents the zener regulator circuit, and outputs a stable 12V DC voltage. This voltage is then applied to the charging circuit, which is responsible for charging the battery. The charging circuit may include additional components, such as current limiting resistors or overcharge protection circuits, to ensure safe and efficient charging.

Circuit Diagram:

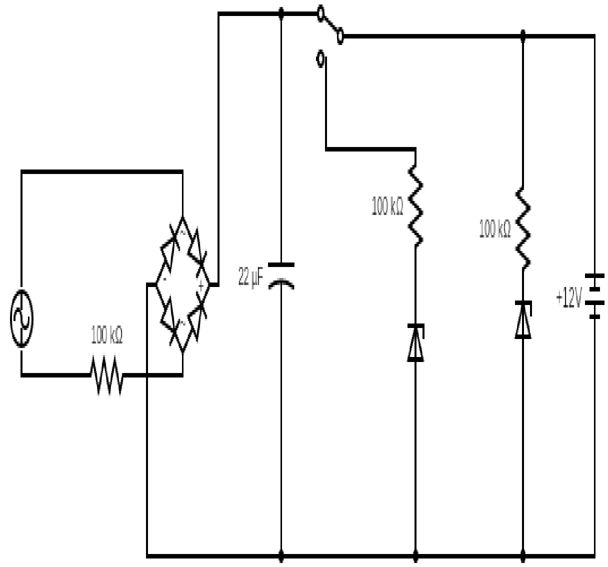

Figure 3: Circuit Diagram for 100V/12V Charging unit

Circuit Diagram Explanation:

The bridge rectifier circuit, which consists of four diodes (D1–D4) arranged in a diamond shape, receives the AC input voltage. Diodes D1 and D3 are forward-biased, allowing current to pass through the circuit during the positive half-cycle of the AC input. After passing through D1, the current then passes through the load (such as a battery or filter capacitor), passes through D3, and then passes back through the AC source. Diodes D2 and D4 are forward-biased during the negative half-cycle, which permits current to flow in the same direction as it does during the positive half-cycleThis indicates that, independent of the AC input's polarity, the output voltage across the load is always positive. Full-wave rectified, or converting both half-cycles of the AC input to DC, is the output of the bridge rectifier circuit. This produces an output voltage that is smoother and more stable than half-wave rectification, which only converts one half-cycle to DC. All things considered, the bridge rectifier circuit is a popular and effective method of converting AC to DC and is an essential part of several power supply and battery charging applications. An electrical component called a 100k resistor is made to function safely when there is a maximum voltage of 100 volts applied across it. This ensures dependable operation in a range of high-voltage applications. The voltage rating shows the highest voltage that the resistor can withstand without running the danger of damaging or failing the insulation. These resistors are used to regulate the flow of electric current in circuits. They are available in a range of resistance levels, expressed in ohms. Additionally, they have a power rating that indicates how much power they can dissipate as heat without breaking, commonly measured in watts. Suitable for use in power supplies, amplifiers, and industrial equipment, 100V resistors are made of materials such as carbon, metal film, or wire-wound structures. Their design prevents arcing at high voltage levels.Their ability to safely manage high voltage is crucial for maintaining circuit stability and preventing component failure in demanding electrical environments. A 120V Zener diode is a semiconductor device designed to maintain a stable 100 volts across its terminals when reverse-biased, making it essential for voltage regulation and protection in electronic circuits. Unlike regular diodes that block reverse current, a Zener diode allows reverse current to flow once the applied voltage reaches its breakdown voltage of 100V, ensuring a constant voltage output. A 15V zener diode is a type of semiconductor device that regulates voltage at a precise level, specifically 15 volts. It acts like an open circuit when the voltage across it is less than 15V, but breaks down and conducts current when the voltage exceeds 15V, limiting it to a stable 15V.This characteristic makes zener diodes useful in voltage regulator circuits to regulate output voltage, provide a stable reference voltage, protect against overvoltage, and stabilize power supply output. When selecting a 15V zener diode, considerations include voltage tolerance, temperature stability, and power handling capability to ensure the device meets specific application requirements .By Maintaining a constant voltage of12V across its terminals. Ina filtering operation, a 22μF capacitor is typically used to smooth out voltage fluctuations in a power supply, providing a stable DC output. When placed across the output terminals of a power supply, the capacitor charges during voltage peaks and discharges during voltage dips, effectively reducing ripple voltage and noise. This process helps to maintain a consistent voltage level, ensuring that electronic devices connected to the power supply receive a clean and steady power source. A two-way switch is a fundamental component in electrical circuits, enabling the control of a circuit from two distinct locations. This switch type is widely employed in various applications, including lighting control in residential and commercial buildings, home automation systems, industrial control of machinery and lighting, and even in smart home systems. The switches are wired in a specific configuration, known as a two-way switching circuit, which allows for the remote control of the circuit. When one switch is turned "on" or "off", the other switch is automatically switched to the same state, providing a convenient and efficient way to control lighting or appliances from multiple locations. two-way switches offer numerous benefits, including enhanced convenience, flexibility, and energy efficiency, as they enable users to turn off lights or appliances when not in use, reducing energy consumption and costs. Moreover, two-way switches are easy to install and maintain, making them a popular choice for electricians and homeowners alike. Overall, the two-way switch is a versatile and practical solution for controlling electrical circuits from multiple locations, making it an essential component in modern electrical systems. A 12V battery is a type of lead-acid battery that stores electrical energy and releases it as needed. It consists cells, each producing 2V, connected in series to produce a total voltage of12V. The battery's capacity is measured in ampere-hours (Ah), with common sizes ranging from 1Ah to 100Ah or more

