International Journal of Electrical and Electronics Engineering (IJEEE)
ISSN(P): 2278–9944; ISSN(E): 2278–9952
Vol. 8, Issue 5, Aug–Sep 2019, 1–10

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

THE SOLAR POWERED UNINTERRUPTED POWER SUPPLY SYSTEM

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ABSTRACT

This paper deals with the research and the development of the solar powered UPS system in India's market as a main source of energy over the conventional AC grid. The design consists of a solar charge controller, inverter circuit, solar panel and 2-channel Relay module automatic switching between the Solar and the conventional grid. It also shows how beneficial the solar powered UPS system over the conventional UPS systems available in the market. It also shows the advantages of the Solar UPS system to the stand-alone system. In this project, the solar panel converts the solar energy to the electrical energy. The DC output of the solar panel is fed to the charge controller which helps in charging the 12V battery and parallelly connects to the inverter circuit where the DC is converted to AC and a step-up transformer is used to increase the level of the voltage from 12V AC to 230V AC. Relay logic is designed for automatic switching between the Solar and the AC grid in case of the failure of any one of the sources. When both the systems fail, the stored charge from the battery drives the load.

***KEYWORDS**: Solar Charge Controller, Half Bridge Inverter, Automatic Switching*

Article History

***Received:** 20 Aug 2019 | **Revised:** 06 Sep 2019 | **Accepted:** 20 Sep 2019*

INTRODUCTION

Humankind is more favourable to comforts and inventing new things without knowledge of hazard of the inventions, creating disturbance on the earth's ecosystem. With fuel depletions and climate changes had driven us to an energy crisis. This has made us realize the urgency for finding alternative sources for requirements of the growing demand for energy. The conventional sources being mostly non-renewable sources of energy, their extensive usage has caused the known reserves to be depleted rapidly. In India alone, the known deposits of petroleum are remained to last only a few decades, whereas coal reserves will last for just another hundred years. Solving this energy crisis needs combined efforts from economies all over the world.

Generally, Renewable sources [1] of energy are those that are naturally replenished in a continues manner. They are also referred to as Green Energy or Clean Energy as they do not contribute for global warming. In India during the year 2017-18, the gross electricity generated by utilities in India was 1,303.49 TWh and the total electricity generation (utilities and non-utilities) in the country was 1,486.5 TWh. Renewable power plants constituted 21.4% of total installed capacity. The Indian electricity sector generates electric power utilizing about 72% of the coal produced in the country.

Solar power in India is a fast-developing industry. India expanded its solar power generation capacity 8 times from 2650 MW on 26 May 2014 to over 20 GW as on 31 January 2018. The 20 GW capacity was initially targeted for 2022 but the government achieved the target four years ahead of the schedule. The country installed 3 GW of solar capacity in 2015-2016 and over 5 GW in 2016-2017, the highest of any year, with the average current price of solar electricity dropping to 18% below the average price of its coal-fired. India's initiative of 100 GW of solar energy by 2022 is an ambitious target, since the world's installed solar-power capacity in 2017 is expected to be 303 GW. The improvements in solar thermal storage power technology in recent years has made this task achievable as the cheaper solar power need not depend on costly and polluting coal-based power generation for ensuring stable grid operation.

Problem Statement and Solution

Since the technological advancements number of sensitive systems that require an absolute reliable power supply has sharply increased. There is no room for error and the equipment's must be provided with the continuous supply. Thus, brings the UPS into the picture but powering the load using a battery dank designed to last until either mains power supply is restores or the backup generator have started which though takes a long time Making solar base energy cost competitive with the traditional, fossil-based sources is a major challenge within the energy industry. If UPS and solar power systems could be successfully combined [2] (resulting in the lower overall system costs), many users of UPS systems might consider investing in their own solar power generation. This would benefit the users, the overall energy systems and the environment. For users of the proposed system the benefit would be the lower lifetime cost of the installed system [3] compared to a conventional stand-alone solar power system. Increased usage of solar energy also decreases the emission intensity if the energy sector, contributing to the more sustainable energy system.

