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Design and Development of Single Board Multipurpose Power Converter

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Abstract: The project presents the development of a multipurpose single board for hands-on power electronics education lab session focusing on power electronics applications. We are trying to apply advanced methods for circuit designs of AC to DC converter and DC to DC converter and an AC to DC converter. The power conversion classification involves AC to DC as a rectifier, DC to AC as an inverter, DC to DC as a chopper. These converters are used to convert voltage from AC to DC (or) from DC to AC and also to step up and to step down the voltage and also to control frequency. The objective is to stimulate the transferring of theory to practical purposes, and to provide hands-on experiences for the development of power electronic systems. The main aim of this project is to obtain a power using power electronics different converters on a single board.

Keywords: Power converter, AC, DC, Rectifer, Buck converter.

I. INTRODUCTION

In today's world, efficient power conversion and reducing the energy consumption are global concerns and achieving the highest power quality on the consumer side is a permanent goal. Development of advanced power electronics systems for the modern industrial applications and hybrid solutions through power energy converters has increased dramatically in various power levels. For this purpose, the generic educational prototype has been designed that enables students to deeply practice the functionality of main power converter topologies through their hands-on experience by using hardware practical testing of training.

II. DESCRIPTION

The following block diagram represents the conversion of power supplies includes AC-DC converter, DC-DC converter, DC-AC converter. In this the AC supply given to the rectifier circuit (AC – DC converter) and that rectified the given AC voltage into a multiple fixed DC voltage outputs. The output of the rectifier is provided as input to the chopper, and the chopper provided in the circuit convert the given fixed DC voltage into a variable DC voltage using buck (Step-down) converter. The output voltage from the chopper will be given as input to the inverter circuit and then will have an AC output voltage. Here, solar panel is used when there is no availability of AC power supply i.e.no electricity. At that time solar panel provide DC supply to chopper circuit and the remaining circuits will run except the rectifier circuit. We can collect output from rectifier, chopper as well as inverter individually.

III. BLOCK DIAGRAM

The block diagram represents the conversion of power supply from AC to various outputs such as fixed DC, variable DC, variable AC using conversion topologies using different types of converters such as rectifier, buck converter, inverter. There is an availability of single input such as AC supply which in turn converts into fixed DC and then to variable DC and further convert to variable DC. There will be multiple outputs from single input. To design the entire module there is a need to develop individual circuits for each converter. The following are the circuit diagrams of each converter and the components used in the circuits respectively.

