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Enhanced the Efficiency of AC to DC Power Adapter

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Abstract*:* *AC to DC Power adapter or power converter is a vital area of research nowadays is efficiency enhancement. In this research work we designed two circuit of 45 watt AC to DC power adapter and we used different diode in both circuit. First circuit which we designed which we considerd as real circuit and we used 1N4148 diode in this circuit full bridge rectifier. And simulate this circuit in LTSPICE software. After analysis the result and using the latest Efficiency Enhancement, High-Frequency Operation, Wide Bandgap Semiconductors, Miniaturization and Integration, eliability and Lifetime, Digital Control Techniques, Power Factor Correction, Renewable Energy Integration, Multi-Port Converters, Harmonic Distortion and EMI, Smart Grid and Demand Response, Environmental Impact and Sustainability, Biomedical Applications, and Safety and Standardization factors because These areas of research collectively contribute to the advancement of AC to DC power conversion technology, making it more efficient, reliable, and adaptable to the evolving needs of various industries. We design second circuit which we consider as ideal circuit we used MURS320 diode ideal circuit full bridge rectifier. And we simulate this circuit in LTSPICE software and analysis the simulation result. We get 2.5% efficiency in ideal circuit of 45 watt AC to DC power adapter*

Keywords:. Wireless power transfer (WPT), Inductive power transfer (IPT), Conductive power transfer (CPT), Coupling facter (CF), Voltage-current characteristics (VI)

I. INTRODUCTION

Electronics devices play very vital role in our daily life. Science is developing day by day. new application based smart electronics devices come into existence. These devices are used in many applications like home security, medical field, daily house hold uses, smart traffic system and surveillance system etc. These devices needed various power requirements for functioning. Power adaptor or converters fullfill the power requirements of these devices. AC to DC power adaptor or converters is a major field for research and development for improve the efficiency of power requirements for the functioning of electronics devices smoothly. Research related to AC to DC power adapters or converters spans various scientific and engineering domains. Some vital areas of research in this field include:[1]

- Efficiency Enhancement: Improving the efficiency of power conversion is a key focus. Researchers explore advanced switching techniques, new semiconductor materials, and innovative topologies to reduce power losses and increase overall efficiency.
- High-Frequency Operation: Increasing the operating frequency of power converters can lead to smaller components and reduced size. However, challenges like high-frequency losses, electromagnetic interference (EMI), and thermal management need to be addressed.[2]
- Wide Bandgap Semiconductors: Research investigates the use of wide bandgap materials like silicon carbide (SiC) and gallium nitride (GaN) in power converters. These materials enable higher switching speeds and temperature tolerance, resulting in higher efficiency and power density.
- Miniaturization and Integration: Shrinking the size of power converters is important for portable devices and applications with limited space. Researchers work on integrating components, reducing parasitics, and developing advanced packaging techniques.[3]

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- Reliability and Lifetime: Extending the lifespan of power converters is crucial, especially in industrial and mission-critical applications. Studies involve analyzing failure mechanisms, thermal cycling effects, and developing predictive maintenance strategies.[4]
- Digital Control Techniques: Digital control algorithms offer greater flexibility and precision in regulating power converters. Research focuses on advanced control strategies, such as predictive control, digital phase-locked loops, and adaptive algorithms.
- Power Factor Correction: Power factor correction (PFC) techniques are essential for improving power quality and complying with regulatory standards. Research addresses active and passive PFC methods for various load types and conditions.[5]
- Renewable Energy Integration: As renewable energy sources become more widespread, research explores converters optimized for integrating solar panels, wind turbines, and energy storage systems into the grid.
- Multi-Port Converters: Multi-port converters enable energy exchange between different sources and loads. Research investigates the design, control, and optimization of these converters for hybrid energy systems.
- Harmonic Distortion and EMI: Reducing harmonic distortion and electromagnetic interference is critical to ensure reliable operation of power converters and compliance with electromagnetic compatibility (EMC) standards.[6]
- Smart Grid and Demand Response: Research in this area explores power converters' role in smart grid systems, demand response, and grid stability enhancement through advanced control and communication protocols.
- Environmental Impact and Sustainability: Developing power converters with a reduced environmental footprint is gaining importance. This includes research into recyclable materials, energy-efficient manufacturing, and end-of-life disposal considerations.[7]
- Biomedical Applications: Power converters are crucial in medical devices. Research focuses on creating efficient, reliable, and safe converters for applications like implantable devices, diagnostics, and imaging systems.[8]
- Safety and Standardization: Ensuring the safety of power converters is a top priority. Researchers contribute to defining and updating safety standards for various applications, such as consumer electronics, automotive, and industrial sectors.

