HYBRID INVERTER WITH SOLAR BATTERY CHARGER

A Project report submitted in partial fulfilment

of the requirements for the degree of B. Tech in Electrical Engineering

By

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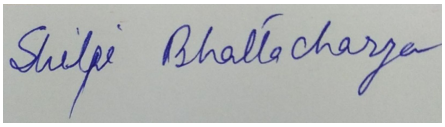
CERTIFICATE

To whom it may concern

This is to certify that the project work entitled **Hybrid Inverter with Solar Battery Charger** is the bona fide work carried out by **Swakhar Shome(11701618013), Souhardya Chakravorty(11701618024), Subhajit Pal(11701618017),**, the students of B.Tech in the Dept. of Electrical Engineering, RCC Institute of Information Technology (RCCIIT), Canal South Road, Beliaghata, Kolkata-700015, affiliated to Maulana Abul Kalam Azad University of Technology (MAKAUT), West Bengal, India, during the academic year 2021-22, in partial fulfillment of the requirements for the degree of Bachelor of Technology in Electrical Engineering and this project has not submitted previously for the award of any other degree, diploma and fellowship.



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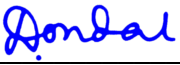

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Signature of the External Examiner

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It is my great fortune that I have got opportunity to carry out this project work under the supervision of **Dr. Shilpi Bhattacharya** in the Department of Electrical Engineering, **RCC Institute of Information Technology (RCCIIT),** Canal South Road, Beliaghata, Kolkata-700015, affiliated to **Maulana Abul Kalam Azad University of Technology (MAKAUT), West Bengal, India**. I express my sincere thanks and deepest sense of gratitude to my guide for her constant support, unparalleled guidance and limitless encouragement.

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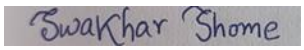
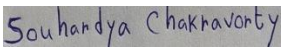
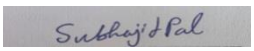
I would also like to convey my gratitude to all the faculty members and staffs of the Department of Electrical Engineering, RCCIIT for their whole hearted cooperation to make this work turn into reality.







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Place: Kolkata

Date:15/06/2022

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ABSTRACT

We live in a wired world, where nearly everything in our lives requires a steady supply of electricity to remain in operation. Sometimes extreme weather conditions, car accidents, falling trees, unusually high power demands, or even damage caused by animals can cause severe disruptions in a local or regional electrical grid, leaving our home without electricity for hours or more at a time. So, we use inverter in our houses.

Inverters are widely used in the domestic as well as industrial environments to serve as a second line of source. A solar inverter's main job is to convert DC power generated from the photovoltaic cell into AC power. Hybrid inverters go a step further and work with batteries to store excess power as well. But this solar inverter system is inefficient in charging the battery during cloudy weather condition.

The battery requires more than 1 Ampere current for proper charging and due to low capacity of the battery, when solar power is not available. the battery dies out with the use of heavy load appliances. To solve this problem, we made a "Hybrid Inverter with Solar Battery Charging". This project is designed in such a way that it overcomes the limitation by the use of only solar energy.

Electricity from the solar panel is generated only during the day, with peak generation around midday. This generation fluctuates with various weather conditions and as there is no generation in the night, it is not possible to constantly supply the demands from the load end. When solar power is not available or insufficient to supply the load demands and if the mains power supply is available, then this "Hybrid Solar Inverter" switches to AC mains power supply for supplying the load. This power supply then charges the battery for using it as back up for the next time when there is a power outage in the mains. 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 provides uninterrupted power supply to the user.

Chapter I : Introduction

Introduction:

An intelligent hybrid inverter or smart grid inverter is a new generation of dedicated U.P.S. (Uninterruptible Power Supply) system which can use both electrical as well as solar energy to charge the system storage battery which can be used to generate electricity in the absence of either or both of energy sources. Usually electricity from solar panels is generated only during the day, with peak production around midday. This electricity is fluctuating and not synchronized with the electric consumption of the household. To overcome this gap between what is produced and what is required 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 in an intelligent way.

Special Features:

- Automatically battery charging by two ways (Solar Power Supply/Main Power Supply). When solar power supply is not available then battery charging is done by main power supply (AC mains). Otherwise, battery charging occurs through solar power supply.
- Optimal utilisation of solar energy.
- Uninterrupted power supply. In case of power outage from either or both the power sources (Solar power and AC mains) the battery provides backup and continues to supply the load.
- Low maintenance cost. This inverter does not require frequent servicing.

Organization of the project report:

Chapter-I, is a discussion on introduction of the "Hybrid Inverter with Solar Battery Charging". The special features, organization of the report, motivation & objective of the project are detailed in this Chapter.

Chapter–II gives a discussion on system components, diagrams, circuits, cost estimation with their detailed explanation presented component wise.

Chapter-III & IV presents the logic and basic operations, advantages and disadvantages and the expected problems associated with the inverter operation.

Chapter-V & VI presents the conclusion and scope of future work .Which contains Scope of Future Work, results, references, literature survey.

Motivation & Objective :

Apparently we don't have so much of sources for production of "Clean Energy" and on the other hand, we do actually have that much more sources and power plants to produce conventional energy such as thermal power plants, diesel power plant as well as nuclear power plants, the raw ingredients of which are bound to come to an end.

As clean energy can be derived from force of water or wind as well as from the energy we get from the sunlight which we don't have any limitations too, it would be wise for us to be innovative and as we are advanced enough, to use those sources rather than to replenish the conventional ones.

So, with that very idea in mind, we chose to exhibit our project of a "Hybrid Inverter with Solar Battery Charger" to kinder the minds of the youth as well as the elderly today to indulge more towards clean energy that'll be beneficiary to everyone living and to live on our dear planet.

