HYBRID INVERTER WITH SOLAR BATTERY CHARGING

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Abstract : This paper is designed in such a way that it overcomes this limitation by the use of solar energy. Hybrid Inverter with Solar Battery Charging System consists of an inverter powered by a 12V Battery. This inverter generates up to 230V AC with the help of driver circuitry and a heavy load transformer. This battery gets charged from two sources, first being the mains power supply itself and second from the solar power. If the mains power supply is available, then the relay switches to main power supply for supplying the load. This power supply also charges the battery for using it as back up the next time when there is a power outage. The use of solar panel to charge the battery gives an additional advantage of surplus power in case the power outage of mains is prolonging. Thus this inverter can last for longer duration's and provide uninterrupted power supply to the user.

I. INTRODUCTION

An inverter is basically a converter that converts DC-AC power. The word "inverter" in the context of power electronics denotes a class of power conversion circuits that operates from a dc voltage source or a dc current source and converts it into ac voltage or current. Even though input to an inverter circuit is a dc source, it not uncommon to have this dc derived from an ac source such as utility ac supply. Thus, for example, the primary source of input power may be utility ac voltage supply that is converted, to dc by an ac to dc converter and then inverted back to ac using an inverter. Here, the final output may be of a different frequency and magnitude than the input ac of the utility supply.

Typical Applications such as Un-interruptible Power Supply (UPS), Industrial (induction motor) drives, Traction, HVDC. Solar Inverter Currently, the necessity of the solar inverter has been improving day by day. It is a common inverter, but uses energy from the sun that is termed as "solar energy". This kind of inverter helps in changing the DC-AC uses solar power. In this circuit, the DC power flows in one direction and also assists in supplying current when there is no electricity. DC is used for minor appliances like electronic gadgets, MP3 players, iPod, etc (where there is power stored in the battery). Usually, the AC power is used for home appliances. A solar inverter aids several devices that work on DC power to run on AC power so that the worker makes use of the AC power.

According to the National Renewable Energy Laboratory, the sunlight received by earth in one hour is enough to meet the annual energy needs of all people worldwide. Solar energy is suitable for heating and electricity generation using photo voltaic cells. Solar power can restrict climate change as it produces no carbon emissions. Solar energy is the best alternative, which can replace the fossil fuels like coal and gas for electricity generation that create air, water, and land pollution. The solar power (i.e. DC form of energy) can be stored in a battery for future use. The conversion efficiency of a solar cell is the percentage of the solar energy shining on a photo voltaic cell that is converted into usable electricity.

A hybrid inverter or smart grid inverter is a trending generation of inverter for solar applications using renewable energy for home consumption, especially for solar photovoltaic installations. Some see this as a new technology, however in some parts of the world the application of such products has been around since the 1990s. Electricity from solar panels is generated only during the day, with peak generation around midday. Generation fluctuates and may not be synchronized with a load's electricity consumption. To overcome this gap between what is produced and what is consumed during the evening, when there is no solar electricity production, it is necessary to store energy for later use and manage energy storage and consumption with an hybrid inverter. With the development of systems that include renewable energy sources and rising electricity prices, private companies and research laboratories have developed smart inverters for synchronizing energy production and consumption.

II. LITERATURE REVIEW

A large number of national and international studies have been conducted to study the opportunities of reducing electricity consumption and improving energy efficiency of institutional and governmental buildings during rush hours. These studies show that, it is quite possible to limit the increase in energy use without having negative effects. So, the Government of Egypt has set a strategy to implement a number of polices up to year 2022 to diversify energy resources and rationalize the energy needs of different activities without hindering the development plans. Among these polices are taking executive actions to increase energy efficiency in order to reduce total energy consumption by 8.3 % by the year 2020, and achieving an electricity generation mix composed of 20 % RE, by year 2022.