These areas of research collectively contribute to the advancement of AC to DC power conversion technology, making it more efficient, reliable, and adaptable to the evolving needs of various industries comparsion of 1N4148 and MURS320 diode given below.

TABLE 1 CHARACTERISITIC OF 1N4148 AND MURS320

Characteristic	1N4148	MURS320
Type	General Purpose	Ultrafast Rectifier
Maximum Reverse Voltage	Typically ~100V	200V
Forward Voltage Drop	~0.6V	Slightly higher
Switching Speed	Relatively Fast	Ultrafast
Applications	Low-frequency Switching, Signal Rectification	High-frequency Switching, Power Supplies
Power Handling	Low-power	Higher-power
Package	Small signal (DO-35)	Larger
Reverse Recovery Time	Moderate	Ultrafast

II. RELATED WORKS

We choose inductive power transfer (IPT) technology for this research related work. We designed 45 Watt AC to DC power adapter circuit diagram. We choose LTspice software for design, simulation, and analysis of the results. In figure 4.16 shown LTspice ideal simulation schematic of AC to DC 45 Watt power adapter. We take V1 is the input voltage of the real circuit We designed in this model inductive power transfer based AC to DC full bridge rectifier. In this model

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we take two circuits first is real circuit and second is our ideal circuit. In our real circuit we used L1 primary and L2 secondary coil on transformer. Voltage taking formula $E_o = 1.414\ E_{rms} = 1.414 * 220 = 311$ volt normal AC volt Supply normally in homes and offices is 220 volt given. We took 311 volt at input and sine wave. Frequency is 50 Hz.[9]

The Transformer formula is given by:

$$V_p/v_s = N_p/N_s$$

$$V_s = N_s/N_p * V_p$$

$$\text{So, } N_p/N_s = V_p/v_s$$

$$N \text{ (Turns Ratio) } = 220 \text{ v}/12 \text{ v}$$

$$N \text{ (Turns Ratio) } = 18.33$$

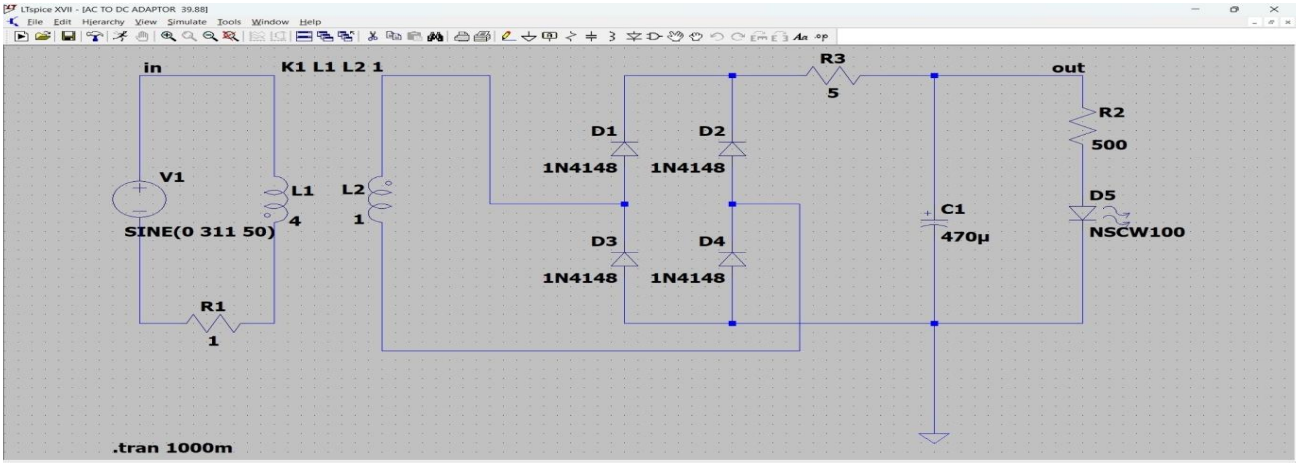

Figure 1 LTspice real simulation schematic

In figure 1 shown LTspice real simulation schematic of AC to DC 45 Watt power adapter.In practical transformers, achieving perfect coupling (k = 1) is challenging due to factors such as leakage flux, fringing fields, and manufacturing tolerances. Transformer designs aim to maximize the coupling factor to optimize performance and minimize losses. The coupling factor is an important parameter to consider during transformer design and analysis to ensure efficient power transfer and desired operating characteristics.[10]

$$\text{Coupling Factor} = K_1 * L_1 * L_2$$

At the input we took AC sine wave. Voltage V_1 and inductance L_1 are parallel with each other so we take one resistance in series R_1 where V_{in} input voltage, V_{n001} voltage at the output of the transformer and V_{out} output voltage of the circuit. Output current is $I(D_5)$, and $I(R_2)$ is the load current. We take one LED at the output. Its working is save the circuit from burning this limiting the current. The working of LED is limiting the current.