In this paper, we are using solar energy for charging 12V DC battery. Solar panel will constantly charge battery with a proper designed charge controller circuit providing over voltage, under voltage protection and over charge protection. The charge from the battery can be inverted to AC by designing an inverter circuit [4] and stepping up the voltage from 12V AC to 230 V AC. To design a circuit that can be suitable to switch the source from the grid to the U.P.S by a proper relay logic circuit that can be successfully used for emergency cases.

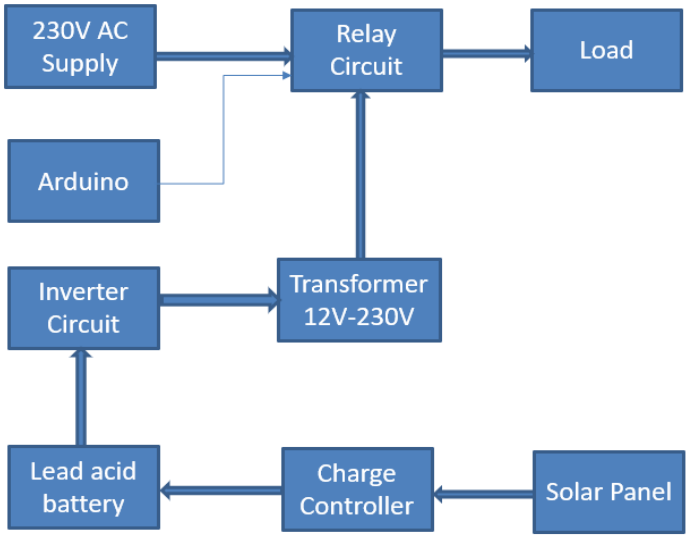

Figure 1: Block Diagram of Solar UPS System

The main objectives of this paper are:

- Modelling and simulation of an inverter
- Design and implementation of a Solar UPS system

Solarphotovoltaic Module

The battery stack is loaded primarily by the photovoltaic system. The SPV module is chosen with reduced power respect to the maximum power delivered by the UPS to the load to reduce the cost and the volume of the system at the expense of a longer recharge time for the batteries.

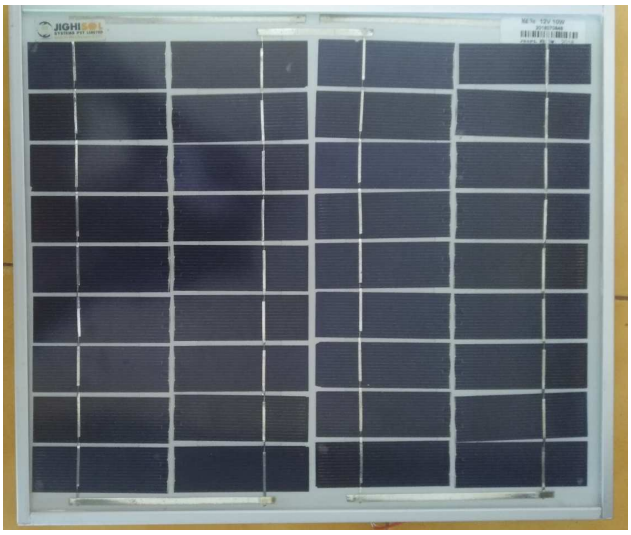

Figure 2: Solar PV Module

Panel Name Plate Details

- Maximum power: 10wp
- Voltage at maximum power: 17.5 V
- Current at maximum power: 0.54 A
- Open circuit voltage: 21.5 V
- Short circuit current: 0.65 A
- Tolerance: +5%
- Specifications are at STC 1000W/m^2 Irradiance, cell temperature 25ºC

Charge Controller

Solar panel is used to charge the 12V lead acid battery for increasing the reliability of the supply from solar and to store the energy. We can directly connect the solar panel to the lead acid battery but due to variation in the irradiance the current may follow in the reverse direction from battery to panel. High voltages may damage the battery and under voltages may decrease the charge of the battery. To overcome the above problems charge controller is used. In our project we have designed a charge controller which has

- Over voltage protection
- Under voltage protection

- Reverse current protection
- Charging bandwidth changer.