Table 1: Results:

Energy supplied	31.85Wh
Energy received	22.93Wh
Charging time	6.37Hrs
Battery voltage before charge	5V
Battery voltage after charge	12V
System efficiency	72%

Equations:

$$Ein = Vt\ x\ It\ x\ charging\ time$$

$$Eout = Vs\ x\ Is\ x\ charging\ time$$

$$Efficiency = (Eout/Ein)100$$

Results and Discussion:

Hardware Model:

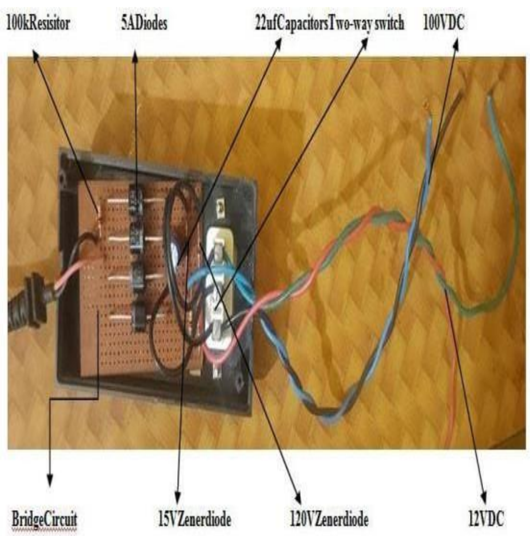

Figure 4:Hardware model

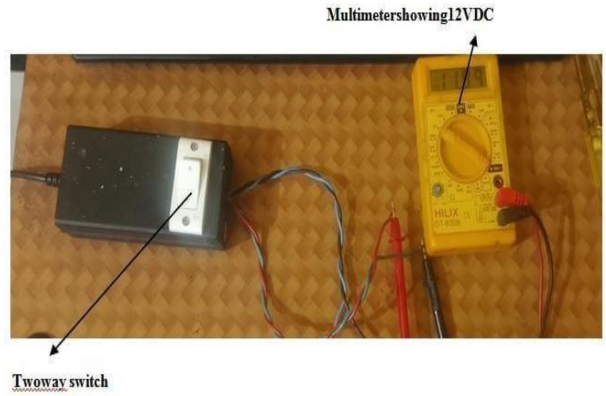

Figure 5: ***12V Dc Charger***

We performed the experimental setup of converting 230V AC to 12V DC to charge the 12V battery by using bridge circuit, capacitor and 15V Zener diode as shown in the **fig 5** the output results are shown in table1.