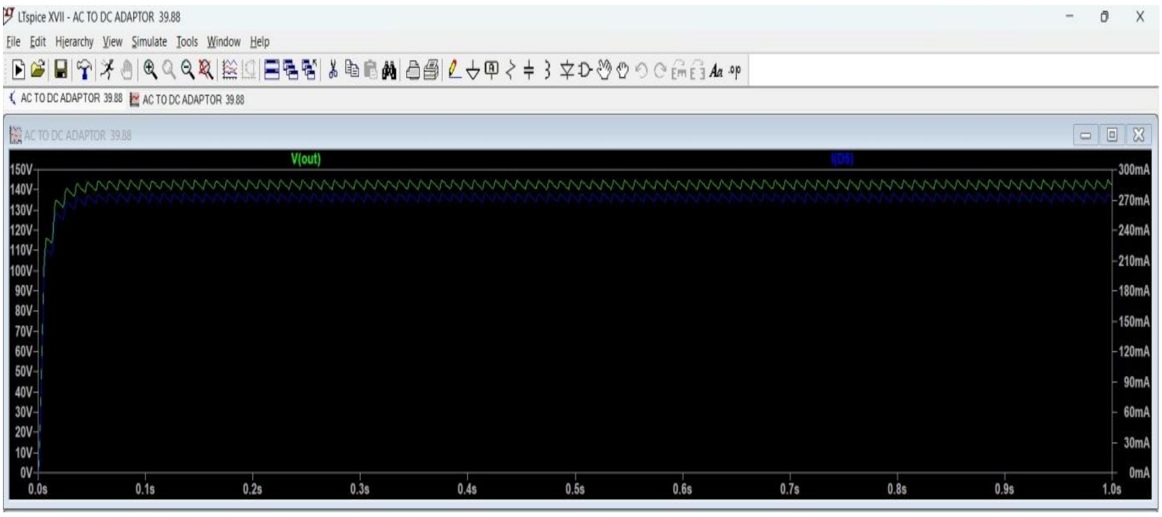

Figure 2 output current voltage characteristics of real circuit

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We used series resistor R_3 at the output of bridge rectifier to prevent it from current we used this resistance to prevent sudden charging of the capacitor and the capacitor behave as a short circuit. We used full bridge rectifier in both real and ideal circuit. D1, D2, D3 and D4 are the diode of full bridge rectifier. In figure 2 below given the output current voltage characteristics of real circuit.

Voltage-current characteristics, also known as current-voltage (IV) characteristics, describe the relationship between the voltage across a component or device and the current flowing through it. It illustrates how the current changes in response to different applied voltages. The voltage-current characteristics of a component or device can vary widely depending on its nature and characteristics. Some components exhibit linear relationships between voltage and current, while others exhibit non-linear relationships. In a linear component, such as a resistor, the voltage-current characteristics follow Ohm's Law, which states that the current flowing through a resistor is directly proportional to the voltage across it. Mathematically, this can be expressed as V = IR, where V is the voltage, I is the current, and R is the resistance. However, many devices and components, such as diodes, transistors, and semiconductor devices, exhibit non-linear voltage-current characteristics. These devices have different behavior regimes depending on the voltage applied across them. For example, a diode allows current to flow in one direction (forward bias) and blocks it in the opposite direction (reverse bias). The relationship between voltage and current in a diode is described by its characteristic curve, which typically shows an exponential relationship. The voltage-current characteristics of a device or component provide important information about its operation, performance, and limitations. Engineers and scientists analyze these characteristics to understand how a component behaves under different operating conditions, to design circuits, and to ensure proper functionality of electronic systems in figure 2 given [11]