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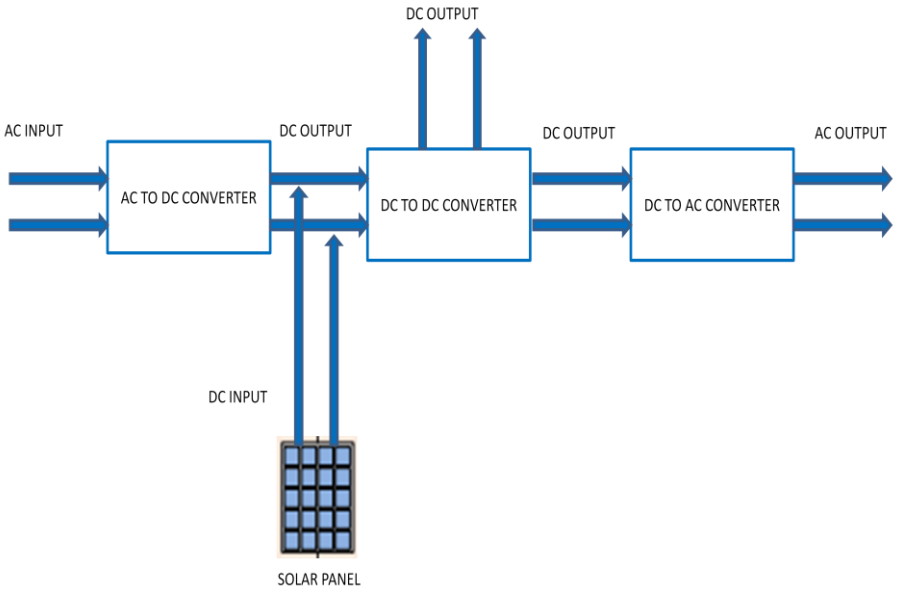
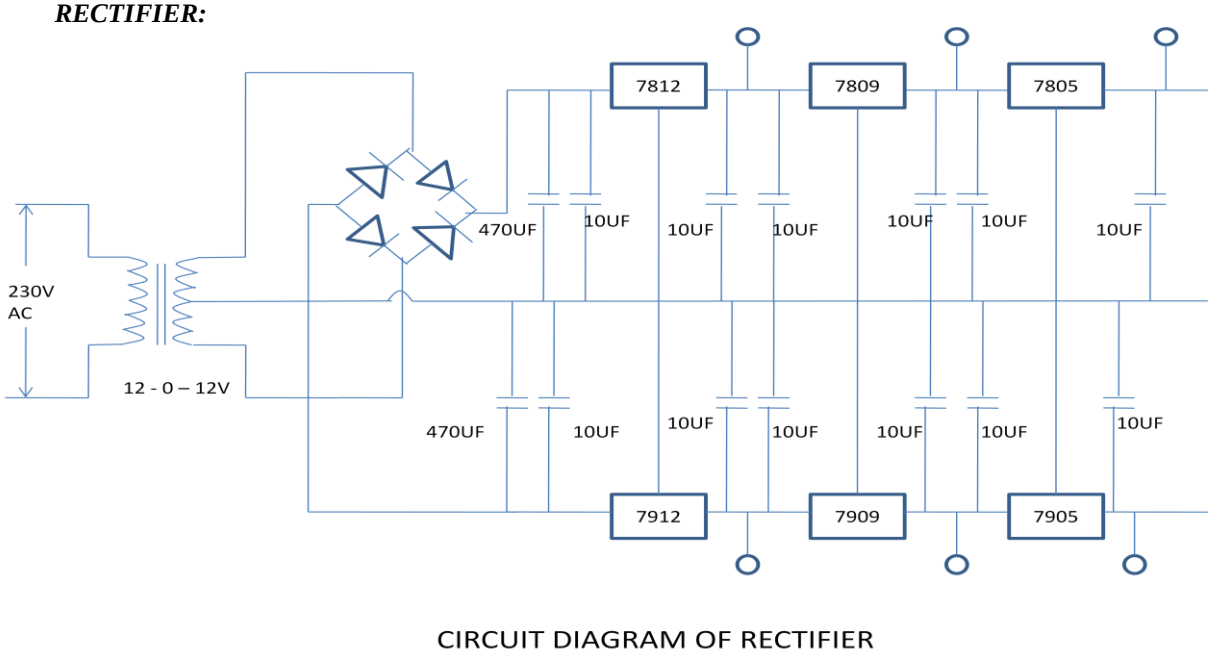


Fig.1. Block Diagram

The circuit diagrams of each converter consists of Circuit Diagram of Rectifier, Buck Converter and Inverter

A. RECTIFIER:



CIRCUIT DIAGRAM OF RECTIFIER

Fig.2. Rectifier

The components of the rectifier unit are LM7812 voltage regulator, LM7809 voltage regulator, LM7805 voltage regulator, LM7912 voltage regulator, LM7909 voltage regulator, LM7905 voltage regulator,IN4007 diodes, 470UF capacitors,10UF capacitors, 12-0-12V Centre tapped transformer

B.BUCK CONVERTER:

The components of the buck converter unit are LM317 voltage regulator, KBU1010 bridge rectifier, IN4007 diode, FR302 diode, IN4148 diode, TIP35C transistor, 5000UF capacitor, 0.1UF capacitor, 270ohm, 10kohm, 1.0 10W resistor, 24 – 0 -24V, Centre Tapped transformer.

