Design and Development of Rooftop Solar Powered Inverter for Home Appliances

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Abstract. This paper begins with a comprehensive analysis of the requirements and specifications of a typical household's power consumption. It then explores various photovoltaic (PV) panel technologies and battery storage options to optimize the system's performance and reliability. The proposed solar based inverter system incorporates several key components, including solar panel, charge controllers, batteries, and inverter circuit. The solar panel is strategically positioned to capture maximum sunlight, and the charge controller regulates the charging process to prevent overcharging and ensure battery longevity. A battery bank stores excess solar energy for use during cloudy days or at night. The inverter converts DC power from the batteries into AC power compatible with home appliances. This paper highlights the design and development of clean, simple and cost-effective solar powered inverter for home appliances. The inverter uses MOSFET IRF540 as a switching device to convert the 24v to 220v. This design will contribute to sustainable energy solutions, reduce electricity bills, and minimize the carbon footprint of households. The results of this development effort demonstrate the feasibility of implementing renewable energy sources for everyday residential needs.

Keywords: Poly-crystalline solar panel, Battery, Transformer, IC, Resistors, MOSFET's, Charging Circuit, Renewable Energy Source.

1. Introduction

The increasing demand for sustainable power solutions has given rise to a significant and growing interest in solar-based systems. This research project is a response to this increasing interest and aims to explore the intricate details involved in the design of a rooftop solar-powered inverter system that is tailored specifically for the usage of household appliances.

At its heart, the primary function of this system is to effectively capture solar energy, store it in batteries, and ultimately convert it into AC power. This conversion into AC power is crucial as it is the type of electricity that is used by standard household appliances. In other words, this system is designed to fulfill the power requirements of a typical household through the utilization of solar energy.

2. Literature Survey

The various sources of renewable energy are tides, sunlight, rain, geothermal energy and wind. These resources can be naturally replenished and never go out of stock. Generally the prime source of energy these days come directly or indirectly from fossil fuels which are slowly getting exhausted from the earth storage unlike these renewable resources which are inexhaustible in nature.

Today to generate most of electrical power conventional sources like coal, gas, nuclear power generators are used. Some of conventional source are polluted the environment to generate the electricity. And nuclear energy is not much preferable because of its harmful radiation effect on the mankind. After some of ten years conventional sources will not be sufficient enough to full-fill the requirements of man-kind. To full-fill the requirements the electrical power should be generated by using renewable energy sources like solar, wind.
Solar energy is a sustainable and environmentally friendly option, as it produces electricity without emitting greenhouse gases or pollutants, contributing to reduced carbon footprint and improved air quality.
Solar power generation have low operating costs and can yield significant long-term savings.

3. Hardware Requirements

1. Solar Panel:

Figure 1: Solar Panel

A solar cell is a device that converts solar energy into electricity. Solar panels are an assembly of multiple solar cells. Solar panels are made up of silicon and are environmentally friendly, producing clean renewable energy. Solar panels help reducing reliance on fossil fuels.

Table 1: Solar Panel Specifications

Material Type	**Poly-crystalline**
Maximum Power (P Max)	5WP
Voltage at Max. Power (Vmp)	18.02V
Current at Max. Power (Imp)	0.27A
Open Circuit Voltage (Voc)	21.5V
Short Circuit Current (Isc)	0.28A
Dimension in mm	260 x 180
Tolearance	± 5%

2. Lead Acid Battery:

Figure 2 :Lead acid Battery

Lead-acid batteries are secondary batteries, also known as rechargeable batteries. This means they can be charged and discharged multiple times, making them suitable for applications where the battery needs to be used repeatedly.

3. Center-tapped Step-up Transformer:

Figure 3: Center-tapped Step-up Transformer

Transformer is energy converting device. A transformer is a constant frequency device.

A transformer works on the principle of mutual induction between two coils. These coils are the primary and secondary coils, which are linked by common magnetic flux. Mutual induction is the process by which a coil of wire magnetically induces a voltage in another closely located coil.

A 12-0-12V center-tapped step-up transformer is a specific type of transformer with all primary winding provided with a center tap which creates three terminals on the primary side.

The transformer turns ratio is 1:9 so that 24V input voltage is converted to 220v. Center tapped transformer are commonly used in various electrical and electronic applications to step up voltage levels while providing a grounded reference point.

4. IC-CD4047:

Figure 4: IC-CD4047

The CD4047 is a low power inverter. The IC CD4047 is a high voltage CMOS (Complementary Metal-Oxide Semiconductor) integrated circuit.