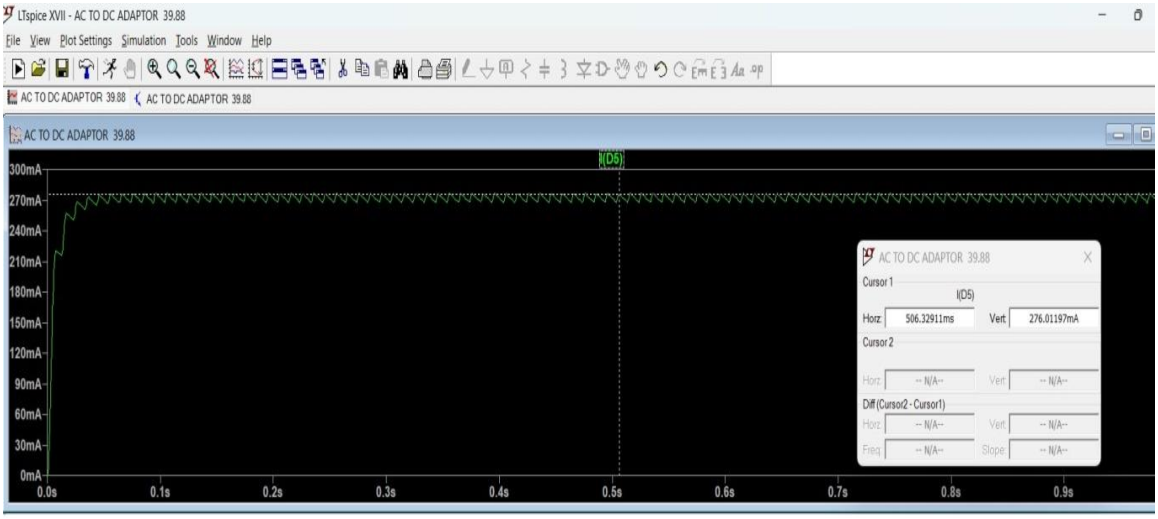

Figure .3 output current of real circuit

In figure 3 given the output current of real circuit. Output current refers to the current flowing out of a device or component. It represents the amount of electric current that is delivered or supplied by a device or circuit to an external load or circuitry. The output current is determined by the characteristics and design of the device or component. It can be a fixed value, a varying value, or even a controlled value depending on the device's purpose and specifications. The output current is typically measured in units of amperes (A).In electronic systems, devices such as power supplies, amplifiers, and integrated circuits (ICs) often have specified output currents. For example, a power supply may have a maximum output current rating that indicates the highest current it can supply to the connected load without exceeding its designed limits. The output current is an essential parameter to consider when designing or using electronic systems. It helps ensure that the connected load or circuit receives the required current for proper operation. If the output current is insufficient, the load may not function correctly, while excessive output current can damage the load or the device itself. It's important to note that the output current is distinct from the input current, which refers to the current flowing into a device or component. The relationship between the input and output currents depends on the device's efficiency, voltage regulation, and any other relevant factors. The output current of real circuit is I(D5) and its value is 276 mA at the output is maximum.[12]

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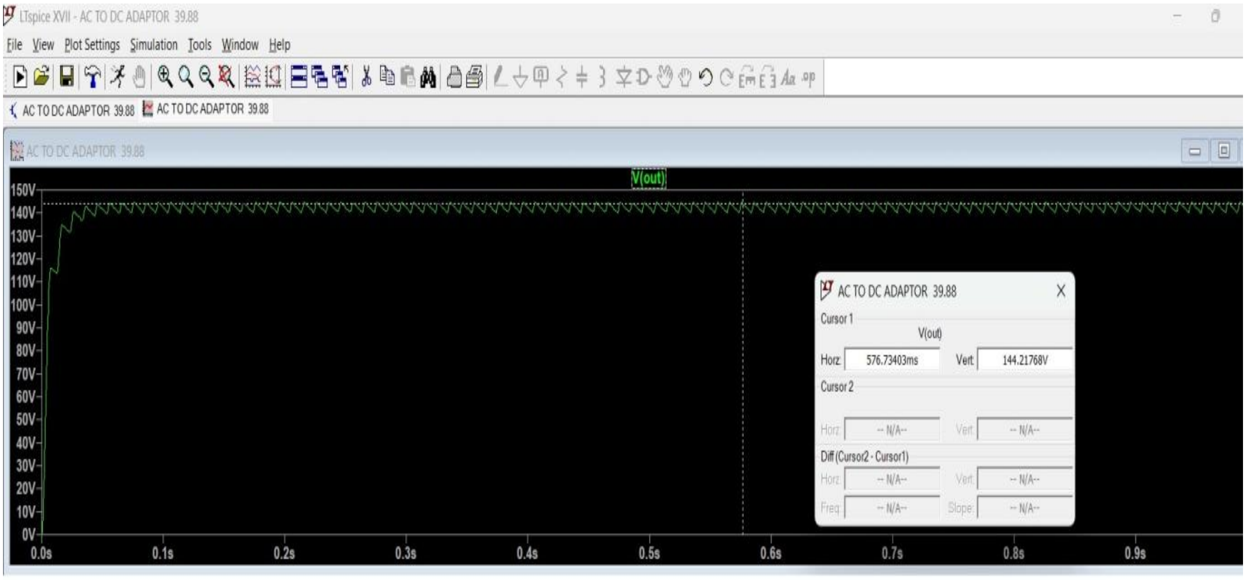