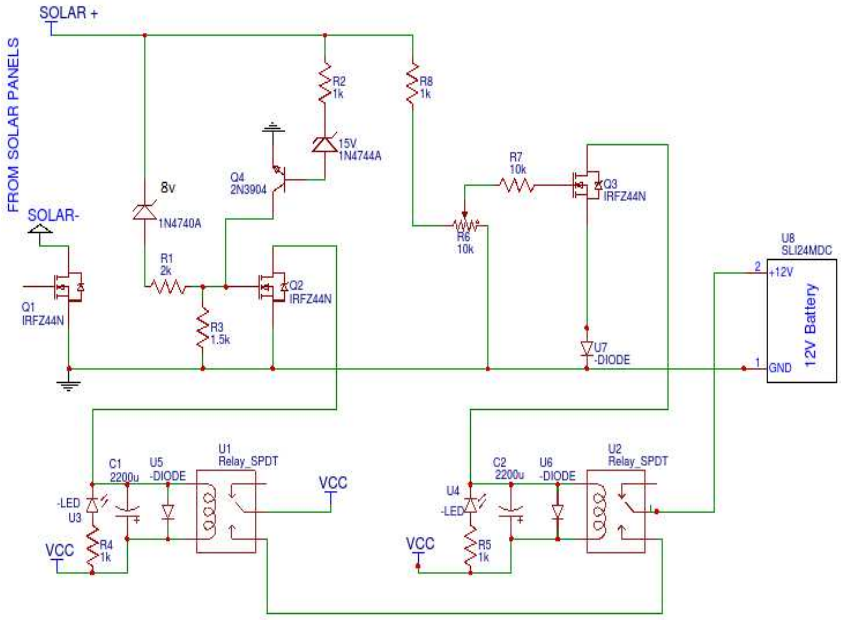

Figure 3: Solar Charge Controller

Battery

Lead acid rechargeable battery is used for storing solar energy. During day time, the battery is charged and when sun goes off, the charge from battery is used to supply the utilities.

Battery rating: 12V/1.3AH/20HR

Figure 4: Rechargeable Lead Acid Battery

Inverter

With the increase of the PV system capacity and the interconnection with the existing power grid, it pushes the design of the PV system to the limit. One of the major parts of the PV system is the conversion of the DC power from the photovoltaic module to the AC source that allows the system to connect to the existing power grid. This conversion is done using a circuit with power electronic device called inverter [6].

A typical inverter divided into two parts, the first one is the power circuit and the second circuit is the control circuit. The power circuit built from MOSFET or IGBT switches the simplest built from four switches shown in Figure 5