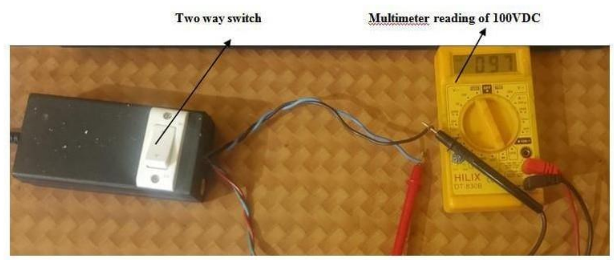

Figure 6: 100V Dc Charger

We performed the experimental setup for converting 230V AC to 100V DC using 120V Zener diode as voltage regulator as the pulsating DC is passing through the Zener Diode which is connected in reverse direction as shown in **fig 6**

Conclusion:

The Achieved results of 12V Charger for 2Ah battery is obtained and for 100V charger there is no proper 100V battery so we are not tested for 100V charger unit. This project successfully designed and developed voltage regulator circuits using Zener diodes to charge 12V and 100V batteries, Show casing a fundamental understanding of voltage regulation and charging circuits

References:

[1] Hunter, B. L., & Matthews, W. E. (2020). A 100-V Battery Charger Voltage Extender IC With 97%Efficiency at 4- A and ±0.5% Voltage Accuracy. IEEE Transactions on Circuits and Systems

[2] Askarian, N. Dohmeier,C.Botting, M. Pahlevani, and A.Knight, "A novel single-stage AC/DC converter used in battery charger applications," in Proc. IEEE Energy Convers. Congr. Exposit. (ECCE), Sep. 2018

[3]S.H.Yangetal.,"Highaccuracykneevoltagedetectionforprimarys idecontrolinflybackbatterycharger,"IEEETrans.CircuitsSyst.I,Reg. Papers,vol.64,no.4,pp.1003–1012,Apr. 2017

[4]C. Enz, E. Vittoz, and F. Krummenacher, "A CMOS chopper amplifier," IEEE J. Solid- State Circuits, vol. SC- 22, pp. 335–342, Jun. 1987.

[5] IEEE J. Solid-State Circuits, vol. 41, no. 12, pp. 2729–2736, Dec. 2006; R. Burt and J. Zhang, "A micropower chopper-stabilized operational amplifier using a SC notch filter with synchronous integration inside the continuous-time signal path."

[6] IEEE Int. Solid-State Circuits Conf. (ISSCC) Dig. Tech. Papers, Feb. 2015; Y. Kusuda, "A60 Vauto-zero and chopper operational amplifier with 800kHz inter leaved clocks and input bias-current trimming." *[7]I.E.OprisandG.T.A.Kovacs,"Arail-to railping-pongop- amp,"IEEEJ.Solid-State Circuits,vol.31,no.9,pp.1320–1324,1996* *[8]M.-G. Jeong, S.-H. Kim, and C. Yoo, "Switching battery charger integrated circuit for mobile devices in a 130- nm BCDMOS process," IEEE Trans. Power Electron., vol. 31, no. 11, pp. 7943–7952, Nov. 2016*

[9] A monolithic high-voltage Li-ion battery charger with sharp mode transition and partial current control approach was published in September 2018 in IEEE Trans. Circuits Syst. I, Reg. Papers, vol. 65, no. 9, pp. 3099–3109, by J.-F. Wu, C.-L. Wei, and Y.-Z. Juang.

[10] In June 2012, IEEE Journal of Solid-State Circuits published a paper by R. Pagano, M. Baker, and R. E. Radke titled "A 0.18-μm monolithic Li-ion battery charger for wireless devicesbased on partial current sensing and adaptive reference voltage."