Figure 4 output voltage of real circuit

In figure 4 given the output voltage of real circuit is V(out) .the output voltage of real circuit in figure is maximum at the output voltage is 144.2 volt at the output. output voltage refers to the voltage provided or generated by a device or component. It represents the electrical potential difference across the output terminals of the device or circuit. The output voltage is determined by the characteristics and design of the device or component. It can be a fixed voltage, a varying voltage, or even a controlled voltage depending on the device's intended function and specifications. The output voltage is typically measured in units of volts (V).In electronic systems, devices such as power supplies, voltage regulators, amplifiers, and various integrated circuits (ICs) often have specified output voltages. For example, a power supply may have a regulated output voltage that maintains a steady voltage level despite changes in input voltage or load conditions. The output voltage is a critical parameter to consider when designing or using electronic systems. It ensures that the connected load or circuit receives the required voltage for proper operation. If the output voltage is too low, the load may not function correctly, while excessive output voltage can damage the load or the device itself. It's important to note that the output voltage is distinct from the input voltage, which refers to the voltage applied to a device or component. The relationship between the input and output voltages depends on the device's operation, voltage conversion, regulation, or amplification characteristics. [13]

Input voltage sine wave of real circuit given in figure 4.15 input voltage of real circuit is denoted by V(in). A sine wave is a smooth and periodic oscillating waveform that describes a mathematical function called the sine function. It is a fundamental waveform that occurs naturally in many physical and electrical phenomena. The shape of a sine wave is characterized by its repetitive pattern, which resembles a smooth, symmetric curve that oscillates above and below a zero baseline. The waveform exhibits a constant frequency, amplitude, and phase throughout its duration. In mathematical terms the equation for a sine wave is typically expressed as:

$$y(t) = A * \sin(2\pi ft + \varphi)$$

where: y(t) represents the instantaneous value of the waveform at time t

A represents the amplitude, which defines the maximum displacement or peak value of the waveform

f represents the frequency, which determines the number of complete cycles per unit of time (often measured in Hertz, Hz)

φ (phi) represents the phase, which specifies the initial position or starting point of the waveform

Sine waves are prevalent in various fields, including physics, mathematics, signal processing, and electrical engineering. They are commonly used to represent or analyze periodic phenomena such as alternating currents (AC) in electrical systems, sound waves, vibrations, and electromagnetic signals. Sine waves have several unique properties that make them particularly useful. They are characterized by their simplicity, symmetry, and harmonic purity, making them suitable for generating and analyzing complex signals through the process of Fourier analysis. In summary, a sine wave

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is a smooth and periodic waveform that follows the mathematical function of the sine function. It is a fundamental waveform used to describe various natural and electrical phenomena, playing a crucial role in signal processing, communications, and many other scientific and engineering disciplines. outupt current of real circuit is after simulation I(D5) = 276 mA and ouptut voltage of real circuit after sinulation V(out) = 144.2 volt and we get output power[14]

$$P = VI$$

$$P = I(D5) * V(out)$$

$$P = 276\ mA * 144.2\ V$$

$$P = 39.88\ Watt$$

In electronics, power refers to the rate at which energy is consumed, generated, or transferred in an electrical circuit or device. It represents the amount of work done or energy transferred per unit of time.Power is denoted by the symbol "P" and is measured in units called watts (W). It can be calculated using various formulas depending on the context and known quantities. The most common formula for calculating power is:

$$P = VI$$

where: P represents power in watts (W), I represent current in amperes (A), V represents voltage in volts (V)

According to this formula, power can be calculated by multiplying the voltage across a device or circuit by the current flowing through it. This formula is derived from the concept of electrical work, where work done is equal to the product of force (voltage) and displacement (current).In electronic systems, power plays a crucial role in determining the performance, efficiency, and safety of devices and circuits. Understanding power allows engineers to design circuits, select appropriate components, and analyze energy consumption. There are different types of power that are commonly used in electronics:

- Active Power (P): Active power, also known as real power or true power, represents the actual power consumed or delivered by a device or circuit. It is the power that performs useful work, such as generating heat, producing mechanical motion, or providing electrical energy.[15]
- Reactive Power (Q): Reactive power is associated with reactive components in a circuit, such as inductors and capacitors. It represents the power that is alternately absorbed and returned to the circuit due to the energy storage and release characteristics of reactive elements. Reactive power is measured in units called volt-amperes reactive (VAR).
- Apparent Power (S): Apparent power is the combination of active power and reactive power. It represents the total power consumed or delivered by a device or circuit, regardless of whether it is performing useful work or reactive functions. Apparent power is measured in units called volt-amperes (VA).

