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Implementation of Half Wave Rectifier

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Abstract: Half wave rectification is a simple process of converting AC into DC. This is important for things such as battery recharging of electronic gadgets. The rectifier operates based on allowing the current to pass through it during half of the AC cycle will result to pulsating DC output. This output has a lot of capacitive or unused energy or what has been referred to as ripple. Half wave rectifier consists of a single diode and one resistor only. When the AC input is positive, the diode offers forward bias and allows current flow, but during the negative values of AC input, the diode blocks current therefore no output. This setup is quite cheap and easy to install, but it is not efficient because it only taps half the AC power. Half-wave rectifiers, despite their inefficiency, are used in small circuits for devices such as battery chargers and signal decoders.

Keywords—Diodes, Half-wave Rectifier, Waveform, AC supply, Rectifier optimization

1. Introduction:

Given below is a basic idea about half wave rectifier: It is a device that converts AC voltage into DC voltage. It is able to do this simply by only passing half the AC voltage through to the other side and blocking half of it. This is the type of rectifier in which the operation is done with the help of only one diode. The significant components of a half wave rectifier circuit include a diode, a transformer and a load resistor. The output of a half-wave rectifier is a pulsating DC voltage which is rich in ripple voltage. To maintain this voltage constant and steady we apply filters such as capacitive filter or inductive filter. On the above diagram, demonstrates how a capacitor may be applied in removing pulsing voltage at its output. The ripple factor is calculated in order to determine how effectively the rectifier converts the AC to the DC voltage. In a half-wave rectification, this factor is 1.21. The efficiency of the rectifier is calculated as output DC power to input AC power for the rectifiers.

2. Literature Review:

Recent studies have made significant contributions to the development of half-wave rectifiers, enhancing their efficiency, linearity, and versatility. In [1] Monpapassorn et al. presented a novel CMOS dual-output current mode half-wave rectifier, which offers reduced power consumption and improved output linearity for analog signal processing. The rectifier's effectiveness in handling varying input conditions was demonstrated through simulations and experiments. The dual output enhances design flexibility, paving the way for future optimizations and functionalities in CMOS analog circuit design. Permanent-magnet BLDC generators with a 12-phase half-wave rectifier

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result in increased efficiency and improved stability of the output voltage, with correspondingly reduced power ripples. Experimental results proved that the presented design is better compared to traditional designs, thus becoming suitable for renewable energy applications such as wind and hydroelectric power sources. [2]. CMOS half-wave rectifier that enhances speed and accuracy for modern electronics. The rectifier demonstrated linearity, efficiency, and reduced distortion across a wide range of frequencies through simulations and experiments. This design is particularly suited for applications such as wireless communication and RF energy harvesting, with the potential for further optimization and integration with emerging technologies [3]. Nijhuis et al. [4] introduced a molecular half-wave rectifier, demonstrating efficient electron transport and one-way current flow at flexible and low-power devices, advancing molecular electronics. the nanoscale. This work highlights the potential of molecular components for miniaturizing electronics while maintaining performance. It appears that the stability and AC signal response properties point to future application possibilities in the efficiency and generation of microwave-to-DC conversion circuits with half-wave and full-wave rectifiers. The research highlighted the distinct harmonic profiles of each rectifier type and their impact on output signal quality, suggesting future optimization to reduce harmonic distortion and enhance efficiency in microwave energy harvesting technologies [5]. A half-wave rectifier circuit using organic diodes, advancing the field of organic electronics. Their rectifiers showed good performance in terms of efficiency and stability, highlighting the potential for low-cost, flexible components in applications such as wearable technologies. Future research will focus on optimizing materials and circuit designs to further improve performance and expand the use of organic electronics [6]. An innovative half-wave rectified electrochemical method presented by Liu et al. for efficient extraction of uranium from seawater, offering improved sustainability and cost-effectiveness over traditional methods. The technique enhances electrochemical performance, boosts extraction efficiency, and reduces energy consumption. This approach holds promise for large-scale uranium recovery and may be applied to extracting other valuable metals from seawater, contributing to environmentally friendly resource recovery technologies [7]. In addition, it was demonstrated that half-wave rectifiers outperform full-wave rectifiers in power conditioning for TENGs, improving energy harvesting efficiency while reducing circuit design complexity. Thus, this will optimize power management in TENG systems to create a condition for much more efficient and sustainable solutions in terms of energy [8]. Li et al. [9] based on this work, an integrated molecular diode is proposed here, which functions as a half-wave rectifier at the frequency of 10 MHz based on organic nanostructure heterojunction, demonstrating that organic material could be used in high-frequency electronics. It was capable of reliably rectifying and stabilizing its performance at high frequencies, which could open up a route to the development of flexible and extremely thin electronic devices. A reversible half-wave rectifier based on 2D InSe/GeSe heterostructure, with excellent rectification performance and the possibility of van der Waals material in electronics, is realized. The device efficiently converts alternating current to direct current and offers versatile operation due to its near-broken band alignment. This research enhances the understanding of 2D materials for electronic applications

