AC to DC Converter

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***Abstract*—This project details the successful design and implementation of an AC to DC converter. By using a transformer, bridge rectifier, capacitor, resistor, and zener diode, we achieved the conversion of 220V AC to a stable 11V DC output. Our experimental results validate the voltage regulation. Future work will focus on optimizing efficiency and enhancing safety features.**

***Keywords*— AC to DC, full-wave bridge rectifier, voltage regulation, ripple factor, filter capacitor.**

I. Introduction

The AC to DC converter is a fundamental circuit used in various electronic devices. Our project focuses on designing a reliable and efficient converter for low-voltage applications.

II. Methodology:

A. Theory:

We started by selecting a suitable transformer with a step-down ratio to convert 220V 50 Hz AC to 12V AC. The bridge rectifier then converted the AC voltage to pulsating DC. The 470µF capacitor smoothed out the rectified waveform, and the 1000Ω resistor provided load resistance. The Zener diode regulated the output voltage to approximately 11V. The schematic and PCB layout of the circuit were created in Proteus software and PSpice to simulate and test the design.

B. Software Simulation:

In this project, we have used Proteus, a software tool to design schematics and PCB layout and to simulate and analyze our experiment. We have also used PSpice Design Manager for simulation.

1. Schematic:

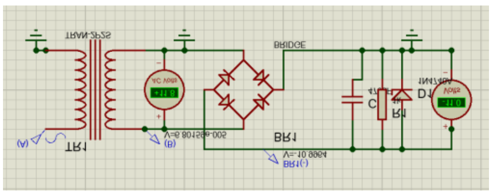

Fig. 1 Circuit diagram (schematic capture) with voltmeter readings in Proteus 8 Professional

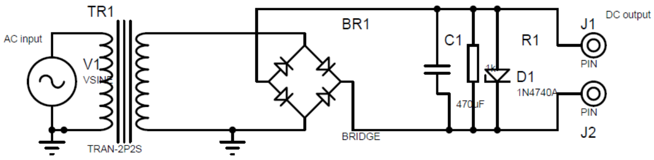

Fig. 2 Circuit diagram (print view) in Proteus 8 Professional

2. PCB layout:

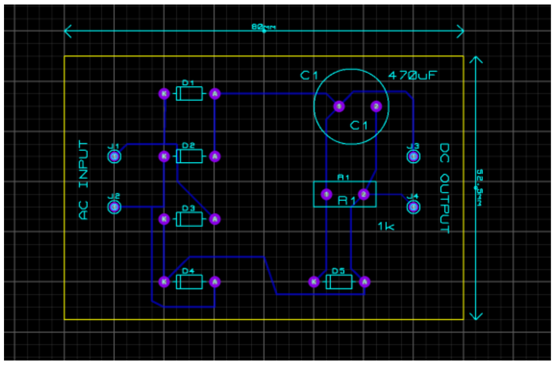

Fig. 3 PCB layout design in Proteus 8 Professional

3. Input and Output:

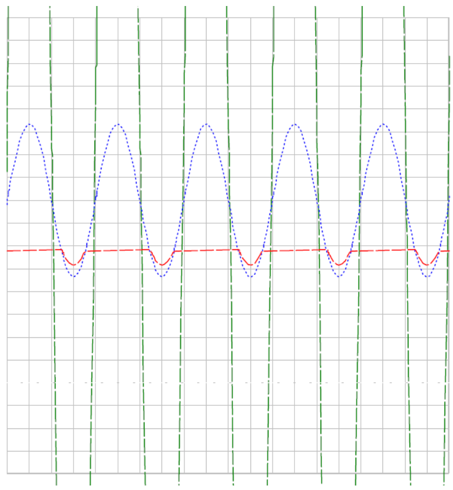

Fig. 4 Input and output voltage (vs time) simulation in Proteus 8 Professional. Green indicates AC 220 volt 50 Hz, blue indicates transformed AC 12 volt, red indicates DC output.