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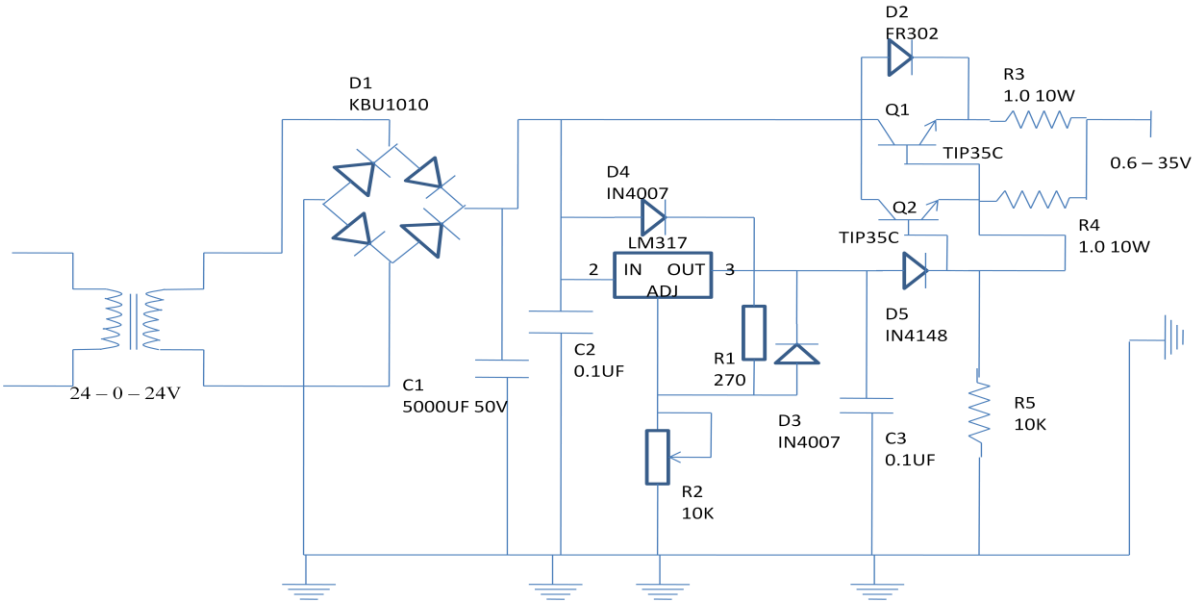
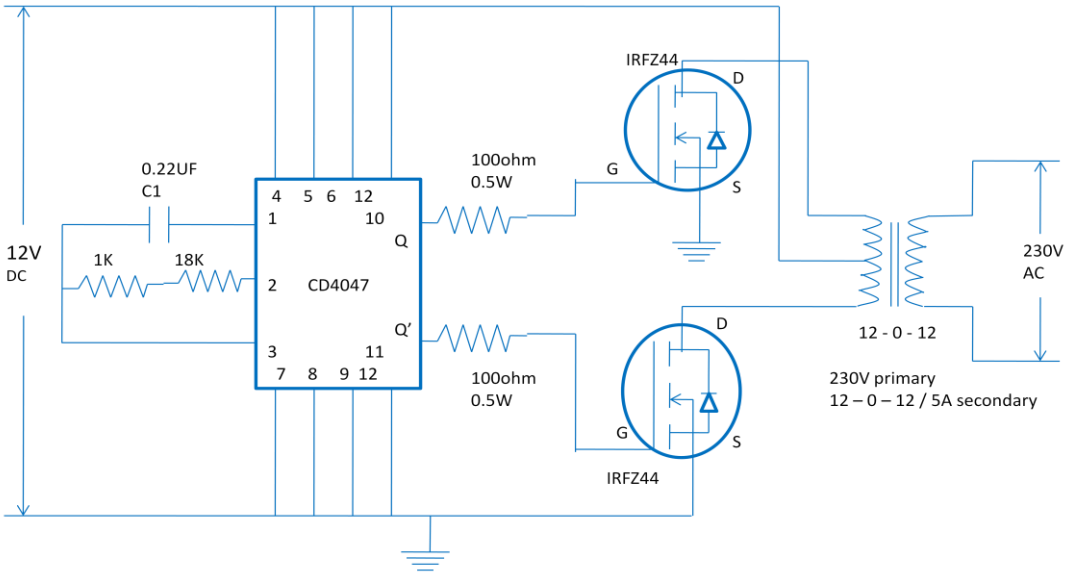


CIRCUIT DIAGRAM OF BUCK CONVERTER

Fig.3. Buck Converter

C.INVERTER:



CIRCUIT DIAGRAM OF INVERTER

Fig.3. Inverter

The components of the inverter unit are CD4047, 100ohm 0.5W resistor, IRFZ44 MOSFET, 1kohm, 18kohm, 0.22UF capacitor, 12-0-12V centre Tapped transformer