Chapter II – Components

Components List and Cost Estimation

Sl NO	Component	Component Specifications	Model/Types	Quantity	Cost Per Piece(INR)
1.	Solar Panel	12 Volt, 10 Watt	Mono/Multi Crystalline Solar Panel	1	700/-
2.	Rechargeable Battery	12 Volt, 7.2 Ah	Rechargeable Lead Acid (Sealed) Battery	1	600/-
3.	Op-Amp		IC 741	1	40/-
4.	Relay	12 Volt DC	Single Change-over Relay	1	25/-
5.	Diode	Simple P-N junction diode	1N4007	5	(2*5/-)=10/-
6.	Zener Diode	11Volt , 0.5 Watt	------	1	10/-
7.	L.E.D.	3-3.2 Volt forward voltage drop	------	6	(6*1/-)= 6/-
8.	Transistor	Silicon based BJT(forward biased voltage drop Vce=0.3 v)	1.BC547 2.MJE13003	1 2	10/- (2*10/-)=20/-

9.	**Mosfet**	**Drain current of 49A and Rds value of 17.5 mΩ**	**1. IRFZ44N** **2.Heat Sink**	**2** **2**	**(2*20/-)=40/-** **(2*10/-)=20/-**
9.	**Transformer**	**230v to 16-0-16v &** **12-0-12v to 220v**	**One for Step-down and another for Step-up**	**(1+1)**	**(120+80)** **=200/-**
10.	**Bulb**	**230 Volt , 5 Watt** **230 Volt , 20 Watt**		**1** **1**	**80/-** **150/-**
11.	**Others**	**Resistors, capacitors, jumper wires,2 pin-plug etc**	**------**	**-----**	**300/-**

Total cost of the project:	**2,211/-**

System Components :

1. 12v,10w Solar Panel
2. 12v, 7200 Mah Rechargeable Battery
3. Ca3130 Op Amp
4. 12v Single Changeover Relay
5. 1n4007 Diodes
6. Zener Diode
7. Light-Emitting Diode
8. Transistor Bc547
9. Step Down Transformer
10. Mosfet
11. Bjt

Component Details:

12V,10W Solar Panel:

Photo voltaic solar panels absorb sunlight as a source of energy to generate electricity. A photovoltaic (PV) module is a connected 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).

Figure 1: Photovoltaic Solar Panel

12V, 7200 MAH RECHARGEABLE BATTERY :

A rechargeable battery, Lead Acid 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.

Figure 2

Figure 3

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.

CA3130 OP AMP :

The IC 741 operational amplifier looks like a small chip. The most significant pins are 2, 3 and 6, where pin 2 and 3 denotes 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.

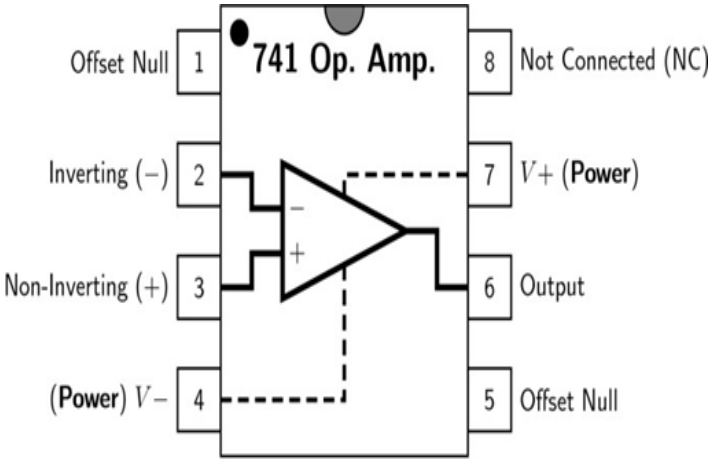


Figure 4: 741 OP-AMP IC Pin Diagram

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.

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.

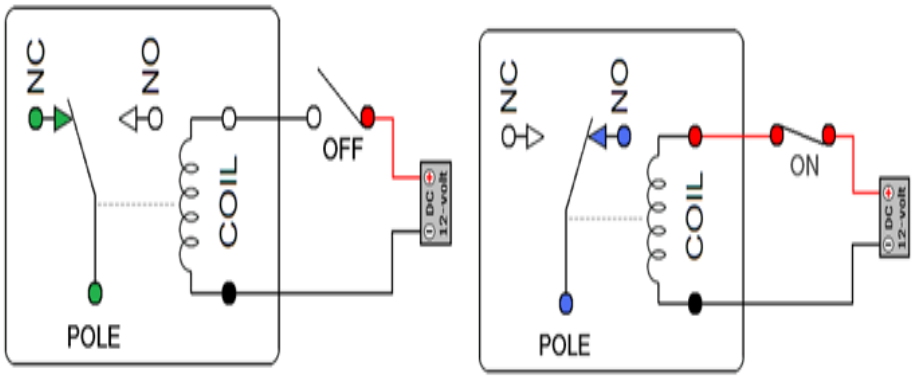


Figure 5: 12 V Single Changeover Relay

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.

1N4007 DIODES:

They are axial type diodes. They are easily mountable on the general purpose PCB. The main features of this diode are:

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

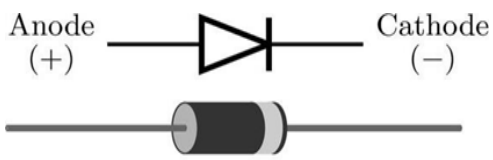


Figure 6: 1N5407 Diodes

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.

Figure 7: Zener Diode

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.

LIGHT-EMITTING DIODE:

A light-emitting diode (LED) 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 in 1962, early LEDs emitted low-intensity red light, but modern versions are available across the visible, ultraviolet and infrared wavelengths, with very high brightness.

Figure 8: Light Emitting Diodes

BC547 and MJE13003 TRANSISTOR:

A 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.

Figure 9 & 10:BC547 and MJE13003 Transistor

In a typical configuration, the current flowing from the base to the emitter controls the collector current. A short horizontal line, which is the base, can indicate the transistor schematic for an NPN transistor, and the emitter, which is a diagonal line connecting to the base, is an arrowhead pointing away from the base.