It is used as Multi-vibrator and it operates in two modes,
1. Mono-stable mode
2. Astable mode
In mono-stable mode, it can generate a single pulse of a specified duration, while in Astable mode, it produces continuous square wave oscillations.
CD4047 having 14pins which includes input and output connections as well as control pins for controlling the mode of operation. The 10th and 11th pins are capable of providing continuous square oscillations.

Specifications:
1. Operating temperature: -55°C to +125°C
2. Operating voltage: 3V to 18V.

5. MOSFET IRF-540:

Figure 5: MOSFET IRF-540

A Metal Oxide Semiconductor Field-Effect Transistor (MOSFET) is a field-effect transistor (FET with an insulated gate) in which the voltage determines the device's conductivity. It is a three-terminal device with Source (S), Drain (D) and Gate(G) terminals.
MOSFET works in two modes, depletion mode and Enhancement mode.The IRF540 is an N-Channel MOSFET. The operation mode of the IRF540 is Enhancement mode. IRF540 Provides faster switching and amplification.
The specifications are:
1. Continuous Drain Current (ID) is 33A at 25°C
2. Pulsed Drain Current (ID-peak) is 110A
3. Minimum Gate threshold voltage (VGS-th) is 2V
4. Maximum Gate threshold voltage (VGS-th) is 4V
5. Gate-Source Voltage is (VGS) is ±20V
6. Maximum Drain-Source Voltage (VDS) is 100V

4. Block Diagram

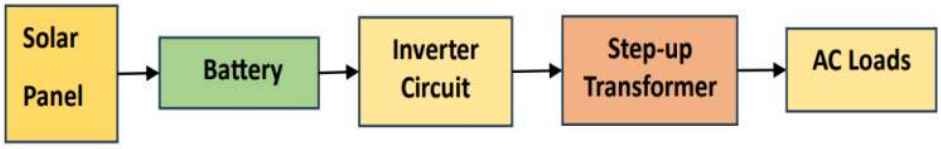

Figure 6: Block diagram of Solar-powered inverter

Above block diagram of a solar-powered inverter for home appliances is a visual representation that illustrates the key components which are used to convert solar energy into usable electricity for running various household appliances. This diagram provides an overview of how the system functions and helps users understand the interaction between different components.

5. Flow Chart

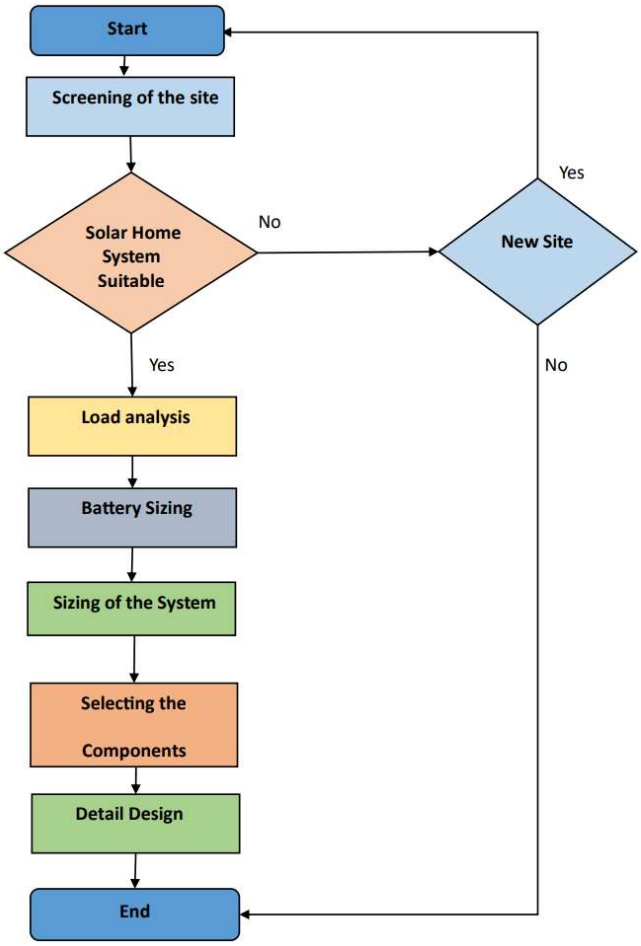

Figure 7: Flow chart of Solar Powered Inverter for Home appliances

6. Working

The working of the circuit can be divided into three parts: Solar panel, Inverter circuit and Transformer. The process begins with a solar panel array typically installed on a rooftop or ground-mounted structure. Solar panels consist of photovoltaic cells that convert sunlight into DC electricity through the photovoltaic effect When sunlight strikes the solar panels, it excites electrons within the photovoltaic cells, creating an electric current. This current generated by the panels is in the form of direct current (DC), which flows in one direction. The DC electricity produced by the solar panels is then fed into the solar inverter.