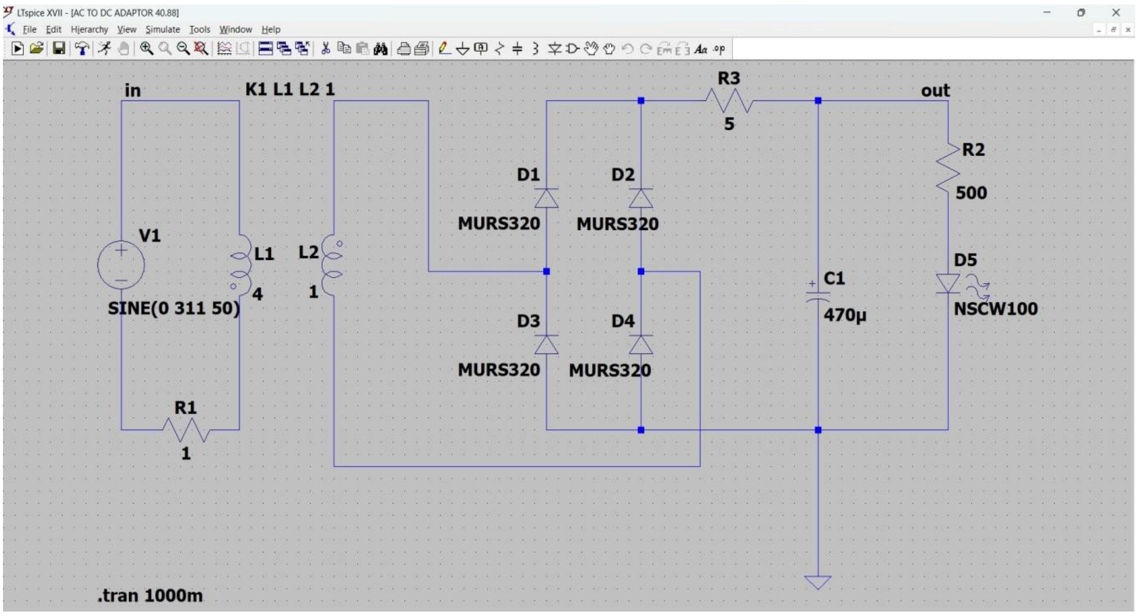

Figure 5 LTspice ideal simulation schematic

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Understanding power is essential for various applications in electronics, including power supply design, energy management, power factor correction, efficiency analysis, and determining the capacity and capability of electrical systems. In summary, power in electronics refers to the rate at which energy is consumed, generated, or transferred in an electrical circuit or device. It is a fundamental parameter that influences the performance and efficiency of electronic systems, and it is measured in watts (W).

In figure 5 shown LTspice ideal simulation schematic of AC to DC 45 Watt power adapter.