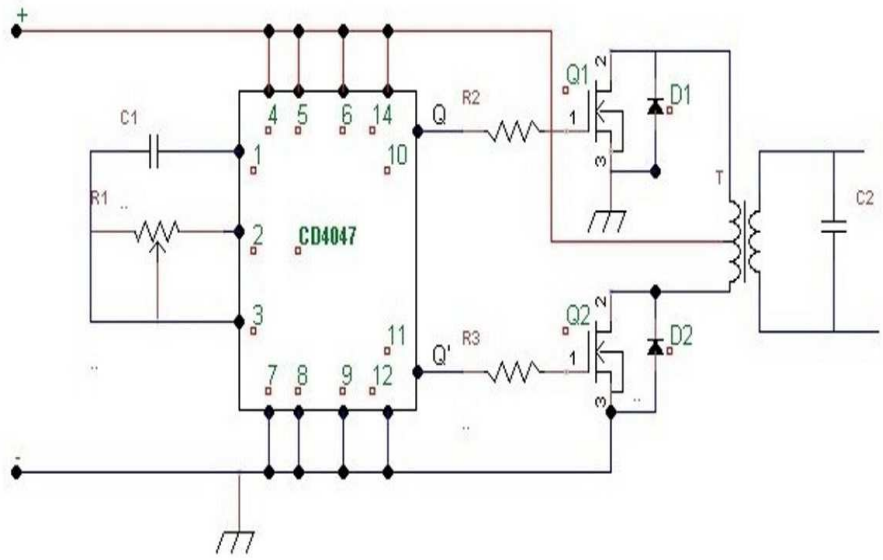

Figure 5: Inverter using IC 4047

The MOSFET switches are switching in predetermined sequence by sending signal to the gate. The signal is sent from the control signal, which built from IC 4047. The control signals are generated from an A stable multivibrator i.e. IC4047. Square wave output from IC 4047 is given as a triggering pulse for the gate of the MOSFET.

IC 4047

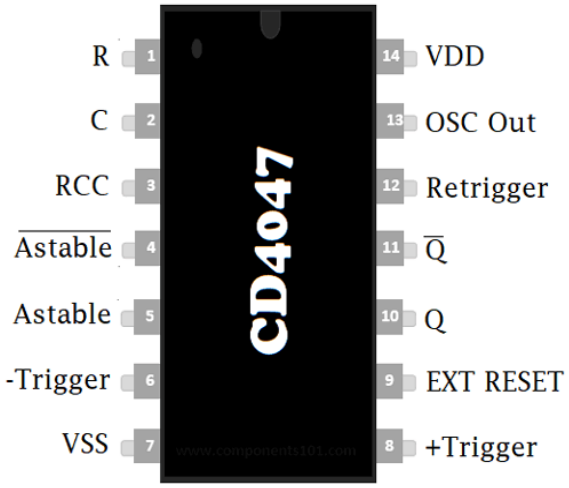

Figure 6: PIN Diagram of IC 4047

The formula for calculating the frequency or the values of R, C components are:

f = 1/8.8RC at pin#10 and pin#11

f = 1/4.4RC at pin#13

Where f is in Hz, R in Ohms and C in Farads.

Relay Logic

Arduino is used as a logic controller for switching between the solar power and conventional mains.

For this purpose, we must sense the voltage of solar incoming and must set a value below which the solar system should not supply the load to protect the battery from over draining and under voltage problems in the utilities which will damage the appliances. The set point of voltage varies with the battery manufacturers

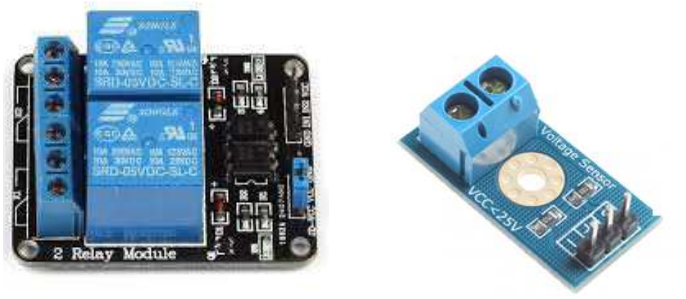

Figure 7: 2-Channel Relay Module and Voltage Sensor

Output Voltage (Vo) =Vi*1/5 Volts

Operation of the Designed Circuit

The design is providing the halls with electricity in two ways depending on whether the grid is on or not.

Scenario 1: Grid is Off

The primary source is the Solar providing the load with power through the charge controller, inverter and the step-up transformer. This bus is the one whom the load takes its power from. In case of failure of solar, the UPS stop charging and the load is fed through the energy stored in the batteries acting as standalone system (island).

Scenario 2: Grid on

In this case the switch between the load and the grid is close which happens only when both the solar and the UPS fails, that means the system is isolated from the solar and is connected to the conventional grid.