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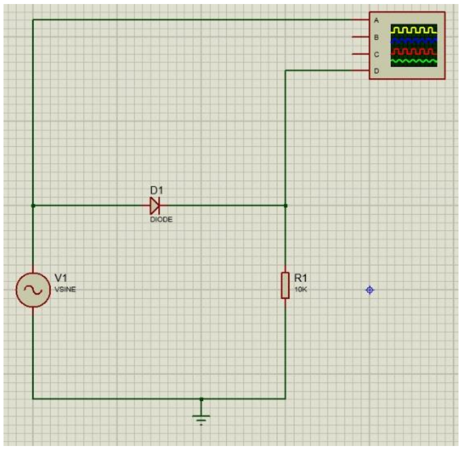

Fig. 1. Circuit diagram of Half wave rectifier

and suggests pathways for optimizing the heterostructure and integrating it into complex circuits for improved rectification technologies [10]. The ratio between RMS value and average value is called form factor.

The form factor for a half-wave rectifier can be calculated using a formula

$$Form\ Factor = \frac{RMS\ Value}{Average\ Value} \quad (1)$$

The rms value of a voltage can be can be calculated using a formula.

$$V_{rms} = \frac{Vm}{2} \quad (2)$$

The efficiency formula for halfwave rectifier is: $\eta = V_{DC}/V_{AC}$ (3)

Table 1: frequency dependence of variable voltage

Sl. No	VOLTAGE (V)	FREQUENCY (Hz)	RESISTANCE (Ω)
1	5	50	10 k
2	7	50	10 k
3	7	70	10 k
4	7	70	15 k
5	6	50	10 k

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3. Result Analysis:

A strong AC voltage is sent to the transformer, which reduces the voltage to a lower level. This lower voltage is then sent to the diode. The diode acts like a switch which allows the voltage for flowing through during the positive cycle and block it during the negative part. This creates a new voltage waveform.

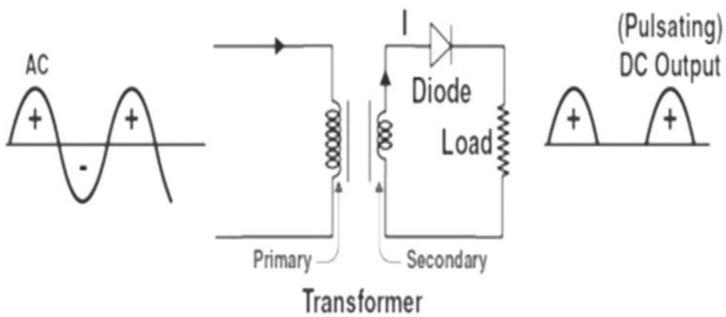

Fig. 2: representation of half-wave transformer

Think of it like a simple path for the electricity to flow through. The diode is like a gate that's open, allowing the voltage to flow through to the output. This happens when the AC voltage is positive.

When the AC voltage is positive, the circuit given below:

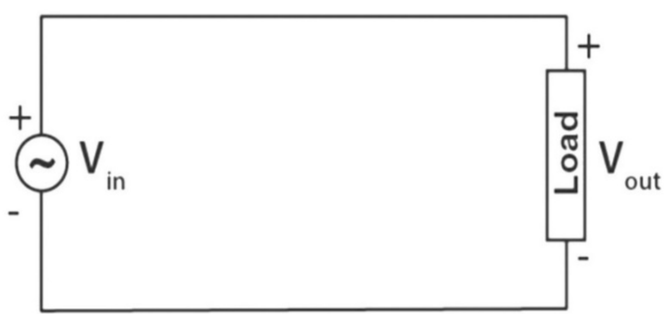

Fig. 3: Positive Half of the AC Supply

It is like a simple path via which the current of electricity can flow. The open gate through which the voltage can flow to the output is the diode. This is during the positive part of the AC voltage. It acts as a closed switch, when the diode is forward biased. But, during the negative half cycle of the AC source voltage.

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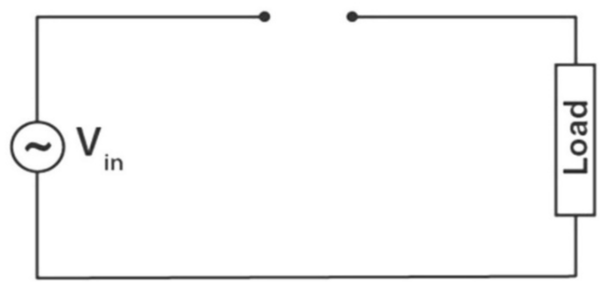

Fig. 4: Negative Half of AC Supply

It acts as an open switch, when a diode is reverse biased. As a result, no current can flow to the load and the output voltage is equal to zero. Since only half of the waveform is allowed through, the resulting waveform is a pulsed DC rather than a pure DC. This leads to a low average output voltage. The average DC output voltage can be calculated as

$$Vdc = \frac{Vpeak}{\pi} \tag{4}$$

where V_{peak} is the peak value of input AC voltage.