III. PROPOSED SYSTEM

Proposed block diagram is shown in figure 3.1

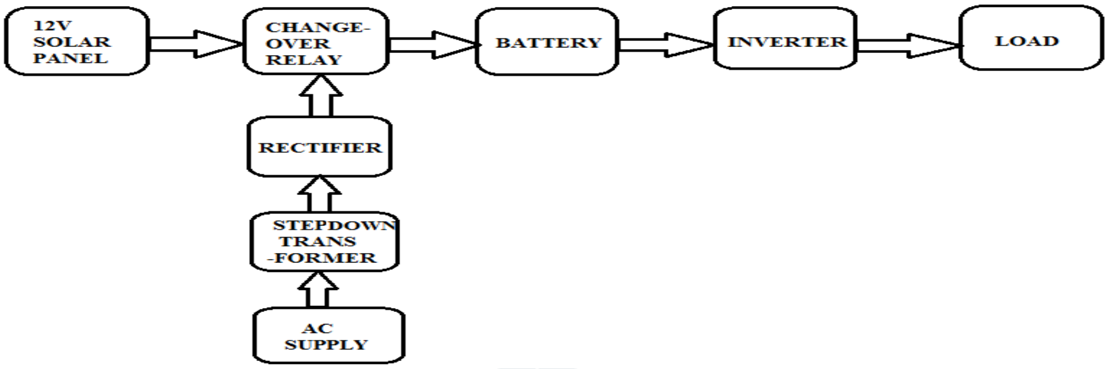

Figure 3.1 Block diagram of hybrid inverter with solar battery charging

3.1 COMPONENTS

3.1.1 SOLAR PANEL

Photo voltaic solar panels absorb sunlight as a source of energy to generate electricity. A photovoltaic (PV) module is a packaged, connect assembly of typically 6x10 photo voltaic solar cells. Photo voltaic modules constitute the photo voltaic array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 365 Watts (W). The efficiency of a module determines the area of a module given the same rated output an 8% efficient 230 W module will have twice the area of a 16% efficient 230 W module. There are a few commercially available solar modules that exceed efficiency of 22% and reportedly also exceeding 24%. A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photo voltaic system typically includes an array of photo voltaic modules, an inverter, a battery pack for storage, interconnection wiring, and optionally a solar tracking mechanism. The most common application of solar panels is solar water heating systems. The price of solar power has continued to fall so that in many countries it is cheaper than ordinary fossil fuel electricity from the grid.

3.1.2 12V, 4.5 AH RECHARGEABLE BATTERY

A rechargeable battery, storage battery, secondary cell, or accumulator is a type of electrical battery which can be charged, discharged into a load, and recharged many times, as opposed to a disposable or primary battery, which is supplied fully charged and discarded after use. It is composed of one or more electrochemical cells. The term "accumulator" is used as it accumulates and stores energy through a reversible electrochemical reaction. Rechargeable batteries are produced in many different shapes and sizes, ranging from button cells to megawatt systems connected to stabilize an electrical distribution network. Several different combinations of electrode materials and electrolyte are used, including lead-acid, nickel-cadmium, nickel-metal hydride, lithium-ion, and lithium-ion polymer.

During charging, the positive active material is oxidized, producing electrons, and the negative material is reduced, consuming electrons. These electrons constitute the current flow in the external circuit. The electrolyte may serve as a simple buffer for internal ion flow between the electrodes, as in lithium-ion and nickel-cadmium cells, or it may be an active participant in the electrochemical reaction, as in lead–acid cells. The energy used to charge rechargeable batteries usually comes from a battery charger using AC mains electricity, although some are equipped to use a vehicle's 12-volt DC power outlet. The voltage of the source must be higher than that of the battery to force current to flow into it, but not too much higher or the battery may be damaged.

3.1.3 IC 741 OP AMP

The IC 741 operational amplifier looks like a small chip. The most significant pins are 2,3 and 6, where pin2 and 3 are pin 2 and 3 denote inverting & non-inverting terminals and pin6 denotes output voltage. The triangular form in the IC signifies an op-amp integrated circuit. The current version of the chip is denoted by the famous IC 741 op amp. The main function of this IC 741 is to do mathematical operations in various circuits. IC 741 op amp is made from various stages of transistor which commonly have three stages like differential i/p, a push-pull o/p and an intermediate gain stage. The differential op-amps comprises of a set of FETs or BJTs.