Hardware Arrangement

Solar Charge Controller

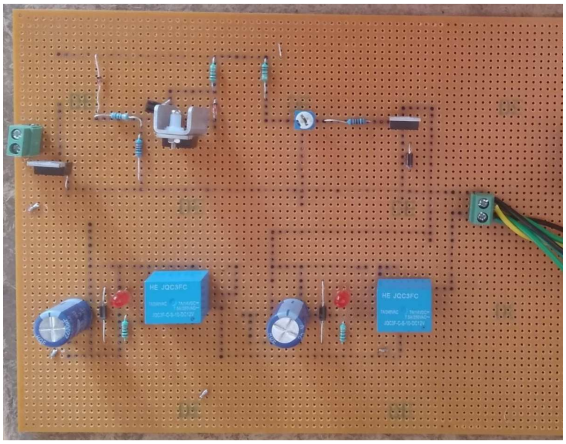

Figure 8: Hardware Implementation of Charge Controller

Here when the panel voltage is less than 8V Zener diode will not conduct so no current passes through it which makes MOSFET Q2 to be in OFF condition. As soon as voltage becomes greater than 8V Zener diode conducts and voltage is given to gate of MOSFET Q2 which turns ON Q2 So, relay 1 connected to Q2 to will be switched ON. Thus, providing Under voltage Protection to battery.

Now, if voltage is greater than 15V then 15V Zener diode conducts turning ON the BJT Q4 which connects gate terminal of MOSFET Q2 to ground turning it OFF, which in turn turns OFF relay 1 connected to it thus, Providing Overvoltage Protection. MOSFET Q1 is used to prevent reverse flow of current when solar panel output is less than battery voltage.

LED across the relay are used to indicate the ON state of relays. Diodes are to protect against reverse Polarity of solar panel

Inverter

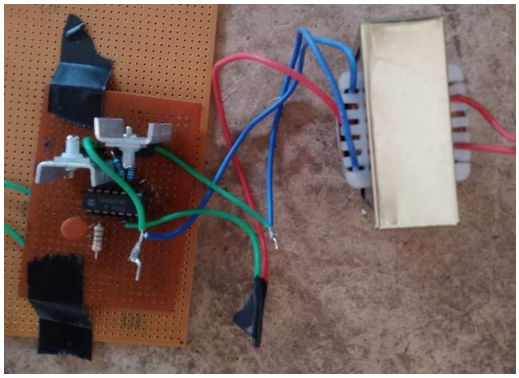

Figure 9: Hardware Arrangement of Inverter

CD4047 is used to get square wave output which is connected to gate terminals of MOSFETs switching them ON and OFF periodically. Connections should be done as per the diagram to configure so that it runs in A stable mode. The frequency of the pulses produced is decided based on the RC values used.

By this if Q1 is switched ON current flows in upper half of the transformer which induces voltage in secondary of transformer. Later when Q1 is OFF and Q2 is ON current flows in lower part of the transformer which induces voltage in secondary but this time in opposite direction. Thus Ac voltage is produced but Output waveform is not a square wave to get a sine wave we need to design a filter which removes the harmonics and can give nearly sinusoidal wave as output. This output is given to Transformer which is stepped up to 230V AC and is given to load.