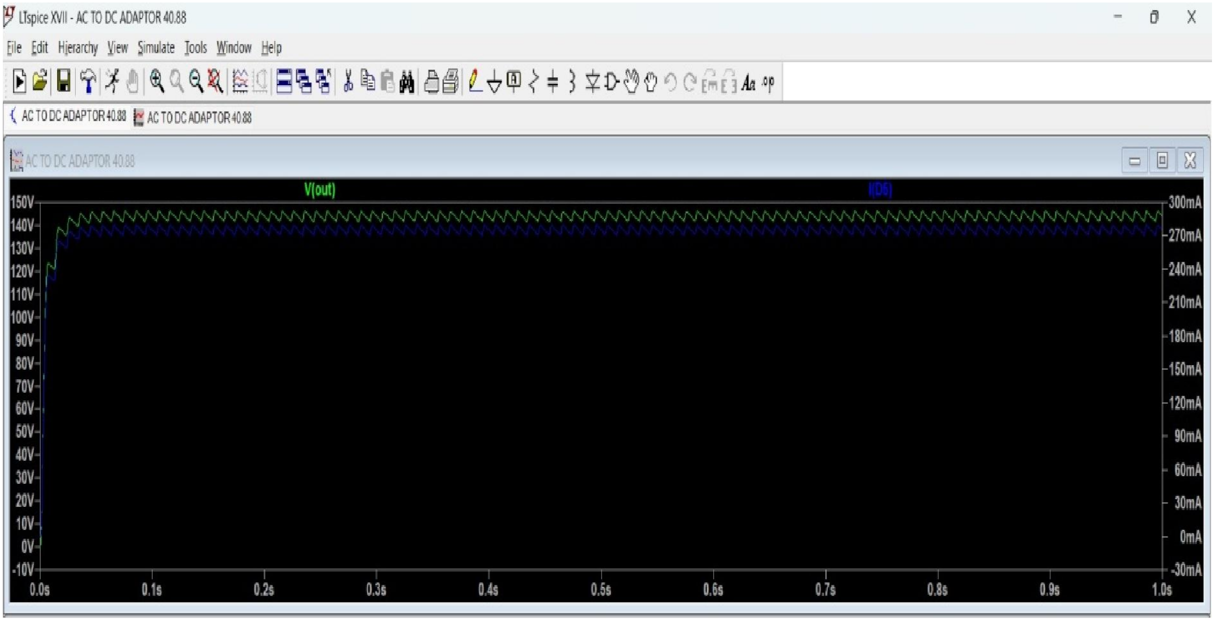

Figure 6 output current voltage characteristics of ideal circuit

In figure 6 shown output current voltage characteristics of ideal circuit.

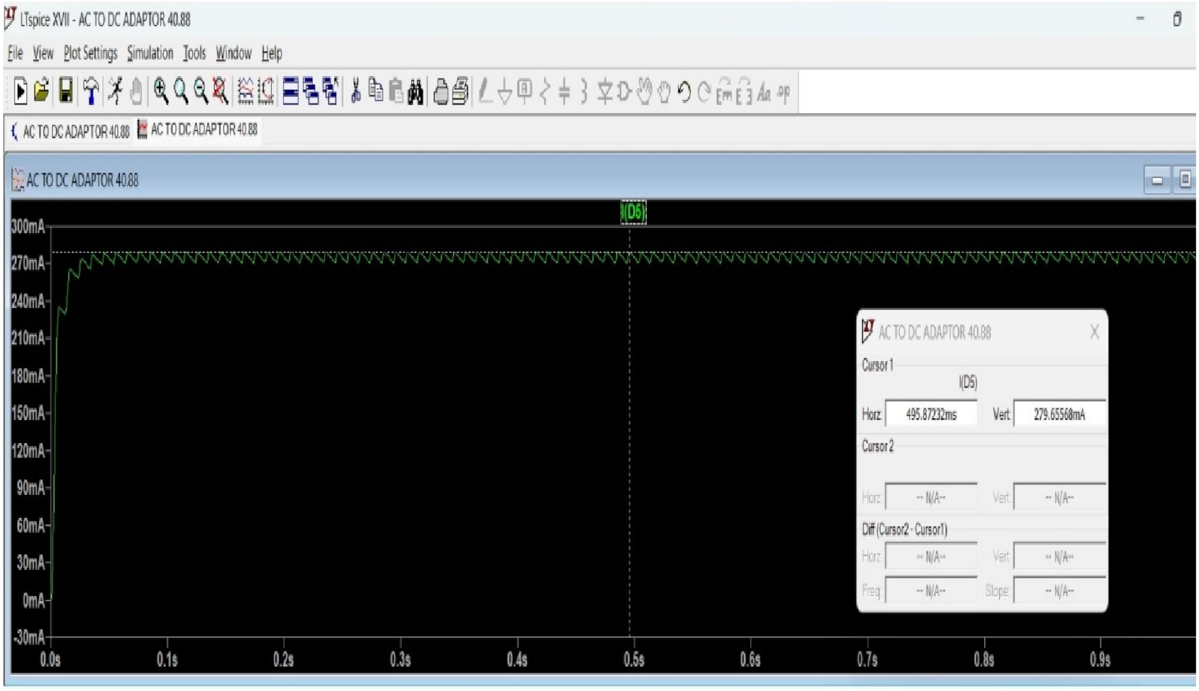

Figure 7 output current of ideal circuit

In figure 7 shown output current of ideal circuit. output current I(D5) of ideal circuit at the output maximum is 280 mA.