The primary function of the inverter is to convert this DC electricity into alternating current (AC). A 50Hz oscillator is required as the frequency of AC supply is 50Hz. This can be achieved by constructing an Astable multi-vibrator which produces a square wave at 50Hz.The pins of IC CD4047 10(Q) and 11(Q') are connected to IRF-540 MOSFET's Gate terminals respectively. Both MOSFET'S Source terminals are connected to common DC supply. MOSFET-1 produce +12v and MOSFET-2 produce -12v, the individual drain terminals are connected to the center-tapped step-up transformer.The turns ratio of the transformer must be 1:9 in order to convert 12V to 220V. The center-tapped step-up transformer is used to convert the 12v to 220v AC. And then produced 220V AC is used for home appliances.

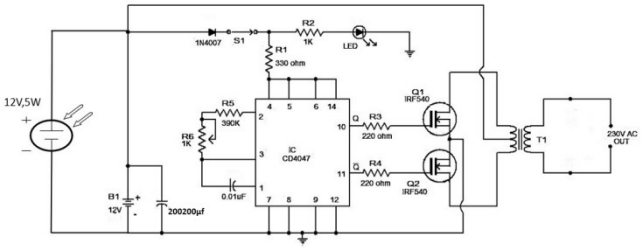

Figure 8: Inverter Circuit

7. Result

7.1Before switching ON the Circuit:

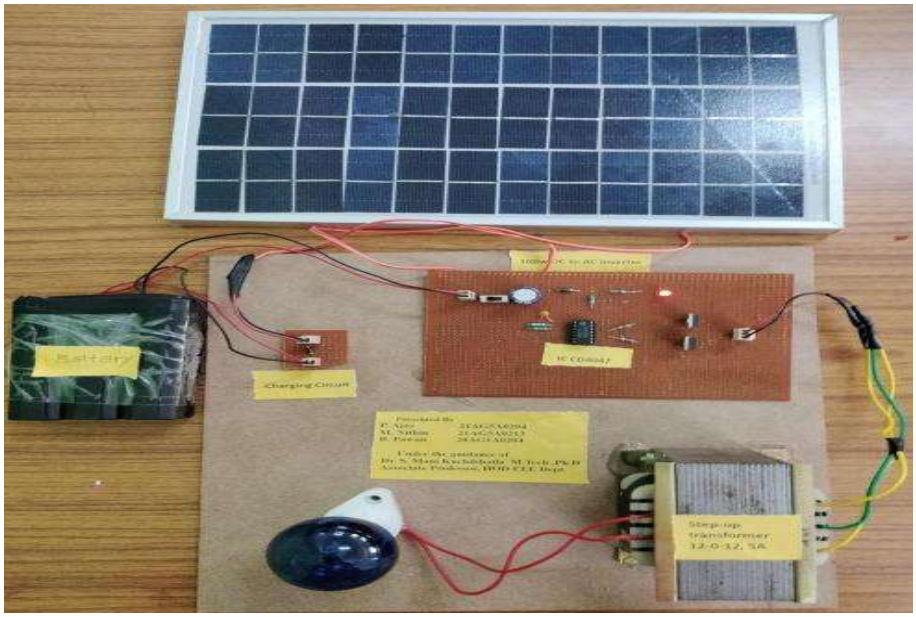

Figure 8: Circuit in Off position

The figure above shows that all of the components are connected according to the circuit diagram and the circuit is in an idle state. In its idle phase, the inverter's photo-voltaic input is primed and ready to receive sunlight, waiting for the solar panels to start generating electrical energy. In the current state, this solar energy is not active in the conversion into usable alternating current (AC).