Complete Hardware Arrangement

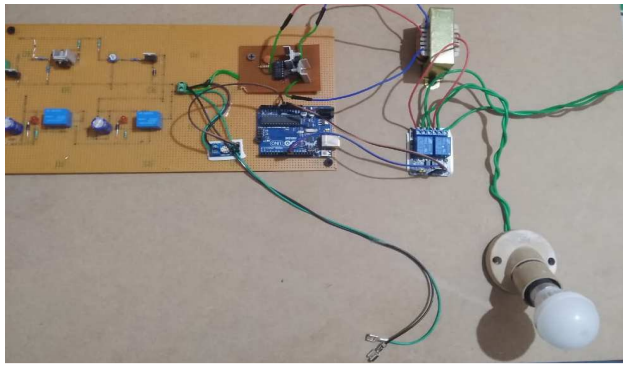

Figure 10: Solar Powered UPS System

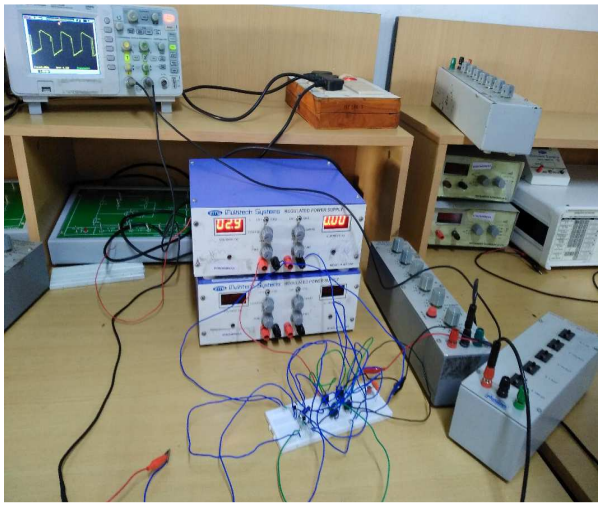

Figure 11: Inverter Circuit

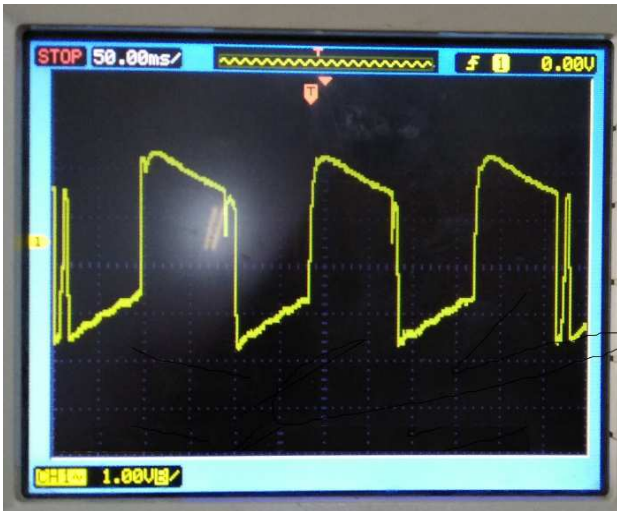

Figure 12: Output of the Inverter Circuit

Depending of the output of solar panel Zener diode conducts and relay switches ON and charge controller continuous to charge the battery. But when voltage is higher than predetermined relay switches OFF and disconnects the battery.

Among all the sources power from solar panel is given the highest priority. It is used to power load as default source and a part of solar energy is used to charge battery simultaneously along with load but if voltage from solar panel is not enough then power from battery is used to feed the load.

When voltage from battery also is low then Arduino senses this using voltage sensor and switches the relay module to ON position and connects conventional source to load. During this time solar panel can charge the battery in sunlight.

CONCLUSIONS

The main goal of this project was to design a circuit that can minimize the grid cost to the consumer while the grid is on and provide us with a continuous supply to the load irrespective of the grid. The conclusions drawn regarding the technical feasibility of the combined system is that it is technically possible to combine solar energy and UPS systems.

The addition of solar energy does not have any significant impact on the power quality of the UPS system. In case of power outages in the electricity grid, solar power can benefit the system with both less impact on power quality at the point of disconnection from the grid and increase the autonomy time of the UPS.

The economics related to the combination of solar power and UPS systems are two-fold: the investment cost of the system and the total generated energy. Based on prices for commercially available inverters and solar charge controllers the conclusion is drawn that the investment cost of the combined system is significantly lower than for separate systems.

In the solar power generation, the combined system is concluded to have the higher total system efficiency than a conventional stand-alone system.

But in the bright side this design allows us to:

- To feed the load with both systems what makes the consumed watt per hour for consumer is reduced.
- The ability to provide continuous supply for the load in sunny good days.
- During black out the load is sufficiently supplied.

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