3.1.4 PIN DIAGRAM OF IC 741 OP-AMP

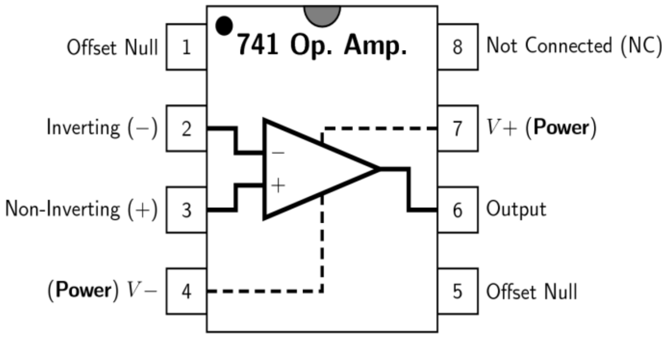

Fig 3.2 Pin diagram of IC 741 op amp

3.1.5 12V SINGLE CHANGEOVER RELAY

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contactor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays". Magnetic latching relays require one pulse of coil power to move their contacts in one direction, and another, redirected pulse to move them back. Repeated pulses from the same input have no effect. Magnetic latching relays are useful in applications where interrupted power should not be able to transition the contacts.

Magnetic latching relays can have either single or dual coils. On a single coil device, the relay will operate in one direction when power is applied with one polarity, and will reset when the polarity is reversed. On a dual coil device, when polarized voltage is applied to the reset coil the contacts will transition. AC controlled magnetic latch relays have single coils that employ steering diodes to differentiate between operate and reset commands.

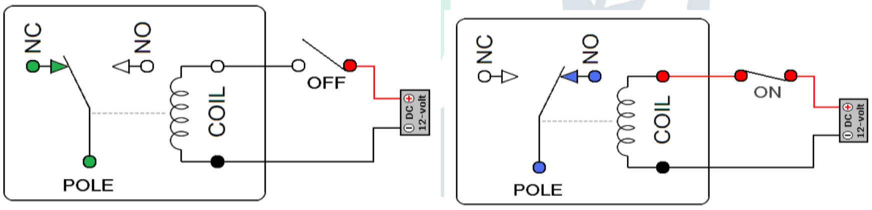

Fig 3.3 Circuits of relay off and on positions

3.1.6 1N5402 DIODES

This is the axial type diode. This is easily mountable on the general purpose PCB. The features of this diode are:

- Low forward voltage drop
- High current capability
- High reliability
- High surge current capability

The symbol of diode is shown in below figure

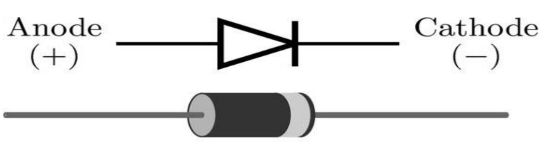

Fig 3.4 Diode symbol

3.1.7 ZENER DIODE

A conventional solid-state diode allows significant current if it is reverse-biased above its reverse breakdown voltage. When the reverse bias breakdown voltage is exceeded, a conventional diode is subject to high current due to avalanche breakdown. Unless this current is limited by circuitry, the diode may be permanently damaged due to overheating.A zener diode exhibits almost the same properties, except the device is specially designed so as to have a reduced breakdown voltage,the so-called zener voltage.By contrast with the conventional device,a reverse-biased zener diode exhibits a controlled breakdown and allows the current to keep the voltage across the zener diode close to the zener breakdown voltage.

Fig3.5 Zener diode

3.1.8 LIGHT-EMITTING DIODE

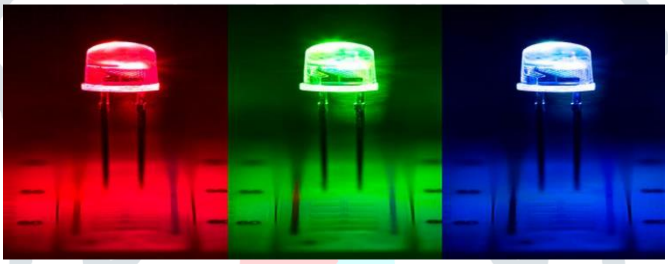

Fig 3.6 LED's

A light-emitting diode (LED) (pronounced) is a semiconductor light source. LEDs are used as indicator lamps in many devices and are increasingly used for lighting. Introduced as a practical electronic component in1962, early LEDs emitted low-intensity red light, but modern versions are available across the visible, ultraviolet and infrared wavelengths, with very high brightness.