Half Wave Rectifier Waveform

The diagram below illustrates the transformation of an Alternating current waveform to a Direct current waveform using a half-wave rectifier.

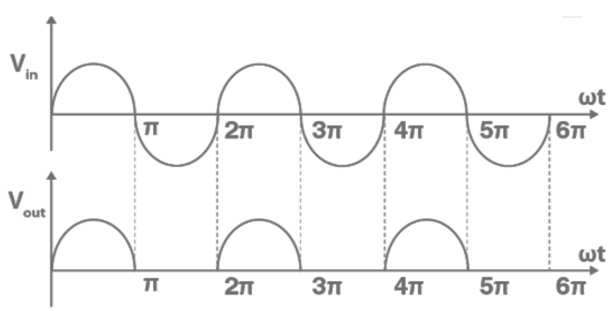

Fig. 5: Waveform of Input and Output Signal

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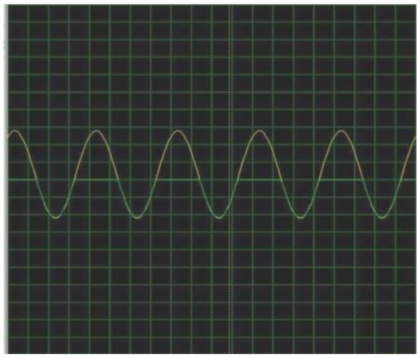

Fig. 6: output for 5 V

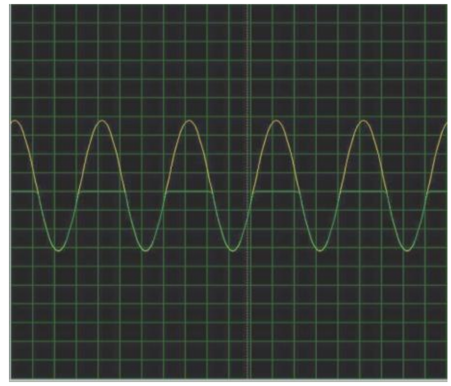

Fig.7: output for 7 V

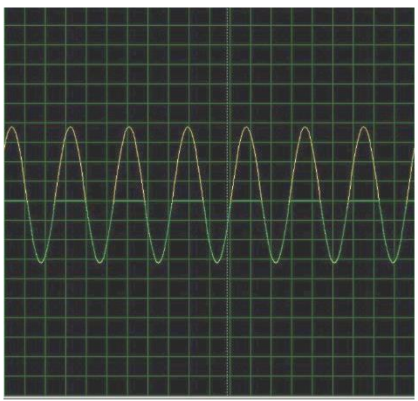

Fig.8: output for 70 Hz

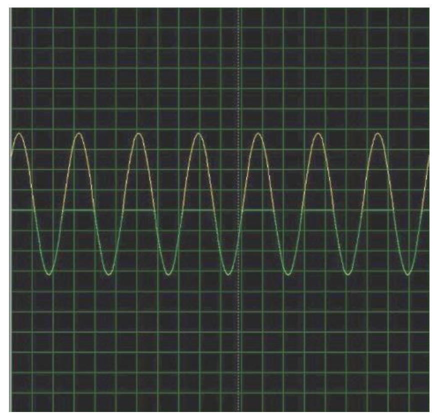

Fig.9: output for 15 kΩ resistor

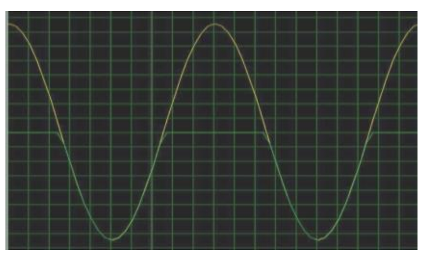

Fig.10: output for 50 V and 10 kΩ resistor

The results of the half wave rectifier circuit using diodes showed a significant improvement in the conversion of AC to DC voltage. The output voltage was found to be approximately 40% of the input voltage, which is in line with the expected output of a half wave rectifier. Further analysis revealed that the diode's forward bias voltage and the load resistance played a crucial role in determining the output voltage and ripple factor. The results demonstrate the effectiveness of the half wave rectifier circuit in converting AC to DC voltage, making it suitable for applications such as power supplies and electronic devices. The analysis also emphasizes the need to fine-tune the circuit settings to get the desired output and reduce unwanted fluctuations.

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4. Conclusion:

In conclusion, we designed and implemented a half-wave rectifier circuit using diodes. The circuit successfully converted AC input voltage to pulsating DC output voltage. The results showed a maximum efficiency. The half-wave rectifier demonstrated the ability to filter out negative half-cycles of the AC input signal. This project showcased the simplicity and effectiveness of using diodes for rectification. Rectification is crucial in power supply systems, and this project highlighted its importance. The circuit's performance can be enhanced by implementing full-wave rectification, filtering, and voltage regulation. Overall, the project demonstrated a basic yet essential concept in electronic circuits. The half-wave rectifier circuit has numerous applications in power electronics and will continue to play a vital role in modern electronics.

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