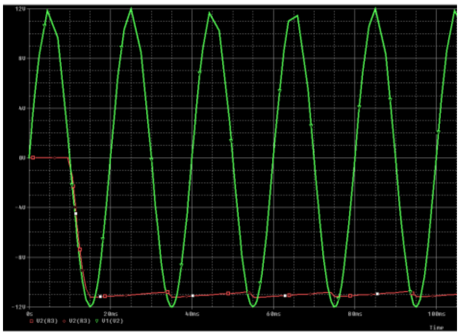

Fig. 5 Input and Output voltage (vs time) simulation when Zener diode is not attached, in PSpice Design Manager. Green indicates AC 12 volt 50 Hz, red indicates DC output.

C. *Hardware Implementation:*

1. *Components Used:*

Transformer: We have chosen a transformer with a step-down ratio that perfectly matched our circuit's needs. By stepping down [1] the high voltage of 220V AC 50 Hz to a lower voltage of 12V AC, we ensured compatibility with our circuit's operating voltage.

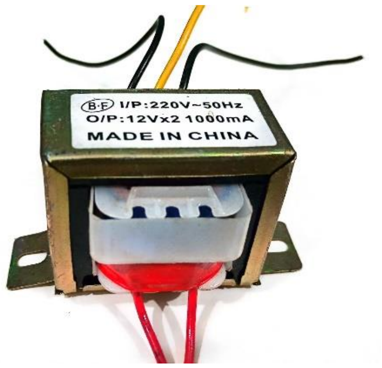

Fig. 6 220/12V step down transformer

Diodes: We have used 4 1N4007 diodes with 0.7V forward voltage drop which are arranged in a bridge configuration. It allows current to flow in one direction during both halves of the AC cycle, producing a full-wave rectified output [2].

Fig. 7 1N4007 diode

Capacitor: A capacitor is used in parallel to reduce voltage ripple in the DC output from the rectifier. It does the filtration part to smooth the DC output [3]. It has a capacitance of 470 uF and can handle various voltage ratings. The value C=470uF is chosen so that it maintains CR>>T (see more at [4]), Where R=1000 ohms, T=1/f and f=50 Hz.

Fig. 8 470 uF capacitor

Resistor: A resistor with a resistance of 1 kiloohm (1000 ohms). It's used to limit current or divide voltages in electronic circuits. We have used it parallel with the capacitor as a part of the filtration process. The value was calculated to get a proper and almost stable output voltage with less fluctuation.

Fig. 9 1k Ohm resistor

Zener Diode: A diode that allows current to flow in the forward direction like a normal diode, but also in the reverse direction when the voltage reaches the breakdown voltage [5] of 10V. We have used a 10V Zener diode in our circuit in parallel with the capacitor and resistor, as a voltage regulator.