3.1.9 TRANSISTOR BC550

A BC550 transistor is a negative-positive-negative (NPN) transistor that is used for many purposes. Together with other electronic components, such as resistors, coils, and capacitors, it can be used as the active component for switches and amplifiers. Like all other NPN transistors, this type has an emitter terminal, a base or control terminal, and a collector terminal. In a typical configuration, the current flowing from the base to the emitter controls the collector current. A short vertical line, which is the base, can indicate the transistor schematic for an NPN transistor, andthe emitter, which is a diagonal line connecting to the base, is an arrowhead pointing away from the base.

Fig 3.7 Symbol of Transistor

3.1.10 STEP DOWN TRANSFORMER

A Transformer is a static apparatus, with no moving parts, which transforms electrical power from one circuit to another with changes in voltage and current and no change in frequency.

There are two types of transformers classified by their function: Step up Transformer and Step down Transformer.A transformer that increases voltage from primary to secondary (more secondary winding turns than primary winding turns) is called a step-up transformer. A transformer that decreases voltage from primary to secondary (less secondary winding turns than primary winding turns) is called a step-down transformer. An electrical transformer works on the principle of Mutual Induction, which states that a uniform change in current in a coil will induce an E.M.F in the other coil which is inductively coupled to the first coil. In its basic form, a transformer consists of two coils with high mutual inductance that are electrically separated but have common magnetic circuit. The following image shows the basic construction of a Transformer.

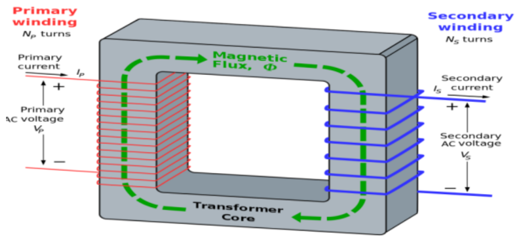

Fig3.8 Basic circuit of transformer

IV. CIRCUIT MODEL AND WORKING

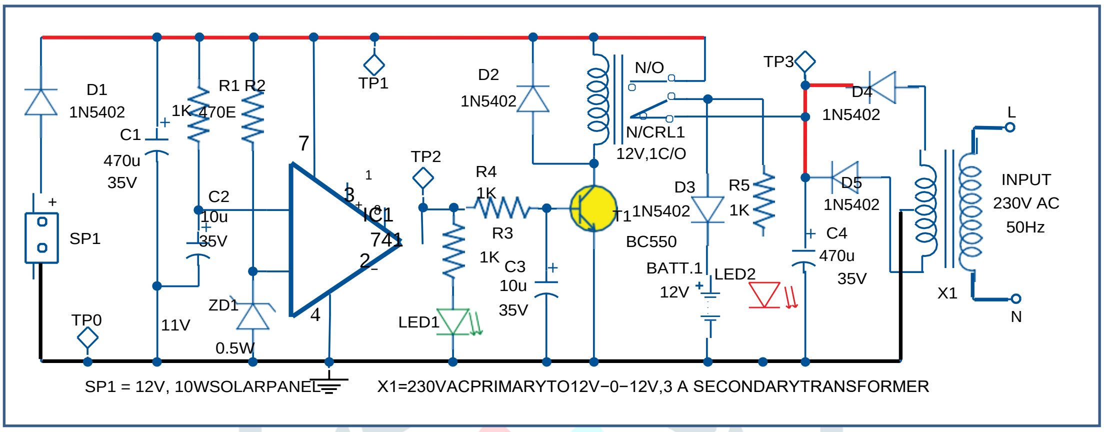

Fig 4.1 Circuit diagram of hybrid inverter with solar battery charging

This Circuit is built around a 12V, 10W solar panel (connected at SP1), operational amplifier 741 (IC1), transistor BC547 (T1), 12V single changeover relay (RL1), step-down transformer X1 and a few other components. In bright sunlight, the 12V, 10W solar panel provides up to 17 volts DC with 0.6-ampere current. Diode D1provides reverse polarity protection and capacitor C1 buffers voltage from the solar panel. IC1 is used as a simple comparator. Zener diode ZD1 provides a reference voltage of 11 volts to the inverting input of IC1, while the IC's non-inverting input gets voltage from the solar panel through R1.