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.

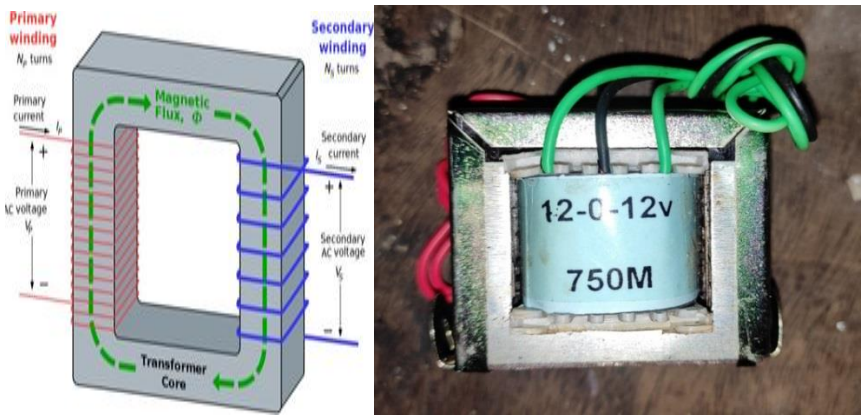


Figure 11: Transformer

Step down transformer that decreases voltage from primary to secondary (less secondary winding turns than primary winding turns) is called a step-down transformer. Step up transformer that increases voltage from primary to secondary (more secondary winding turns than primary winding turns) is called a step-up transformer. An electrical transformer works on the principle of Mutual Induction.

MOSFET IRFZ44N:

MOSFET is a power electronic device and is called as Metal Oxide Semiconductor Field Effect Transistor. They have improved current carrying capacity and high OFF state blocking voltage capacity. They are capable of switching at very high switching frequency about 100KHz.It is a voltage control device which has low input current. The switching speeds are of the order nano seconds and they not have the problem of second breakdown.

There are two types of MOSFET:

1.Depletion MOSFET

2.Enhancement MOSFET

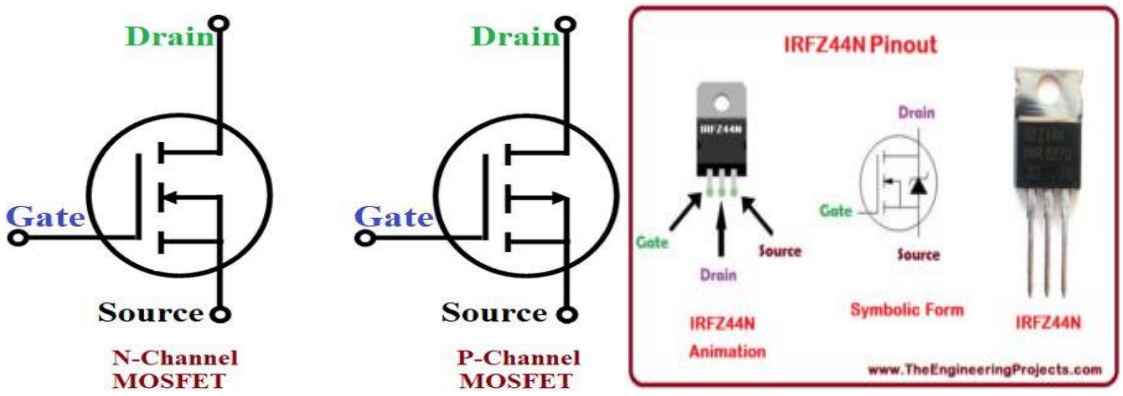
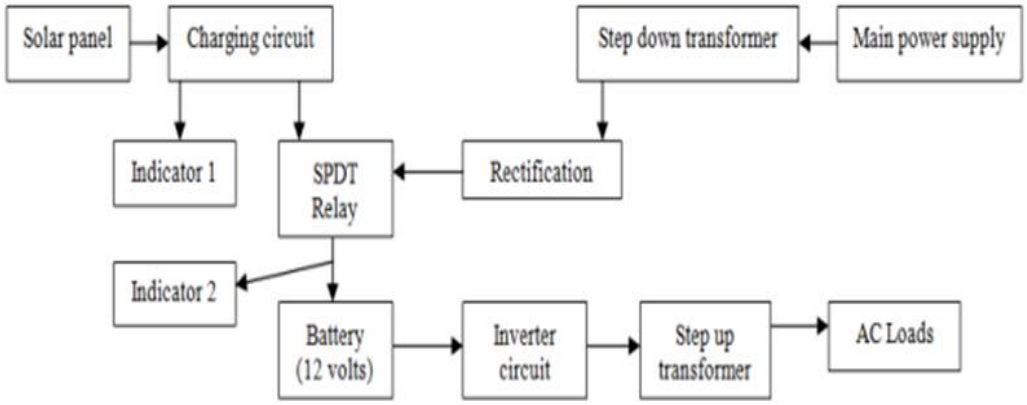


Figure 12: MOSFET IRFZ44N

CHAPTER III :Control Circuit and Operation

When solar power is unavailable and AC mains is available, the battery gets the charging current from the transformer based power supply through the Normal Close(N/C) and common contacts of the relay. When solar power is available battery gets the charging current from solar panel through Normal Open(N/O) and common contacts of the relay.

BLOCK DIAGRAM:



This is the block diagram of our entire circuit. The Relay automatically connects the battery to either Solar Power or AC mains whichever is available at that moment and thus supplies the load uninterruptedly.