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IV.HARDWARE IMPLEMENTATION

A. DESIGN OF RECTIFIER:

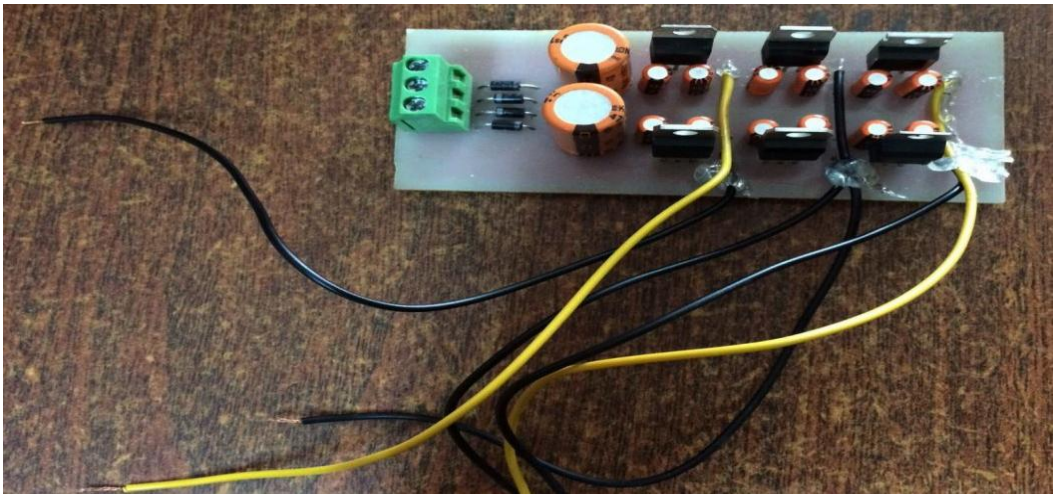

Fig.4. Hardware implementation of the rectifier

Fig. 4 shows the circuit design of rectifier with an input of 230V AC supply and a transformer connected to the circuit to step down the voltage and the output of the rectifier is a fixed DC voltage at ranges of 12V, 9V and 5V. There is a bridge connection of diodes, and capacitors provided in the circuit to reduce the ripple content at the output, it is used as a filter circuit to the entire circuit. The capacitor used in the circuit convert the pulsating DC to pure DC. There is a fixed voltage of both positive and negative voltages.

B.DESIGN OF BUCK CONVERTER:

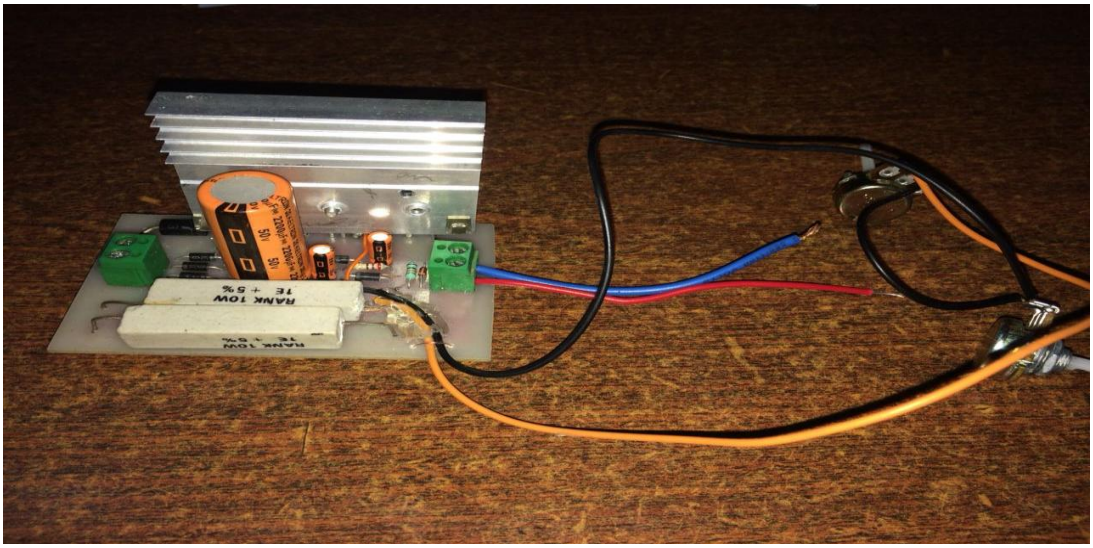

Fig.5. Hardware implementation of the buck converter

Fig.5 shows the circuit design of buck converter with an input of 12V fixed DC and is raised to 45V using a capacitor and is stepped down to a variable DC voltage of range 0-35V. There is heat sink provided at transistors to reduce the heat induced in the circuit. There is rectifier circuit (centre tapped bridge rectifier) included in the buck converter circuit it can work both AC-DC converter and also DC-DC converter.