Working of the circuit is simple. When output from the solar panel is 12 volts or more, Zener diode ZD1 conducts and provides 11 volts to the inverting terminal of IC1. Since its non-inverting input gets a higher voltage at this time, the output of the comparator turns high and the same is indicated by glowing green LED1. Transistor T1 then conducts and relay RL1 energizes. Thus the battery gets charging current from the solar panel through the normally-open (N/O) and common contacts of relay RL1. LED2 indicates charging of the battery. Capacitor C3 is provided for clean switching of transistor T1. Diode D2 protects T1 from back EMF and diode D3 prevents the discharge of battery current into the circuit. When output from the solar panel drops below 12 volts, output of the comparator turns low and the relay de-energizes. Now the battery gets charging current from the transformer-based power supply through the normally closed (N/C) and common contacts of the relay. This power supply comprises step-down transformer X1, rectifying diodes D4 and D5, and smoothing capacitor C4.

4.1 CIRCUIT DIAGRAM OF SIMPLE INVERTER

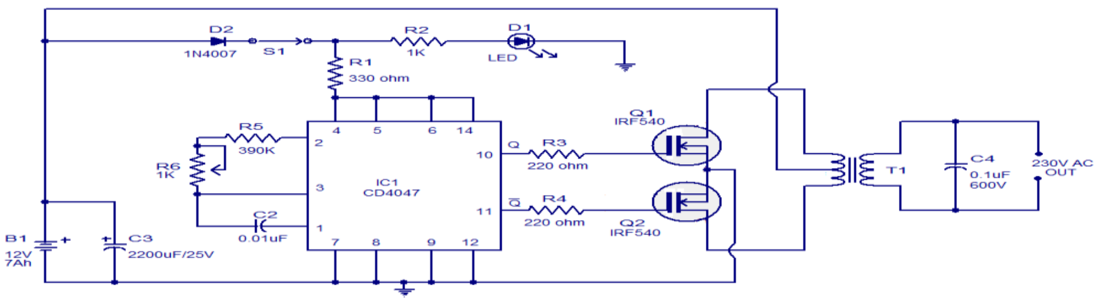

Fig 4.2 Circuit diagram of a simple inverter

A simple watt inverter using IC CD4047 and MOSFET IRF540 is shown above. CD 4047 is a low power CMOS astable/monostable multivibrator IC. Here it is wired as an astable multivibrator producing two pulse trains of 0.01s which are

180 degree out of phase at the pins 10 and 11 of the IC. Pin 10 is connected to the gate of Q1 and pin 11 is connected to the gate of Q2. Resistors R3 and R4 prevents the loading of the IC by the respective MOSFETs. When pin 10 is high Q1 conducts and current flows through the upper half of the transformer primary which accounts for the positive half of the output AC voltage. When pin 11 is high Q2 conducts and current flows through the lower half of the transformer primary in opposite direction and it accounts for the negative half of the output AC voltage.

- B1 can be a 12V/ 6Ah lead acid battery.
- Q1 and Q2 must be fitted to a proper heat sink.
- T1 can be a 9-0-9 V primary, 230V secondary, 150VA transformer.
- This is very simple one suitable for low grade applications.

V. PRACTICAL RESULTS OF THE CIRCUIT

5.1 HYBRID INVERTER WITH SOLAR BATTERY CHARGING

The below figure 5.1 shows the practical setup for hybrid inverter with solar battery charging.