POWER FLOW DIAGRAM:

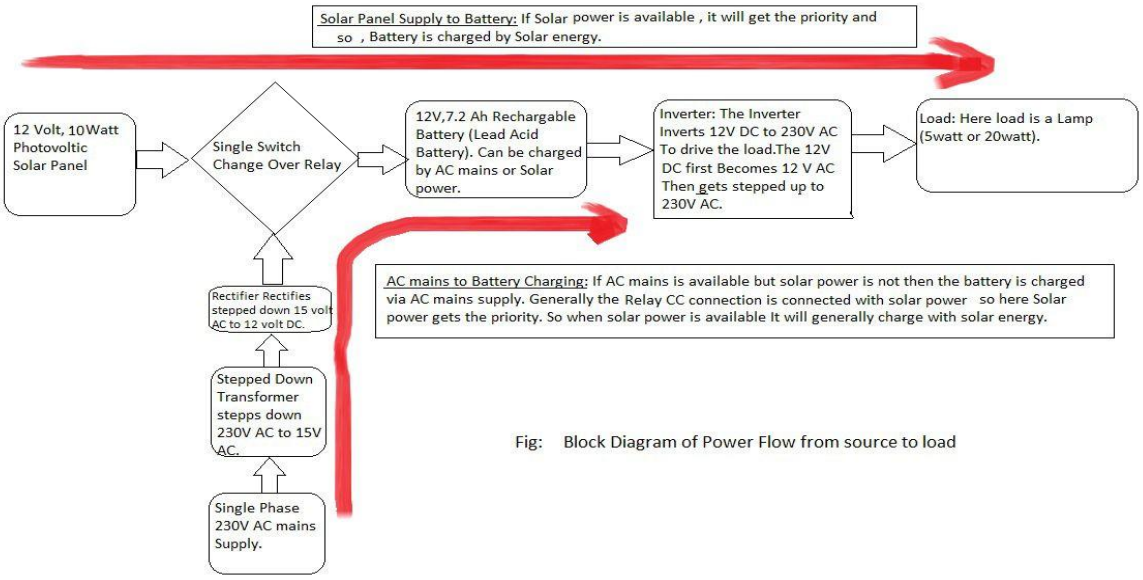


Fig: Block Diagram of Power Flow from source to load

This is the power flow diagram of our entire circuit. The red arrow indicates the flow of power from AC mains and Solar Panel.

CIRCUIT DIAGRAM:

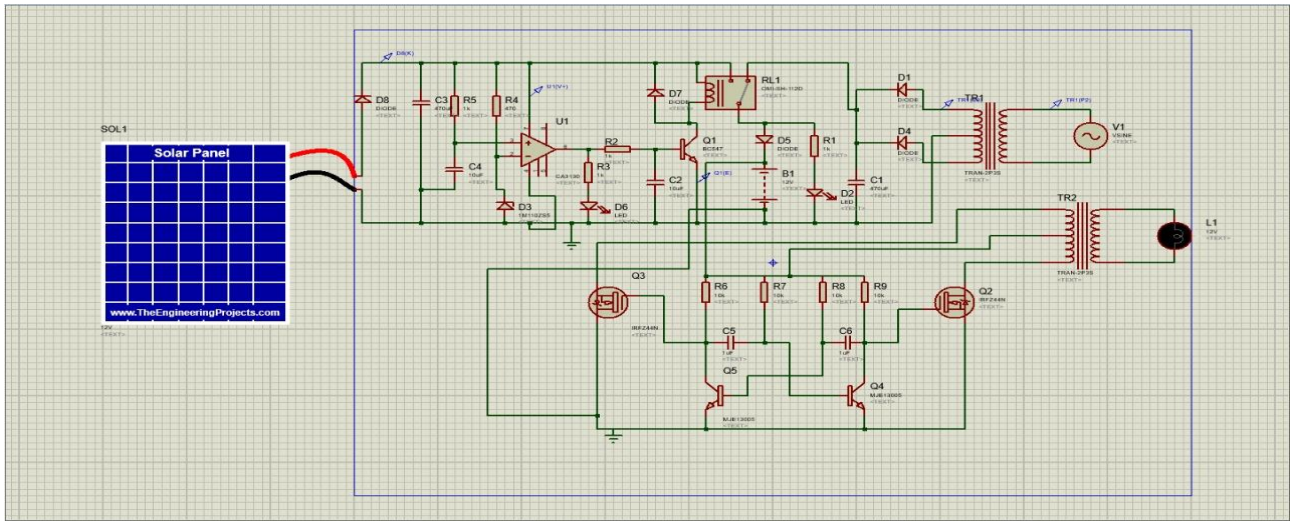


Figure 13: PROTEUS Model of the entire circuit

This is the schematic of the circuit. The schematic contains two parts. The upper part of the schematic is the Charging circuit and the lower part is the Inverter circuit.

Working Principle :

Hybrid inverter using solar charger is combination of two circuits

1. Charging circuit.

And

2. Inverter circuit.

Working of Charging circuit:

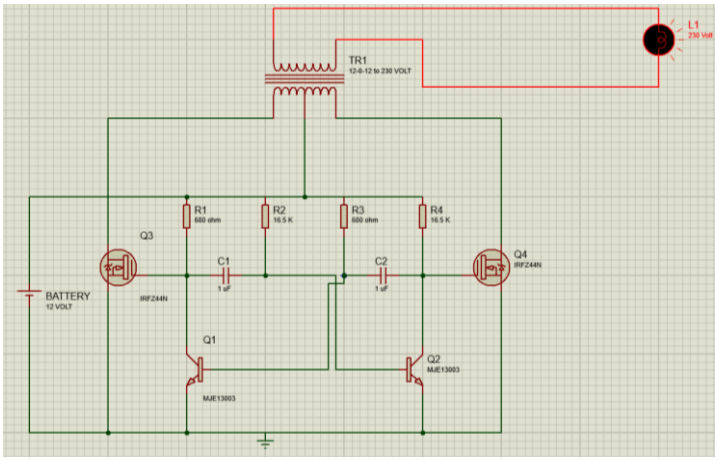
In charging circuit, when output from the solar panel is 12 volts, the battery charges using the solar power. When the output of solar panel drops below 12 volts, the battery charges through the AC mains power supply. This changeover is done through the 12 volts SPDT (single pole double throw) relay.