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C. DESIGN OF INVERTER:

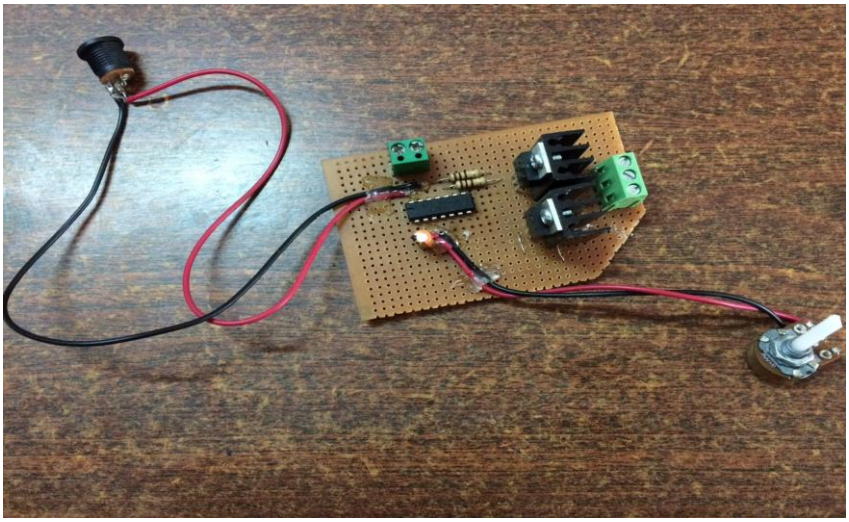
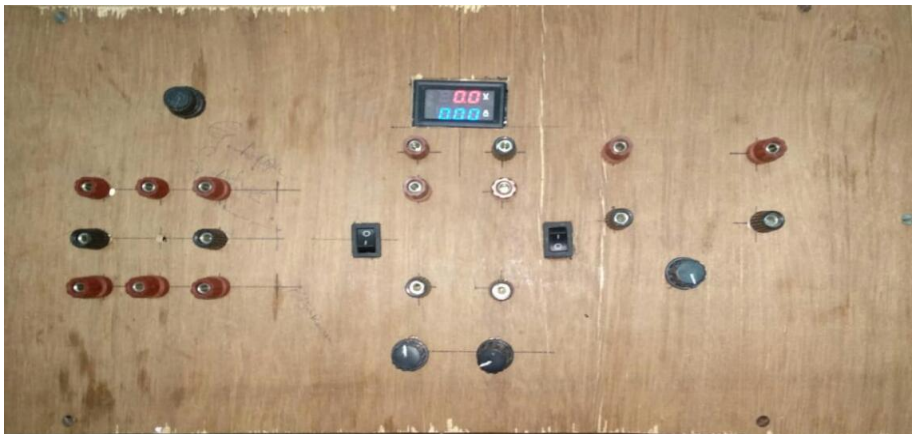


Fig.6. Hardware implementation of inverter

Fig.6 shows the circuit design of inverter with an input of 12V variable DC supply and an output is a 230V AC supply. The MOSFET's used in the circuit provided switching action to produce positive and negative peak of the AC output. Two transistors work alternatively to produce positive and negative peaks respectively. The resistor and capacitor (R & C) combination provides the oscillator action to control over the frequency of the circuit.

D.PROTO-TYPE MODEL OF THIS PROJECT:



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In this model we have used the switches to run the individual circuit and when there is no availability of AC power supply then there is an alternative for that i.e., DC source is available from solar panel to give input as chopper and the entire kit will run except the rectifier circuit. There is a digital display on the kit which provides the voltage and current of buck converter.

V. RESULTS

The rectifier circuit provides an output of fixed voltages of 12V, 9V,5V of both positive and negative and are used for the applications where there is a need of fixed voltages like battery charging, op-amp applications(negative voltages) and the output of the rectifier is provided as input to the buck converter which included in this model. The buck converter output is variable DC which ranges from 0 – 33V and is used in the applications where there is a use of variable DC and the output of buck converter is given as input to inverter which included in the model. The inverter circuit gives the output with 220V, 1A which will be used for the power of 9Watt. The output of inverter circuit is a variable AC which can be used where there is a use of it.

VI. CONCLUSION

In this project we designed different converters for hands-on experience for the training and understand the functioning of converter and are placed on a single board. This makes the circuit easier when compared to individual circuits by the way that from a single input there will be multiple outputs such as fixed DC, variable DC (step down voltage), and variable AC. Single board multipurpose power converter costs low when compared to individual power converters.

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