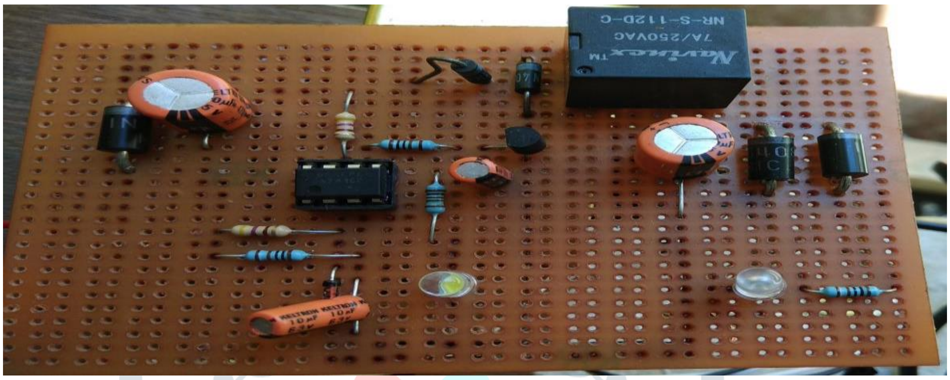

Fig 5.1 Practical setup for hybrid inverter with solar battery charging

The hybrid inverter with solar battery charging circuit gets charged from two sources i.e., from AC mains supply and solar power. whenever the output from the solar panel is above 12 volts, the 12 volts and the voltage reference provided by zener diode is compared by using an operational amplifier which acts as a voltage comparator. If the non-inverting terminal input is less than the inverting terminal input, then the battery gets charged from the solar power otherwise the battery gets charged from AC supply. When the battery gets charged from AC supply, then the red LED will glow and when the battery gets charged from solar panel, then the green LED will glow.

5.2 INVERTER CIRCUIT

The below figure 5.2 shows the practical setup for inverter circuit.

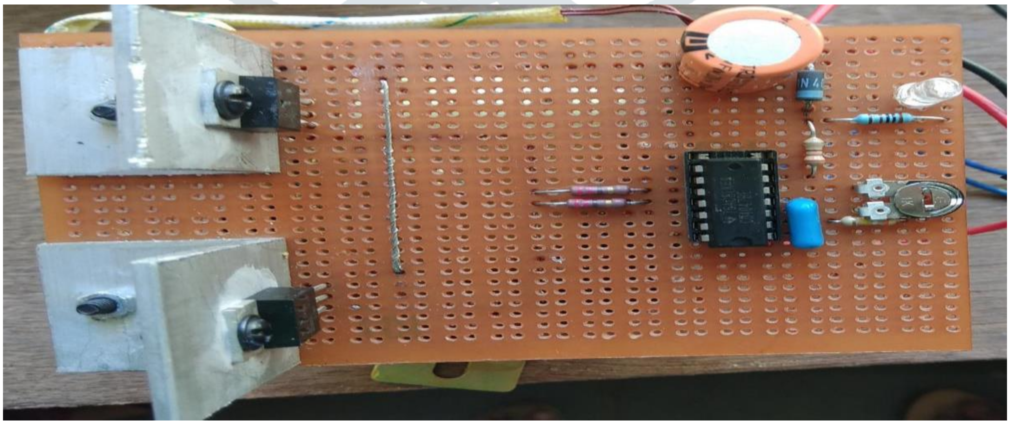

Fig 5.2 Practical setup for Inverter circuit

A power inverter, or inverter, is an electronic device or circuitry that changes direct current (DC) to alternating current (AC).The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source Inverter is used to convert dc power into ac power. The output dc voltage from the battery is converted to ac voltage by using a simple inverter. The 12 volts output voltage from the battery is fed to the inverter. The inverter converts the 12 volts dc voltage to 9 volts ac voltage and the obtained 9 volts ac voltage is stepped up to 230 volts ac voltage by using an step up transformer. This ac voltage can be used for home appliances, domestic needs etc.

5.3 WORKING WITH AC SUPPLY

The below figure 5.3 shows the hybrid inverter with solar battery charging circuit while charging with AC supply.