In bright sunlight solar panel gives a steady output of 12 volts.Then the zener diode goes in breakdown region and provides 11 volts to the inverting terminal of the comparator . 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.then the Transistor conducts and the relay energizes. Thus the battery gets charging current from the solar panel through the normally-open (N/O) and common contacts of relay. A glowing green LED indicates charging of the battery from the solar panel. A capacitor is provided for clean switching of transistor. There is a diode to protect the transistor from back EMF and another diode 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, two rectifying diodes, and smoothing capacitor.

Working of Inverter Circuit:

The inverter circuit is basically a multivibrator. The negative voltage passing through the capacitor C2 turns off the transistor Q1 which causes the capacitor C1 to initiate charging through resistor R and Vcc, as well as through the base emitter of transistor Q2. This causes the transistor Q2 to acquire the momentary ON state.

During the process, the capacitor C2 gradually discharges until it's completely empty, and then it starts charging from opposite direction through R2.



As soon as the voltage in capacitor C2 is sufficient to turn ON transistor Q1, Q1 switches ON and forces capacitor C1 to initiate discharging.

The above process keeps recycling causing a sustained and alternate switching of the transistors as long as the circuit in the powered state and produces a near sinusoidal wave of frequency 60 Hz.

Chapter IV : Basic Operations

LOGIC AND BASIC OPERATIONS:

Operation 1:

CHARGING FROM AC MAINS

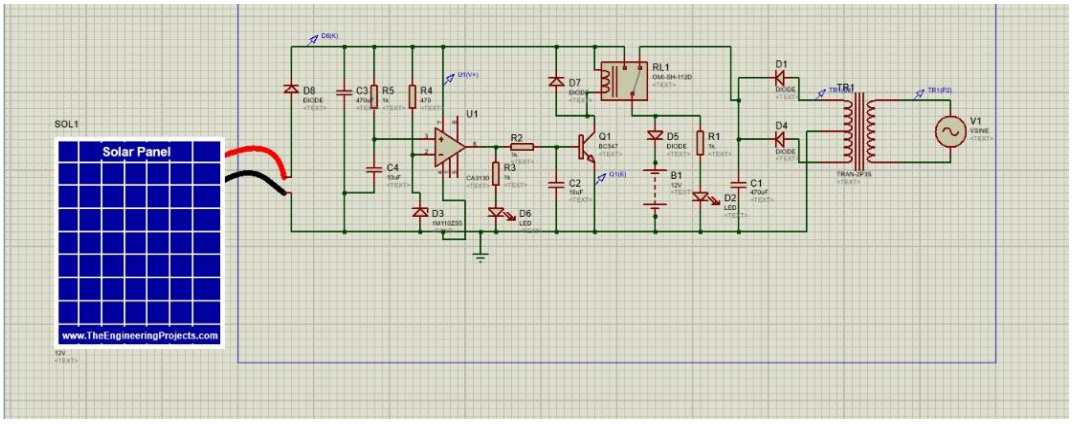


Figure 14: Charging of battery when only AC mains is available

- When solar power is unavailable and AC mains is available, the battery gets the charging current from the transformer based power supply through the Normal Close(N/C) and common contacts of the relay. This power supply comprises step down transformer which steps down the 230v AC to 15v DC and two rectifying diodes and a smoothing capacitor which filters out the ripple in the dc voltage.
- When the output of the solar panel is below 12volts, the relay switches to the AC supply and the battery takes charge from the AC mains, the indicator red LED turns on and whenever the output of the solar panel is 12 volts, the relay switches to solar power.

Operation 2:

CHARGING FROM SOLAR POWER

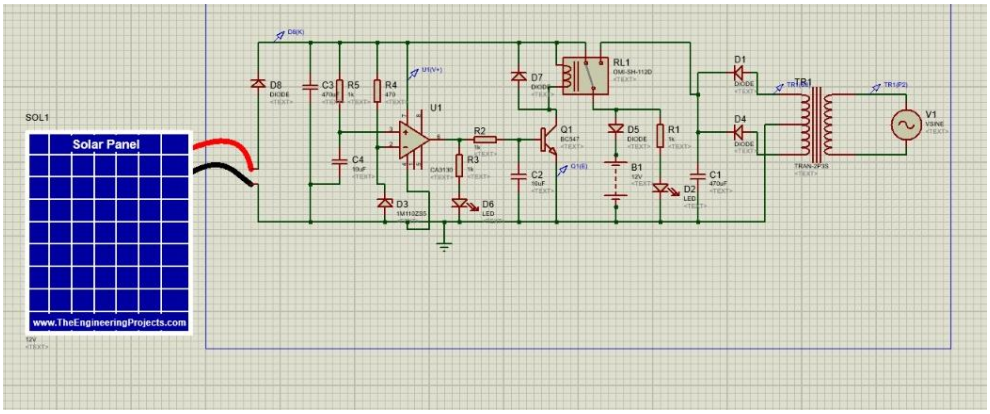


Figure 15: Charging from solar power

- In bright sunlight, the 12V, 10W solar panel provides 12 volts DC with up to 0.5-ampere current. There is a diode to provide reverse polarity protection and a capacitor buffers voltage from the solar panel. The OP-AMP is used as a simple voltage comparator. Zener diode provides a reference voltage of 11 volts to the inverting input of comparator, while the IC's non-inverting input gets voltage from the solar panel. When the solar panel gives 12 volts at its output terminal, the output of the comparator turns high and the same is indicated by a glowing green LED. Then the transistor conducts and the relay energizes to normal open (N/O) position and the battery gets the charging current from the solar panel through the normally-open (N/O) and common contacts of the relay. So with the help of both ac mains and solar panel, we can charge the battery continuously.