Fig. 10 10V Zener diode

D. *Breadboard implementation:*

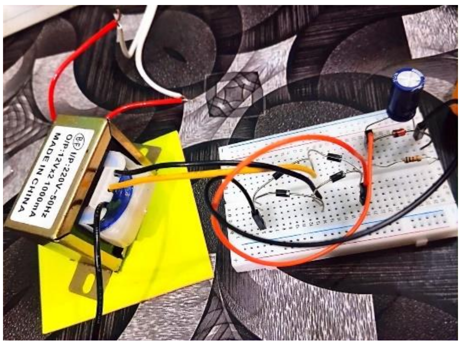

Fig. 11 Circuit connection on a breadboard with AC input from a transformer

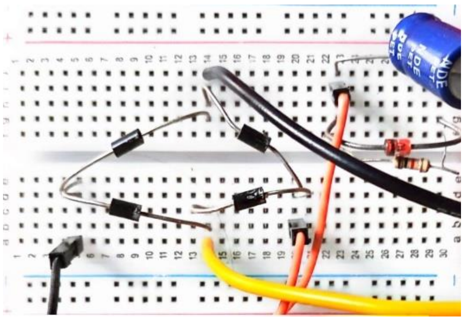

Fig. 12 Breadboard zoomed in

E. PCB implementation:

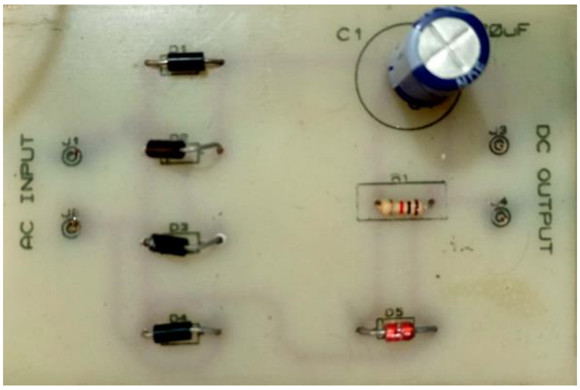

Fig. 13 PCB top layer

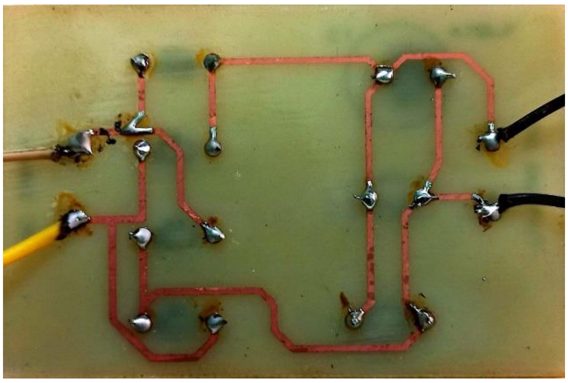

Fig. 14 PCB bottom layer

III. RESULT AND OUTPUT

A. Expected result:

The output voltage was expected to be 10V.

$$\begin{aligned} \textit{Rectified peak output voltage} &= \textit{peak input voltage-}2\times 0.7V \\ &= 12V\text{-}1.4V \\ &= 10.6V \end{aligned} \tag{1}$$

After regulation, it should be 10V.

B. Actual result:

But the actual multimeter reading from the circuit was 11.34V.

Fig. 15 Voltmeter reading from output pins

C. Ripple factor:

The ripple factor (r) is an indication of the effectiveness of the filter [6] and is defined as:

$$r = \frac{V_{r(pp)}}{V_{DC}} \tag{2}$$

In one of our experiments with the circuit,

$$\begin{aligned} V_{r(pp)} &\cong \frac{1}{fR_LC} \times V_{p(rect)} \\ &\cong \frac{1}{50 \times 1000 \times 470 \times 10^{-6}} \times 11.35 \\ &\cong 0.482978 \end{aligned} \tag{3}$$

$$\begin{aligned} V_{DC} &\cong \left(1 - \frac{1}{2fR_LC}\right) \times V_{p(rect)} \\ &\cong \left(1 - \frac{1}{2 \times 50 \times 1000 \times 470 \times 10^{-6}}\right) \\ &\times 11.35 \\ &\cong 11.108510 \end{aligned} \tag{4}$$

$$\begin{aligned} \therefore r &= \frac{0.482978}{11.108510} \times 100\% \\ &= 4.348\% \end{aligned}$$

IV. Cost Analysis

TABLE I
List of Components and Associated Costs

Components	Unit	Per Unit Cost (BDT)	All unit Total Cost (BDT)
1N4007 Diode	4	1	4
470uF 35V Capacitor	1	6	6
Transformer 220/12V	1	190	190
1k ohm Resistor	1	1	1
1N4740A 10V Zener diode	1	5	5
Wires	4	1.5	6
PCB	1	90	90
Total Cost per design			302

Per unit design of this AC to DC converter will cost 302 BDT.

V. Application

This AC to DC converter can be applied in various industries and systems where low DC voltage is required, including:

- Electronic Devices: Powering radios, TVs, computers, and consumer electronics with stable DC power.
- Automotive Systems: Charging batteries and powering electronics in vehicles.
- UPS Systems: Providing uninterrupted power by charging batteries during outages.
- LED Lighting: Driving LED lights with regulated DC power etc.

This converter will ensure reliable and stable operation across these applications, making it a versatile solution for diverse needs.

VI. Conclusion

Our AC to DC converter project proved successful in delivering a reliable solution for transforming AC power into stable DC output with a ripple factor of 4.348%. Despite encountering some minor issues with voltage regulation, we effectively met our project objectives. By employing a comprehensive approach that combined theoretical analysis, software simulation, and practical implementation, we were able to navigate challenges and achieve the desired outcome.

References

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