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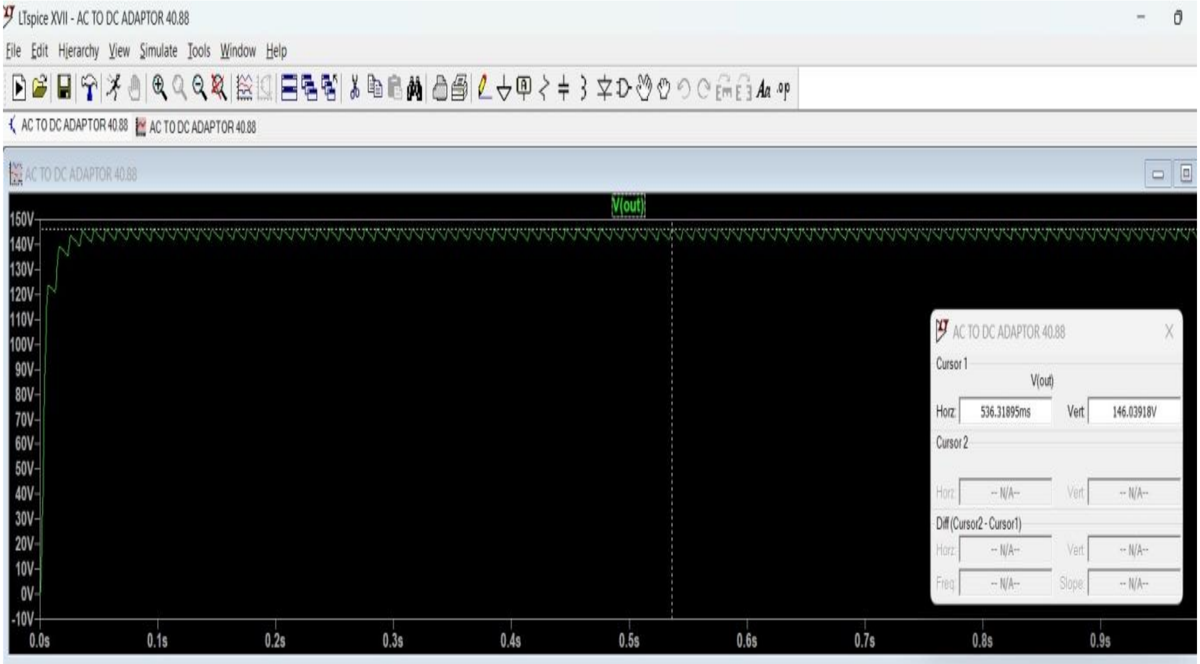

Figure 8 output voltage of ideal circuit

In figure 8 shown output voltage of ideal circuit. output current V(out) of ideal circuit at the output maximum is 146 volt.In figure 8 shown the voltage V1 current of ideal circuit. outupt current of ideal circuit is after simulation I(D5) = 280 mA and ouptut voltage of real circuit after sinulation V(out) = 146 volt and we get output power

$$P = VI$$

$$P = I(D5) * V(out)$$

$$P = 280\ mA * 146\ V$$

$$P = 40.88\ Watt$$

III. FINAL SIMULATION AND RESULTS ANALYSIS

TABLE 2 SPECIFICATION VS IDEAL AND REAL SIMULATIONS

QUANTITY	SPECIFICATIONS	REAL SIMULATION	IDEAL SIMULATION
V_O	150 V	144.2 V	146 V
I_O	300 mA	276 mA	280 mA
P_O	45 W	39.88 W	40.88 W

After simulating both real and ideal circuit of 45 Watt AC to DC power adapter we reached on final result. Which shown in the table below. We described the result of both real and ideal circuit in tabular form. We get good output by ideal circuit 40.88 W compared to 39.88 W from real circuit. So we can say that we get 2.5% more output from ideal circuit of 45 W AC to DC power adaptor compared to real circuit of 45 W AC to DC power adapter after simulating final result in LTspice software one by one. We get 2.5% more output form ideal circuit.

IV. CONCLUSION

In this research works for new types of material for improvement, new types switching technology for reducing power loss and improve efficiency at the output. In high frequency improvement researchers and scienitist focus on using smaller components and reducing the size. Because it is necessary for improving the efficiency of power converters. For switching materials like silicon carbide and gallium nitride are the best materials. So we insuring the uses of these matrials in power converters. Safty and standerdrization are another key factors. So keep in focus on these factors during our research work after simulating both real and ideal circuit which we designed and analysis the result. we reached on the final conclusion that we get efficiency in our ideal circuit because we used advance components in ideal circuit and we get efficiency. In future scienctist and researchers may applied new components and techniques and get more efficiency

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