Operation 3:

TO OPERATE THE LOAD(INVERTER CIRCUIT):

- Upto now we use the dc power inside the charging circuit to charge the 12v battery but we have to operate ac load. So, we use inverter circuit then use transformer to step up the voltage to 230v.

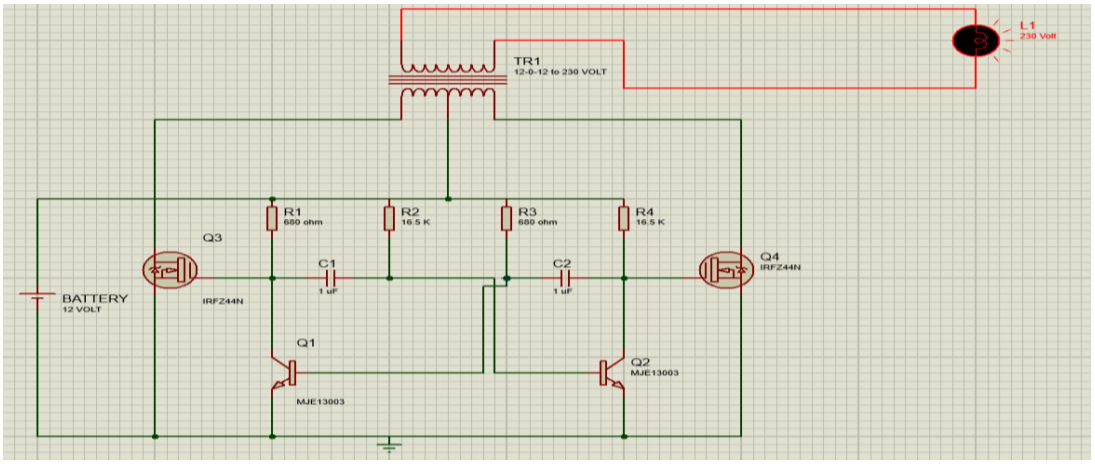


Figure 16: Inverter Circuit

- The circuit composed of the two MJE13003 NPN transistors, the two 1µF electrolytic capacitors, the two 680Ω resistors, and two 16.5KΩ resistors form a multivibrator circuit that determines the frequency of the output. It's really the 1µF capacitors and the 16.5KΩ resistors that chiefly determine the frequency. Since the resistor and capacitor pair form an RC network, the time constant that the output switches on and off at is determined by the formula, =RC= (16.5KΩ)(1µF)= 0.0165s. The inverse of the time constant is the frequency, f=1/τ= 1/0.0165s ≈ 60Hz.
- This part of the circuit is a multivibrator. It creates a closely resembling sinusoidal waveform. When one transistor is on, the other is off. Since the capacitor charges up in a cycle that is closely sinusoidal.
- The MOSFET transistors are power transistors. They provide amplification to the signal created from the multivibrator circuit. Since the MOSFETs are power transistors, they can withstand a lot of power.

Advantages:

- The daily output will be more stable- since the inverter is run by two sources. Both energy sources may offset the demand in output mutually.
- Providing uninterruptable power supply- when solar power supply is not available load connects with main power supply and when both solar and mains power supply is not available load connects to the battery backup.
- It utilises clean energy and doesn't involve any conventional fuel. So there is no chance of pollution by any means.
- The efficiency of the process is more as no moving parts are involved. Also this hybrid inverter has higher efficiency than conventional inverters as it mainly uses the solar energy and takes power from AC mains only when it is absolutely necessary.
- It doesn't require frequent maintenance and operating cost is also less.

Disadvantages:

- One of the main problems in Solar Inverter system is inefficient charging of Battery during cloudy weather condition.
- Initial cost is high and area required for installation is high.
- If the battery is dead the whole circuit fails.
- The battery needs to be monitored and serviced on a regular basis and also we have to replace the battery after a interval of 2-3 years.

Expected Problems and Solving:

For charging circuit, if circuit is not functioning properly, remove the solar panel from connector and connect a DC variable voltage source. Set some voltage below 12volts and slowly increase it. As the voltage reaches 12 volts and goes beyond, the logic at 6 pin of CA3130 changes from low to high. For inverting circuit, when output not available check the output of CD4047 multivibrator at pin 10 and 11 compare with pin 7 and 14 respectively. Next check the output value in transformer primary side.

Chapter V : Hardware Prototype and Results

Hardware Prototype: A hardware prototype is a standard model that meets the specifications of the project. The prototype given below can efficiently utilizes solar energy as well as ac mains and can uninterruptedly supply the load.

Charging circuit: This is the charging circuit which offers two modes of battery charging i.e. one from ac mains and other from solar power.