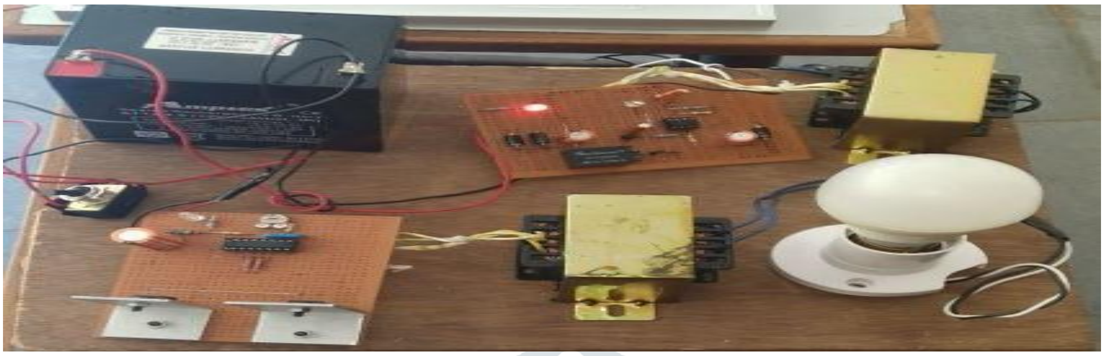

Fig 5.3 Hybrid inverter with solar battery charging circuit while charging with AC supply

As the output from the solar panel is below 12volts,the relay switches to the AC supply and the battery gets charged from AC supply which is indicated by red LED. Whenever the output from the solar panel is above 12 volts,the relay switches to solar power.

5.4 WORKING WITH SOLAR POWER

The below figure 5.4 shows the hybrid inverter with solar battery charging circuit while charging with solar power.

Fig 5.4 Hybrid inverter with solar battery charging circuit while charging with solar power

As the output from the solar panel is above 12volts, the relay switches to solar power and the battery gets charged from solar power which is indicated by green LED.Whenever the output from the solar panel is below 12 volts, the relay switches to AC supply.

5.5 WORKING OF INVERTER

The below figure 5.5 shows the practical setup for working of inverter circuit.

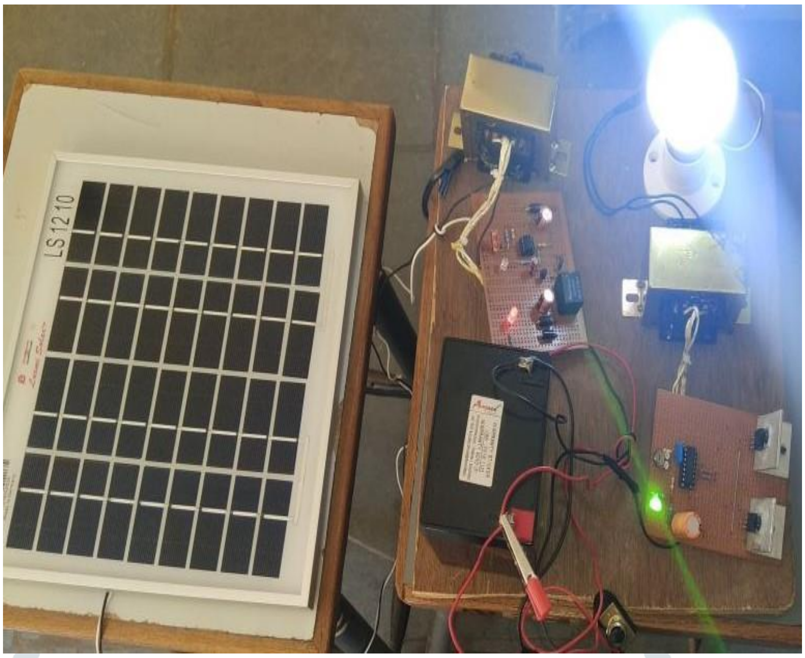

Fig 5.5 Practical setup for inverter circuitry

After the battery was charged by either AC supply or solar power,the battery output voltage of 12 volts is fed to inverter. Inverter is switched ON and OFF by using an switch. When the switch is ON, the inverter supplies 230 AC voltage to the applied load. The switch can be switched OFF when the load is not in use.

VI. CONCLUSION & FUTURE SCOPE

From this paper It is observed that the hybrid inverter with solar battery charging provides an uninterrupted power supply during the power cuts. It is also economical as we are using solar power, which is free of cost. The solar power is also pollution free and eco-friendly in nature. A solar hybrid system stores your excess solar energy and can also provide back-up power during a blackout. As the inverter provides uninterrupted power supply, this project is applicable in the areas like hospitals, educational institutions etc. All the circuit topologies proposed in the present work is related to a single-phase inverter system. Thus, these topologies can be easily extended for the three-phase system. The inverter used in this project is combined with both ac and solar power. This can be extended by combing solar with wind energy and other renewable sources.

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