7.2 After switching ON the Circuit:

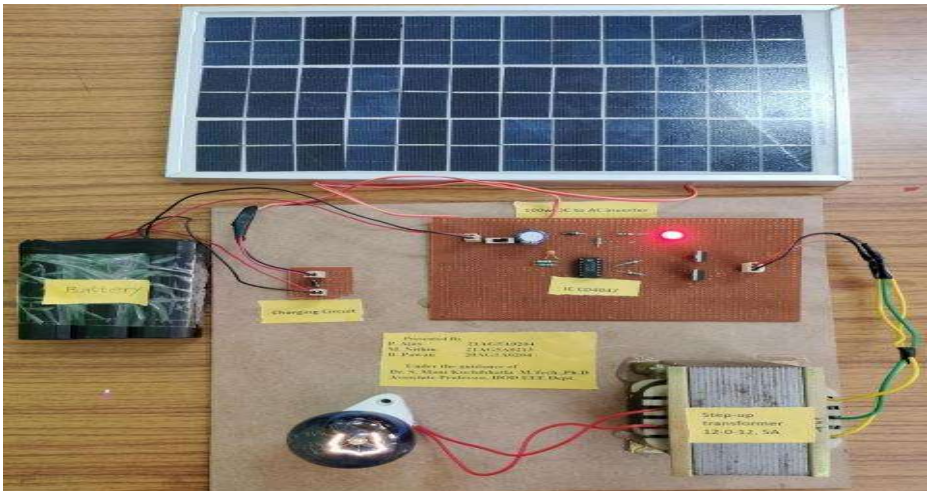

Figure 9: Circuit in ON position

The above figure shows the inverter circuit in the ON Position, here the LED glows which indicate the circuit is in working condition. Therefore, the conversion starts and the output 220V is obtained across the load (Bulb).
The Benefits of using solar-powered inverter are:

1. It is one of the methods of renewable generation.
2. This is an eco-friendly means of power generation.
3. It can be used in distant villages where transmission cost is much high.
4. Reduction in consumption from conventional sources ofenergy.
5. It acts as a power back-up solution.
6. Grid Support and Stabilization
7. Uninterruptible Power Supply (UPS).

Rooftop Solar-powered inverter specially used at:

- Rooftop solar power inverters are commonly used in residential settings to harness solar energy for household electricity needs.
- Commercial and Industrial Installations are also used on the rooftops of commercial and industrial buildings to offset electricity costs and reduce carbon footprints.
- In remote areas or where a grid connection is not available, rooftop solar inverters are used in off-grid systems to provide self-sustaining power.

8. Expense Analysis

Table 2: Cost analysis of various components

S. No	COMPONENT	RATING	QUANTITY	COST
1.	Center-tapped Step-up Transformer	12V/230V, 5A	1	Rs.650
2.	IC	CD4047	1	Rs. 25
3.	Lead-Acid Battery	4V, 1.5A	3	Rs.475
4.	Solar panel	12V, 5W	1	Rs.450
5.	MOSFET	IRF 540	2	Rs. 80
6.	LED	-	1	Rs. 5
7.	Capacitors	0.01µf	1	Rs. 5
		200200µf	1	Rs. 5
8.	Resistors	220 Ω	2	Rs. 20
		330 Ω	2	Rs. 10
		390kΩ	1	Rs. 5
9.	Diode	IN40007	2	Rs. 10
10.	Connecting wires	-	-	Rs.100
11.	Miscellaneous	-	-	Rs.500
TOTAL COST			Rs. 2340	

9.Conclusion

We conclude that the described 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 one of the few attempts and contributions in the Arab world, in the field of renewable energy: where such projects could be implemented extensively. With the increasing improvements in solar cell technologies and power electronics, such projects would have more value added and should receive more attention and support. Photovoltaic power production is gaining more significance as a renewable energy source due to its many advantages. These advantages include everlasting pollution free energy production scheme, ease of maintenance, and direct sunbeam to electricity conversion. However the high cost of PV installations still forms an obstacle for this technology. More over the PV panel output power fluctuates as the weather conditions, such as the insulation level, and cell temperature.

10. Future Scope

As whole world is facing a problem of global warming and energy crisis, our project will help to reduce these problems by using solar energy to generate electricity. Solar energy is an infinite source of energy. Main motto of our project is to promote use of renewable energy sources. This project is most useful in our life because in this project one time investment fixed on life time. In future one day non-renewable energy will end then we will use to the renewable energy.
The solar inverter made by us is just a prototype for making future projects which incorporate 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.

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Biography

Dr. S. Mani Kuchibhatla. HOD EEE, ACE Engineering College, India. She was born in the year 1979 and having 20+ years of Teaching Experience. She did her B.Tech from JNTU Kakinada; M.Tech from NIT Warangal & Awarded Ph.D. from JNTU Kakinada .She has severalInternational and National Journal Publications. She is Re-viewer for several Peer-Reviewed Journals. She organized several Workshops & National Conferences. She is Lifetime member of Indian society of Technical Education (ISTE) and also life time member of Indian institute of Electronics & Telecommunications (IETE). Her areas of interests are power quality improvement, Flexible AC Trans-mission, PLC& SCADA.

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