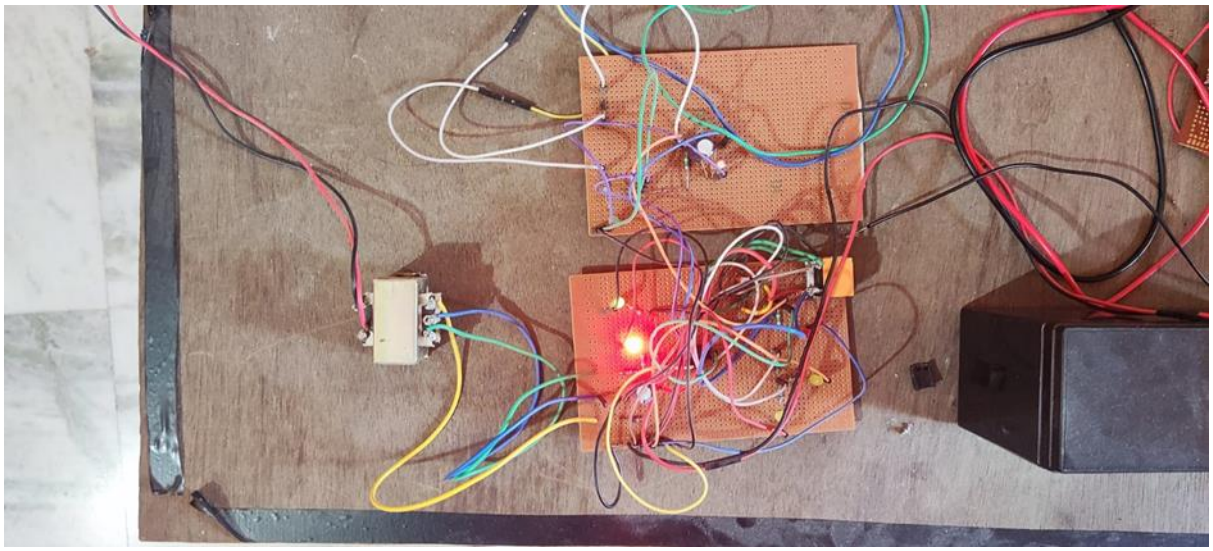


Figure 17: Actual charging circuit

Inverter circuit: This circuit helps to invert the 12v dc to 230v ac to operate the loads.

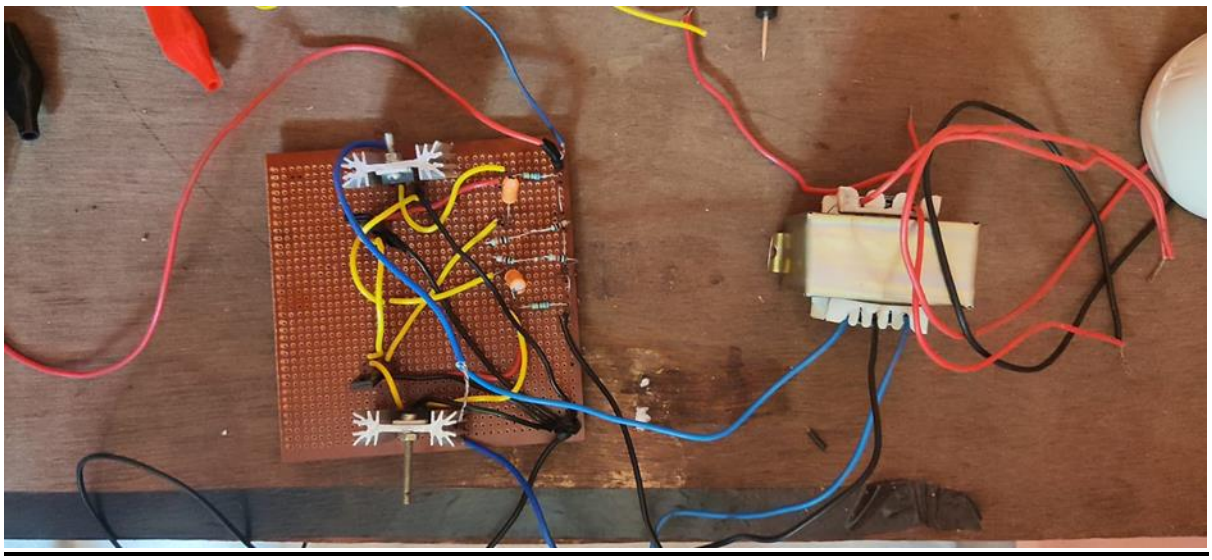


Figure 18: Actual inverter circuit

Prototype Model: This is the practical circuit of our project. The important components have been highlighted here.

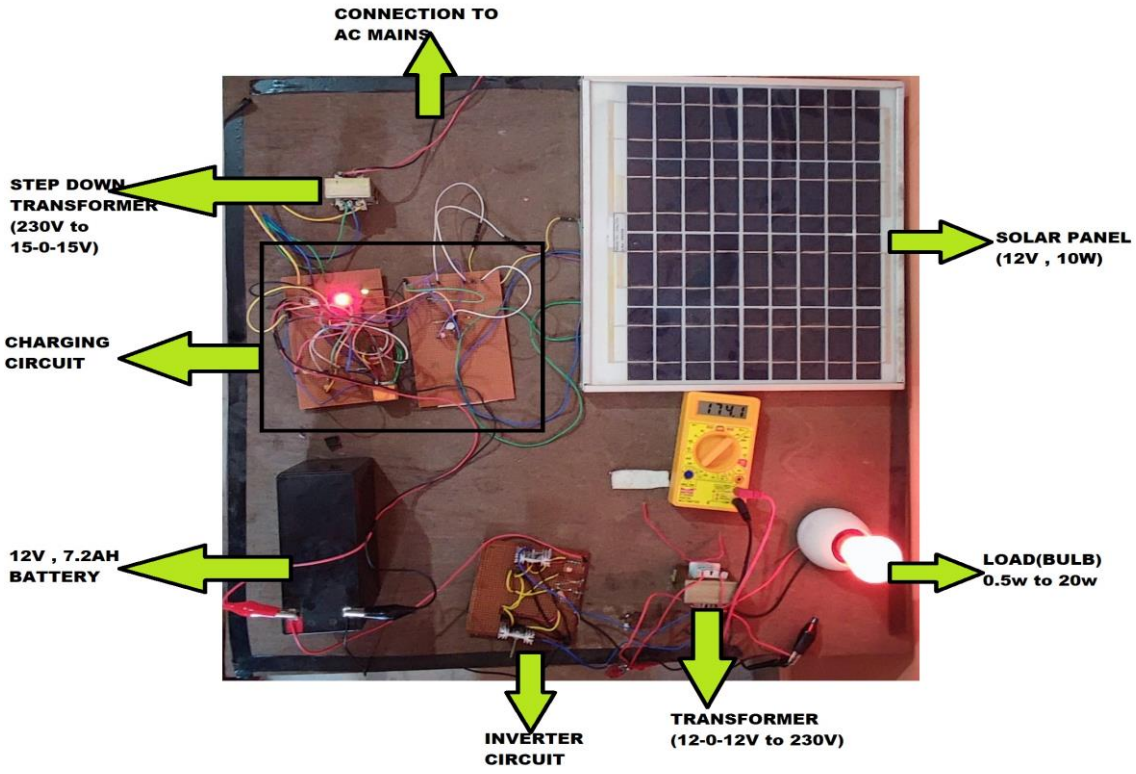


Figure 19: Prototype model of the project

Results:

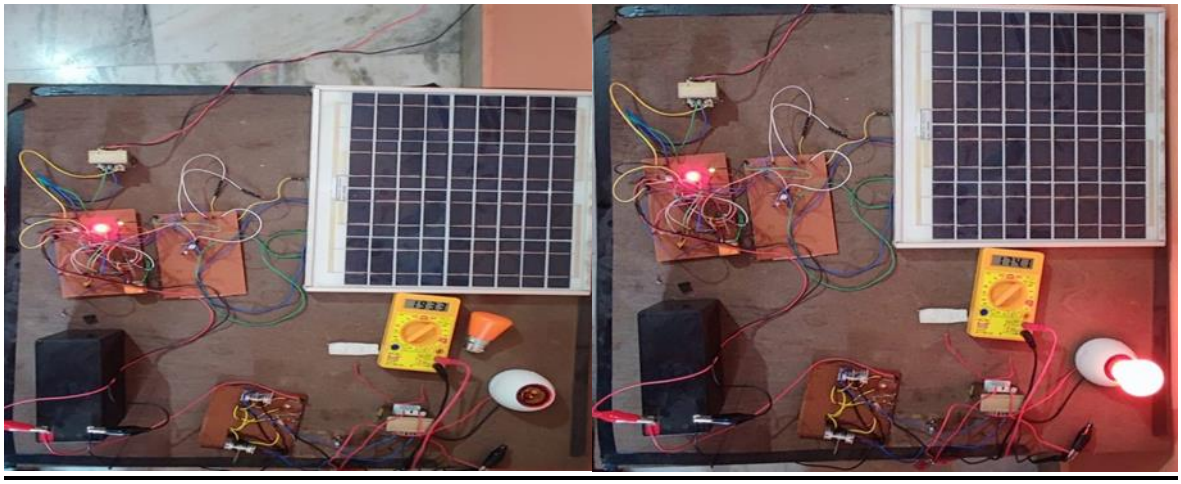


Figure 20: Reading with no load

Figure 21: Reading with 0.5W load

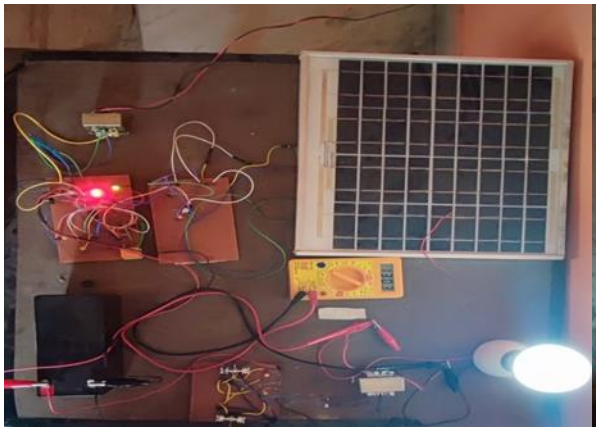


Figure 22: Reading with 15W load

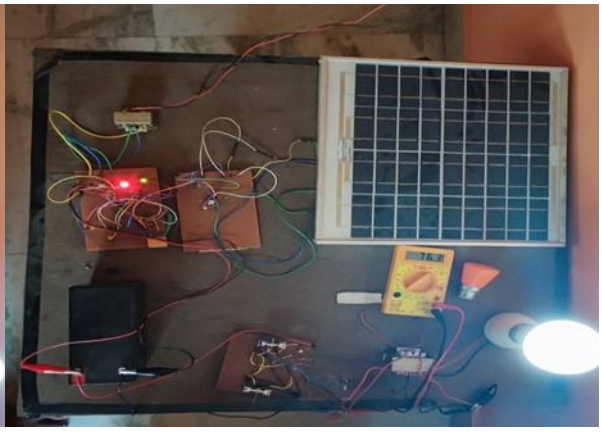


Figure 23: Reading with 20W load

Output:

Serial No.	Load Rating(Watts)	O/P Voltage(V)	O/P Current(mA)
1.	No Load	193.3	0.001≅ 0
2.	0.5	174.1	2.25
3.	5	140.47	31.8
4.	15	130.3	96
5.	20	76.3	182

Chapter VI : Conclusion and Future Scope

Conclusion:

- Sun, being source of clean, pollution-free energy and Photovoltaic power production is gaining more significance as a renewable energy source due to its various advantages. The advantages include everlasting production scheme, ease of maintenance, and direct sunbeam to electricity conversion. However the high cost of installations still forms an obstacle for this technology. Moreover the PV panel output power fluctuates as the weather conditions, such as the luminosity of the solar beam, cell temperature etc.
- The desired design of the system will produce the desired output of the project. The inverter will supply an AC source from a DC source.
- The project described is valuable for the promising potentials it holds within. Ranging from the long run economic benefits to the important environmental advantages. This work will mark an attempt and contribution in the field of renewable energy and can be implemented extensively.

Scope for Future Work :

- 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 the 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 combining solar with wind energy and other renewable sources.
- The hybrid solar inverter made by us is just a prototype for making future projects which incorporates advanced technologies like micro controlled solar tracking, charge control, etc. this is to show that solar inverters are very cheap and easy to install so that the energy demands are shifted on using renewable sources of energy. There is more advancements pending in this field which will revolutionise the energy stream and solar energy will be playing the most important role.

LITERATURE SURVEY :

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 INDIA 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 % ARE, by year 2022.

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Reference Links:

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